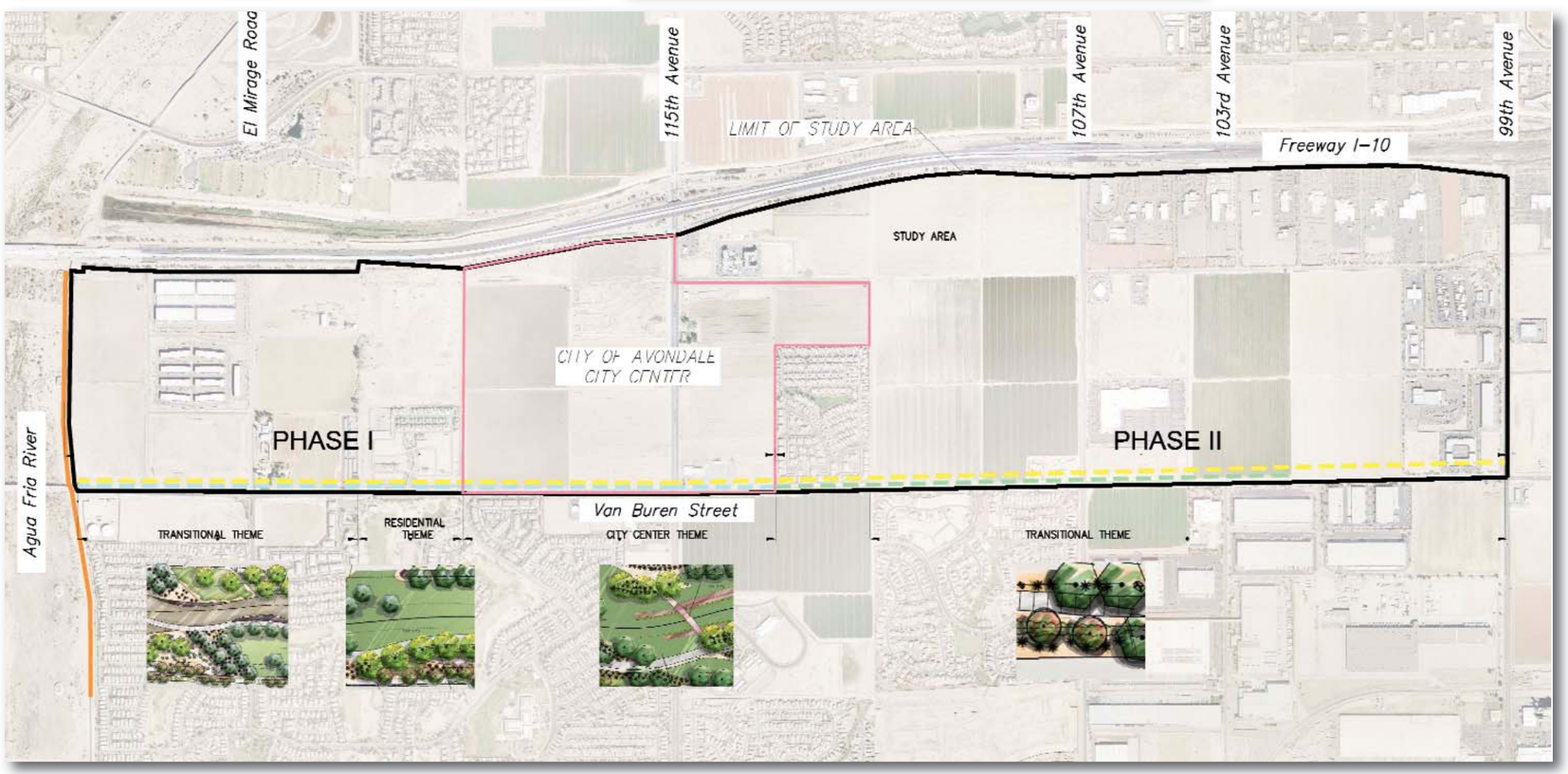
DESIGN CONCEPT REPORT

for the

VAN BUREN STREET CHANNEL
99TH AVE. TO AGUA FRIA RIVER
10-YEAR SOLUTION

FCD Contract #2010C004
Work Assignment No. 3
SEI Project Number 03700.001

July 2013



Flood Control District of Maricopa County

City of Avondale

SUNRISE ENGINEERING

DESIGN CONCEPT REPORT

FOR THE

VAN BUREN STREET CHANNEL
99TH AVENUE TO AGUA FRIA RIVER

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY & CITY OF AVONDALE

JULY 2013

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WORK ASSIGNMENT NO. 3
SEI PROJECT NO. 03700.001

