CITY OF MORGAN HILL

CITY OF MORGAN HILL

2018

STORM DRAINAGE SYSTEM MASTER PLAN

Final

September 2018

AKEL ENGINEERING GROUP, INC.

AKEL ENGINEERING GROUP, INC.

Smart Planning Our Water Resources

September 6, 2018

City of Morgan Hill
17575 Peak Avenue
Morgan Hill, CA 95037-4128

Attention: Scott Creer, P.E.
Director of Public Works/City Engineer

Subject: 2018 Storm Drainage System Master Plan – Final Report

Dear Scott:

We are pleased to submit the final report for the City of Morgan Hill Storm Drainage System Master Plan. This master plan is a standalone document, though it was prepared as part of the integrated infrastructure master plans for the water, sewer, and storm drainage master plans. The master plan documents the following:

- Existing system facilities, acceptable hydrologic and hydraulic performance criteria, and projected stormwater runoff consistent with the Urban Planning Area.
- Development of the City's GIS-based hydrologic and hydraulic stormwater models.
- Capacity evaluation of the existing system with improvements to mitigate existing deficiencies and to accommodate policy updates and future growth.
- Capital Improvement Program (CIP) with an opinion of probable construction costs and suggestions for cost allocations to meet AB 1600.
- Hydrologic analysis and modeling completed by Hydmet.

We extend our thanks to you, Dan Repp, Deputy Director of Public Utilities, and other City staff whose courtesy and cooperation were valuable components in completing this study.

Sincerely,

AKEL ENGINEERING GROUP, INC.

Tony Akel, P.E.
Principal

Enclosure: Report

Acknowledgements

City Council

Steve Tate, Mayor

Rich Constantine, Mayor Pro Tempore

Larry Carr

Rene Spring

Caitlin Robinett Jachimowicz

Management Personnel

Scott Creer, City Engineer

Chris Ghione, Public Services Director

Dan Repp, Deputy Director of Utility Services

Karl Bjarke, Former Public Works Director/City Engineer

John Baty, Senior Planner

Other City Engineering, Planning, and Operations Staff

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EXECUTIVE SUMMARY

This executive summary presents a brief background of the City of Morgan Hill's stormwater drainage system, the planning area characteristics, the hydrology and hydraulic criteria, and the hydrology and hydraulic model developments.

These hydrology and hydraulic models were used to evaluate the capacity adequacy of the existing stormwater drainage system, for recommending improvements to mitigate existing deficiencies and for servicing future growth. The prioritized capital improvement program accounts for growth throughout the City of Morgan Hill.

ES.1 STUDY OBJECTIVES

The City of Morgan Hill (City) recognizes the importance of planning, developing, and financing stormwater drainage facilities. In order to provide enhanced stormwater drainage to existing developed areas and for servicing anticipated growth, City staff initiated the preparation of this 2018 Storm Drainage System Master Plan (SDMP)

City Council approved Akel Engineering Group Inc. to prepare this master plan in June of 2013. The 2018 SDMP analyzes the capacity of the City's stormwater drainage system using hydrology and hydraulic models and recommends prioritized capacity improvements.

The area and horizon for the master plan is stipulated in the City's General Plan. Should planning conditions change, and depending on their magnitude, adjustments to the master plan recommendations might be necessary.

The City authorized Akel Engineering Group Inc. to complete the following tasks:

- Summarizes the City's existing stormwater system facilities.
- Document growth planning assumptions and known future developments.
- Update the Storm Drainage system performance criteria.
- Project future stormwater flows.
- Develop new hydrologic and hydraulic models based on updated planning assumptions.
- Evaluate the storm drainage facilities to address hydraulic capacity requirements from existing and projected developments.
- Perform a capacity analysis for the existing collection system and recommending improvements.
- Recommend a Capital Improvement Program (CIP) with an opinion of probable costs.
- Perform a capacity allocation analysis for cost sharing purposes.
- Develop a Storm Drainage System Master Plan report.

ES.2 INTEGRATED APPROACH TO MASTER PLANNING

The City implemented an integrated master planning approach and contracted the services of Akel Engineering Group to prepare the following documents:

- Water System Master Plan
- Sanitary Sewer System Master Plan
- Storm Drainage System Master Plan

While each of these reports is published as a standalone document, they have been coordinated for consistency with the City's General Plan document. Additionally, each document has been cross referenced to reflect relevant analysis results with the other documents.

ES.3 STUDY AREA DESCRIPTION

The City of is located in Santa Clara County, approximately 20 miles southeast of the city of San Jose and 24 miles northwest of the city of Hollister. The City's closest neighbor, the city of Gilroy, is located 10 miles to the south. Highway 101 bisects the eastern boundary of the City in the north-south direction. The City limits currently encompass 12.9 square miles, with an approximate population of 44,000 residents.

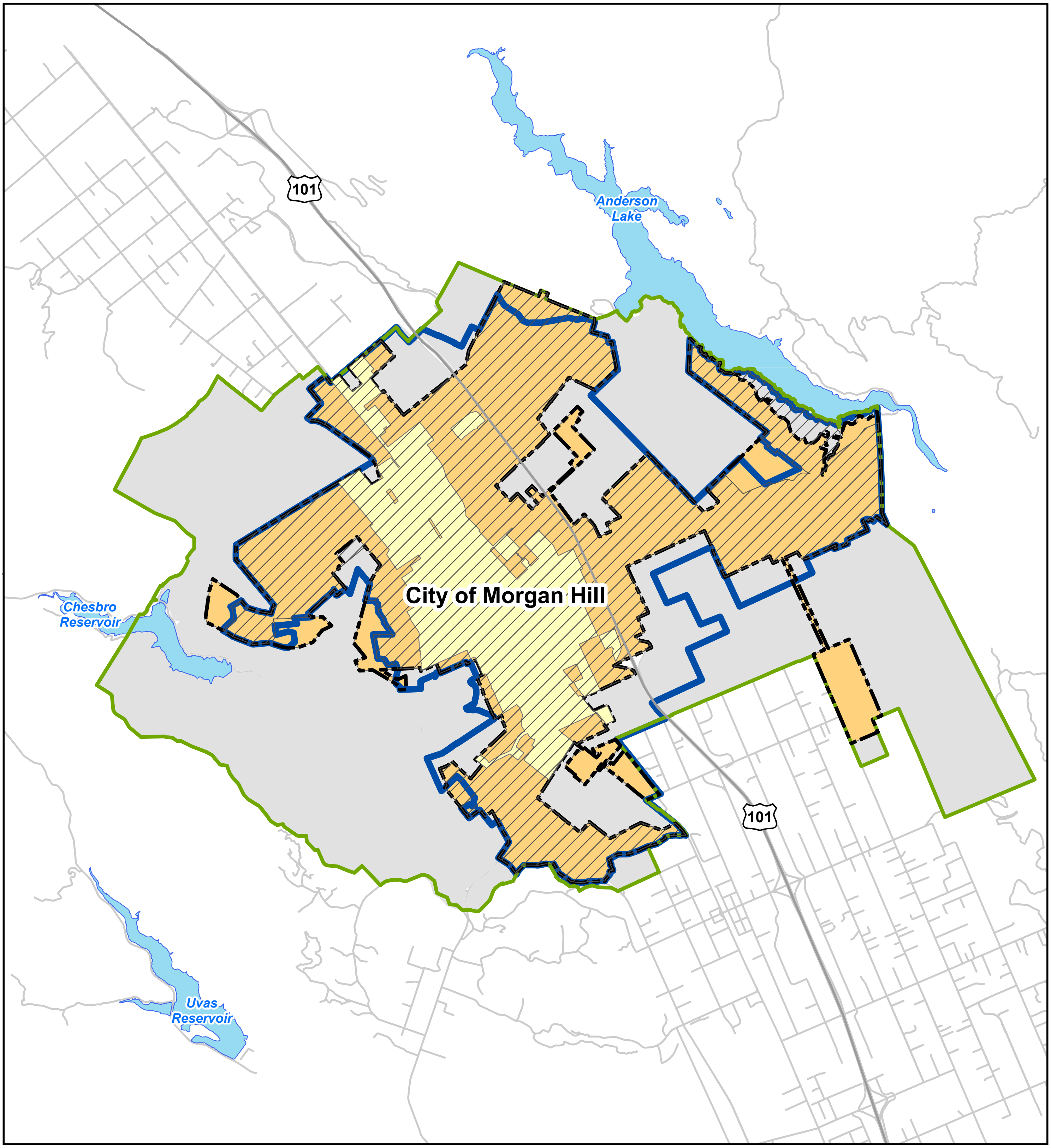
The City is generally bound by Anderson Lake to the east, rolling foothills to the west, Cochrane Road to the north, as well as Maple Avenue and Atherton Way to the south. There are two unincorporated areas to the north and south of the City respectively: Santa Teresa and San Martin. The topography is generally gently sloped upward from south to north. **Figure ES.1** displays the planning area showing city limits, the Urban Growth Boundary of the City and the Census Designated Places (CDP).

ES.4 SYSTEM PERFORMANCE AND DESIGN CRITERIA

This report documents the City's performance and design criteria that were used for evaluating hydrologic and hydraulic systems within the City's drainage watershed (**Table ES.1**). Hydrologic criteria are developed to characterize the flood routing of rainfall runoff in a defined drainage system. Akel Engineering Group retained the services of Hydmet to complete the hydrologic evaluation of this project. The hydraulic criteria for the storm drainage system were used to evaluate the capacity requirements of conveyance facilities, retention basins, and pump stations.

ES.5 HYDROLOGIC MODEL DEVELOPMENT

Factors critical to the hydrologic model development include the watersheds, drainage basins within each watershed, overland flow routing within drainage subbasins, and conveyance that makes full use of pipes as well as streets for routing 100-year design storm events. This section discusses the existing watersheds, and the delineation of drainage basins and subbasins.



Legend

- City Limits
- City Limits Area
- Redevelopment Area
- Urban Service Area
- Urban Growth Boundary
- Sphere of Influence Boundary
- General Plan Area
- Roads
- Highways
- Lakes

N W E S GIS

0 0.25 0.5 1 Mile

Updated: September 6, 2018

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ES. 1
Planning Area

Storm Drainage System Master Plan
City of Morgan Hill

CITY OF MORGAN HILL

Table ES.1 Hydrologic and Hydraulic Design Criteria

Storm Drainage System Master Plan
City of Morgan Hill

Hydrology and Hydraulics Design Criteria	
Ponding Basins	
Design Storm	
Detention	25-Year 24-Hour of 5.24'' rainfall if downstream conveyance is capable of conveying excess flows up to the 100-year 24-hour of 6.50'' rainfall design storm
Retention	100-Year 24-Hour, 6.50" rainfall
Conveyance System	
Pipelines	10-Year 24-Hour design storm
Pump Station Individual Sizing Requirements	**Detention:** Sizing is based on the downstream receiving facilities **Direct Discharge:** Sizing based on flows that reach the pumps (largely dependent on upstream facilities)
Streets	100-Year 24-Hour design storm to determine if flooding exceeds one foot in depth and can flood buildings or create safety hazards
Receiving Waters (Streams, Creeks, Channels)	**Existing System:** FEMA 100-year water surface elevations used for downstream control for facilities where 100-year flood maps are available **Proposed System:** For areas where planned channel improvements mitigate backwater deficiencies, the adjusted 100-year water surface elevation was used
Obstructions (Roads, Railroads, Freeways)	Shall be noted in master plan with all drainage structures through them designed to convey 100-Year 24-Hour storm

The selected modeling software that was used for the hydrology analysis on this project was developed by the U.S. Army Corps of Engineers' Hydrologic Engineering Center System 1 (HEC-1). HEC-1 is capable of evaluating a wide array of flood hydrology systems, including large river watersheds, and small urban drainage runoff.

ES.6 HYDRAULIC MODEL DEVELOPMENT

The hydraulic model was developed to evaluate the capacity adequacy of the City's storm drainage system. The model was used to identify capacity deficiencies and to recommend improvements to mitigate those deficiencies. An inventory of the existing modeled pipe inventory is included on **Table ES.2**.

The hydraulic modeling software used for evaluating the capacity adequacy of the City's storm drainage system, InfoSWMM by Innovyze Inc., which utilizes the fully dynamic St. Venant's Equation, has a more accurate engine for simulating backwater and surcharge conditions, in addition to having the capability for simulating manifolded force mains. The software also incorporates the use of the Manning Equation in other calculations including upstream pipe flow conditions.

The hydraulic model was thus developed, as shown on **Figure ES.2**. The model was populated to include rim elevations at manholes, invert elevations of pipelines, pipe sizes, pipe slopes, pipe lengths, and outfall elevations. Input hydrographs were developed using the HEC-1 hydrology model and were used as inputs into the InfoSWMM hydraulic model to simulate stormwater runoff entering the system.

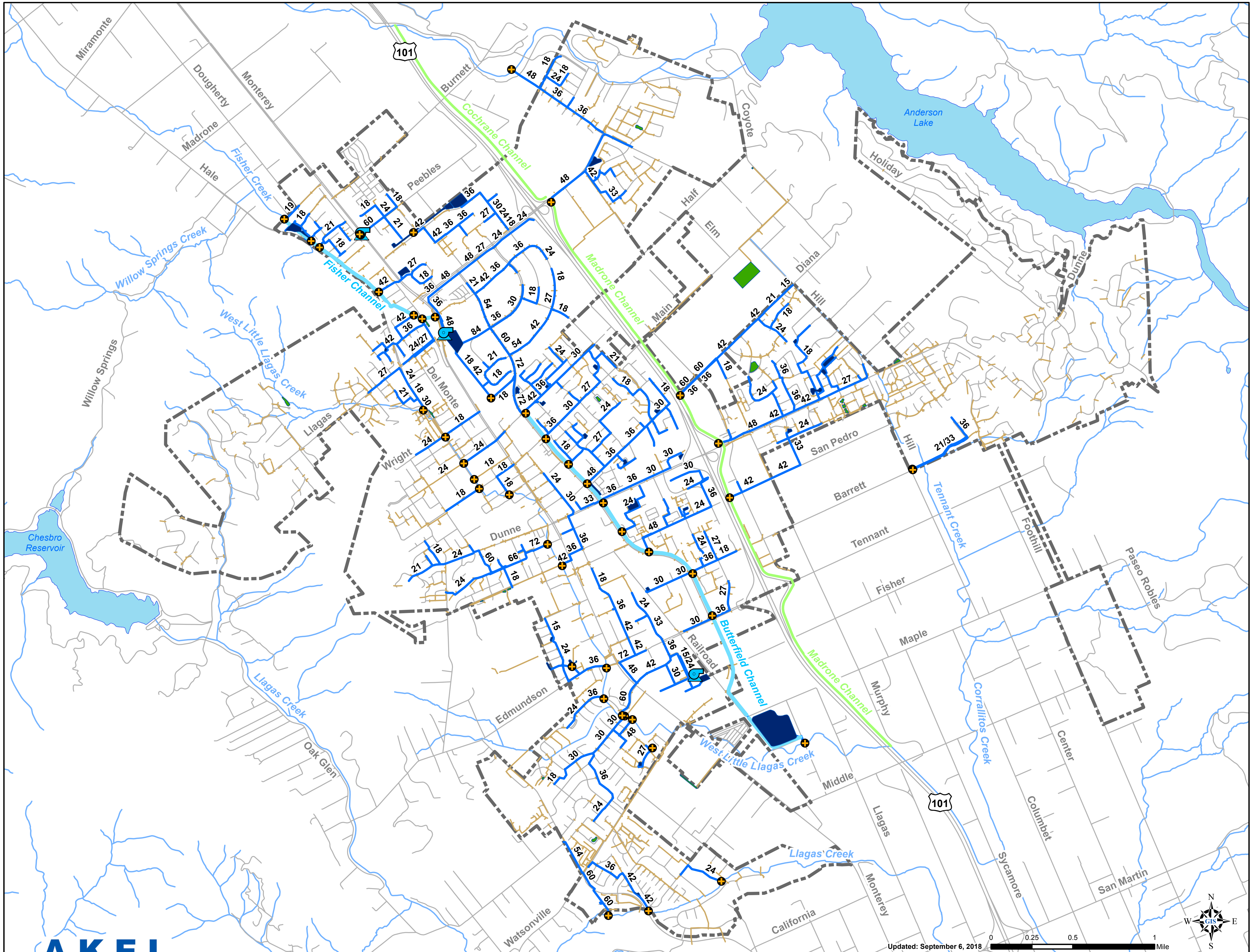
ES.7 CAPACITY EVALUATION

The City's hydrology and hydraulic models were used to evaluate the capacity adequacy of the existing system and for sizing future improvements. This section lists the location of known flooding problem areas and describes the existing stormwater facilities.

Using the criteria described in the System Performance and Design Criteria chapter, the hydrology and hydraulic models were used to recommend size improvements. The recommended pipe improvements to mitigate existing system deficiencies and to serve future growth are shown on **Figure ES.3**.

ES.8 TWO-DIMENSIONAL FLOW ANALYSIS

The City's hydrologic and hydraulic models were incorporated into a two-dimensional stormwater model, which combines the hydrologic and hydraulic calculations of a SWMM engine with overland flow hydraulics. A two-dimensional model can evaluate the impact of flooding during intense rainfall events and be used to identify improvements to mitigate existing deficiencies through the use of accurate topography (at least 1 foot definition). For the purpose of the 2018 SDMP this two-dimensional model was used to evaluate the capacity adequacy of the PL-566 improvement to the West Little Llagas Creek.



Legend

Existing Modeled System
- Pumps
- Outfalls
- Pipes
- Channels
- Storage Basins

Non-Modeled System
- Pipes
- Channels
- Storage Basins
- Roads
- City Limits
- Creeks
- Lakes

ES. 2
Existing Storm Drainage System
Storm Drainage System Master Plan
City of Morgan Hill

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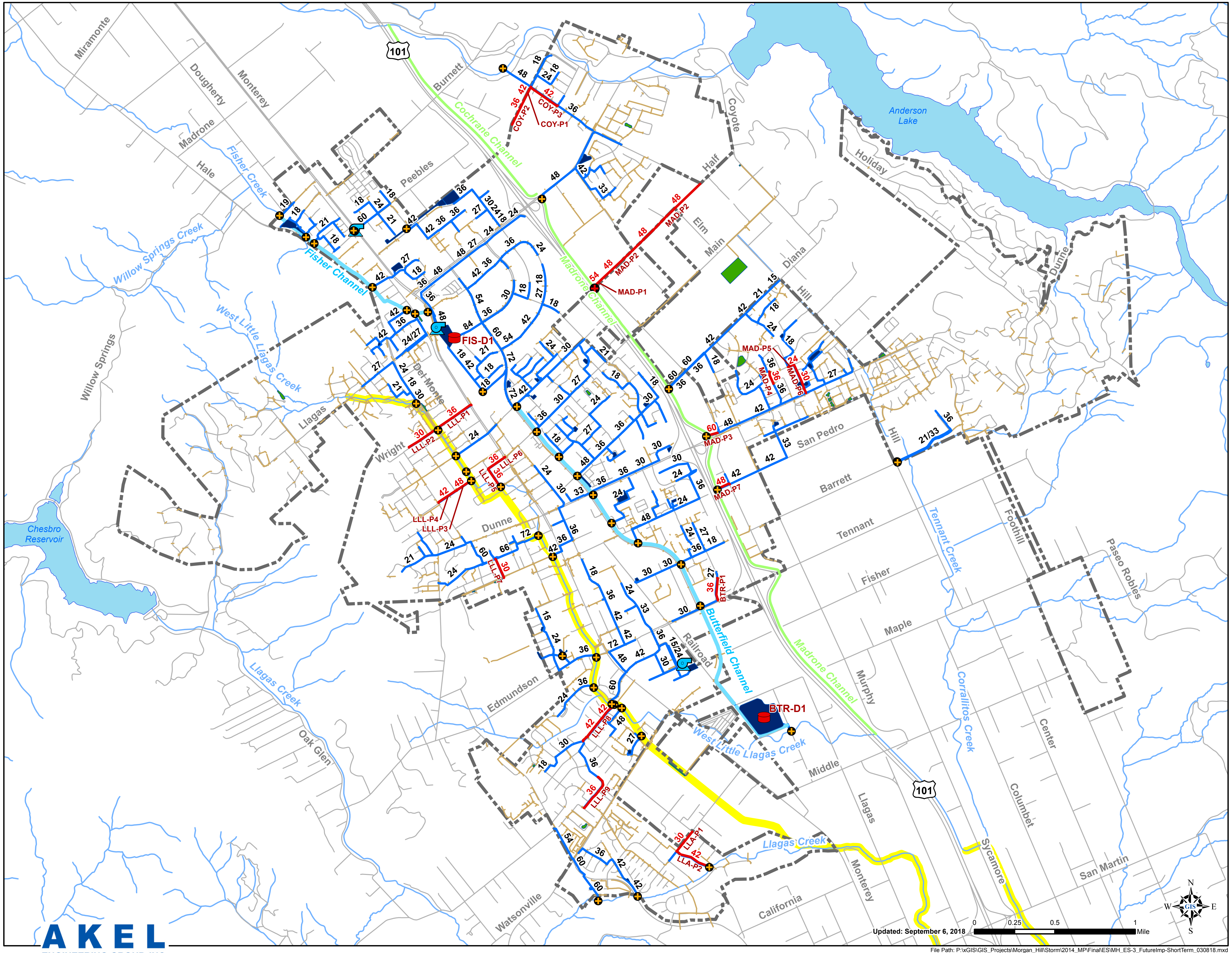

Legend

Proposed Improvements

- Outfalls
- Detention Basins
- Pipes
- PL566 Flood Protection Project

Existing Modeled System

- Pumps
- Outfalls
- Pipes
- Channels
- Storage Basins

Non-Modeled System

- Pipes
- Channels
- Storage Basins
- Roads
- City Limits
- Creeks
- Lakes

ES. 3
Proposed Storm Drainage System Improvements

Storm Drainage System Master Plan
City of Morgan Hill

CITY OF MORGAN HILL

Table ES.2 Existing Modeled Storm Drainage System Inventory

Storm Drainage System Master Plan

City of Morgan Hill

Size	Total (ft)	(miles)	
Pipelines			
12	2,154	0.4	< 1%
15	5,376	1.0	2.7%
18	30,039	5.7	14.8%
21	15,625	3.0	< 1%
24	24,966	4.7	12.3%
27	12,726	2.4	6.3%
30	17,710	3.4	8.7%
33	9,699	1.8	4.8%
36	37,181	7.0	18.4%
42	18,424	3.5	9.1%
48	12,582	2.4	6.2%
54	2,663	0.5	1.3%
60	7,359	1.4	3.6%
66	970	0.2	0.5%
72	4,020	0.8	2.0%
84	1,033	0.2	< 1%
Total	**202,528**	**38.4**	**100%**
Open Channel			
Channel	**23,885**	**4.5**	

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ES.9 CAPITAL IMPROVEMENT PROGRAM

The Capital Improvement Program includes pipeline and detention basin projects recommended in this master plan (**Table ES.3**). Each improvement was assigned a uniquely coded identifier corresponding to its respective hydrologic subbasin. It should be noted that the recommended detention basin capacities shown on **Figure ES.3** and summarized on **Table ES.3** represent a placeholder amount for existing and future developments; the specific detention requirements of individual developments should be evaluated and constructed as development occurs.

The estimated construction costs include the baseline costs plus **30 percent** contingency allowance to account for unforeseen events and unknown field conditions, as described in a previous section. Capital improvement costs include the estimated construction costs plus **30 percent** project-related costs (engineering design, project administration, construction management and inspection, and legal costs).

The costs in this Storm Drainage System Master Plan were benchmarked using a 20-City national average ENR CCI of 10,532, reflecting a date of January 2017. In total, the CIP project cost totals approximately $18.5 million dollars.

Table ES.3 Capital Improvement Program
Storm Drainage System Master Plan
City of Morgan Hill

Improv. No.	Type of	Alignment	Limits	Pipeline Improvements: Existing Diameter (in)	Pipeline Improvements: New/Parallel/ Replace	Infrastructure Costs: Diameter (in)	Infrastructure Costs: (ft')	Infrastructure Costs: Length (ft)	Infrastructure Costs: Unit Cost[1] ($/LF)	Infrastructure Costs: Infr. Cost ($)
Pipeline Capacity Improvements										
Butterfield Drainage Basin										
BTR-P1	Pipeline	Juan Hernandez Dr	From 150' s/o Saint James Dr to Tennant Ave	27	Replacement	36	752	750	286	214,401
										Subtotal - Butterfield Drainage Subbasin
Coyote Drainage Basin										
COY-P1	Pipeline	Eagle View Dr	From 310' s/o Peet Rd to Peet Rd	-	New	42	309	300	331	99,302
COY-P2	Pipeline	Eagle View Dr	From 1,400 ft s/o Peet Rd to 310' s/o Peet Rd	-	New	36	1,069	1,050	286	300,162
COY-P3	Pipeline	Peet Rd	From Eagle View Dr to Morningstar Dr	36	Replacement	42	1,095	1,100	331	364,106
										Subtotal - Coyote Drainage Subbasin
Madrone Drainage Basin										
MAD-P1	Pipeline	Half Rd	From Condit Rd to NB US 101	-	New	54	381	400	436	174,530
MAD-P2	Pipeline	Half Rd	From Peet Rd to Condit Rd	-	New	48	2,463	2,450	391	958,412
MAD-P3	Pipeline	Dunne Ave	From Condit Rd to NB US 101	48	Replacement	60	398	400	451	180,549
MAD-P4	Pipeline	Aspen Wy	From Bluebonnet Wy to Pine Wy	27	Replacement	36	431	450	286	128,641
MAD-P5	Pipeline	Bluebonnet Ct	From Almond Wy to Percheron Ct	18	Replacement	24	210	200	196	39,119
MAD-P6	Pipeline	Percheron Ct	From Bluebonnet Ct to 170' s/o Bayo Claros Cir	21	Replacement	30	1,029	1,050	241	252,768
MAD-P7	Pipeline	San Pedro Ave	From Condit Rd to NB US 101	36	Replacement	48	475	500	391	195,594
										Subtotal - Madrone Drainage Subbasin
Little Llagas Drainage Basin										
LLL-P1	Pipeline	Wright Ave	From Monterey Rd to Hale Ave	-	New	36	1,458	1,450	286	414,509
LLL-P2	Pipeline	Wright Ave	From 450' sw/o Crest Ave to Hale Ave	-	New	30	1,145	1,150	241	276,841
LLL-P3	Pipeline	Main Ave	From Crest Ave to Hale Ave	-	New	48	593	600	391	234,713
LLL-P4	Pipeline	Main Ave	From Peak Ave to Crest Ave	-	New	42	730	750	331	248,254
LLL-P5	Pipeline	Del Monte Ave	From Main Ave to 2nd St	-	New	36	725	750	286	214,401
LLL-P6	Pipeline	Main Ave	From Del Monte Ave to Monterey Rd	-	New	36	683	700	286	200,108
LLL-P7	Pipeline	Lone Hill Dr	From Spring Ave to Chargin Wy	18	Replacement	30	690	700	241	168,512
LLL-P8	Pipeline	La Crosse Dr	From La Baree Dr to 200' se/o intersection of the Vineyard Blvd and La Crosse Dr	27/30	Replacement	42	1,657	1,650	331	546,159
LLL-P9	Pipeline	Alamo Dr	From La Rocca Dr to 80' n/o Unnamed St	18	Replacement	36	1,337	1,350	286	385,923
										Subtotal - Little Llagas Drainage Subbasin
Llagas Drainage Basin										
LLA-P1	Pipeline	Middle Ave	From Olive Ave to Gallant Fox Wy	-	New	30	828	850	241	204,622
LLA-P2	Pipeline	Gallant Fox Wy	From Middle Ave to 1,200' e/o Middle Ave	24	Replacement	42	1,222	1,200	331	397,207
										Subtotal - Llagas Drainage Subbasin
										Subtotal - Pipeline Capacity Improvement Costs

Improv. No.	Baseline Constr. Costs ($)	Estimated Constr. Cost[1] ($)	Capital Improvement Costs[2] ($)	Suggested Construction Timeline	Suggested Cost Allocation: Existing Users (%)	Suggested Cost Allocation: Future Users (%)	Cost Sharing: Existing Users	Cost Sharing: Future Users
BTR-P1	214,401	278,722	362,338	With Development	0%	100%	0	362,338
Subtotal - Butterfield Drainage Subbasin	**214,401**	**278,722**	**362,338**				**0**	**362,338**
COY-P1	99,302	129,092	167,820	Intermediate-Term	0%	100%	0	167,820
COY-P2	300,162	390,211	507,274	Intermediate-Term	0%	100%	0	507,274
COY-P3	364,106	473,338	615,340	Intermediate-Term	100%	0%	615,340	0
Subtotal - Coyote Drainage Subbasin	**763,570**	**992,641**	**1,290,433**				**615,340**	**675,094**
MAD-P1	174,530	226,889	294,956	With Development	0%	100%	0	294,956
MAD-P2	958,412	1,245,936	1,619,716	With Development	0%	100%	0	1,619,716
MAD-P3	180,549	234,713	305,127	Near-Term	100%	0%	305,127	0
MAD-P4	128,641	167,233	217,403	Near-Term	100%	0%	217,403	0
MAD-P5	39,119	50,855	66,111	Near-Term	100%	0%	66,111	0
MAD-P6	252,768	328,598	427,178	Near-Term	100%	0%	427,178	0
MAD-P7	195,594	254,273	330,554	With Development	60%	40%	198,333	132,222
Subtotal - Madrone Drainage Subbasin	**1,929,613**	**2,508,497**	**3,261,046**				**1,214,152**	**2,046,894**
LLL-P1	414,509	538,862	700,521	Near-Term	50%	50%	350,260	350,260
LLL-P2	276,841	359,893	467,862	Near-Term	50%	50%	233,931	233,931
LLL-P3	234,713	305,127	396,665	Near-Term	50%	50%	198,333	198,333
LLL-P4	248,254	322,731	419,550	Near-Term	50%	50%	209,775	209,775
LLL-P5	214,401	278,722	362,338	Near-Term	50%	50%	181,169	181,169
LLL-P6	200,108	260,140	338,183	Near-Term	50%	50%	169,091	169,091
LLL-P7	168,512	219,066	284,785	Long-Term	20%	80%	56,957	227,828
LLL-P8	546,159	710,007	923,009	Long-Term	100%	0%	923,009	0
LLL-P9	385,923	501,699	652,209	Long-Term	100%	0%	652,209	0
Subtotal - Little Llagas Drainage Subbasin	**2,689,421**	**3,496,248**	**4,545,122**				**2,974,735**	**1,570,387**
LLA-P1	204,622	266,008	345,811	Long-Term	0%	100%	0	345,811
LLA-P2	397,207	516,369	671,280	Long-Term	20%	80%	134,256	537,024
Subtotal - Llagas Drainage Subbasin	**601,829**	**782,377**	**1,017,090**				**134,256**	**882,834**
Subtotal - Pipeline Capacity Improvement Costs	**6,198,834**	**8,058,485**	**10,476,030**				**4,938,482**	**5,537,548**

Table ES.3 Capital Improvement Program
Storm Drainage System Master Plan
City of Morgan Hill

Improv. No.	Type of	Alignment	Limits	Pipeline Improvements: Existing Diameter	Pipeline Improvements: New/Parallel/ Replace	Infrastructure Costs: Diameter	Infrastructure Costs	Infrastructure Costs: Length	Infrastructure Costs: Unit Cost[1]	Infrastructure Costs: Infr. Cost	Baseline Constr. Costs	Estimated Constr. Cost[1]	Capital Improvement Costs[2]	Suggested Construction Timeline	Suggested Cost Allocation: Existing Users	Suggested Cost Allocation: Future Users	Cost Sharing: Existing Users	Cost Sharing: Future Users
				(in)		(in)	(ft²)	(ft)	($/LF)	($)	($)	($)	($)		(%)	(%)		
Detention Capacity Improvements						**(AF)**												
New Detention Basins																		
Butterfield Drainage Basin																		
BTR-D1	Basin		Approx. 900' nw/o Pollard Ave and Seymour Ave		New	96			73,156	1,171,894	1,171,894	1,523,462	1,980,500	Intermediate-Term	50%	50%	990,250	990,250
						Subtotal - Butterfield Drainage Subbasin					**1,171,894**	**1,523,462**	**1,980,500**				**990,250**	**990,250**
Fisher Drainage Basin																		
FIS-D1	Basin		Approx 1,000' sw/o Sutter Blvd and Butterfield Blvd		New	50			73,156	609,641	609,641	792,534	1,030,294	Intermediate-Term	50%	50%	515,147	515,147
						Subtotal - Fisher Drainage Subbasin					**609,641**	**792,534**	**1,030,294**				**515,147**	**515,147**
						Subtotal - Detention Capacity Improvements					**1,781,535**	**2,315,996**	**3,010,794**				**1,505,397**	**1,505,397**
Other Storm Drainage Improvements																		
Hale[4]	Misc Storm Drain Improv	Hale Ave	From Hillwood Lane to Spring Avenue and Dewitt Avenue		New / Replace					5,000,000	5,000,000	5,000,000	5,000,000			100%	0	5,000,000
						Subtotal - Fisher Drainage Subbasin					**5,000,000**	**5,000,000**	**5,000,000**				**0**	**5,000,000**
Total Improvemet Costs						**(AF)**												
						Pipeline Capacity Improvements					**6,198,834**	**8,058,485**	**10,476,030**				**4,938,482**	**5,537,548**
						Detention Capacity Improvements					**1,781,535**	**2,315,996**	**3,010,794**				**1,505,397**	**1,505,397**
						Other Storm Drainage Improvements					**5,000,000**	**5,000,000**	**5,000,000**				**0**	**5,000,000**
						Total Capital Improvement Costs					**12,980,369**	**15,374,480**	**18,486,824**				**6,443,879**	**12,042,945**

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9/6/2018

Notes:

1. Baseline construction costs plus 30% to account for unforeseen events and unknown conditions.
2. Estimated construction costs plus 30% to cover other costs including: engineering design, project administration (developer and City staff), construction management and inspection, and legal costs.
3. New detention basin depth assumed to be equal to 6 feet.
4. Hale Avenue improvements include storm drain piping, inlets, basins, curb and gutter, and biodetention swales.

CHAPTER 1 - INTRODUCTION

This chapter provides a brief background of the City's Storm Drainage system, the need for this master plan, and the objectives of the study. Abbreviations and definitions are also provided in this chapter.

1.1 BACKGROUND

The City of Morgan Hill (City) is located approximately 22 miles southeast of the City of San Jose, 29 miles southeast of the City of Cupertino, 24 miles east of City of Santa Cruz and 8 miles northwest of the City of Gilroy (**Figure 1.1**). The City provides potable water service to approximately 44,000 residents, as well as a myriad of commercial, industrial, and institutional establishments. The City currently owns and operates approximately 41 miles of storm drainage pipeline, pump stations, and detention and retention basins.

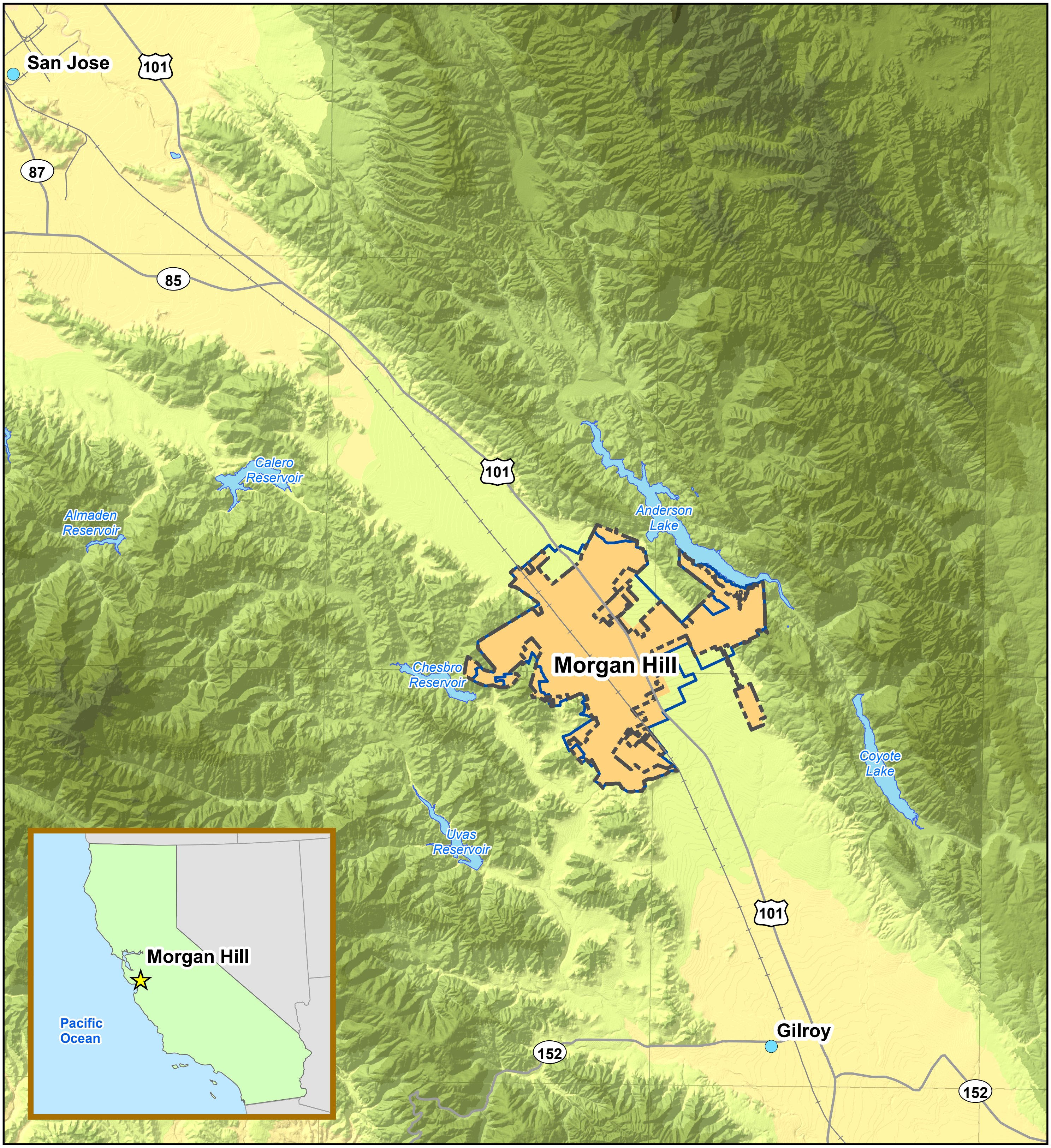
In 2002, the City of Morgan Hill developed a Storm Drainage System Master Plan that identified capacity deficiencies and flooding problem areas caused by stormwater runoff in the City and recommended improvements to alleviate existing deficiencies and serve future developments in the Urban Growth Boundary.

Recognizing the importance of planning, developing, and financing system facilities to provide reliable stormwater drainage to existing developed areas and for servicing anticipated growth within the Morgan Hill Urban Growth Boundary, the City initiated updating elements of the 2002 Storm Drainage Master Plan, to reflect current land use conditions and the updated 2035 General Plan.

1.2 SCOPE OF WORK

City Council approved Akel Engineering Group Inc. to prepare this master plan in June of 2013. This 2018 Storm Drainage System Master Plan is intended to serve as a tool for planning and phasing the construction of future storm drainage infrastructure for the projected buildout of the City of Morgan Hill. The 2018 SDMP evaluates the capacity of the City's existing stormwater drainage system using hydrology and hydraulic models, recommends improvements to mitigate existing deficiencies and serve areas of future growth.

The purpose and horizon for the master plan is stipulated in the City's General Plan. Should planning conditions change, and depending on their magnitude, adjustments to the master plan recommendations might be necessary.



Legend

- Cities
- Study Area
- City Limits
- Urban Growth Boundary
- Highways
- Railroads
- Lakes

Elevation (ft)

- 100 - 250
- 251 - 500
- 501 - 1,000
- 1,001 - 2,000
- 2,001 - 3,000
- 3,001 - 4,000
- > 4,000

0 0.5 1 2 Miles

Updated: September 6, 2018

AKEL ENGINEERING GROUP, INC.

Figure 1.1
Regional Location Map

Storm Drainage System Master Plan
City of Morgan Hill

CITY OF MORGAN HILL

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The City authorized Akel Engineering Group Inc. to complete the following tasks:

- Summarize the City's existing stormwater system facilities.
- Document growth planning assumptions and known future developments.
- Update the Storm Drainage system performance criteria.
- Determine future stormwater flows.
- Develop new hydrologic and hydraulic models based on updated planning assumptions.
- Evaluate the storm drainage facilities to address hydraulic capacity requirements from existing and projected developments, and water quality requirements from recent regulations.
- Perform a capacity analysis for the existing collection system and recommending improvements.
- Perform a two-dimensional flow analysis to evaluate the capacity adequacy of the PL-566 improvement to the West Little Llagas Creek.
- Recommend a Capital Improvement Program (CIP) with an opinion of probable costs.
- Perform a capacity allocation analysis for cost sharing purposes.
- Develop a Storm Drainage System Master Plan report.

1.3 INTEGRATED APPROACH TO MASTER PLANNING

The City implemented an integrated master planning approach and contracted the services of Akel Engineering Group to prepare the following documents:

- Water System Master Plan
- Sewer System Master Plan
- Storm Drainage System Master Plan

While each of these reports is published as a standalone document, they have been coordinated for consistency with the City's General Plan document. Additionally, each report has been cross referenced to reflect relevant analysis results with the other reports.

1.4 PREVIOUS MASTER PLANS

The City's most recent storm drainage system master plan was completed in 2002. This master plan included evaluation of servicing growth to the planning area boundary, evaluating the existing system, and projecting future storm drainage improvements for a horizon year of 2020. Additionally, the 2002 Master Plan included the development of hydrologic and hydraulic models which were used for evaluating the storm drainage system. Improvements were recommended for servicing existing and future growth areas, and a corresponding Capital Improvement Program was developed to quantify the corresponding costs.

1.5 RELEVANT REPORTS

The City's storm drainage requirements have undergone multiple transformations since the completion of the 2002 Storm Drainage System Master Plan. The following lists relevant reports that were used in the completion of this master plan, as well as a brief description of each document:

- **Storm Drainage Master Plan, January 2002 (2002 SDMP).** This report documents the planning and performance criteria, evaluates the storm drainage system, recommends improvements and provides an estimate of costs.

- **City of Morgan Hill General Plan, July 2001, updated February 2010 (2001 General Plan).** The City's 2001 General Plan provides future land use planning, and growth assumptions for the planning areas. Additionally, this report establishes the planning horizon for improvements in this master plan.

1.6 REPORT ORGANIZATION

This Storm Drainage System Master Plan report contains the following chapters:

Chapter 1 – Introduction. This chapter provides a brief background of the City's Storm Drainage system, the need for this master plan, and the objectives of the study. Abbreviations and definitions are also provided in this chapter.

Chapter 2 – Planning Area Characteristics. This chapter presents a discussion of the planning area characteristics affecting the hydrologic and hydraulic analysis of this master plan. These characteristics include soil, topography, floodplains, and land use.

Chapter 3 – System Performance and Design Criteria. This chapter presents the City's planning and design criteria that were used for evaluating hydrologic and hydraulic systems within the City's drainage watershed.

Chapter 4 – Existing Facilities Model Development. This chapter defines the hydrologic delineation of storm drainage basins, routing to their respective receiving facilities, and includes the hydrologic model development. Additionally, this chapter includes an overview of the storm drainage system, and the hydraulic model development.

Chapter 5 –Evaluation and Proposed Improvements. This chapter presents a summary of the storm drainage system evaluation and identifies improvements needed to mitigate existing deficiencies, as well as improvements needed to expand the system and service future growth.

Chapter 6 – Capital Improvement Program. This chapter provides a summary of the recommended storm drainage system improvements intended to mitigate existing capacity deficiencies and for accommodating anticipated future growth. The chapter also presents the cost criteria and methodologies for developing the Capital Improvement Program.

1.7 ACKNOWLEDGEMENTS

Obtaining the necessary information to successfully complete the analysis presented in this report, and developing the long term strategy for mitigating the existing system deficiencies and for accommodating future growth, was accomplished with the strong commitment and very active input from dedicated team members including:

- Scott Creer, City Engineer
- Chris Ghione, Public Services Director
- Dan Repp, Deputy Director of Utility Services
- Karl Bjarke, Former Public Works Director/City Engineer
- John Baty, Senior Planner
- David Gittleson, Associate Engineer
- Mark Rauscher, Engineering Technician

As part of the preparation of this Storm Drainage System Master Plan, Hydmet provided hydrological and meteorological planning services to the City and Akel Engineering Group. Hydmet was a valuable partner in the development of this master plan.

1.8 UNIT CONVERSIONS AND ABBREVIATIONS

Engineering units were used in reporting flow rates and volumes pertaining to the design and operation of various components of the storm drainage system. Where it was necessary to report values in smaller or larger quantities, different sets of units were used to describe the same parameter.

Values reported in one set of units can be converted to another set of units by applying a multiplication factor. A list of multiplication factors for units used in this report is shown on **Table 1.1**.

Various abbreviations and acronyms were also used in this report to represent relevant stormwater system terminologies and engineering units. A list of abbreviations and acronyms is included in **Table 1.2**.

1.9 GEOGRAPHIC INFORMATION SYSTEMS

This master planning effort made extensive use of Geographic Information Systems (GIS) technology, for completing the following tasks:

- Developing the physical characteristics of the hydraulic model (pipes and junctions, outfalls and ponds).
- Delineating stormwater tributary basins, and outlining watershed areas.
- Extracting ground elevations along the collection system from available contour maps.
- Generating maps and exhibits used in this master plan.