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EXECUTIVE SUMMARY

The Van Buren Street Channel Design Concept Report (DCR) documents the conceptual design development of the proposed Van Buren Street Channel 10-year drainage corridor from 99th Avenue to the Agua Fria River. The project has the benefit of reduced retention requirements at City Center, trail connectivity within the city, and reduction of flows in the Durango Regional Outfall Project (DROP) channel.

The Flood Control District of Maricopa County's (District) and the City of Avondale (COA) entered into an intergovernmental agreement (IGA) under the Districts Capital Project program to develop conceptual flood control solutions that satisfy the project goals. The project milestones are:

- Hydrology update of land uses in project area
- Alternative Analysis for 100-year solutions
- Hydrology update for project area to NOAA 14 rainfall.
- Alternative Analysis for 10-year solutions
- Final DCR and Conceptual plan and profiles

Initially the project analyzed three 100-year storm event solutions. The three solutions costs ranged too high to be considered feasible. As a result of these high costs, the District and COA than chose to review 10-year storm event solutions.

A second Alternatives Analysis for the 10-year storm event was performed for two alternative alignments for the proposed drainage improvements that were provided by the District and COA. Each of these alternatives provides the study area a connection to the Agua Fria River. These alternatives are briefly described as follows:

Alternative 1-3: A combination of open channel, box culverts and pipe with an alignment adjacent to Van Buren Street on the north side for the entire length of the project.

Alternative 3-2: A combination of open channel, box culverts and pipe with an alignment adjacent to Van Buren Street (north side) from the Agua Fria River to 119th Avenue and then shifting north to the future Fillmore Street alignment, through City Center and finally on the Pierce Street alignment.

Upon the completion of the Alternatives Analysis the project team selected Alternative 1-3 as the Recommended Alternative. The alternative minimizes construction conflicts, does not disrupt planned City Center drainage and keeps with the City's desires to have the conveyance parallel to Van Buren Street. This best fit the goals of the stakeholders, provides the necessary drainage improvements and accomplishes parks and trails connectivity within the City of Avondale.

This report shows the 10-year Recommended Alternative (1-3) being constructed in phases. **Phase I** extends from the Agua Fria River to 113th Avenue (the City Center area). **Phase II** is from 113rd Avenue to 99th Avenue.

The Phase I conveyance is an open channel parallel to the Van Buren Street right-of-way. The channel is trapezoidal shaped with meandering side slopes ranging from 4:1 to 8:1. Reinforced box culverts (RCB) will be used at roadway crossings and where existing development constrains the channel. RCB's are typically three barrels of 10-feet by 4-feet. The project will rework existing development drainage improvements and open space, where feasible, to maintain as much open channel as possible. This will also include landscape and trail features.

The Phase II conveyance consists of 60-inch reinforced concrete pipe. The pipe will be installed at the northern edge of the Van Buren Street right-of-way or in a 20-foot drainage easement. This will also include landscape and trail features within the easement for the pipe.

Conceptual Plans (15% level) for the Recommended Alternative (Appendix B) have been prepared as part of this report. These plans identify the alignment, proposed improvements, property/easement acquisition and utility conflicts associated with implementing this Alternative.

The Recommended Plan cost estimate has been provided based on the conceptual level Alternative 1-3 alignment with open channel for Phase I and concrete pipe for Phase II. Unit prices are median prices from recent bid prices provided by the District and COA. The total cost of the project (Phases I & II) has estimated to be $18.6 million dollars for a 10-year level of flood protection.

The Recommended Alternative was presented at a public meeting addressed to the public, COA Parks and Recreation Board, and the COA City Council. The public meeting was held at COA City Hall on March 20, 2013 and the project was presented in an open house format. Generally the public reception of the project has been excellent.