Table 1.1 Unit Conversions

Storm Drainage System Master Plan
City of Morgan Hill

Volume Unit Calculations

To Convert From:	To:	Multiply by:
acre feet	gallons	325,857
acre feet	cubic feet	43,560
acre feet	million gallons	0.3259
cubic feet	gallons	7.481
cubic feet	acre feet	2.296×10^{-5}
cubic feet	million gallons	7.481×10^{-6}
gallons	cubic feet	0.1337
gallons	acre feet	3.069×10^{-6}
gallons	million gallons	1×10^{-6}
million gallons	gallons	1,000,000
million gallons	cubic feet	133,672
million gallons	acre feet	3.069

Flow Rate Calculations

To Convert From:	To:	Multiply By:
ac-ft/yr	mgd	8.93×10^{-4}
ac-ft/yr	cfs	1.381×10^{-3}
ac-ft/yr	gpm	0.621
ac-ft/yr	gpd	892.7
cfs	mgd	0.646
cfs	gpm	448.8
cfs	ac-ft/yr	724
cfs	gpd	646300
gpd	mgd	1×10^{-6}
gpd	cfs	1.547×10^{-6}
gpd	gpm	6.944×10^{-4}
gpd	ac-ft/yr	1.12×10^{-3}
gpm	mgd	1.44×10^{-3}
gpm	cfs	2.228×10^{-3}
gpm	ac-ft/yr	1.61
gpm	gpd	1,440
mgd	cfs	1.547
mgd	gpm	694.4
mgd	ac-ft/yr	1,120
mgd	gpd	1,000,000

Table 1.2 Abbreviations and Acronyms

Storm Drainage System Master Plan

City of Morgan Hill

Abbreviation	Expansion	Abbreviation	Expansion
AACE International	Association for the Advancement of Cost Engineering	gpm	gallons per minute
AC	acre	GPS	Global Positioning System
AF	Acre Feet	HEC	Hydrologic Engineering Center
Akel	Akel Engineering Group, Inc.	HEC-HMS	Hydrologic Engineering Center - Hydrologic Modeling System
CCI	Construction Cost Index	in	inch
cfs	cubic feet per second	LF	linear feet
CI	cast iron pipe	MG	million gallons
City	City of Morgan Hill	MGD	million gallons per day
County	County of Santa Clara	mi	miles
DWR	Department of Water Resources	NRCS	National Resource Conservation Service
ENR	Engineering News Record	ROW	Right of Way
EPA	Environmental Protection Agency	RWCQB	Regional Water Quality Control Board
EPS	Extended Period Simulation	SCS	Soil Conservation Service
FEMA	Federal Emergency Management Agency	SCVWD	Santa Clara Valley Water District
ft	feet	SWMM	Stormwater Management Model
fps	feet per second	SWRCB	State Water Resources Control Board
GIS	Geographic Information Systems	TBD	to be determined
gpd	gallons per day	UGB	Urban Growth Boundary

CHAPTER 2 – PLANNING AREA CHARACTERISTICS

This chapter presents a discussion of the planning area characteristics affecting the hydrologic and hydraulic analysis of this master plan. These characteristics include soil, topography, floodplains, and land use.

2.1 STUDY AREA DESCRIPTION

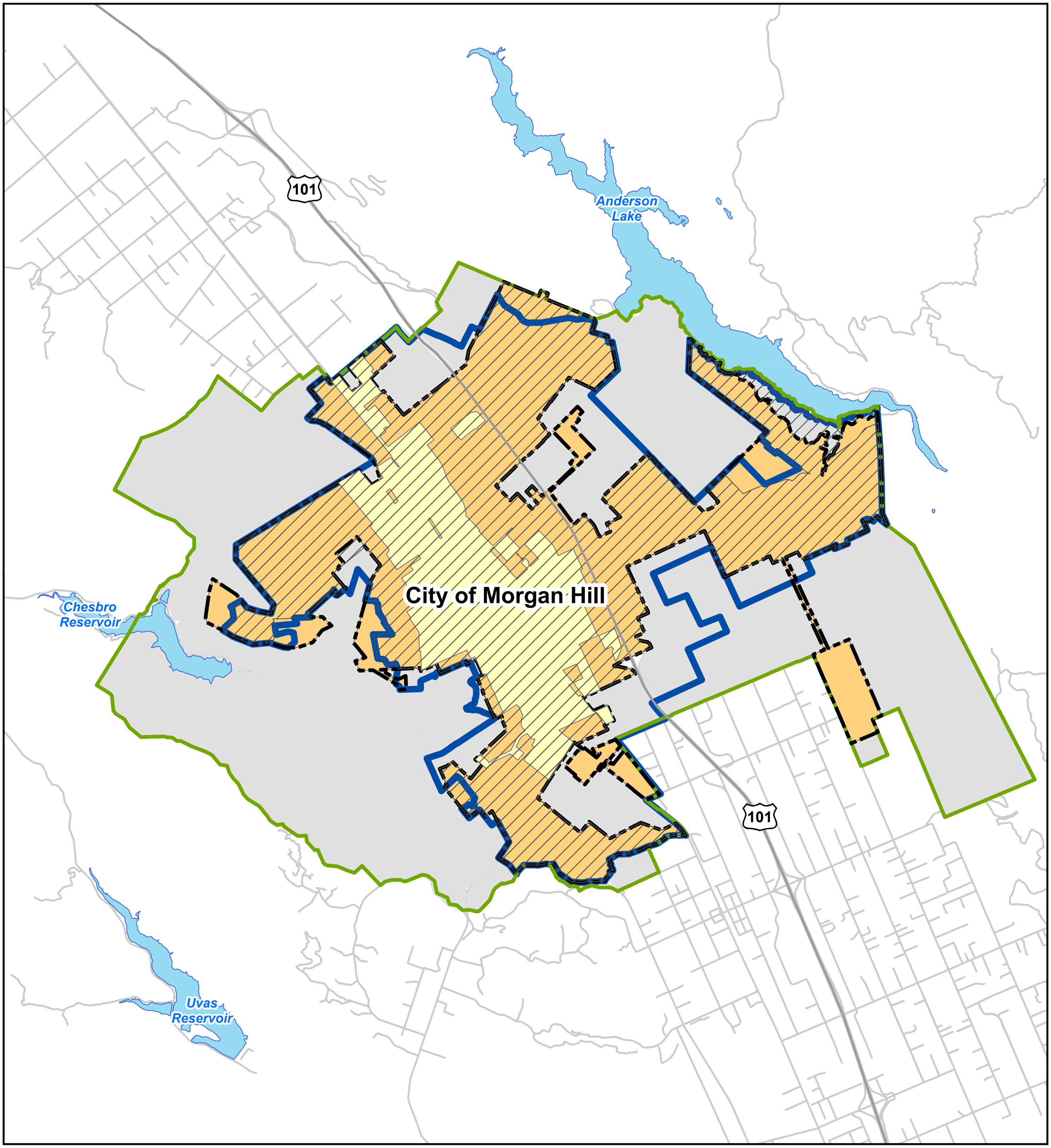
The City of Morgan Hill is located in Santa Clara County near the west coast of California, south of the City of San Francisco. The City of Morgan Hill lies within the seismically active region of San Francisco Bay and it is in the southern portion of the Santa Clara County. The City of Morgan Hill is located approximately 74 miles southeast of the City of San Francisco and 52 miles northeast of the City of Monterey. U.S. Route 101 runs in a southeast-northwest direction and the Monterey Road also runs parallel through the city to the west of the U.S. Route 101, dividing the City into 3 parts. The City Limits currently encompass 12.9 square miles, with an approximate 2015 population of 42,382 to the California Department of Finance (DOF).

The City is generally bound to the north by Burnett Avenue, to the east by Anderson Lake, to the southeast by Foothill Avenue, to the west by Sunnyside Drive, and to the south by East Middle Avenue. There are several creeks flowing through and along the boundaries of the City, including: Fisher Creek, West Little Llagas Creek, and Llagas Creek. The topography is generally flat in the valley portion of the city, with increasing slopes in east and west side of the city due to the Santa Cruz Mountain to the west and the Diablo Range to the east. There are two unincorporated areas to the north and south of the City respectively: Santa Teresa and San Martin. **Figure 2.1** displays the planning area showing City Limits, the Urban Growth Boundary of the City, and the City's Sphere of Influence Boundary.

The City operates and maintains a storm drainage system that covers the majority of the area within the city limits. Currently, stormwater runoff discharges to retention basins, the Fisher Creek, West Little Llagas Creek and Llagas Creek, and channels such as Butterfield Channel and Madrone Channel that transect the City.

2.2 WATERSHEDS AND DRAINAGE AREAS

The City of Morgan Hill maintains a rich diversity of land use types, which contribute to a varying degree of stormwater runoff containment needs. Several creeks, a vast array of agricultural lands, small pockets of development, and the City itself comprises the wide array of runoff generation and conveyance within the planning area.



Legend

- City Limits
- City Limits Area
- Redevelopment Area
- Urban Service Area
- Urban Growth Boundary
- Sphere of Influence Boundary
- General Plan Area
- Roads
- Highways
- Lakes

Updated: September 6, 2018

0 0.25 0.5 1 Mile

N W E S

Figure 2.1
Planning Area

Storm Drainage System Master Plan
City of Morgan Hill

CITY OF MORGAN HILL

AKEL ENGINEERING GROUP, INC.

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2.2.1 Watersheds

The City has multiple major watersheds within the Urban Growth Boundary (**Figure 2.2**). These watersheds collect and convey stormwater runoff via conveyance facilities, pumps and detention basins within the existing City service area.

- Upper Coyote Creek Watershed – The portion of the Upper Coyote Creek Watershed within the City limits is generally defined as the area between Anderson Lake and the ridge west of Andersen Lake.
- Lower Coyote Creek Watershed – The portion of the Lower Coyote Creek Watershed within the City limits is generally bounded by Willow Springs Creek to the west and Coyote Creek to the east. Runoff from the watershed is primarily conveyed through the City by Fisher Creek and Cochrane Channel.
- Llagas Creek Watershed – The Llagas Creek Watershed is generally defined as the area east of Llagas Creek and west of Coyote Creek, with the northern and southern boundaries approximately represented by Half Road and Church Creek respectively.
- Cochrane Channel & Coyote Creek Watershed – The Cochrane Channel and Coyote Creek Watershed is generally defined as the area north of Madrone Channel Watershed, bound to the north by Coyote Creek and to the east of US HWY 101.

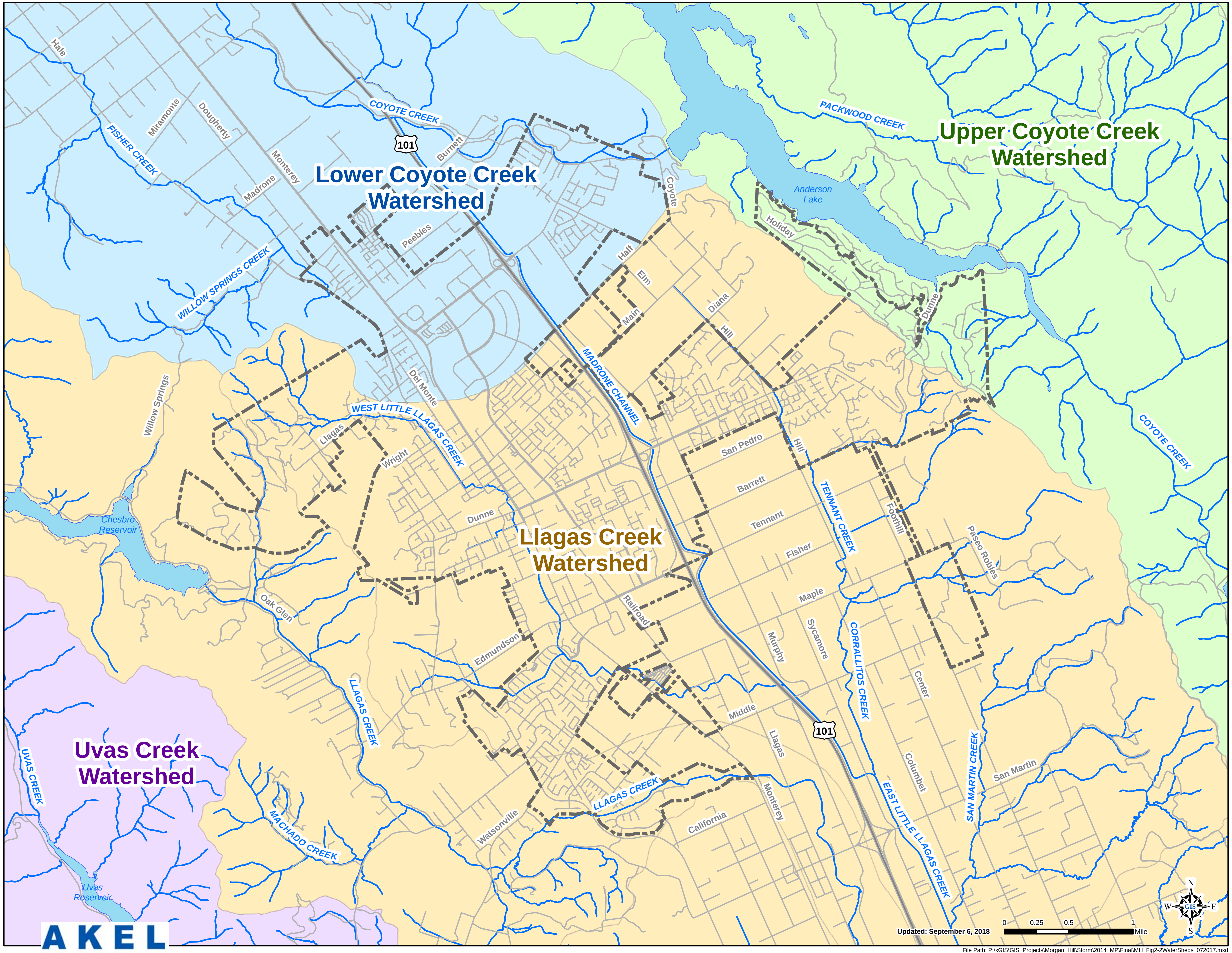
2.2.2 Drainage Areas

While watersheds are typically comprised of smaller drainage basins defined by topographical features, the drainage areas in the City, do not necessarily align with the NRCS defined watersheds. The City's storm drainage system consists of many complex systems, which divert, retain, and dispose of stormwater runoff through a series of conveyance networks. These networks have different means of disposing of stormwater runoff, such as outfalling to Llagas Creek or Coyote Creek, or diversion to detention facilities, which hold stormwater runoff during peak rainfall events before being conveyed to the canals and sloughs throughout the City.

2.3 FLOODPLAINS

Floodplains are important for delineating the extent of water-level rise during major floods. Typically, floodplains are estimated for the historic 100-Year and 500-Year flood. Most of the floodplains for the City are located along the Llagas Creek, West Little Llagas Creek and East Little Llagas Creek, as shown on **Figure 2.3**.

The Federal Emergency Management Agency (FEMA) produces Flood Insurance Rate Maps that show areas subject to flooding during major storm events. The flood risk information that is conveyed is based on historical data, including meteorological, hydrological, and hydraulic data for the specified area. The map creation is a result of the 1968 National Flood Insurance



Legend

- Creeks
- Lakes
- Watershed Boundaries
  - Llagas Creek
  - Lower Coyote Creek
  - Upper Coyote Creek
  - Uvas Creek
- Roads
- Highways
- City Limits

Figure 2.2
Waterways and Watersheds
Storm Drainage System Master Plan
City of Morgan Hill

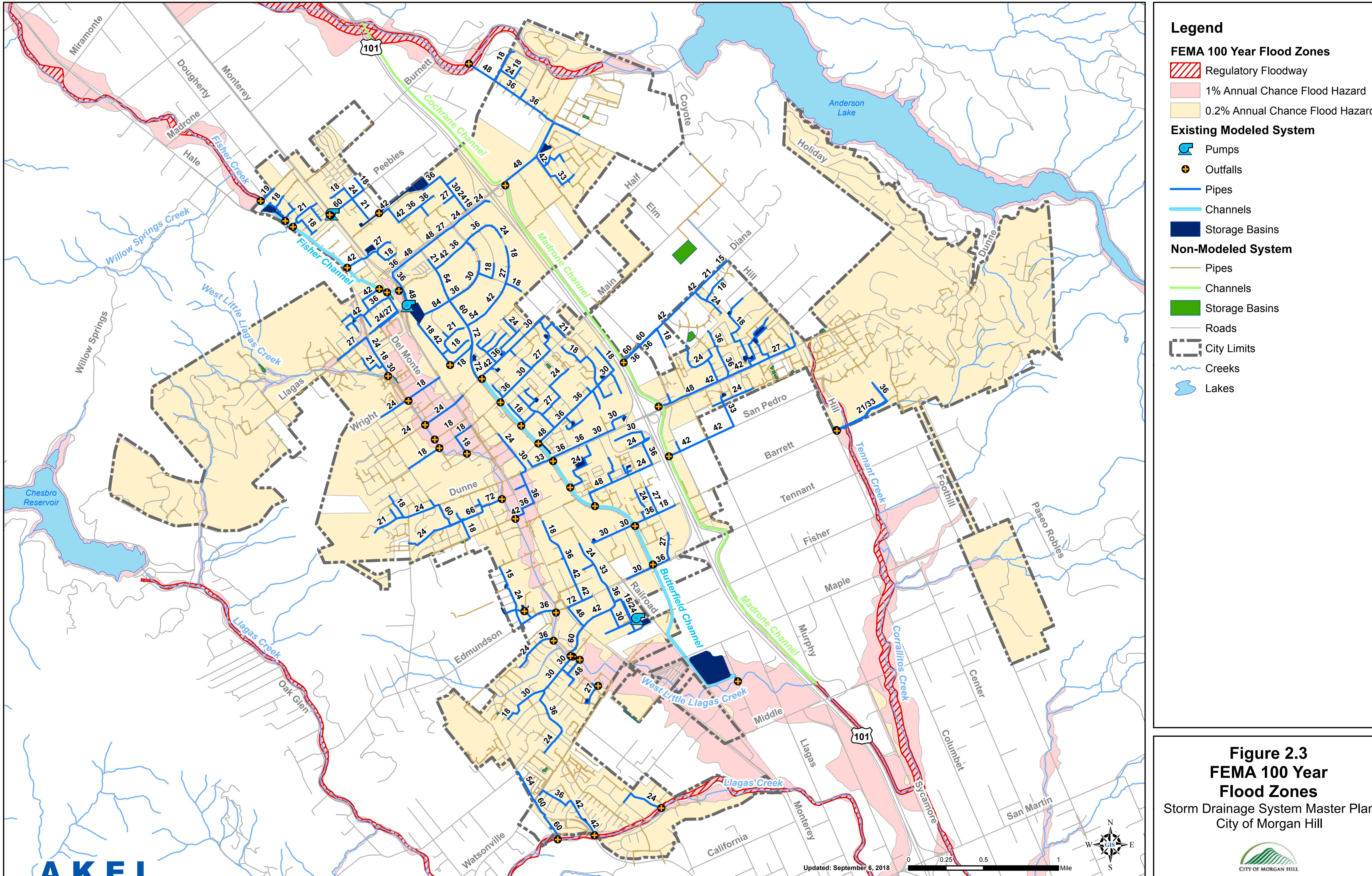


Figure 2.3
FEMA 100 Year Flood Zones
Storm Drainage System Master Plan
City of Morgan Hill

Program, aimed at reducing or preventing property owner losses due to flooding by allowing premiums to be paid for those in need of protection.

2.4 EXISTING SERVICE AREA AND LAND USE

The City's storm drainage system services residential and non-residential lands primarily within the City limits, as summarized on **Table 2.1**. This service area includes:

- 5,260 net acres of developed lands inside the service area.
- 1,732 net acres of undeveloped lands inside the service area.

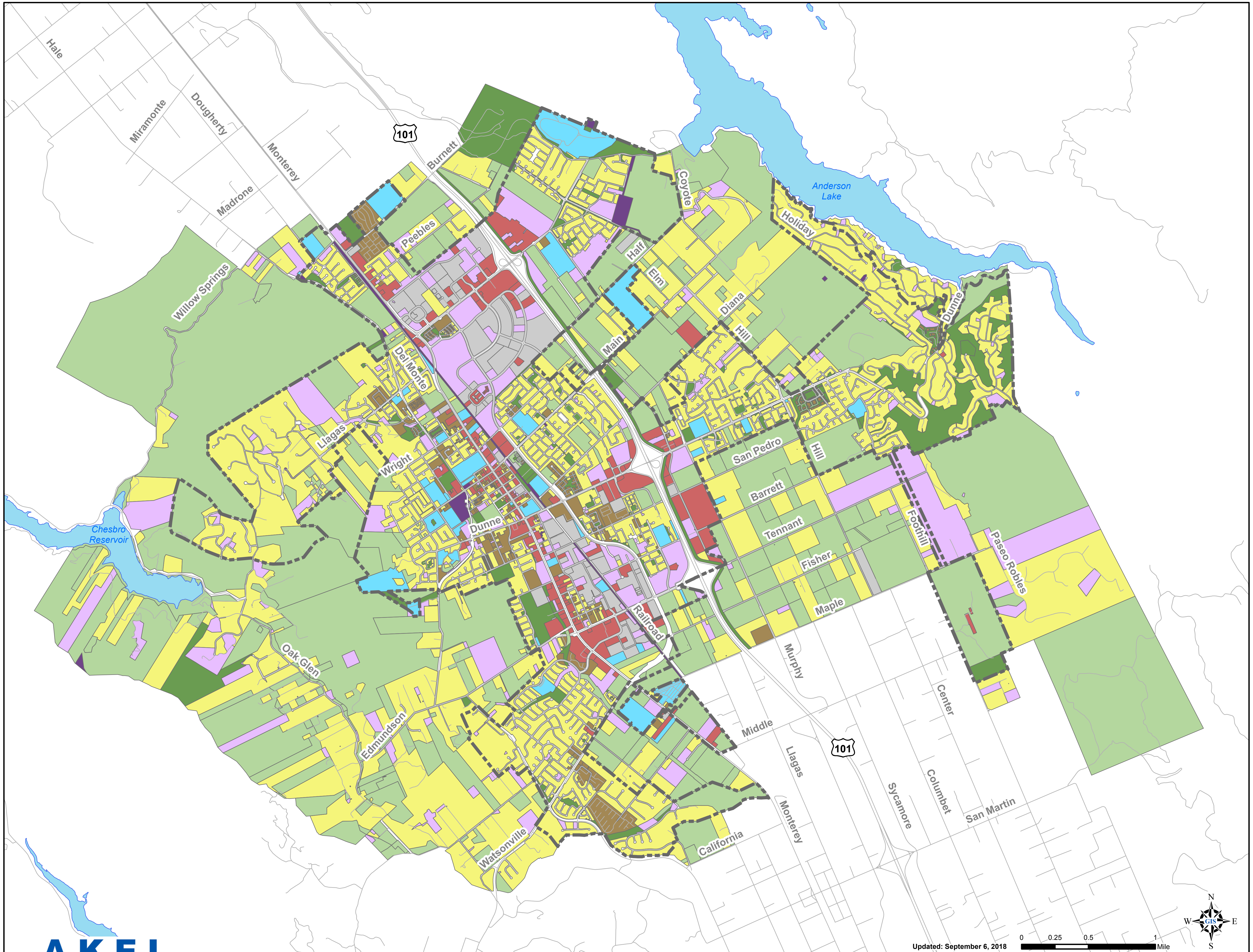
The existing land use statistics were based on information received from Placeworks staff, as shown on **Figure 2.4**.

The land use designations utilized in this master plan are consistent with the Land Use Element of the City's General Plan, and as received from the City's planning division and shown on **Figure 2.5**.

2.5 HISTORICAL AND FUTURE GROWTH

The City is a growing community, with over 2 percent of the Santa Clara County population residing within the City limits. DOF records estimate the 2015 population at 42,382. Between 1970 and 1980 the City saw dramatic growth, with the population increasing from 5,579 to 16,924 at an average annual growth rate of approximately 18 percent. This rapid growth led to the City's adoption of a growth management system, known as the Residential Development Control System (RDCS), which regulates growth by limiting the number of new homes approved annually. Following the implementation of the RDCS the average annual growth rate between 1980 and 2000 fell to approximately 4.7 percent. From 2000 to present the City has observed an average annual growth rate of approximately 2.4 percent.

The 2016 General Plan Update anticipates a 2035 population of 58,200 and this 2018 SDMP is consistent with the General Plan projections. The current and projected service area population is summarized in **Table 2.2**. The City's RDCS sets a maximum number of annual housing allotments that would not be exceeded and can only be reduced. Furthermore, if the number of allotments is reduced in a given year, they cannot be added to a future year. The population limit, which is a ceiling and not a target, is then a function of the maximum number of allotments.



Legend

Existing Land Use

- Agriculture
- Parks
- Single-Family
- Multi-Family
- Commercial
- Industrial
- Public/Institutional
- Vacant
- Other
- Roads
- City Limits
- Lakes

Figure 2.4
Existing Land Use
Storm Drainage System Master Plan
City of Morgan Hill

CITY OF MORGAN HILL

AKEL ENGINEERING GROUP, INC.

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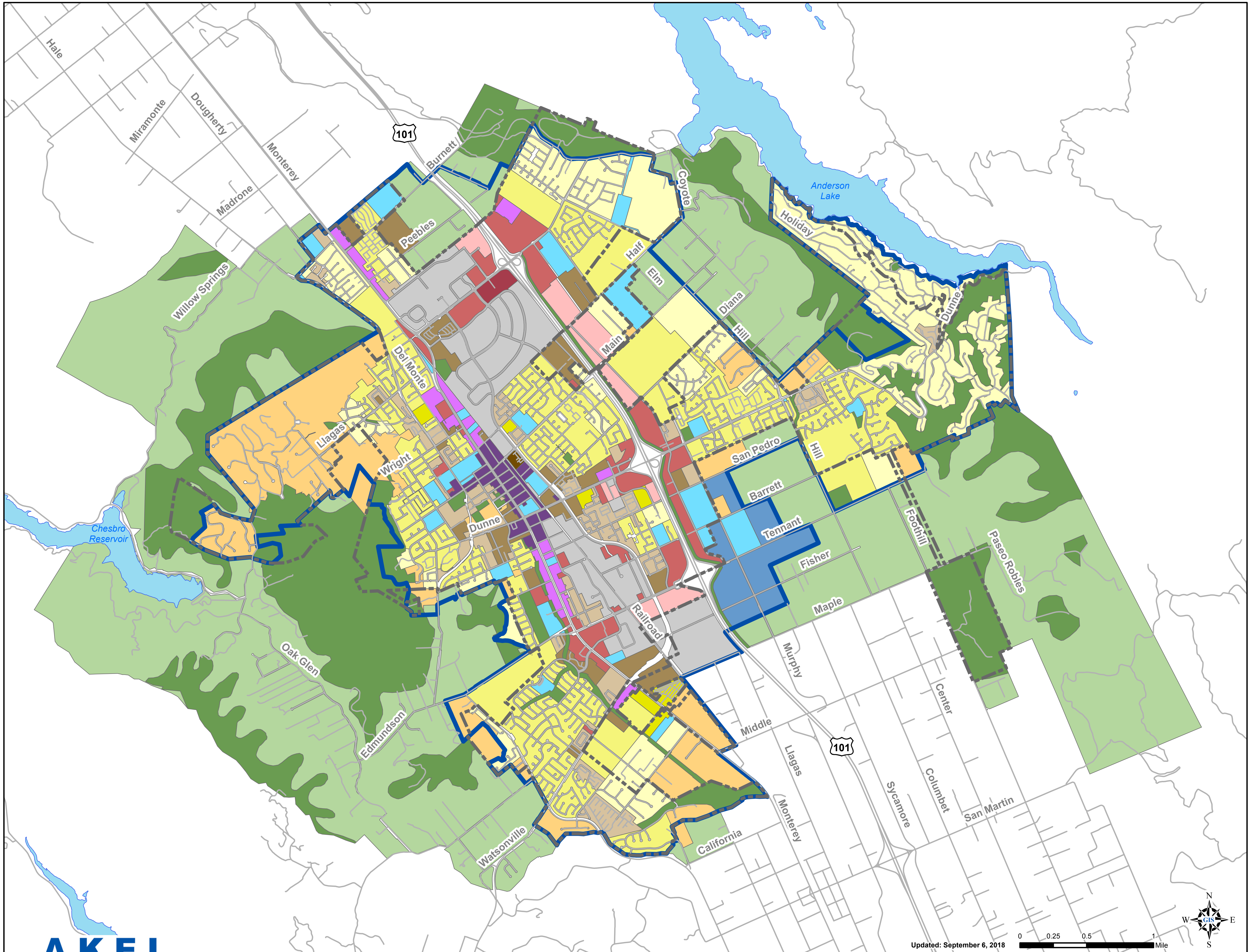

Figure 2.5
General Plan Land Use
Storm Drainage System Master Plan
City of Morgan Hill

CITY OF MORGAN HILL

AKEL ENGINEERING GROUP, INC.

Table 2.1 Existing and Future Storm Drainage Service Areas

Storm Drainage System Master Plan
City of Morgan Hill

Land Use Classification	Existing Service Area (City Limits)		Development Outside City Limits	
	Developed (net acres)	Undeveloped (net acres)	Developed (net acres)	Undeveloped (net acres)
Residential				
Rural County	0	0	3,966	2,435
Residential Estate	508	198	228	94
Single Family Low	979	171	169	70
Single Family Medium	1,252	187	294	117
Single Family High	30	4	7	12
Subtotal - Single Family Residential	2,770	560	4,664	2,728
Multi-Family Low	340	114	2	0
Multi-Family Medium	100	53	0	7
Multi-Family High	1	5	0	0
Subtotal - Multi-Family Residential	441	173	2	7
Subtotal - Residential	**3,211**	**732**	**4,666**	**2,736**
Non-Residential				
General Commercial	24	0	0	0
Commercial	260	130	4	0
Commercial / Industrial[1]	501	230	145	75
Mixed Use	93	6	0	0
Mixed Use Flex	64	40	8	0
Sports-Recreation-Leisure	0	0	212	39
Public Facility	302	12	46	0
Subtotal	1,244	**419**	**416**	**113**
Other (Non-Flow Generating)				
Landscape Irrigation	201	0	0	0
Open Space	605	581	1,409	1,328
Subtotal	806	**581**	**1,409**	**1,328**
Total	**5,260**	**1,732**	**6,491**	**4,177**

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9/6/2018

Note:

1. "Commercial / Industrial" combines land use types "Commercial / Institutional" and "Industrial"

Table 2.2 Historical and Projected Population
Storm Drainage System Master Plan
City of Morgan Hill

Year	Population[1]	Percent Growth (%)	Dwelling Units Added[2,3] (DU/year)
Historical			
2000	33,586	-	-
2001	33,914	1.0%	105
2002	34,210	0.9%	95
2003	34,109	-0.3%	-32
2004	34,618	1.5%	164
2005	35,011	1.1%	126
2006	35,535	1.5%	168
2007	36,467	2.6%	300
2008	37,107	1.8%	206
2009	37,653	1.5%	176
2010	37,882	0.6%	75
2011	38,456	1.5%	143
2012	39,432	2.5%	205
2013	40,486	2.7%	330
2014	41,562	2.7%	268
2015	42,382	2.0%	351
Projected			
2016 General Plan (RDCS Population Limit)			
	Population[2]		Dwelling Units Added (3.16 persons/DU) (DU/year)
2016	43,645	3.0%	275
2017	44,692	2.4%	275
2018	45,765	2.4%	275
2019	46,863	2.4%	275
2020	48,000	2.4%	275
2021	48,680	1.4%	215
2022	49,360	1.4%	215
2023	50,040	1.4%	215
2024	50,720	1.4%	215
2025	51,400	1.3%	215
2026	52,080	1.3%	215
2027	52,760	1.3%	215
2028	53,440	1.3%	215
2029	54,120	1.3%	215
2030	54,800	1.3%	215
2031	55,480	1.2%	215
2032	56,160	1.2%	215
2033	56,840	1.2%	215
2034	57,520	1.2%	215
2035	58,200	1.2%	215
2036	58,880	1.2%	215
2037	59,560	1.2%	215
2038	60,240	1.1%	215
2039	60,920	1.1%	215
2040	61,600	1.1%	215

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Notes:

1. Historical Populations per California Department of Finance estimates.
2. Historical values received from City staff August 17, 2016.
3. People per dwelling unit at approximate historical averages.

CHAPTER 3 – SYSTEM PERFORMANCE AND DESIGN CRITERIA

This chapter presents the City's planning and design criteria that were used for evaluating hydrologic and hydraulic systems within the City's drainage watershed.

3.1 HYDROLOGIC CRITERIA

Hydrologic criteria are developed to characterize the flood routing of rainfall runoff in a defined drainage system. Akel Engineering Group retained the services of Hydmet to complete the hydrologic evaluation of this project. This section discusses the precipitation characteristics, the design storms used in this master plan, and soil imperviousness.

3.1.1 Precipitation Characteristics

A dominating factor in the generation of rainfall in California is the oscillation of the semi-permanent high pressure area of the north Pacific Ocean. This high pressure center moves north in the summer and south in the winter, adjusting the flow of moisture into California. In the winter, when the high pressure center moves further south, moisture can move south and bring widespread rainfall.

In certain instances when circulation patterns allow for subtropical moisture to enter California from a southwesterly direction, rainfall amounts can be quite heavy, and may result in widespread flooding. The City of Morgan Hill receives an average 19.4 inches of total precipitation per year. The City's wet weather season typically starts in October and ends in April.

3.1.2 Design Storms

Design storms are typically defined by three important features: depth, duration and frequency.

- **Depth.** The depth of the storm identifies the amount of precipitation occurring during a specific time interval.
- **Duration.** The duration of the storm identifies how long it lasted. The 2002 Storm Drainage System Master Plan recommended two different design storms: one for evaluation of conveyance facilities, and an additional storm duration for evaluation of retention facilities. To provide a consistent means of evaluating stormwater runoff and to provide a conservative approach to design conveyance facilities, storm durations were consolidated to 24-hour duration. The design storm duration for the City is listed below:

  24-hour NOAA Atlas 14 Balanced Centered Hyetograph is intended to represent a typical rainfall event for the City of Morgan Hill. This storm is used for evaluating conveyance facilities.

The balance centered hyetograph provides a design storm with the peak intensity occurring during the middle of the day (**Figure 3.1**).

- **Frequency.** The frequency of the storm is the recurrence interval at which the storm may occur at a given area.

This master plan included the precipitation depth-duration-frequency table consistent with the City's 2002 Storm Drainage System Master Plan (**Table 3.1**). The depth-duration-frequency values reflect rainfall events specific to the City and lists precipitations, in inches and inches per hour, for return intervals up to 100 years.

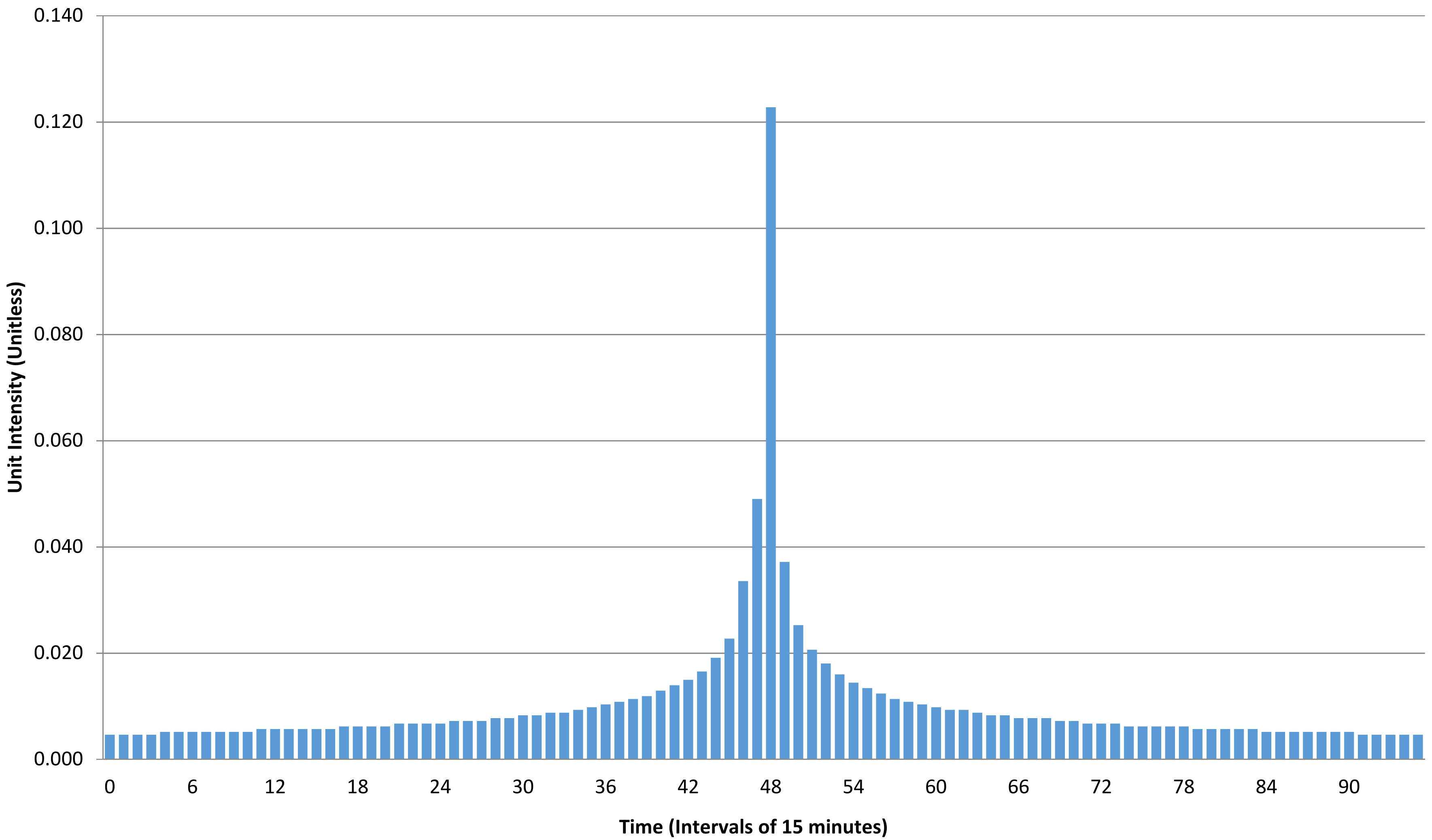
The design storms used in this evaluation, and which are specific to the City, are listed on **Table 3.2**. The values used in evaluating the storm drainage system are as follows:

- **10-year 24-hour.** This design storm is used in evaluating pipeline conveyance facilities and is quantified at 4.42 inches.
- **25-year 24-hour.** This design storm is used in evaluating detention facilities if the downstream conveyance is capable of conveying excess flows up to the 100-year 24-hour design storm; this storm was quantified at 5.24 inches.
- **100-year 24-hour.** This design storm is used in evaluating City street performance for conveying stormwater flows, while allowing up to one foot of flooding; this storm was quantified at 6.50 inches.

3.1.3 Soil Imperviousness

In determining the quantity of rainfall runoff generated from a given land use type, three factors dictate the volume of water that enters the storm drainage system: effective imperviousness, ineffective imperviousness, and effective pervious area.

- **Effective Impervious.** An effective impervious area is the percentage of impervious area that generates stormwater runoff entering the storm drainage system. The effective impervious percentages are based on land uses identified in the General Plan, and are included in **Table 3.3**.
- **Ineffective Impervious.** An ineffective impervious area is land that has no flow path, or the flow path results in delayed timing of the runoff, to the storm drainage system. These areas are typically noted as residential backyards, pools, or dense shrub landscaping. The values for these areas are shown on **Table 3.3**.
- **Effective Pervious.** Effective pervious areas contribute to runoff based on the National Resource Conservation Service (NRCS) Soil Classification Group, and the subsequent SCS Curve Number. The Curve Number is listed by soil group in **Table 3.3**.



LEGEND

PRELIMINARY

Rainfall Unit Intensity

September 6, 2018

Figure 3.1
24-Hour Unit Hyetograph

Storm Drainage System Master Plan
City of Morgan Hill

CITY OF MORGAN HILL

AKEL ENGINEERING GROUP, INC.

Table 3.1 Precipitation Depth-Duration-Frequency

Storm Drainage System Master Plan

City of Morgan Hill

Duration	2-Year (in)	2-Year (in/hr)	5-Year (in)	5-Year (in/hr)	10-Year (in)	10-Year (in/hr)	25-Year (in)	25-Year (in/hr)	100-Year (in)	100-Year (in/hr)
5-min	0.12	1.44	0.15	1.80	0.18	2.16	0.21	2.52	0.26	3.12
10-min	0.18	1.08	0.23	1.38	0.26	1.56	0.31	1.86	0.38	2.28
15-min	0.23	0.92	0.29	1.16	0.33	1.32	0.39	1.56	0.48	1.92
30-min	0.34	0.68	0.42	0.84	0.49	0.98	0.58	1.16	0.72	1.44
1-hr	0.51	0.51	0.63	0.63	0.72	0.72	0.86	0.86	1.06	1.06
2-hr	0.75	0.38	0.93	0.47	1.07	0.54	1.27	0.64	1.58	0.79
3-hr	0.95	0.32	1.18	0.39	1.35	0.45	1.60	0.53	1.99	0.66
6-hr	1.40	0.23	1.75	0.29	2.01	0.34	2.38	0.40	2.95	0.49
12-hr	2.08	0.17	2.59	0.22	2.98	0.25	3.53	0.29	4.38	0.37
24-hr	3.09	0.13	3.85	0.16	4.42	0.18	5.24	0.22	6.50	0.27

AKEL ENGINEERING GROUP, INC.

9/6/2018

Note:

1. Source: City of Morgan Hill 2002 Storm Drainage System Master Plan

Table 3.2 Relevant Design Storms

Storm Drainage System Master Plan
City of Morgan Hill

Design Criteria	Design Storm
10-year 24-hour.	Used to evaluate existing non-residential areas and all future land use, as long as street conveyance capacity is not exceeded. Quantified at 4.42 inches.
25-year 24-hour.	Used to evaluate detention facilities if the downstream conveyance is capable of conveying excess flows up to the 100-year 24-hour design storm; this storm was quantified at 5.24 inches.
100-year 24-hour.	Used in evaluating street conveyance capacity in excess of the 10-year 24-hour design storm for all other land use. Quantified at 6.50 inches

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9/6/2018

Note:

1. Design storm volumes as extracted from NOAA Atlas 14.

Table 3.3 Effective Percent Imperviousness and SCS Curve Numbers

Storm Drainage System Master Plan

City of Morgan Hill

Land Use Category	Percent Impervious (%)	AMC-II Pervious Soil B	AMC-II Pervious Soil C	AMC-II Pervious Soil D
Residential Estate	10	64	74	82
Single Family Low	20	65	75	82
Single Family Medium	35	67	77	83
Multi-Family Low	50	70	79	83
Multi-Family Medium	80	79	86	88
Commercial	95	80	87	89
Industrial	70	76	84	86
Open Space	1	63	75	81
Public Facilities	50	70	79	83
Rural County	5	63	73	82
Other Uses				
Water Surface	99	99	99	99
Natural Grassland	1	633	75	81
Oak Woodland	1	65	77	82
Chaparral/Shrubs/Weeds	1	62	74	80
Orchards, Vineyards	2	86	91	93
Pasture, Golf Courses, Parks	2	69	79	84
Agricultural Crops	2	78	85	89
Pavement/Parking/Highways	98	99	99	99
Urban Landscaping	1	56	69	75
Urban Lawns (fair quality)	1	65	77	82
Urban Lawns (poor quality)	1	74	83	87

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Note:

1. Source: City of Morgan Hill 2002 Storm Drainage Master Plan

3.2 HYDRAULIC CRITERIA

The hydraulic criteria for the storm drainage system were used to evaluate the capacity requirements of conveyance facilities, retention basins, and pump stations.

3.2.1 Gravity Conveyance Facilities

Gravity pipeline capacities depend on several factors including: material and roughness of the pipe, the limiting velocity and slope, and the maximum allowable depth of flow. The hydraulic modeling software used for evaluating the capacity adequacy of the Morgan Hill storm drainage system is InfoSWMM by Innovyze Inc. This software utilizes the fully dynamic St. Venant's Equation, and has a more accurate engine for simulating backwater and surcharge, in addition to manifolded force mains. The software also incorporates the use of the Manning Equation in other calculations including upstream pipe flow conditions.

Storm Hydraulic Design

The 10-year 24-hour design storm was used to evaluate the City's existing stormwater system as well as to size pipelines to serve areas of future growth. (**Table 3.4**). During the hydraulic analysis of the 100-year 24-hour design storm, City streets were sometimes allowed to flood to provide reasonable conveyance and storage capacity, thus reducing additional

Manning's Equation for Pipe Capacity

The Continuity Equation and the Manning's Equation for steady-state flow are used for calculating pipe capacities in open channel flow. Open channel flow can consist of either open conduits or, in the case of gravity pipelines, partially full closed conduits. Gravity full flow occurs when the conduit is flowing full but has not reached a pressure condition.

- Continuity Equation: $Q = V A$

  Where:
  Q = peak flow, in cubic feet per second (cfs)
  V = velocity, in feet per second (fps)
  A = cross-sectional area of pipe, in square feet (sq. ft.)

- Manning Equation: $V = (1.486\, R^{2/3}\, S^{1/2})/n$

  Where:
  V = velocity, in feet per second (fps)
  n = Manning's roughness coefficient
  R = hydraulic radius, area divided by wetted perimeter (ft)
  S = slope of pipe, in feet per foot (ft/ft)

Table 3.4 Hydrologic and Hydraulic Design Criteria

Storm Drainage System Master Plan
City of Morgan Hill

Hydrology and Hydraulics Design Criteria	
Ponding Basins	
Design Storm	
Detention	25-Year 24-Hour of 5.24'' rainfall if downstream conveyance is capable of conveying excess flows up to the 100-year 24-hour of 6.50'' rainfall design storm
Retention	100-Year 24-Hour, 6.50'' rainfall
Conveyance System	
Pipelines	10-Year 24-Hour design storm
Pump Station Individual Sizing Requirements	**Detention:** Sizing is based on the downstream receiving facilities **Direct Discharge:** Sizing based on flows that reach the pumps (largely dependent on upstream facilities)
Streets	100-Year 24-Hour design storm to determine if flooding exceeds one foot in depth and can flood buildings or create safety hazards
Receiving Waters (Streams, Creeks, Channels)	**Existing System:** FEMA 100-year water surface elevations used for downstream control for facilities where 100-year flood maps are available **Proposed System:** For areas where planned channel improvements mitigate backwater deficiencies, the adjusted 100-year water surface elevation was used
Obstructions (Roads, Railroads, Freeways)	Shall be noted in master plan with all drainage structures through them designed to convey 100-Year 24-Hour storm

St. Venant's Equation for Pipe Capacity

A dynamic type of modeling facilitates the analysis of unsteady and non-uniform flows (dynamic flows) within a gravity conveyance system. Some hydraulic modeling programs have the ability to analyze these types of flows using the St. Venant Equation, which take into account unsteady and non-uniform conditions that occur over changes in time and cross-section within system pipes.