An IGA will be entered into by the District and COA for final design and construction of the project. The District will provide a cost share of 40% of the design for Phases I and II, Phase I right-of-way-acquisition, utility relocations and construction. COA will be expected to contribute 60% cost for final design, Phase I right-of-way, utility relocations and construction. COA will be responsible for 100% of Phase II construction. It is also understood COA will be lead agency for design, right-of-way acquisition, utility relocations and construction. COA will also be responsible for operation and maintenance. District funding is available to COA for up to 15 years.

1 INTRODUCTION

The Van Buren Design Concept Report documents the conceptual design development for the Recommended Alternative for the Van Buren Street Channel from 99th Avenue to the Agua Fria River. It has been prepared for the Flood Control District of Maricopa County (District) and the City of Avondale (COA). The Recommended Alternative provides a drainage conveyance that satisfies the project objectives. The Recommended Alternative is divided into two phases with reaches of open channel and reaches of storm drain pipe that provide a 10-year level of flood protection.

The Recommended Alternative phases are; Phase I from 113th Avenue (the City Center area) to the Agua Fria River and Phase II from 99th Avenue to 113th Avenue. Phase I is an open channel parallel to the Van Buren Street right-of-way. Phase II is a storm drain pipe in an extended Van Buren Street right-of-way.

The Recommended Alternative was selected as the preferred alignment by the COA and the District. The alternative minimizes construction conflicts, does not disrupt planned City Center drainage and is in keeping with the City's desires to have the conveyance parallel to Van Buren Street.

1.1 Objective

The purpose of the project is to reduce retention requirements at the COA's City Center located at Avondale Boulevard, provide trail connectivity within the City of Avondale, reduce flows in the Durango Regional Outfall Project (DROP) channel south of this project, and stay ahead of development. Staying ahead of development allows greater control of alignment and conveyance type. See **Figure 1.1.1 – Study Area** for the study area and DROP location.

1.2 Existing Data & Reports

Sunrise Engineering, Inc, (Sunrise) conducted a topographic survey of the north half of Van Buren Street from the Agua Fria River to 99th Avenue. The topographic data provided current mapping of existing retention basins, power poles, existing utilities, and street grades along the alignment. The data was collected by a GPS survey using cross sections from the centerline of Van Buren Street to approximately 200 feet north of the proposed right-of-way at 100 to 200 foot spacing.

An Alternatives Analysis was completed by Sunrise in December 2010 which studied three conveyances for the 100-year storm event. It was determined by the District and Avondale that the cost of all three conveyance options were too high to continue the project. The December 2010 Alternatives Analysis has been archived in the District's library and is available for review.

A second Alternatives Analysis dated October 2012 (also available in the District's Library) was conducted for the project that analyzed two alignments and conveyance alternatives for a 10-year storm event system along Van Buren Street. Alignment Alternatives 1-3 and 3-2, and conveyance options for Alternative 1-3 were each reviewed. As well as hydrologic and hydraulic modeling and cost estimates of the alternatives. This final DCR includes the October 2012 Alternatives Analysis data and analysis.

Durango Regional Outfall Project (DROP) Channel

Prior to the December 2010 Alternatives Analysis, the area was studied in the *Durango Area Drainage Master Plan* by Dibble and Associates, FCD#99-41. The study proposed storm drain alignments and retention basins to serve the overall study area. The study limits for this project are within the larger Durango ADMP study area.

1.3 Project Coordination

Coordination amongst project stakeholders and the project consultants has occurred throughout the project. There have been the kick off meeting, project coordination meetings, informal meetings, and frequent email and telephone correspondence.

The project stakeholders consist of:

- Charles Andrews, P.E. - City of Avondale
- Jackie Keller, R.L.A. – City of Avondale
- Gary Wesch, P.E. - FCDMC
- Richard Waskowsky, P.E. - FCDMC
- Harry Cooper, R.L.A. – FCDMC

1.4 Deliverables

The project deliverables consist of:

- Electronic submittal of hydrology models
- Alternatives Analysis Technical Memorandum
- Design Concept Review Report

The technical memorandum reports were intermediate points for the District and project stakeholders to provide commentary while working towards the goal of the final DCR Report.

1.5 Acknowledgements

We would like to thank the District and the City of Avondale for their input and continued guidance throughout the project. Special thanks go to Gary Wesch, District Project Manager, and Charles Andrews, City of Avondale Project Manager.