The St. Venant Equations are a set of two equations, a Continuity Equation and a Dynamic Equation, used to analyze dynamic flows within a system. The first equation, the Continuity Equation, relates the continuity of flow mass within the system pipes in terms of: (A) the change in the cross-sectional area of flow at a point over time, and (B) The change of flow over the distance of piping in the system. The continuity equation is shown as follows:

- Continuity Equation: $$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial x} = 0$$

  (A) (B)

  Where:
  t = time
  x = distance along the longitudinal direction of the channel
  Q = discharge flow
  A = flow cross-sectional area perpendicular to the x directional axis

The second equation, the Dynamic Equation, relates changes in flow to fluid momentum in the system using: (A) Changes in acceleration at a point over time, (B) Changes in convective flow acceleration, (C) Changes in momentum due to fluid pressure at a given point, (D) Changes in momentum from the friction slope of the pipe, and (E) Fluid momentum provided by gravitational forces. The Dynamic Equation is provided as follows:

- Dynamic Equation: $$\frac{\partial Q}{\partial t} + \frac{\partial}{\partial t}\left(\beta \frac{Q^2}{A}\right) + gA\frac{\partial y}{\partial x} + gAS_f - gAS_o = 0$$

  (A) (B) (C) (D) (E)

  Where:
  t = time
  x = distance along the longitudinal direction of the channel
  Q = discharge flow
  A = flow cross-sectional area perpendicular to the x directional axis
  y = flow depth measured from the channel bottom and normal to the x directional axis
  S_f = friction slope
  S_o = channel slope
  β = momentum
  g = gravitational acceleration

Use of this method of analysis provides a more accurate and precise analysis of flow conditions within the system compared to steady state flow analysis methods. It must be noted that two assumptions are made for use of St. Venant Equations in the modeling software. First, flow is one dimensional. This means it is only necessary to consider velocities in the downstream direction and not in the transverse or vertical directions. Second, the flow is gradually varied. This means the vertical pressure distribution increases linearly with depth within the pipe.

Manning's Roughness Coefficient (n)

The Manning Roughness Coefficient 'n' is a friction coefficient that is used in the Manning formula for flow calculation in open channel flow. In conveyance systems, the coefficient can vary between 0.011 and 0.017 depending on pipe material, size of pipe, depth of flow, root intrusion, smoothness of joints, and other factors.

For the purpose of this evaluation, an "n" value of 0.013 was used for both existing and proposed gravity pipes.

3.2.2 Detention and Retention Basins

The capacities of existing detention basins were evaluated to meet the runoff requirements of a 25-year 24-hour design storm if the downstream conveyance was capable of conveying excess flows up to the 100-year 24-hour design storm. The capacities of existing retention basins were evaluated to meet the runoff requirements of a 100-year 24-hour design storm.

Detention basins are recommended as multi-function sites, capable of housing parks during the dry season, and serving as a stormwater receiving facility during the wet weather season. This practice enhances greenspace throughout the City, and mitigates costly land acquisition for regional stormwater facilities.

3.2.3 Pump Stations

Pump stations were sized to meet either of the following criteria:

- **Detention Pump Station:** A pump station discharging from a detention basin shall be sized to not exceed the capacity of the downstream receiving facilities.
- **Direct Discharge Station:** A pump station directly discharging to stormwater storage facility shall be sized to convey the flow that reaches the pump location, based on the capacity of the upstream facilities.

It should be noted that under normal operating conditions, pump stations should include a contingency for having the equivalent of the largest capacity pump out of service as a standby. This criteria is waived during the 100-year storm event.

CHAPTER 4 – EXISTING FACILITIES AND MODEL DEVELOPMENT

This chapter defines the hydrologic delineation of storm drainage basins, routing to their respective receiving facilities, and includes the hydrologic model development. Additionally, this chapter includes an overview of the storm drainage system, and the hydraulic model development.

4.1 HYDROLOGIC SYSTEM OVERVIEW

Factors critical to the hydrologic model development include watersheds, drainage basins within each watershed, overland flow routing within drainage subbasins, and conveyance that makes full use of pipes as well as streets for routing 100-year design storm events. This section discusses the existing watersheds, and the delineation of drainage basins and subbasins.

4.1.1 Watersheds

Watersheds in the City and outlying areas were defined based on the receiving tributary creek or river system, with topographical or physical barriers dictating the limits of the watershed. The City has multiple natural watersheds that collect and convey stormwater runoff within Urban Growth Boundary: Lower Coyote Creek Watershed, Upper Coyote Creek Watershed, Llagas Creek Watershed, and the Uvas Creek Watershed. (**Figure 2.2**).

4.1.2 Drainage Basins

Drainage basins are typically defined by existing or natural conveyance systems within each watershed. The City's drainage basin boundaries are generally dictated by the natural and man-made open channel conveyance facilities throughout the City (**Figure 4.1**). Drainage basins in the City may discharge to stormwater detention or retention basins, pump stations, or directly outfall to natural conveyance systems.

Each drainage basin was assigned a unique identifier intended for cross-referencing purposes. The identifier reflects the name of the receiving water body or storm drainage infrastructure that receives the stormwater. The project divided the City into seven drainage basins, which are briefly summarized as follows:

- **Butterfield Channel Basin:** The Butterfield Channel Basin is generally defined as the area west of Highway 101 and east of Railroad Avenue, with the northern and southern boundaries approximately represented by Half Road and Maple Avenue respectively.
- **Coyote Creek Basin:** The Coyote Creek Basin is generally defined as the area west of Anderson Lake and east of the ridge located west of Anderson Lake, with the northern and southern boundaries approximately represented by Burnett Avenue and Barrett Avenue respectively.

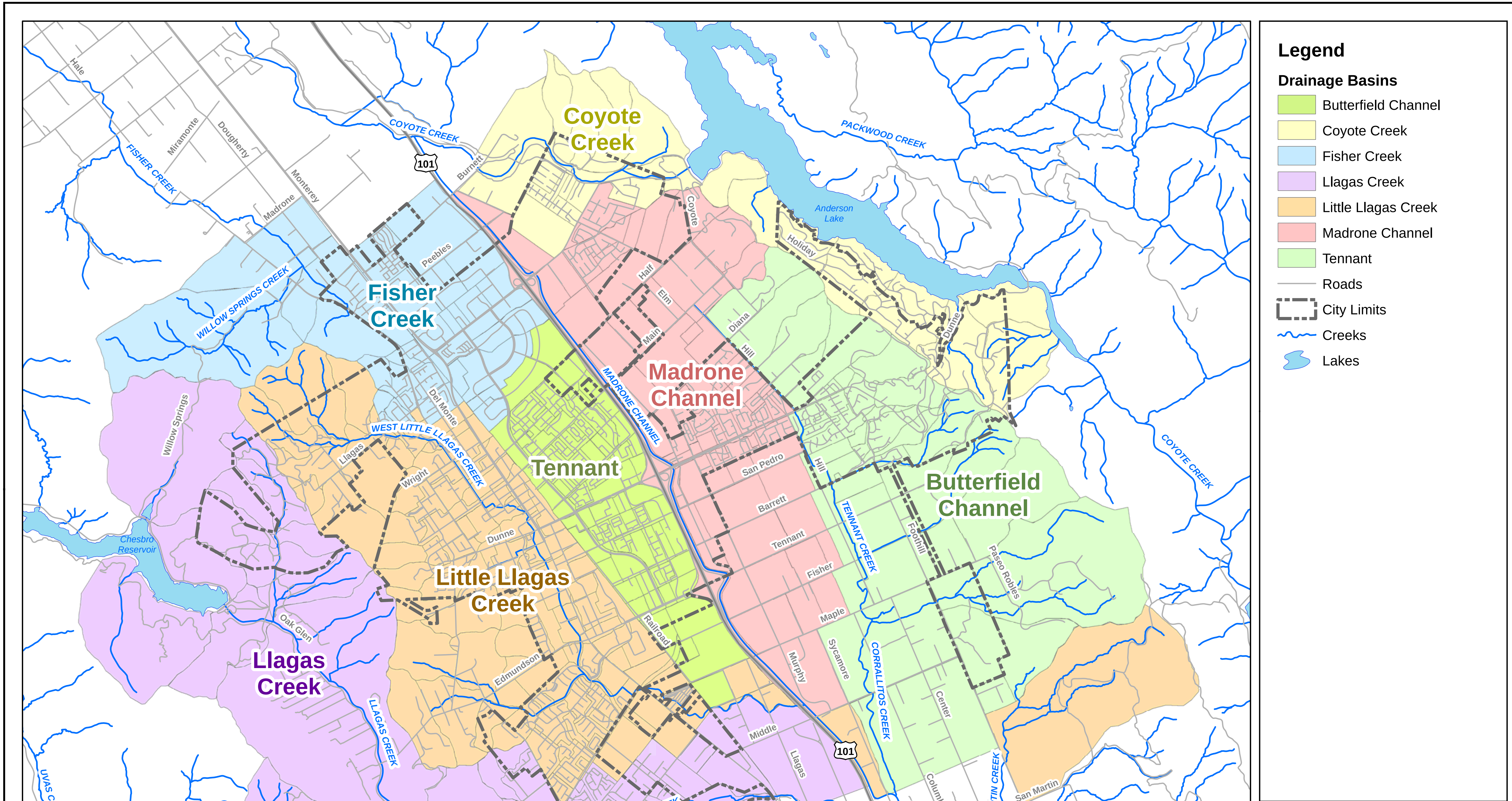


Figure 4.1
Hydrologic Drainage Basins
Storm Drainage System Master Plan
City of Morgan Hill

- **Fisher Creek Basin:** The Fisher Creek Basin is generally defined as the area west of Highway 101 and east of the ridge located east of the Chesbro Reservoir, with northern and southern boundaries approximately represented by Madrone Avenue and Half Road respectively.

- **Llagas Creek Basin:** The Llagas Creek Basin is generally defined as the area west of the ridge located east of the Chesbro Reservoir, with northern and southern boundaries approximately represented by Burnett Avenue and California Avenue respectively.

- **Little Llagas Creek Basin:** The Little Llagas Creek Basin is generally defined as the area west of Railroad Avenue and east of the ridge located east of the Chesbro Reservoir, with northern and southern boundaries approximately represented by Pebbles Avenue and California Avenue.

- **Madrone Channel Basin:** The Madrone Channel Basin is generally defined as the area east of Highway 101 and west of Hill Road, with northern and southern boundaries approximately represented by Burnett Avenue and Middle Avenue.

- **Tennant Creek Basin:** The Tennant Creek Basin is generally defined as the area west of the ridge located west of Anderson Lake and east of Hill Road, with northern and southern boundaries approximately represented by Alpet Drive and California Avenue.

4.1.3 Drainage Subbasins

The basins shown on **Figure 4.1** was further divided into smaller subbasins for the purpose of routing hydrologic stormwater flows. Each individual subbasin included hydrologic and hydraulic modeling information to address Overland Flow Routing and Combined Pipe Street Conveyance.

- **Overland Flow Routing.** This element consists of routing rainfall runoff to the stormwater conveyance system. Overland flow routing is dependent on land use and physical barriers blocking the flow paths within the drainage basins. In this analysis, the Kinematic Wave Equation was used to calculate overland flow, and was built into the developed hydrology model.

- **Combined Pipe Street Conveyance.** During typical storm events, and up to 10-year 24-hour design storms, streets are used to convey rainfall runoff from house gutters to nearest catchments where it enters the storm collection system.

  To mitigate very costly conveyance facility improvements during more intense storm events and up to the 100-year 24-hour design storm, this analysis assumed that existing streets may also provide additional capacity for routing rainfall runoff at a flood depth not to exceed one foot.

4.2 HYDRAULIC SYSTEM OVERVIEW

The City's storm drainage system includes conveyance facilities, outfalls, pump stations, and retention basins. This section discusses the components of the storm drainage system.

4.2.1 Conveyance System

The modeled storm drainage system includes approximately 41 miles of stormwater conveyance to local water bodies, retention systems, or canals (**Table 4.1**). Pipe sizes range from 12-inches to those equivalent to 84-inches in diameter, and are shown on **Figure 4.2**. The storm conveyance system is predominantly composed of 18-, 24-, and 36-inch pipelines.

The City-owned system of open channel conveyance systems, the Fisher, Madrone and Butterfield channels that transect the City play a role in relieving stormwater runoff. The City currently diverts water into these channels, from north to south, which is again diverted out of city-owned facilities and into large retention basins via a dam control structure or natural creeks.

4.2.2 Detention and Retention Basins

There are currently 30 modeled detention and retention basins located in and around the City that receive stormwater (**Figure 4.3**). These basins range in size from approximately 0.4 acre-foot (AF) to 179 AF (**Table 4.2**). Basin depths vary largely, and depend on the size and location of the basin. Depths of the basins ranged from approximately 2 feet in depth to over 19 feet.

4.2.3 Pump Stations

There are three active pump stations that serve the City's storm drainage system (**Figure 4.2**) that vary in size and have separate discharge points. The first is located in the Morgan Hill Business Park and pumps to Fisher Channel. The second, located at Concord Circle, pumps to Little Llagas Creek. The third pump station serves to empty a sump location at the Monterey Road rail road crossing.

4.2.4 Outfalls

As part of this master plan, more than 50 outfalls were identified the discharge to swales, creeks, and channels. Outfalls were located along the Madrone Channel, the Butterfield Channel, West Little Llagas Creek, Llagas Creek, the Fisher Channel, and tributaries to Tennant Creek. **Figure 4.2** shows the location of the existing outfalls that were included in the hydraulic model.

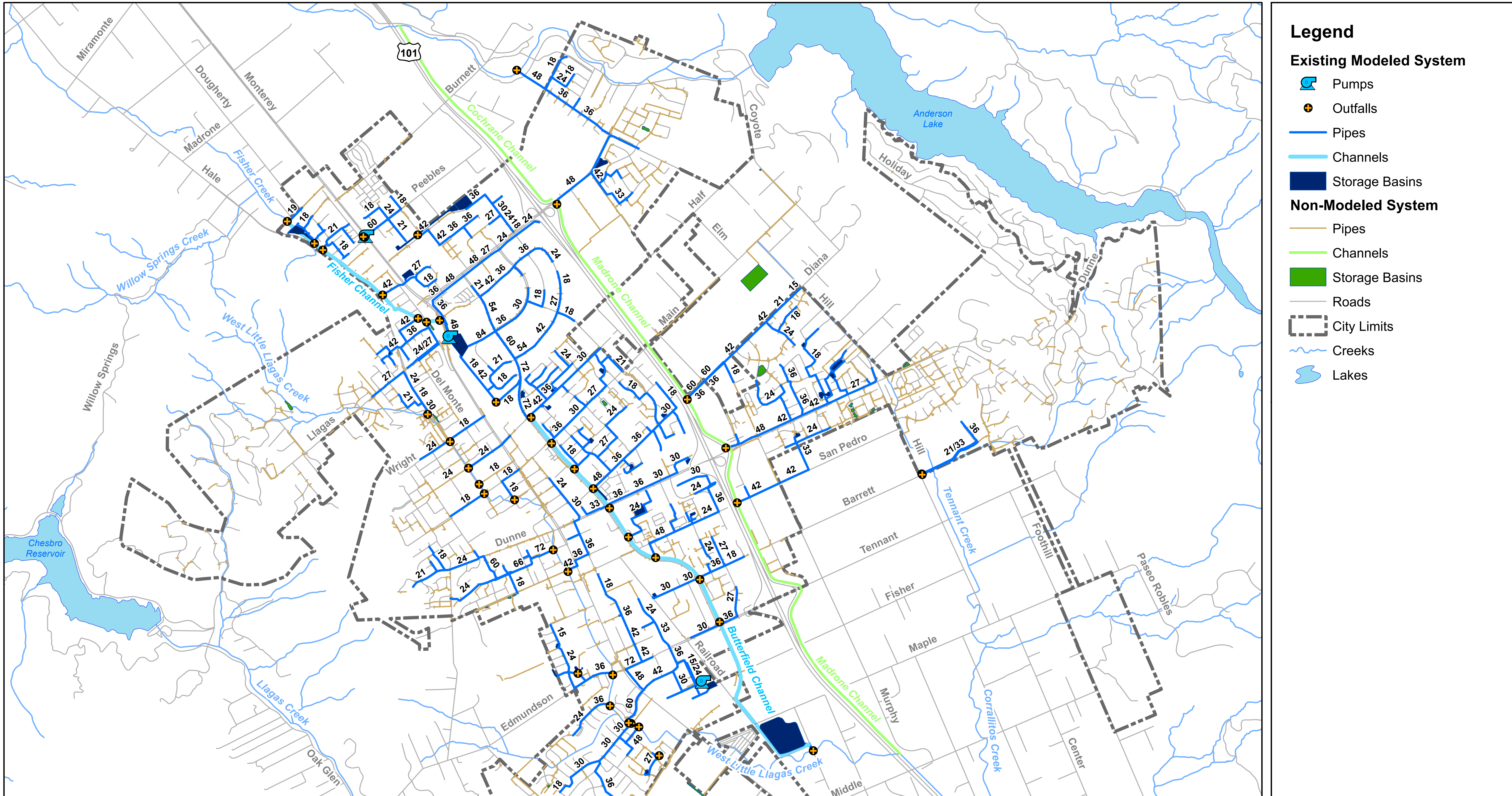
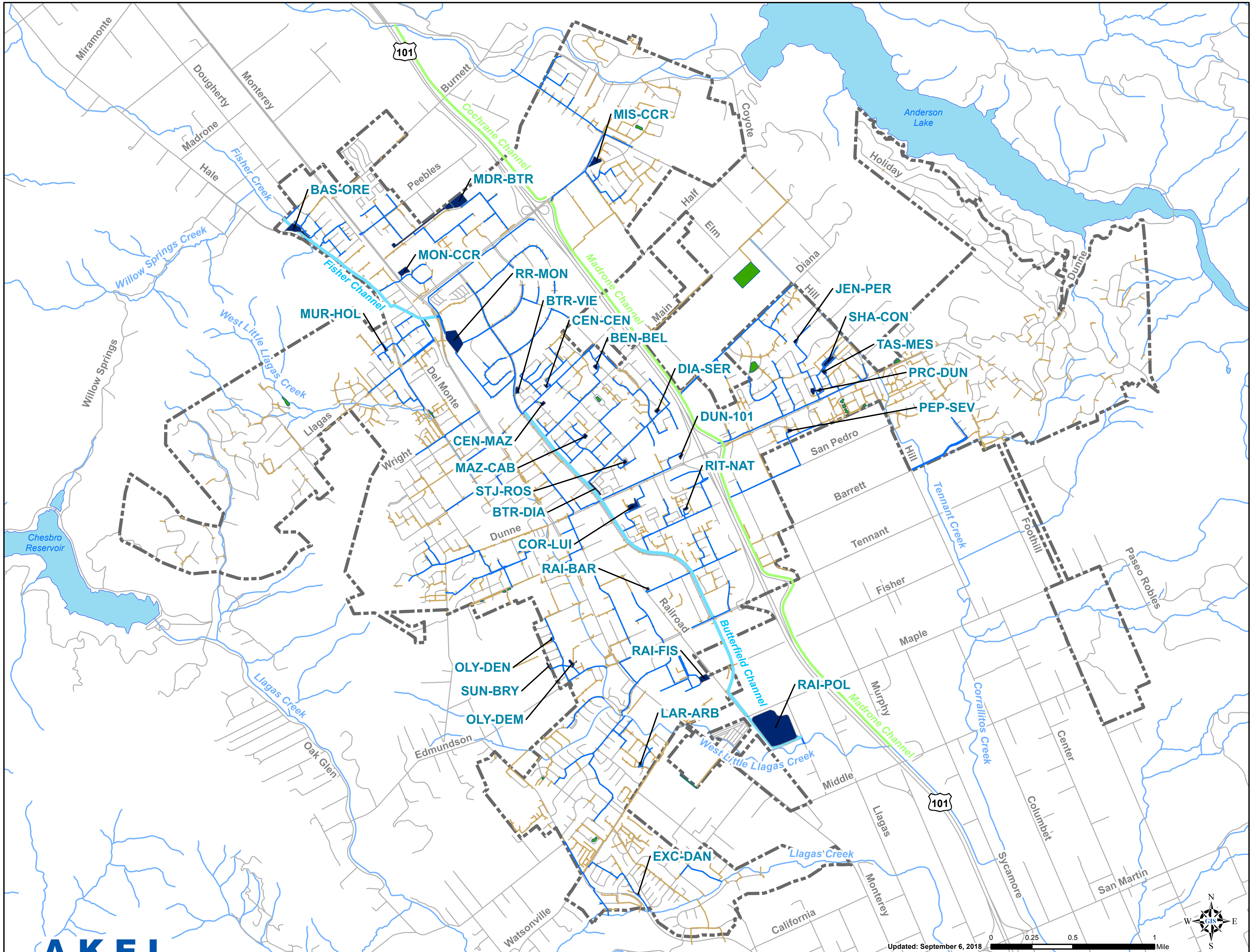


Figure 4.2
Existing Storm Drainage System
Storm Drainage System Master Plan
City of Morgan Hill

CITY OF MORGAN HILL



Legend

Existing Modeled System

- Channels
- Storage

Non-Modeled System

- Pipes
- Channels
- Storage
- Roads
- City Limits
- Creeks
- Lakes

Figure 4.3
Modeled Storage Basins
Storm Drainage System Master Plan
City of Morgan Hill

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CITY OF MORGAN HILL

Table 4.1 Existing Modeled Storm Drainage System Inventory

Storm Drainage System Master Plan

City of Morgan Hill

Size	Total		
	(ft)	(miles)	
Pipelines			
12	2,154	0.4	< 1%
15	5,376	1.0	2.7%
18	30,039	5.7	14.8%
21	15,625	3.0	< 1%
24	24,966	4.7	12.3%
27	12,726	2.4	6.3%
30	17,710	3.4	8.7%
33	9,699	1.8	4.8%
36	37,181	7.0	18.4%
42	18,424	3.5	9.1%
48	12,582	2.4	6.2%
54	2,663	0.5	1.3%
60	7,359	1.4	3.6%
66	970	0.2	0.5%
72	4,020	0.8	2.0%
84	1,033	0.2	< 1%
Total	**202,528**	**38.4**	**100%**
Open Channel			
Channel	**23,885**	**4.5**	

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Table 4.2 Existing Detention Ponds

Storm Drainage System Master Plan

City of Morgan Hill

	Storage ID	Location	Area (acres)	Depth (ft)	Capacity (AF)
1	BEN-BEL	NW of intersection of Belleto Dr and Bentley Dr	0.36	3.2	1.16
2	RR-MON	East of Railroad overpass on Monterey Rd	5.58	14.0	78.15
3	MAZ-CAB	Approx. 325 feet NE of intersection of Calle Mazatan & Calle Caballeria	0.35	3.0	1.06
4	CEN-MAZ	SE of intersection of Central Ave and Calle Mazatan	0.34	2.0	0.69
5	MON-CCR	NE of intersection of Cochrane Cir And Monterey Rd	1.30	6.0	7.83
6	MIS-CCR	East of intersection of Cochrane Rd and Mission View Dr	1.39	8.0	11.13
7	RAI-FIS	West of intersection of Fisher Ave and Railroad Ave	1.27	19.0	24.14
8	TAS-MES	SW cul-de-sac of Conte Way	0.39	4.2	1.66
9	OLY-DEN	NW of intersection of Olympic Dr and Denali Dr	0.16	3.0	0.48
10	DIA-SER	Approx. 350 feet NE of intersection of Serene Dr and Diana Ave	0.37	8.8	3.26
11	MUR-HOL	NE cul-de-sac of Fox Hollow Dr	0.14	3.0	0.41
12	CEN-CEN	NW of intersection of E. Central Ave and Calle Central	0.24	3.0	0.73
13	RAI-BAR	NE of intersection of Railroad Ave and Barrett Ave	0.19	4.0	0.77
14	LAR-ARB	North of intersection of Via Largo and La Arboleda Way	0.25	4.0	0.98
15	EXC-DAN	Cul-de-sac of Excaliber Dr	0.13	4.0	0.53
16	MDR-BTR	Approx. 1300 feet NE of intersection of Madrone Pkwy And Monterey R	4.07	10.0	40.67
17	OLY-DEM	NE of intersection of W. Edmundson Ave and Olympic Dr	0.55	6.5	3.55
18	JEN-PER	SW cul-de-sac of Pear Dr	0.23	3.0	0.69
19	PEP-SEV	SE of intersection of Peppertree Dr and Majorca Dr	0.34	4.0	1.37
20	STJ-ROS	South of intersection of Saint Joseph Dr and Rosemary Cir	0.33	4.0	1.30
21	DUN-101	South of cul-de-sac of Laurel Rd	0.29	7.0	2.05
22	BTR-DIA	SE of intersection of Butterfield Blvd and Diana Ave	0.60	8.0	4.84
23	COR-LUI	Cul-de-sac of San Simeon Ct	1.41	8.0	11.27
24	SHA-CON	SW of intersection of Shafer Ave and Katybeth Way	0.94	4.0	3.75
25	RIT-NAT	SE of intersection of Joseph Ln and Rita Dr	0.29	4.0	1.14
26	SUN-BRY	SW of intersection of Bryce Dr and Sunset Ave	0.28	6.0	1.68
27	BAS-ORE	W of Oregano Ct. and Basil Ave	2.30	7.5	17.25
28	RAI-POL	SE of intersection of Railroad Ave and Maple Ave	23.88	7.5	179.12
29	BTR-VIE	Between Butterfield Blvd and Calle Viento	0.52	4.0	2.08
30	PRC-DUN	N of intersection of Dunne Ave and Percheron Ct	0.92	4.0	3.70

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Note:

1. Existing basin inventory was extracted from the City's GIS-based hydraulic model developed in 2016.

4.3 HYDROLOGIC MODEL

The hydrologic model was used for calculating stormwater runoff volumes from each identified drainage subbasin. This section discusses the hydrologic modeling software and the model development.

4.3.1 Modeling Software

The selected modeling software that was used for the hydrology analysis on this project was developed by the U.S. Army Corps of Engineers' Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS). HEC-HMS is capable of evaluating a wide array of flood hydrology systems, including large river watersheds, and small urban drainage runoff.

This program is largely based on its predecessor, HEC-1, and includes additional methodologies for stormwater runoff computation. Additionally, this program was chosen due to the modernized graphical user interface.

4.3.2 Model Development

A hydrologic model was developed for each identified drainage basin. The characteristics for each subbasin were populated to account for land use types, flood routing, conveyance, and routing methodology.

- **Land Use.** Land use was used to define impervious area and the SCS Curve Number for pervious runoff. Residential areas included soil classifications to define non-effective runoff mostly confined in backyards.
- **Flood Routing.** Flood routing consists of determining the flow path and connectivity to the storm drainage collection system.
- **Conveyance.** Muskingum-Cunge conveyance methodology for pipe connections, channelized systems, and stream routing.
- **Routing Methodology.** Kinematic wave routing methodology for transforming precipitation into runoff for overland flow routing, street flow, and pipe conveyance.

4.4 HYDRAULIC MODEL

The hydraulic model was developed to evaluate the capacity adequacy of the City's storm drainage system. The model was used to identify capacity deficiencies and to recommend improvements to mitigate those deficiencies. This section discusses the hydraulic modeling software, the field survey, and associated quality control, and the model development.

4.4.1 Modeling Software

The City's hydraulic model combines information on the physical characteristics of the storm drainage system (pipelines, pump stations, outfalls, and retention basins) and operational characteristics (how they operate). The hydraulic model then performs calculations and solves series of equations to simulate flows in pipes, including backwater calculations for surcharged conditions.

There are several network analysis software products released by different manufacturers that can equally perform the hydraulic analysis satisfactorily. The selection of a particular software depends on user preferences, the storm drainage system's unique requirements, and the costs for purchasing and maintaining the software.

The hydraulic modeling software used for evaluating the capacity adequacy of the Morgan Hill storm drainage system, InfoSWMM by Innovyze Inc. This software utilizes the fully dynamic St. Venant's Equation, and has a more accurate engine for simulating backwater and surcharge, in addition to manifolded force mains. The software also incorporates the use of the Manning Equation in other calculations including upstream pipe flow conditions. The St Venant's and Manning's Equations were discussed in the System Performance and Design Criteria chapter.

4.4.2 Model Development

The hydraulic model was populated to include rim elevations at manholes, invert elevations of pipelines, pipe sizes, pipe slopes, pipe lengths, and outfall elevations. Input hydrographs were developed using the HEC-HMS hydrology model and were used as inputs into the InfoSWMM hydraulic model to simulate stormwater runoff entering the system.

CHAPTER 5 – EVALUATION AND PROPOSED IMPROVEMENTS

This chapter presents a summary of the storm drainage system evaluation and identifies improvements needed to mitigate existing deficiencies as well as improvements needed to expand the system and service future growth.

5.1 OVERVIEW

The City's hydrologic and hydraulic models were used for evaluating the capacity adequacy of the existing storm drainage system based on the relevant design storms. The criteria used for evaluating the storm drainage system capacity (pipelines, drainage basins, and pump stations) were discussed and summarized in the System Performance and Design Criteria chapter.

5.2 KNOWN FLOODING AND FACILITY PROBLEM AREAS

This evaluation reviewed known flooding problems experienced within the city limits. City staff have maintained an inventory of known maintenance areas that may experience surface water ponding during large storm events. The known maintenance areas are documented on **Table 5.1**. The capacity improvement recommended in this chapter are intended to mitigate some of these problem areas.

5.3 PIPELINE CONVEYANCE CAPACITY EVALUATION

The 10-year 24-hour design storm was used for evaluating the capacity adequacy of pipeline conveyance facilities. The existing capacity analysis indicates that the conveyance facilities are generally adequate to accommodate the design storms, with certain areas experiencing surcharging and flooding as shown on **Figure 5.1**.

The recommended pipeline capacity improvements necessary for mitigating existing system deficiencies and accommodating future growth are summarized on **Table 5.2** and shown graphically on **Figure 5.2**. Each pipeline has been assigned a uniquely coded identifier corresponding to the drainage basin in which it resided; this unique identifier is intended to aid in defining the location of the improvement for mapping purposes. The improvements are briefly described as follows:

Butterfield Drainage Basin

- **BTR-P1:** Replace the existing 27-inch pipeline on Juan Hernandez Drive with a new 36-inch pipeline from 150 feet south of Saint James Drive to Tennant Avenue.

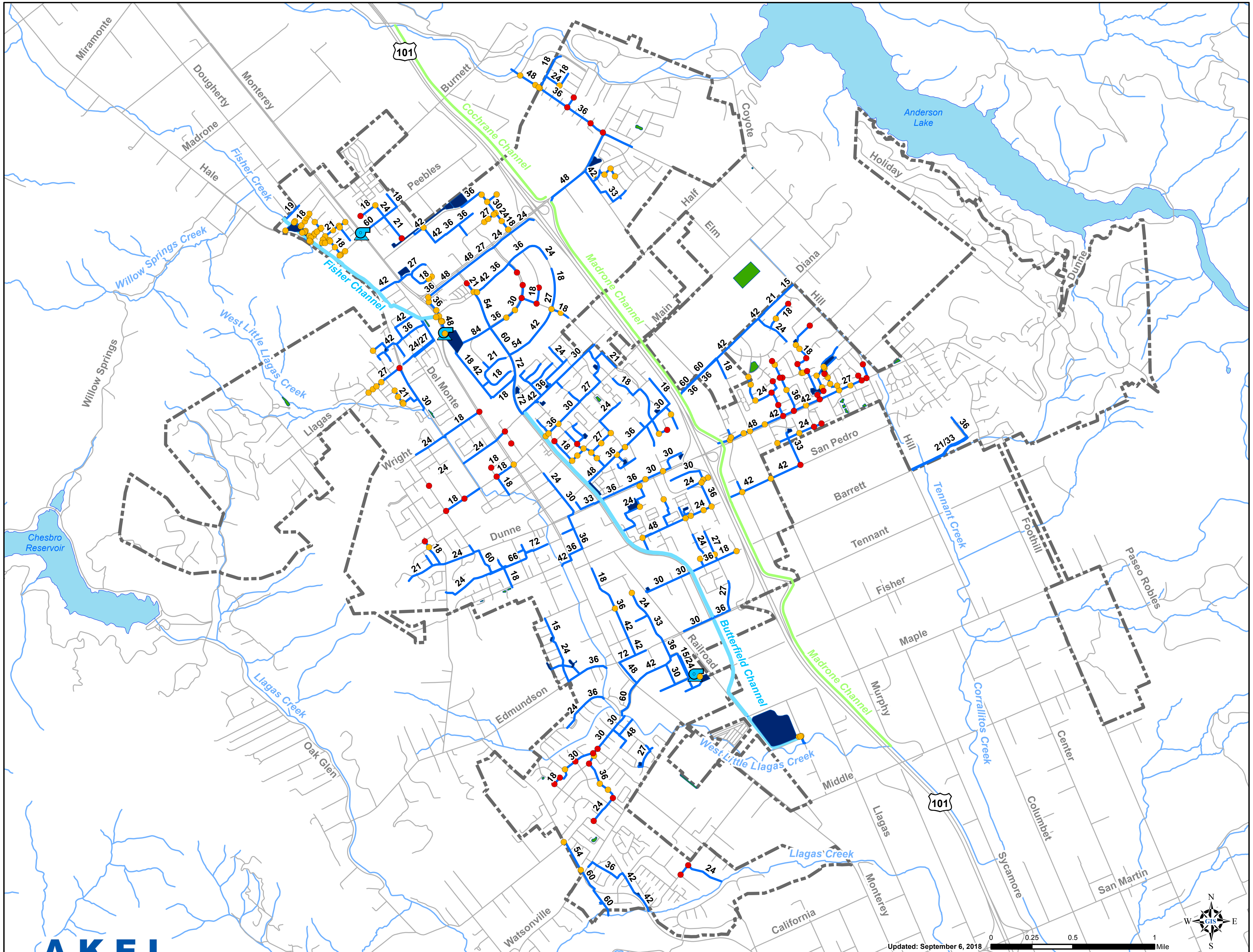

Figure 5.1
Existing System Analysis
10-Year Design Storm
Storm Drainage System Master Plan
City of Morgan Hill

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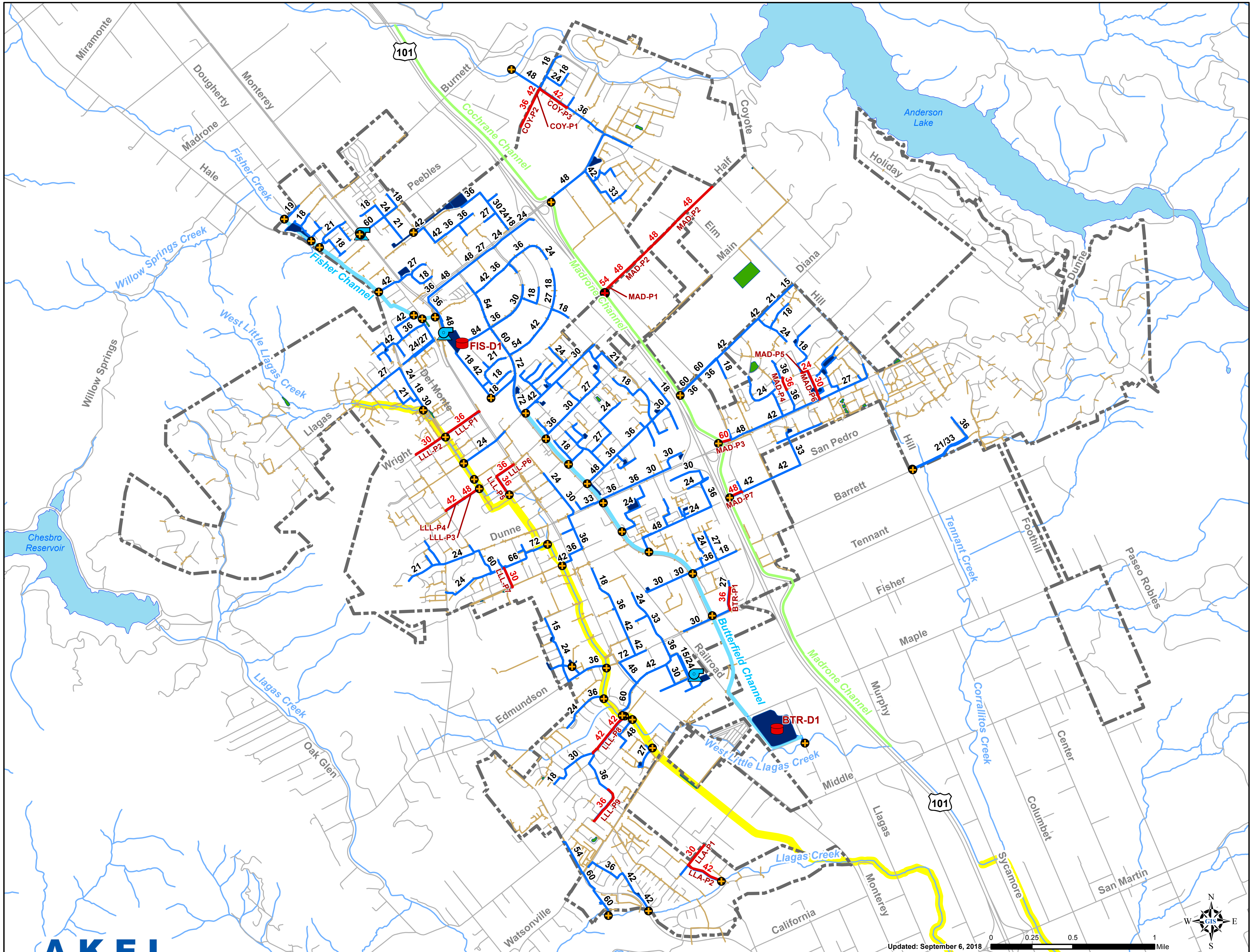

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Legend

Proposed Improvements
- Outfalls
- Detention Basins
- Pipes
- PL566 Flood Protection Project

Existing Modeled System
- Pumps
- Outfalls
- Pipes
- Channels
- Storage Basins

Non-Modeled System
- Pipes
- Channels
- Storage Basins
- Roads
- City Limits
- Creeks
- Lakes

Figure 5.2
Proposed Storm Drainage System Improvements

Storm Drainage System Master Plan
City of Morgan Hill

CITY OF MORGAN HILL

Table 5.1 Storm Drainage System Problem Areas
Storm Drainage System Master Plan
City of Morgan Hill

Location	Type of Concern	Issue
Citywide	Structural	Bridges & major culverts should be evaluated for structural integrity on a multi-year schedule.
Spring St. and Bisceglia	Flooding	Frequent flooding due to slow drainage to creek. New leak in manhole at Monterey & Bisceglia found 1/17/12.
Burnett at Monterey	Flooding	Flooding at intersection due to slow drainage. Nowhere for water to once ditch on the west side of Monterey is full.
Fisher Creek retention basin	Flooding	During storm event on October 13, 2009 Fisher creek flooded but large retention pond had little water in it.
17910 Woodland Ave.	Erosion	Erosion near booster station, undermining edge of road.
SB Monterey Rd, gutter between Ciolino & San Pedro	Flooding	Gutter drains very poorly and there are no catch basins. Water collects year around at corner of Monterey & Ciolino. Gutter/park strip flood between Ciolino & San Pedro during storms.
150 W Main Ave.	Flooding	Catch basin near mail box is not connected to anything. This area floods during major storms.
Mission View & Half Road	Flooding	Flooding.
16115 Condit, at Ramada Inn	Flooding	Catch basin in street in front of Ramada collects water from the parking lot but it not connected to any storm drain.
1390 Llagas Rd, between Castle Ridge & Glen Ayre	Sediment/Erosion	Inlets on uphill side of road fill with dirt every year, frequent small slides onto roadway.
Cochrane Circle	Flooding	Area floods frequently - storm drains are full of roots and likely damaged.
18200 Sabini Ct.	Flooding	Resident filled in ditch on his own property so street floods during heavy storms.
17661 Peak Ave.	Flooding	Alley drain can't receive water volume so back yard floods.
Downtown storm drains	Structural	Some storm catch basins in the old part of town are made of brick. Would need to do a survey to identify locations.
2776 Hayloft Ct.	Erosion	Water collects at bottom of driveway, has nowhere to go and asphalt curb is deteriorating.
Badger Pass, Gray Ghost, and other outlets near creeks	Flooding	When Llagas Creek level rose winter 2010 due to reservoir release, water backed up into street. A ch backing up.
17730 Del Monte Ave, at Lindo Lane	Flooding	Existing bubble up storm line is full of roots and catch basin has a dirt bottom. Location is subject to flooding.
3660 Jackson Oaks Ct.	Flooding	Catch basin is not capable of receiving water from street during even small storms so houses nearby have flooded. Also neighbor downstream has experienced flooding.
15645 Oakridge Ct.	Flooding	Stormwater from court flows onto property instead of to open space.
Trail Dr. drainage channels (4)	Sediment/Erosion	Channels erode and silt up downstream catch basins.
Circle Lane & Oak View	Sediment	Inlet silts up.
6" pump to pump out flooded areas	Flooding	Areas subject to flooding that could require use of a large pump: Monterey underpass, Bisceglia.
Butterfield Channel between Diana & Main	Sediment	Sediment has raised bottom of channel to level higher than storm drain invert in two locations.
Butterfield Channel between Central & Tennant	Sediment/Capacity	Check dams are not needed now that channel has been extended. Over time they are eroding and channel capacity is being reduced by sediment.
Butterfield Channel	Vegetation Overgrowth	Inlets/outlets at road crossings become overgrown with volunteer reeds and willows. Annual task of clearing vegetation requires extensive hand labor in a difficult to access location.
16335 Oak Canyon Dr.	Sediment	Inlet fills with dirt.
Sutter Blvd, north of Cochrane	Flooding	Water collects at curb. Large pond forms during storms. Tree roots have lifted gutter and paving so water doesn't drain.
Hill Rd. & E. Dunne Ave.	Sediment	Inlet in dirt field is too low and fills with dirt. Streets crew has to place straw wattles around inlet every year.
16817 Gallop Dr.	Sediment	Inlet above Gallop needs re-work, some cobbles are loose.

Note:
1. Source: Received from City, titled Morgan Hill Storm System Improvements/Major Repairs/Maintenance Needed, on 03/05/2014

Table 5.2 Proposed Pipeline Capacity Improvements

Storm Drainage System Master Plan
City of Morgan Hill

Improv. No.	Alignment	Limits	Existing Diameter (in)	Pipeline Improvements New/Parallel/ Replace	Diameter (in)	(ft')	Length (ft)
Butterfield Drainage Basin							
BTR-P1	Juan Hernandez Dr	From 150' s/o Saint James Dr to Tennant Ave	27	Replacement	36	752	750
Coyote Drainage Basin							
COY-P1	Eagle View Dr	From 310' s/o Peet Rd to Peet Rd	-	New	42	309	300
COY-P2	Eagle View Dr	From 1,400 ft s/o Peet Rd to 310' s/o Peet Rd	-	New	36	1,069	1,050
COY-P3	Peet Rd	From Eagle View Dr to Morningstar Dr	36	Replacement	42	1,095	1,100
Madrone Drainage Basin							
MAD-P1	Half Rd	From Condit Rd to NB US 101	-	New	54	381	400
MAD-P2	Half Rd	From Peet Rd to Condit Rd	-	New	48	2,463	2,450
MAD-P3	Dunne Ave	From Condit Rd to NB US 101	48	Replacement	60	398	400
MAD-P4	Aspen Wy	From Bluebonnet Wy to Pine Wy	27	Replacement	36	431	450
MAD-P5	Bluebonnet Ct	From Almond Wy to Percheron Ct	18	Replacement	24	210	200
MAD-P6	Percheron Ct	From Bluebonnet Ct to 170' s/o Bayo Claros Cir	21	Replacement	30	1,029	1,050
MAD-P7	San Pedro Ave	From Condit Rd to NB US 101	36	Replacement	48	475	500
Little Llagas Drainage Basin							
LLL-P1	Wright Ave	From Monterey Rd to Hale Ave	-	New	36	1,458	1,450
LLL-P2	Wright Ave	From 450' sw/o Crest Ave to Hale Ave	-	New	30	1,145	1,150
LLL-P3	Main Ave	From Crest Ave to Hale Ave	-	New	48	593	600
LLL-P4	Main Ave	From Peak Ave to Crest Ave	-	New	42	730	750
LLL-P5	Del Monte Ave	From Main Ave to 2nd St	-	New	36	725	750
LLL-P6	Main Ave	From Del Monte Ave to Monterey Rd	-	New	36	683	700
LLL-P7	Lone Hill Dr	From Spring Ave to Chargin Wy	18	Replacement	30	690	700
LLL-P8	La Crosse Dr	From La Baree Dr to 200' se/o intersection of the Vineyard Blvd and La Crosse Dr	27/30	Replacement	42	1,657	1,650
LLL-P9	Alamo Dr	From La Rocca Dr to 80' n/o Unnamed St	18	Replacement	36	1,337	1,350
Llagas Drainage Basin							
LLA-P1	Middle Ave	From Olive Ave to Gallant Fox Wy	-	New	30	828	850
LLA-P2	Gallant Fox Wy	From Middle Ave to 1,200' e/o Middle Ave	24	Replacement	42	1,222	1,200

Coyote Drainage Basin

- **COY-P1:** Construct a new 42-inch pipeline on Eagle View Drive from 310 ft south of Peet Road to Peet Road.
- **COY-P2:** Construct a new 36-inch pipeline on Eagle View Drive from 1,400 feet south of Peet Road to 310 feet south of Peet Road.
- **COY-P3:** Replace the existing 36-inch pipeline on Peet Road from Eagle View Drive to Morningstar Drive with a new 42-inch pipeline.