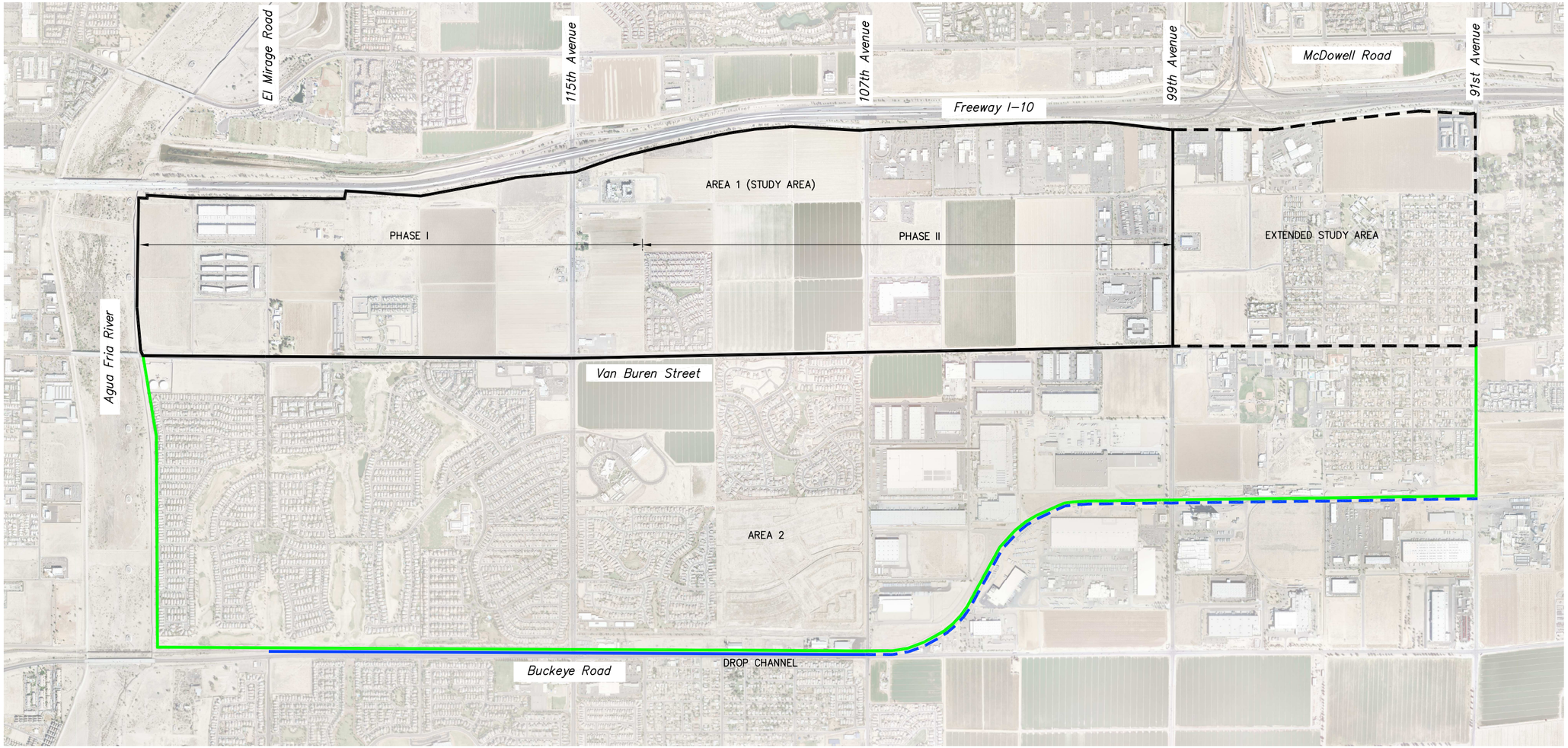
1.6 Project Consultants

Sunrise Engineering, Inc. is the prime consultant for the project. The Sunrise team consists of:

- Geoff Child, P.E. - Principal
- Ricky Holston, P.E., CFM - Project Manager
- Li Qi, P.E. CFM - Project Hydrologist
- Randy Perham, E.I.T., CFM – Design Technician
- Tony Elley, R.L.S., CFeDS – Survey Manager