Madrone Drainage Basin

- **MAD-P1:** Construct a new 54-inch pipeline on Half Road from Condit Road to northbound US Highway 101.
- **MAD-P2:** Construct a new 48-inch pipeline on Half Road from Peet Road to Condit Road.
- **MAD-P3:** Replace the existing 48-inch pipeline on Dunne Avenue from Condit Road to northbound US Highway 101 with a new 60-inch pipeline.
- **MAD-P4:** Replace the existing 27-inch pipeline on Aspen Way from Bluebonnet Way to Pine Way with a new 36-inch pipeline.
- **MAD-P5:** Replace the existing 18-inch pipeline on Bluebonnet Court from Almond Way to Percheron Court with a new 24-inch pipeline.
- **MAD-P6:** Replace the existing 21-inch pipeline on Percheron Court from Bluebonnet Court to 170 feet south Bayo Claros Circle with a new 30-inch pipeline.
- **MAD-P7:** Replace the existing 36-inch pipeline on San Pedro Avenue from Condit Road to northbound US Highway 101 with a new 48-inch pipeline

Little Llagas Drainage Basin

- **LLL-P1:** Construct a new 36-inch pipeline on Wright Avenue from Monterey Road to Hale Avenue.
- **LLL-P2:** Construct a new 30-inch pipeline on Wright Avenue from Hale Avenue to 450 feet southwest of Crest Avenue.
- **LLL-P3:** Construct a new 48-inch pipeline on Main Avenue from Hale Avenue to Crest Avenue.
- **LLL-P4:** Construct a new 42-inch pipeline on Main Avenue from Crest Avenue to Peak Avenue.

- **LLL-P5:** Construct a new 36-inch pipeline on Del Monte Avenue from Main Avenue to 2nd Street.

- **LLL-P6:** Construct a new 36-inch pipeline on Main Avenue from Monterey Road to Del Monte Avenue.

- **LLL-P7:** Replace the existing 18-inch pipeline on Lone Hill Drive from Chargin Way to Spring Avenue with a new 30-inch pipeline.

- **LLL-P8:** Replace the existing 27-inch and 30-inch pipelines on La Crosse Drive from La Baree Drive to 200 feet southeast of the intersection of Vineyard Boulevard and La Cross Drive.

Llagas Drainage Basin

- **LLA-P1:** Construct a new 30-inch pipeline on Middle Avenue from Olive Avenue to Gallant Fox Way.

- **LLA-P2:** Replace the existing 24-inch pipeline on Gallant Fox Way from Middle Avenue to 1,200 feet east of Middle Avenue with a new 42-inch pipeline.

5.4 DETENTION AND RETENTION CAPACITY ANALYSIS

Existing detention and retention basins were evaluated based on the 100-year 24-hour storm, and assumed no percolation during the 10-day storm. The existing detention and retention basins performed adequately for the City's existing development.

To the extent practicable, the stormwater runoff from future development was intercepted before outfalling to creeks or channels tributary to creeks. The new basins intended to service future developments are summarized on **Table 5.3** and shown graphically on **Figure 5.2**; they are also briefly described as follows:

Butterfield Drainage Basin

BTR-D1: Construct a new 96 AF detention basin at approximately 900 feet northeast of Pollard Avenue and Seymour Avenue.

Fisher Drainage Basin

FIS-D1: Construct a new 50 AF detention basin at approximately 1,000 feet southwest of Sutter Boulevard and Butterfield Boulevard.

Table 5.3 Proposed Detention Basins

Storm Drainage System Master Plan
City of Morgan Hill

Detention Basin ID	Preliminary Basin Location	Recommended Capacity (AF)
Butterfield Drainage Basin		
BTR-D1	Approx. 900' nw/o Pollard Ave and Seymour Ave	96
Fisher Drainage Basin		
FIS-D1	Approx 1,000' sw/o Sutter Blvd and Butterfield Blvd	50

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Table 5.4 Long Term Replacement Recommendation
Storm Drainage System Master Plan
City of Morgan Hill

Improv. No.	Type of Improv	Alignment	Limits	Existing Diameter (in)	New/Upgrade/ Replace	Pipeline Information	
						Diameter (in)	Length (ft)
LT-P1	Pipe	Cochrane Rd	From Peet Rd to 350' n/o Mission View Dr	36	Replace	48	1,000
LT-P2	Pipe	Cochrane Rd/ Monterey Rd	From Cochrane Cir to 285' s/o Jarvis Dr	36	Replace	42	1,400
LT-P3	Pipe	Butterfield Blvd	From 450' nw/o Jarvis Dr to Jarvis Dr	21	Replace	30	450
LT-P4	Pipe	Sutter Blvd	From 430' n/o Serene Dr to Serene Dr	21	Replace	30	450
LT-P5	Pipe	Technology Dr	From 525' n/o Serene Dr to Serene Dr	21	Replace	24	550
LT-P6	Pipe	Serene Dr	From Technology Dr to Sutter Blvd	21	Replace	30	550
LT-P7	Pipe	Sutter Blvd	From Serene Dr to Butterfield Blvd	30/36	Replace	42	1,550
LT-P8	Pipe	Jarvis Dr	From Serene Dr to 590' s/o Serene Dr	27	Replace	42	600
LT-P9	Pipe	Justino Dr	From Jenece Ct to Ringel Dr	15	Replace	18	350
LT-P10	Pipe	Morgan Ave	From 350' e/o Almond Wy to Almond Wy	18	Replace	24	350
LT-P11	Pipe	Almond Way	From 325' n/o Bluebonnet Ct to Bluebonnet Ct	18	Replace	24	350
LT-P12	Pipe	Dunne Ave	From Percheron Ct to 380' e/o Peppertree Dr	42	Replace	48	900
LT-P13	Pipe	Dunne Ave	From 380' e/o Peppertree Dr to Murphy Ave	42/48	Replace	54	1,600
LT-P14	Pipe	Pinecone Ct / Seville Dr	From Sugarpine Dr to Peppertree Dr	24	Replace	30	1,200
LT-P15	Pipe	Central Ave	From McLaughlin Ave to Hale Ave	24	Replace	30	1,700
LT-P16	Pipe	Tennant Ave	From Foothill Ave to Hill Rd	-	New	48	2,150
LT-P17	Pipe	Maple Ave	From Seymour Ave to Railroad Ave	-	New	48	1,300
LT-P18	Pipe	Monterey Rd	From 315' e/o Starswept Ln to 1,400' e/o Crowner Ave	-	New	18	2,950
LT-D1	Detention Basin		Approximately 180' n/o Monterey Rd and Cochrane Rd	-	New/Upgrade		
LT-D2	Detention Basin		Approximately 60' w/o Bentley Dr and Belleto Dr	-	New/Upgrade		
LT-D3	Detention Basin		Approximately 80' w/o Calle Central and Central Ave	-	New/Upgrade		
LT-D4	Detention Basin		Approximately 75' e/o Central Ave and Calle Mazatlan	-	New/Upgrade		
LT-D5	Detention Basin		Approximately 620' sw/o Viewcrest Ln and Dunne Ave	-	New/Upgrade		
LT-D6	Detention Basin		Approximately 745' n/o San Pedro Ave and Railroad Ave	-	New/Upgrade		
LT-D7	Detention Basin		Approximately 115' se/o Cory Dr and San Luis Way	-	New/Upgrade		
LT-D8	Detention Basin		Approximately 940' e/o Railroad Ave and San Pedro Ave	-	New/Upgrade		
LT-D9	Detention Basin		Approximately 100' n/o Railroad Ave and Barrett Ave	-	New/Upgrade		

5.5 OUTFALLS

Direct outfalls in the City have several primary discharge points including: Fisher Channel, Butterfield Channel, Madrone Channel, West Little Llagas Creek, and Llagas Creek. As part of this master plan, outfalls were identified and their points of discharge were documented. Outfalls were assumed in adequate condition, and capable of conveying stormwater flows from upstream facilities.

5.6 TWO-DIMENSIONAL FLOW ANALYSIS

The City's hydrologic and hydraulic models were incorporated into a two-dimensional stormwater model, which combines the hydrologic and hydraulic calculations of a SWMM engine with overland flow hydraulics. This two-dimensional model was completed by Hydmet, inc. A two-dimensional model can evaluate the impact of flooding during intense rainfall events and be used to identify improvements to mitigate existing deficiencies through the use of accurate topography (typically 1 foot definition). For the purpose of the 2018 SDMP this two-dimensional model was used to evaluate the capacity adequacy of the PL-566 improvement to the West Little Llagas Creek. The following subsections are adaptations from a technical memorandum submitted by Hydmet to Akel Engineering Group.

Background

The Federal Emergency Management Agency (FEMA) has a defined 100-year floodplain effective May 2009 (**Figure 2.3**). This study was based on information effective from December 1998. This study evaluated the revised hydrology for the West Little Llagas Creek for existing conditions and future conditions in an effort to determine and limit potential future flood damage. The updated hydrology was determined for the study area using HEC-1 and revised precipitation data from NOAA Atlas 14.

The HEC-1 hydrology models were revised with the 2035 General Plan land use for the City of Morgan Hill and surrounding County of Santa Clara areas. Additionally, the 1-foot Light Detection and Ranging (LiDAR) topography with updated Google Earth imagery were used to update the models. Finally, Santa Clara Valley Water District and the City of Morgan Hill have recently designed, and begun upgrades to, the PL-566 system. The upgrades were included in the model to determine the effectiveness of the improvements to date, and the results of the remaining PL-566 improvements. This updated information was used in the development of a new 100-year flood study.

Initial Modeling

The initial modeling setup from flow 2-D included: HEC-1, SWMM, and HEC-RAS. The model and purpose are described in the following.

- HEC-1. This model was used for the purposes of developing hydrology inputs for the FLO-2D modeling.

- SWMM. This model was used to evaluate the 10-year and 100-year flooding, and to determine backwater issues that would resulted from rising water levels in the West Little Llagas Creek.
- HEC-RAS. This model was used to develop cross-sections and flood profiles and elevations for the West Little Llagas Creek. The HEC-RAS profiles were developed from the 1-foot LiDAR data.

The results from each of the modeling efforts were incorporated into the FLO-2D analysis.

FLO-2D Analysis

FLO-2D is a comprehensive two-dimensional floodplain simulation model that has been approved by FEMA for flood study use. This modeling platform is capable of integrating HEC-1, HEC-RAS, and SWMM results. The model uses user-defined cells to store hydrologic information such as, elevation, overland roughness, channels, buildings and streets. The model for the West Little Llagas Creek was set up using 10-meter dimensions, and 1-foot average elevations.

Using the cell parameters documented above, the FLO-2D model was simulated with the 100-year flood runoff developed from HEC-1. The HEC-1 models were used to simulate the local runoff, and develop upland hydrographs for the tributary area outside the FLO-2D model area.

The FLO-2D analysis indicated that flood water depths in downtown Morgan Hill may exceed approximately 4 feet (**Figure 5.3**). This is largely due to storm drains that are located below the West Little Llagas flood water level heights. When the water levels rise in the creek, they exceed the rim elevation of some storm drains, causing flooding. When the flooding occurs, there is no defined flow path through central Morgan Hill that allows the water to vacate the City. As such, water begins to pond, creating the flooding conditions.

The FLO-2D analysis indicates that the PL-566 improvements do reduce the flood potential for the southern portion of the City. The flood analysis was performed with and without what was termed the Watsonville Bypass. This bypass consisted of the still-to-be-completed channel improvements from Watsonville Road to the Llagas Creek. Based on the FLO-2D analysis, it is highly recommended that the Watsonville Bypass be completed. This improvement was estimated to divert approximately 1,000 cubic feet per second from the West Little Llagas Creek.

Analysis Findings

The purpose of this analysis was to determine the effects of the PL-566 improvements on the 100-year floodplain based on updated land use and precipitation data. The results indicate the following:

- The PL-566 improvements were effective at reducing the flood width and elevation upstream of Watsonville Road.

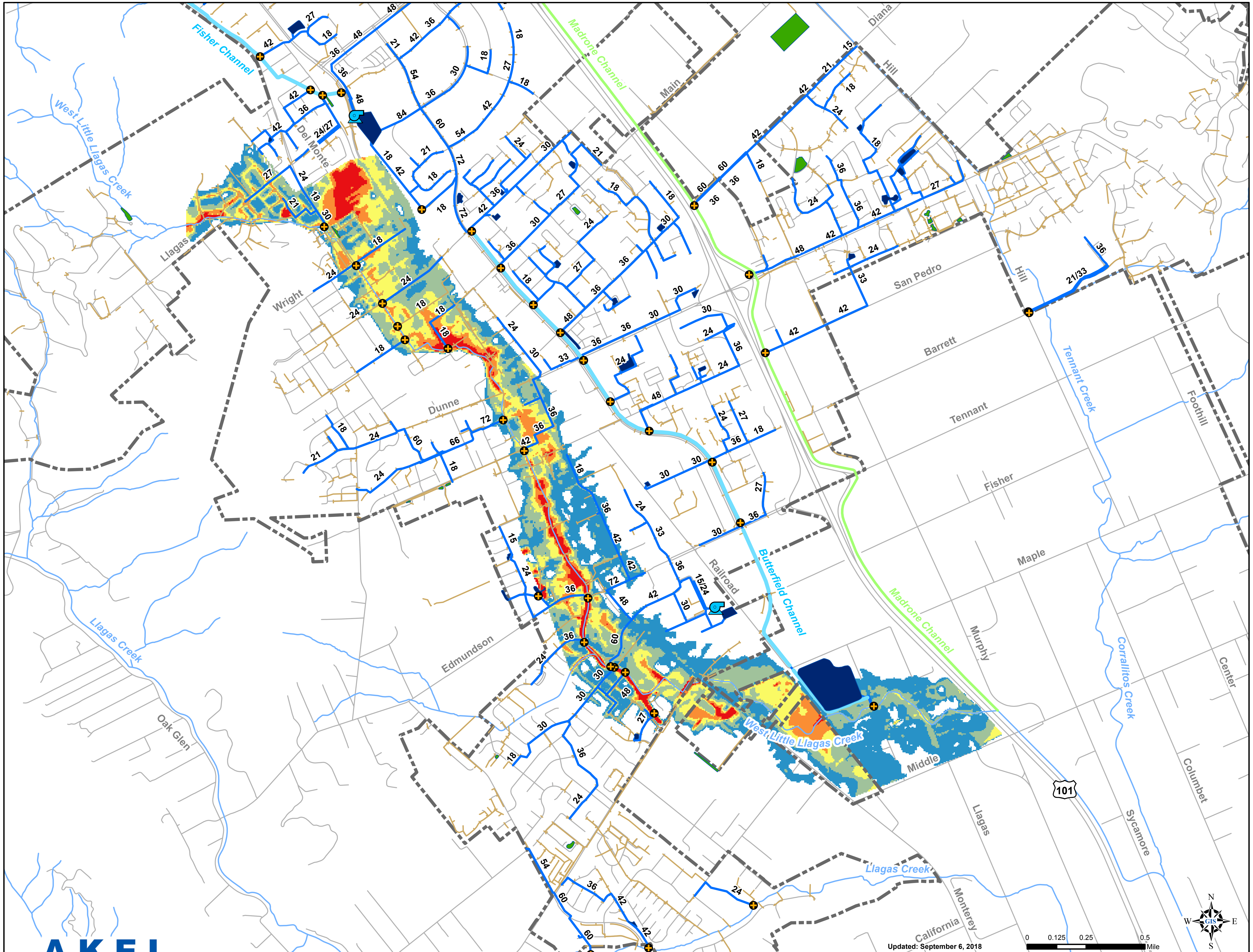

Figure 5.3
West Little Llagas Creek
100-Year Flooding
Storm Drainage System Master Plan
City of Morgan Hill

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- The Watsonville Bypass, once constructed, will reduce the flooding between Monterey Road and Highway 101. It should be noted that some developments directly adjacent to the creek may still flood in the 100-year event.

- The 100-Year water surface elevations for the Morgan Hill interior are largely due to creek bank overflow and backup of storm drains due to the water level rise.

5.7 LONG TERM IMPROVEMENT RECOMMENDATIONS

As part of the Master Plan, an analysis of the recently updated NOAA Atlas 14 precipitation was completed and corresponding recommendations were presented to City staff for review. City staff reviewed and requested a similar analysis using the previously approved precipitation data from the 2002 SDSMP.

City staff chose to maintain the previously approved precipitation data from the 2002 SDSMP for the purposes of developing the capital improvement program (CIP) discussed in a later chapter. While not included in the CIP, the improvements discussed in this section may be completed as funds are available and the existing system pipelines end their useful life. It should be noted that, while identified as deficient under the 2014 NOAA Atlas 14 analysis, these improvements were not identified in the 2002 SDSMP rainfall analysis, and historically, City staff have not noted flooding due to pipeline capacity constraints. These improvements are summarized on **Table 5.4** and shown graphically on **Figure 5.4**.

5.7.1 Long Term Pipeline Replacement Recommendations

The following pipeline improvements are considered long term replacement projects to be implemented as needed, or as funds become available.

- **LT-P1:** Replace the existing 36-inch pipeline on Cochrane Road from Peet Road to 350 feet north of Mission View Drive with a new 48-inch pipeline.

- **LT-P2**: Replace the existing 36-inch pipeline along Cochrane Boulevard and Monterey Road from Cochrane Circle to 285 feet south of Jarvis Drive with a new 42-inch pipeline.

- **LT-P3**: Replace the existing 21-inch pipeline on Butterfield Boulevard from 450 feet northwest of Jarvis Drive to Jarvis Drive with a new 30-inch pipeline.

- **LT-P4**: Replace the existing 21-inch pipeline on Sutter Boulevard from 430 feet north of Serene Drive to Serene Drive with a new 30-inch pipeline.

- **LT-P5**: Replace the existing 21-inch pipeline on Technology Drive from 525 feet north of Serene Drive to Serene Drive with a new 24-inch pipeline.

- **LT-P6**: Replace the existing 21-inch pipeline on Serene Drive from Technology Dr to Boulevard with a new 30-inch pipeline.

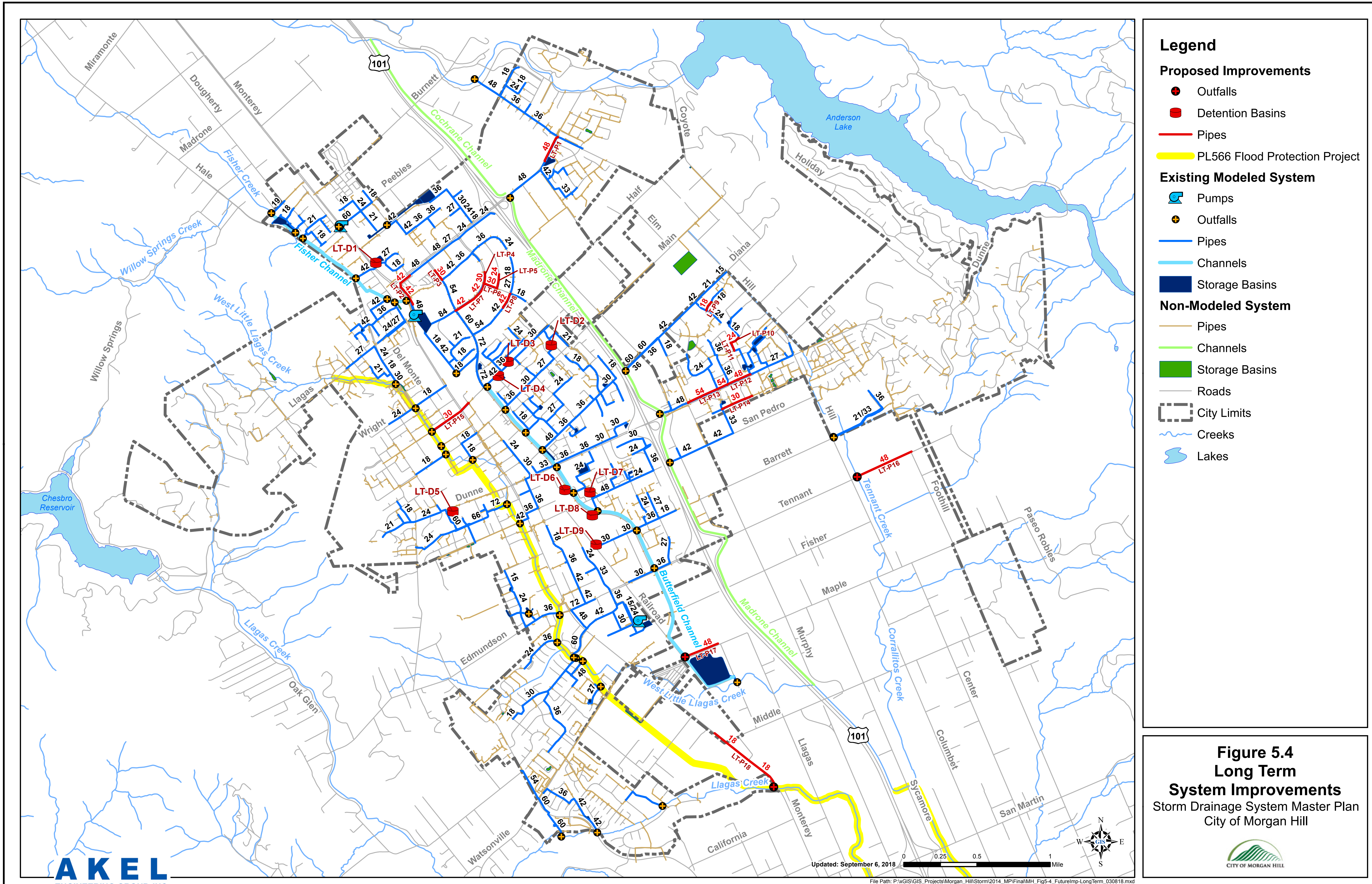

Figure 5.4
Long Term
System Improvements
Storm Drainage System Master Plan
City of Morgan Hill

- **LT-P7**: Replace the existing 30-inch and 36-inch pipelines on Sutter Boulevard from Serene Drive to Butterfield Boulevard with a new 42-inch pipeline.
- **LT-P8**: Replace the existing 27-inch pipeline on Jarvis Drive from Serene Drive to 590 feet south of Serene Drive with a new 42-inch pipeline.
- **LT-P9**: Replace the existing 15-inch pipeline on Justino Drive from Jenece Court to Ringel Drive with a new 18-inch pipeline.
- **LT-P10**: Replace the existing 18-inch pipeline on Morgan Avenue from 350 feet east of Almond Way to Almond Way with a new 24-inch pipeline.
- **LT-P11**: Replace the existing 18-inch pipeline on Almond Way from 325 feet north of Bluebonnet Court to Bluebonnet Court with a new 24-inch pipeline.
- **LT-P12:** Replace the existing 42-inch pipeline on Dunne Avenue from Percheron Court to 380 feet east of Peppertree Drive with a new 48-inch pipeline.
- **LT-P13**: Replace the existing 42-inch and 48-inch pipelines on Dunne Avenue from 380 feet east of Peppertree Drive to Murphy Avenue with a new 54-inch pipeline.
- **LT-P14**: Replace the existing 24-inch pipeline along Pinecone Court and Seville Drive from Sugarpine Drive to Peppertree Drive with a new 30-inch pipeline.
- **LT-P15**: Replace the existing 24-inch pipeline on Central Avenue from McLaughlin Avenue to Hale Avenue with a new 30-inch pipeline.
- **LT-P16**: Construct a new 48-inch pipeline on Tennant Avenue from Foothill Avenue to Hill Road.
- **LT-P17:** Construct a new 48-inch pipeline on Maple Avenue from Seymour Avenue to Railroad Avenue.
- **LT-P18**: Construct a new 18-inch pipeline on Monterey Road from 315 east of Starswept Lane to 1,400 feet east of Crowner Avenue.

5.7.2 Long Term Detention Basin Capacity

The following detention basin capacity improvements are considered long term projects. These improvements may be constructed as funds are available, and where feasible.

- **LT-D1**: Construct a new detention basin approximately 180 feet north of Monterey Road and Cochrane Road.
- **LT-D2**: Construct a new detention basin approximately 60 feet west of Bentley Drive and Belleto Drive

- **LT-D3:** Construct a new detention basin approximately 80 feet west of Calle Central and Central Avenue.
- **LT-D4**: Construct a new detention basin approximately 75 feet east of Central Avenue and Calle Mazatlan.
- **LT-D5**: Construct a new detention basin approximately 620 feet southwest of Viewcrest Lane and Dunne Avenue.
- **LT-D6**: Construct a new detention basin approximately 745 feet north of San Pedro Avenue and Railroad Avenue.
- **LT-D7**: Construct a new detention basin approximately 115 feet southeast of Cory Drive and San Luis Way.
- **LT-D8**: Construct a new detention basin approximately 940 feet east of Railroad Avenue and San Pedro Avenue.
- **LT-D9**: Construct a new detention basin approximately 100 feet north of Railroad Avenue and Barrett Avenue.

CHAPTER 6 – CAPITAL IMPROVEMENT PROGRAM

This chapter provides a summary of the recommended storm drainage system improvements intended to mitigate existing capacity deficiencies and for accommodating anticipated future growth. The chapter also presents the cost criteria and methodologies for developing the Capital Improvement Program (CIP).

6.1 COST ESTIMATE ACCURACY

Cost estimates presented in the CIP were prepared for general master planning purposes and, where relevant, for further project evaluation. Final costs of a project will depend on several factors including the final project scope, costs of labor and material, and market conditions during construction.

The Association for the Advancement of Cost Engineering (AACE International), formerly known as the American Association of Cost Engineers has defined three classifications of assessing project costs. These classifications are presented in order of increasing accuracy: Order of Magnitude, Budget, and Definitive.

- **Order of Magnitude Estimate.** This classification is also known as an “original estimate”, “study estimate”, or “preliminary estimate”, and is generally intended for master plans and studies.

  This estimate is not supported with detailed engineering data about the specific project, and its accuracy is dependent on historical data and cost indexes. It is generally expected that this estimate would be accurate within -30 percent to +50 percent.

- **Budget Estimate.** This classification is also known as an “official estimate” and generally intended for predesign studies. This estimate is prepared to include flow sheets and equipment layouts and details. It is generally expected that this estimate would be accurate within -15 percent to +30 percent.

- **Definitive Estimate.** This classification is also known as a “final estimate” and prepared during the time of contract bidding. The data includes complete plot plans and elevations, equipment data sheets, and complete specifications. It is generally expected that this estimate would be accurate within -5 percent to + 15 percent.

Costs developed in this study should be considered “Order of Magnitude” and have an expected accuracy range of **-30 percent** and **+50 percent**.

6.2 COST ESTIMATE METHODOLOGY

Cost estimates presented in this chapter are opinions of probable construction and other relevant costs developed from several sources including cost curves, Akel experience on other master planning projects, and input from City staff on the development of public and private cost sharing. Where appropriate, costs were escalated to reflect the more current Engineering News Record's (ENR) Construction Cost Index (CCI).

This section documents the unit costs used in developing the opinion of probable construction costs, the Construction Cost Index, the land acquisition costs, and markups to account for construction contingency and other project related costs.

6.2.1 Unit Costs

The unit cost estimates used in developing the Capital Improvement Program are summarized on **Table 6.1**. The unit costs are intended for developing the Order of Magnitude estimate, and do not account for site specific conditions, labor or material costs during the time of construction, final project scope, implementation schedule, detailed utility and topography surveys, investigation of alternative routings for pipes, and other various factors. These factors are assumed included in the contingencies applied to the final capital improvement cost.

6.2.2 Construction Cost Index

Costs estimated in this study are adjusted utilizing the Engineering News Record (ENR) Construction Cost Index (CCI), which is widely used in the engineering and construction industries.

The costs in this Storm Drainage System Master Plan were calculated using a 20-City national average ENR CCI of 10,532, reflecting a date of January 2017.

6.2.3 Construction Contingency Allowance

Knowledge about site-specific conditions for each proposed project is limited at the master planning stage; therefore, construction contingencies were used. The estimated construction costs in this master plan include a **30 percent** contingency allowance to account for unforeseen events and unknown field conditions.

6.2.4 Project Related Costs

The capital improvement costs also account for project-related costs, comprised of engineering design, project administration (developer and City staff), construction management and inspection, and legal costs. The project related costs in this master plan were estimated by applying an additional **30 percent** to the estimated construction costs.

Table 6.1 Unit Costs

Storm Drainage System Master Plan

City of Morgan Hill

Pipe Size (in)	Unit Costs[1] ($/lineal foot)
18	135
21	166
24	196
27	226
30	241
36	286
42	331
48	391
54	436
60	451
72	542
84	692
96	767
108	858
120	948
Detention Basin	**Capacity Cost[1]** ($/acre)
New Detention Basin	73,156
Detention Basin Expansion	36,578

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Note:

1. Construction costs estsimated using January 2017 ENR CCI of 10,533.

6.3 CAPITAL IMPROVEMENT PROGRAM

This section documents the capital improvement program, contingencies included in the costs, and the allocation of costs to meet the requirements of AB1600.

6.3.1 Capital Improvement Costs

The Capital Improvement Program costs for the projects identified in this master plan for mitigating existing system deficiencies and for serving anticipated future growth throughout the City are summarized on **Table 6.2**.

Each improvement was assigned a unique coded identifier associated with the improvement type and is summarized graphically on **Figure 6.1**. The estimated construction costs include the baseline costs plus **30 percent** contingency allowance to account for unforeseen events and unknown field conditions, as described in a previous section. Capital improvemTExtent costs include the estimated construction costs plus **30 percent** project-related costs (engineering design, project administration, construction management and inspection, and legal costs).

6.3.2 Recommended Cost Allocation Analysis

Cost allocation analysis is needed to identify improvement funding sources, and to establish a nexus between development impact fees and improvements needed to service growth. In compliance with the provisions of Assembly Bill AB 1600, the analysis differentiates between the project needs of servicing existing users and for those required to service anticipated future developments. The cost responsibility is based on model parameters for existing and future land use, and may change depending on the nature of development. **Table 6.2** lists each improvement, and separates the cost by responsibility between existing and future users.

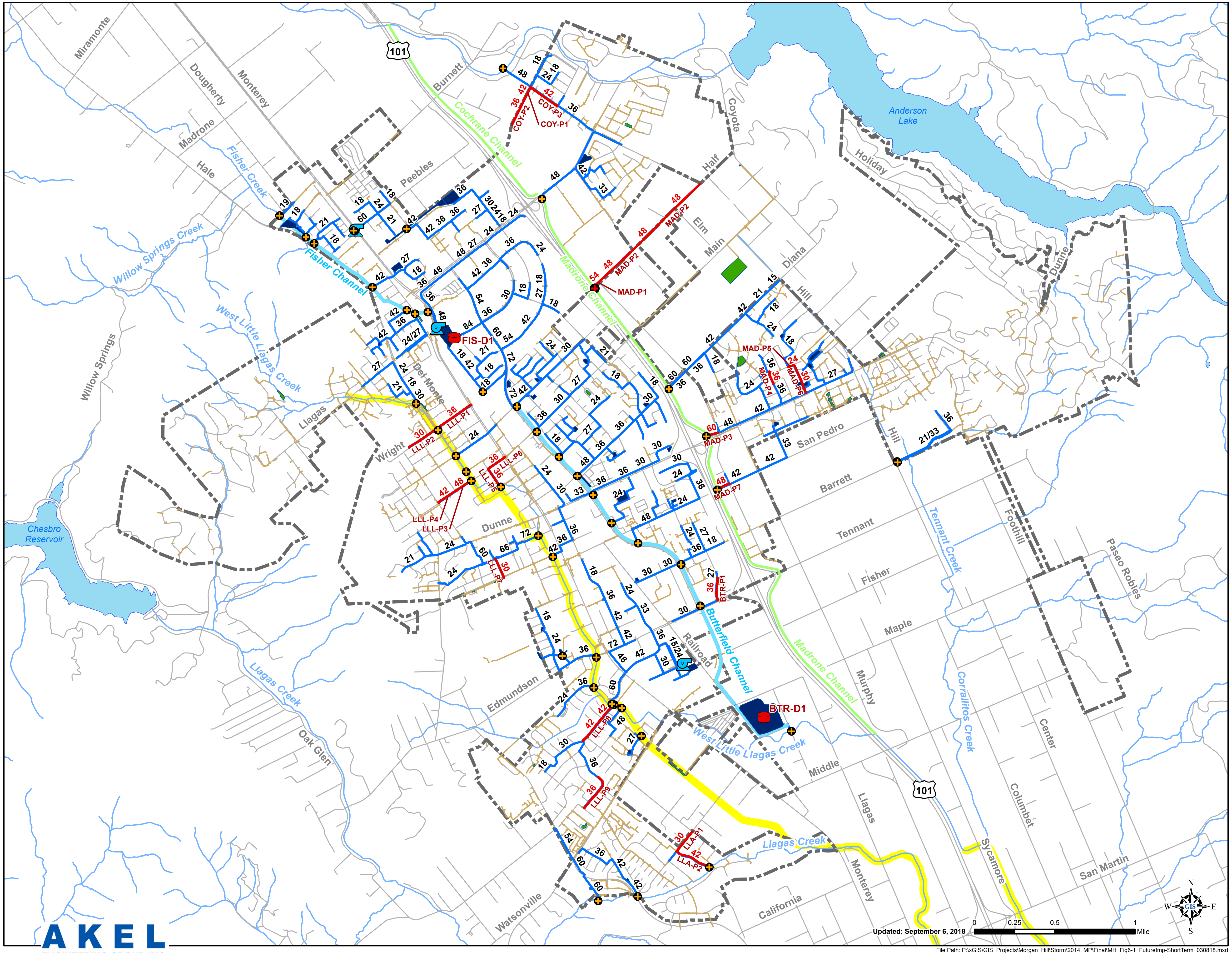
6.3.3 Pipelines

The recommended pipeline improvements are grouped by drainage basin and listed on **Table 6.2**. Each improvement includes a general description of the street alignment and limits, as well as existing pipe diameter and length.

The opinion of probable construction costs, for the projects included in this master plan, are based on the pipe unit costs summarized on **Table 6.1**.

6.3.4 Detention Basins

New detention basins are shown graphically in **Figure 6.1** and summarized on **Table 6.2**. It should be noted that the nature and timing of development is subjective and dependent on market conditions. As such, the location of new detention facilities recommended in this master plan, and intended to service new development, are subject City Engineer approval. The detention values provided are intended to address the drainage basin requirements as a whole.



Legend

Proposed Improvements

- Outfalls
- Detention Basins
- Pipes
- PL566 Flood Protection Project

Existing Modeled System

- Pumps
- Outfalls
- Pipes
- Channels
- Storage Basins

Non-Modeled System

- Pipes
- Channels
- Storage Basins
- Roads
- City Limits
- Creeks
- Lakes

Figure 6.1
Proposed Storm Drainage System Improvements

Storm Drainage System Master Plan
City of Morgan Hill

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Table 6.2 Capital Improvement Program
Storm Drainage System Master Plan
City of Morgan Hill

Improv. No.	Type of	Alignment	Limits	Pipeline Improvements		Infrastructure Costs					Baseline Constr. Costs	Estimated Constr. Cost[1]	Capital Improvement Costs[2]	Suggested Construction Timeline	Suggested Cost Allocation		Cost Sharing	
				Existing Diameter	New/Parallel/ Replace	Diameter		Length	Unit Cost[1]	Infr. Cost					Existing Users	Future Users	Existing Users	Future Users
				(in)		(in)	(ft')	(ft)	($/LF)	($)	($)	($)	($)		(%)	(%)		
Pipeline Capacity Improvements																		
Butterfield Drainage Basin																		
BTR-P1	Pipeline	Juan Hernandez Dr	From 150' s/o Saint James Dr to Tennant Ave	27	Replacement	36	752	750	286	214,401	214,401	278,722	362,338	With Development	0%	100%	0	362,338
										Subtotal - Butterfield Drainage Subbasin	**214,401**	**278,722**	**362,338**				**0**	**362,338**
Coyote Drainage Basin																		
COY-P1	Pipeline	Eagle View Dr	From 310' s/o Peet Rd to Peet Rd	-	New	42	309	300	331	99,302	99,302	129,092	167,820	Intermediate-Term	0%	100%	0	167,820
COY-P2	Pipeline	Eagle View Dr	From 1,400 ft s/o Peet Rd to 310' s/o Peet Rd	-	New	36	1,069	1,050	286	300,162	300,162	390,211	507,274	Intermediate-Term	0%	100%	0	507,274
COY-P3	Pipeline	Peet Rd	From Eagle View Dr to Morningstar Dr	36	Replacement	42	1,095	1,100	331	364,106	364,106	473,338	615,340	Intermediate-Term	100%	0%	615,340	0
										Subtotal - Coyote Drainage Subbasin	**763,570**	**992,641**	**1,290,433**				**615,340**	**675,094**
Madrone Drainage Basin																		
MAD-P1	Pipeline	Half Rd	From Condit Rd to NB US 101	-	New	54	381	400	436	174,530	174,530	226,889	294,956	With Development	0%	100%	0	294,956
MAD-P2	Pipeline	Half Rd	From Peet Rd to Condit Rd	-	New	48	2,463	2,450	391	958,412	958,412	1,245,936	1,619,716	With Development	0%	100%	0	1,619,716
MAD-P3	Pipeline	Dunne Ave	From Condit Rd to NB US 101	48	Replacement	60	398	400	451	180,549	180,549	234,713	305,127	Near-Term	100%	0%	305,127	0
MAD-P4	Pipeline	Aspen Wy	From Bluebonnet Wy to Pine Wy	27	Replacement	36	431	450	286	128,641	128,641	167,233	217,403	Near-Term	100%	0%	217,403	0
MAD-P5	Pipeline	Bluebonnet Ct	From Almond Wy to Percheron Ct	18	Replacement	24	210	200	196	39,119	39,119	50,855	66,111	Near-Term	100%	0%	66,111	0
MAD-P6	Pipeline	Percheron Ct	From Bluebonnet Ct to 170' s/o Bayo Claros Cir	21	Replacement	30	1,029	1,050	241	252,768	252,768	328,598	427,178	Near-Term	100%	0%	427,178	0
MAD-P7	Pipeline	San Pedro Ave	From Condit Rd to NB US 101	36	Replacement	48	475	500	391	195,594	195,594	254,273	330,554	With Development	60%	40%	198,333	132,222
										Subtotal - Madrone Drainage Subbasin	**1,929,613**	**2,508,497**	**3,261,046**				**1,214,152**	**2,046,894**
Little Llagas Drainage Basin																		
LLL-P1	Pipeline	Wright Ave	From Monterey Rd to Hale Ave	-	New	36	1,458	1,450	286	414,509	414,509	538,862	700,521	Near-Term	50%	50%	350,260	350,260
LLL-P2	Pipeline	Wright Ave	From 450' sw/o Crest Ave to Hale Ave	-	New	30	1,145	1,150	241	276,841	276,841	359,893	467,862	Near-Term	50%	50%	233,931	233,931
LLL-P3	Pipeline	Main Ave	From Crest Ave to Hale Ave	-	New	48	593	600	391	234,713	234,713	305,127	396,665	Near-Term	50%	50%	198,333	198,333
LLL-P4	Pipeline	Main Ave	From Peak Ave to Crest Ave	-	New	42	730	750	331	248,254	248,254	322,731	419,550	Near-Term	50%	50%	209,775	209,775
LLL-P5	Pipeline	Del Monte Ave	From Main Ave to 2nd St	-	New	36	725	750	286	214,401	214,401	278,722	362,338	Near-Term	50%	50%	181,169	181,169
LLL-P6	Pipeline	Main Ave	From Del Monte Ave to Monterey Rd	-	New	36	683	700	286	200,108	200,108	260,140	338,183	Near-Term	50%	50%	169,091	169,091
LLL-P7	Pipeline	Lone Hill Dr	From Spring Ave to Chargin Wy	18	Replacement	30	690	700	241	168,512	168,512	219,066	284,785	Long-Term	20%	80%	56,957	227,828
LLL-P8	Pipeline	La Crosse Dr	From La Baree Dr to 200' se/o intersection of the Vineyard Blvd and La Crosse Dr	27/30	Replacement	42	1,657	1,650	331	546,159	546,159	710,007	923,009	Long-Term	100%	0%	923,009	0
LLL-P9	Pipeline	Alamo Dr	From La Rocca Dr to 80' n/o Unnamed St	18	Replacement	36	1,337	1,350	286	385,923	385,923	501,699	652,209	Long-Term	100%	0%	652,209	0
										Subtotal - Little Llagas Drainage Subbasin	**2,689,421**	**3,496,248**	**4,545,122**				**2,974,735**	**1,570,387**
Llagas Drainage Basin																		
LLA-P1	Pipeline	Middle Ave	From Olive Ave to Gallant Fox Wy	-	New	30	828	850	241	204,622	204,622	266,008	345,811	Long-Term	0%	100%	0	345,811
LLA-P2	Pipeline	Gallant Fox Wy	From Middle Ave to 1,200' e/o Middle Ave	24	Replacement	42	1,222	1,200	331	397,207	397,207	516,369	671,280	Long-Term	20%	80%	134,256	537,024
										Subtotal - Llagas Drainage Subbasin	**601,829**	**782,377**	**1,017,090**				**134,256**	**882,834**
										Subtotal - Pipeline Capacity Improvement Costs	**6,198,834**	**8,058,485**	**10,476,030**				**4,938,482**	**5,537,548**

Table 6.2 Capital Improvement Program
Storm Drainage System Master Plan
City of Morgan Hill

Improv. No.	Type of	Alignment	Limits	Pipeline Improvements: Existing Diameter (in)	Pipeline Improvements: New/Parallel/ Replace	Infrastructure Costs: Diameter (in)	Infrastructure Costs: (ft')	Infrastructure Costs: Length (ft)	Infrastructure Costs: Unit Cost[1] ($/LF)	Infrastructure Costs: Infr. Cost ($)	Baseline Constr. Costs ($)	Estimated Constr. Cost[1] ($)	Capital Improvement Costs[2] ($)	Suggested Construction Timeline	Suggested Cost Allocation: Existing Users (%)	Suggested Cost Allocation: Future Users (%)	Cost Sharing: Existing Users	Cost Sharing: Future Users
Detention Capacity Improvements						**(AF)**												
New Detention Basins																		
Butterfield Drainage Basin																		
BTR-D1	Basin		Approx. 900' nw/o Pollard Ave and Seymour Ave		New	96			73,156	1,171,894	1,171,894	1,523,462	1,980,500	Intermediate-Term	50%	50%	990,250	990,250
						Subtotal - Butterfield Drainage Subbasin					**1,171,894**	**1,523,462**	**1,980,500**				**990,250**	**990,250**
Fisher Drainage Basin																		
FIS-D1	Basin		Approx 1,000' sw/o Sutter Blvd and Butterfield Blvd		New	50			73,156	609,641	609,641	792,534	1,030,294	Intermediate-Term	50%	50%	515,147	515,147
						Subtotal - Fisher Drainage Subbasin					**609,641**	**792,534**	**1,030,294**				**515,147**	**515,147**
						Subtotal - Detention Capacity Improvements					**1,781,535**	**2,315,996**	**3,010,794**				**1,505,397**	**1,505,397**
Other Storm Drainage Improvements																		
Hale[4]	Misc Storm Drain Improv	Hale Ave	From Hillwood Lane to Spring Avenue and Dewitt Avenue		New / Replace					5,000,000	5,000,000	5,000,000	5,000,000	Near-Term		100%	0	5,000,000
						Subtotal - Fisher Drainage Subbasin					**5,000,000**	**5,000,000**	**5,000,000**				**0**	**5,000,000**
Total Improvemet Costs						**(AF)**												
						Pipeline Capacity Improvements					**6,198,834**	**8,058,485**	**10,476,030**				**4,938,482**	**5,537,548**
						Detention Capacity Improvements					**1,781,535**	**2,315,996**	**3,010,794**				**1,505,397**	**1,505,397**
						Other Storm Drainage Improvements					**5,000,000**	**5,000,000**	**5,000,000**				**0**	**5,000,000**
						Total Capital Improvement Costs					**12,980,369**	**15,374,480**	**18,486,824**				**6,443,879**	**12,042,945**

AKEL ENGINEERING GROUP, INC.

9/6/2018

Notes:

1. Baseline construction costs plus 30% to account for unforeseen events and unknown conditions.
2. Estimated construction costs plus 30% to cover other costs including: engineering design, project administration (developer and City staff), construction management and inspection, and legal costs.
3. New detention basin depth assumed to be equal to 6 feet.
4. Hale Avenue improvements include storm drain piping, inlets, basins, curb and gutter, and biodetention swales.

New detention facilities should be evaluated for potential dual use as a park facility during non-rainfall seasons. Dual use facilities may be constructed with multi-tiered levels to enable seasonal storms to be retained in a lower level, while allowing an upper level to serve recreational purposes.

The opinion of probable construction costs for new or upgraded detention basins are based on the costs summarized on **Table 6.1**.

6.4 SUGGESTED EXPENDITURE BUDGET

The suggested expenditure budget is shown on **Table 6.3** and includes the total costs for pipelines and detention basins. The total improvement costs shown on **Table 6.3** are generally consolidated into four categories, which are briefly described as follows:

- **Near-Term Improvements:** Improvements classified as near-term are intended to mitigate existing system deficiencies as well as serve immediate growth. These improvements are recommended in the next 5-7 years.
- **Intermediate Term Improvements:** Improvements classified as intermediate term are intended to benefit existing users as well as future growth generally expected to occur within the next 10 to 15 years.
- **Long Term Improvements:** Improvements classified as long-term improvements are intended to benefit existing users as well as future growth generally expected to occur at the buildout of the City's General Plan.
- **With Development:** Improvements only intended to serve future growth are planned to be constructed as development occurs.

Construction of pipeline improvements, within any drainage basin identified in this master plan, is recommended only after the completion of any downstream improvements are completed. The actual phasing of improvement construction as recommended in this master plan is subject to the approval of the City Engineer.

Table 6.3 Suggested Expenditure Budget

Storm Drainage System Master Plan

City of Morgan Hill

Improvement Type	Suggested Construction Timeline			
	Near Term ($)	Intermediate Term ($)	Long Term ($)	With Development ($)
Pipelines	3,700,937	1,290,433	2,877,094	2,607,565
Detention Basins	0	0	3,010,794	0
Other Storm Drainage Improvements	5,000,000	0	0	0
Total	**8,700,937**	**1,290,433**	**5,887,888**	**2,607,565**

9/6/2018