Logan Simpson Design is the partner consultant providing landscape architecture for project. Their team consists of:

- Diane Simpson-Colebank, R.L.A. – Principal
- Jay Hicks, R.L.A. – Principal



LEGEND

- BOUNDARY OF AREA 1 (STUDY AREA)
- BOUNDARY OF EXTENDED STUDY AREA
- BOUNDARY OF AREA 2
- EXISTING DROP CHANNEL
- PROPOSED DROP CHANNEL

FIGURE 1.1.1 - STUDY AREA

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2 BACKGROUND

The project began in July 2009 when COA submitted a District Capital Project Letter of Intent for the Van Buren Street Channel Improvement Project. The District proceeded with a DCR effort for 100-year alternatives. The 100-year alternatives were deemed too costly and a second Alternatives Analysis was conducted for 10-year alternatives.

Two alternatives analyses were conducted for the project. The first was the December 2010 Alternatives Analysis which analyzed three 100-year alternatives. The second alternatives analysis was the October 2012 Alternatives Analysis which analyzed 10-year conveyances.

2.1 100-Year Alternatives Analysis

The 100-year analysis included a hydrology update, brainstorming of alternatives and the alternative analysis. Hydrology was extracted from the Durango ADMP and updated within the study areas. This update was completed in September 2010 and updated the current and future land uses for the study area. The hydrology update used the same NOAA 2 rainfall used in the Durango ADMP.

A brainstorming meeting was held at the District to develop three alternatives to analyze. The meeting was attended by District staff, COA staff, LSD, and Sunrise. Meeting objectives were met and three alternative alignments were selected to be further analyzed.

In December 2010 the alternatives analysis was completed. It analyzed the costs of constructing the three alternatives. Generally the alternatives included large retention basins at 99th Ave and the Agua Fria River, and no retention at the City Center. Costs ranged from $37.1 to $53.5 million.

The projected costs were deemed too high to continue the project. The District and COA then gave direction to study 10-year alternatives that would have lower costs.

2.2 10-Year Alternatives

The October 2012 10-year alternatives analysis used two predetermined alignments while leaving the conveyance type open for determination. The alignments were predetermined by the District and COA. The two alignments are Alternative 1-3 and Alternative 3-2. The alignments for both alternatives are on the north side of Van Buren Street, eliminating large utility crossings within Van Buren Street. All alignments and conveyance alternatives were developed by the project partners. Several conveyance alternatives were analyzed also, open channel, box culvert, U-type concrete, and pipe. All options provide the goal of reduced retention within the City Center and trail connectivity with the Agua Fria River.

The 10-year alternative also introduced phasing. Phase I is from the Agua Fria River to east of Avondale Boulevard. Phase II is from 113th Avenue to 99th Avenue.

Alternative 1-3

Alternative 1-3 alignment is a conveyance corridor on the north side of Van Buren Street. The parallel alignment begins at the Agua Fria River and ends at 103rd Avenue. The alignment will be contiguous with the 65 foot ultimate right-of-way on Van Buren Street. See **Figure 2.2.1 – Alternative 1-3, 10-Year Event** and **Figure 2.2.2 Alternative 1-3 Cross Section**.

Conveyances

The base conveyance for Alternative 1-3 is an open channel from the Agua Fria River to 113th Avenue for Phase I with reinforced box culverts at roadway crossings. Alternatives to the open channel conveyance are reinforced box culvert or an open top rectangular concrete channel. The Phase II conveyance is a 60-inch reinforced concrete pipe from 113th Avenue to 103rd Avenue. There is no need to extend the pipe all the way to 99th Avenue due to low flow rates in the initial reaches the pipe.

Phase I open channels will consist of a trapezoidal channel with varying side slopes ranging from a maximum of four to one and a minimum of eight to one. The water depth is three feet, with freeboard varying from one to four feet. Inverts were set at seven feet deep at intersection crossings to accommodate culverts. At El Mirage Road the invert was set at six feet so a positive slope could be maintained toward the Agua Fria River.

Varying side slopes will create a meandering bottom while leaving the right-of-way width and top of channel consistent. The side slopes will be covered with granite mulch and appropriate landscape plant material and trees.

The trail component will typically be on the south side of the channel adjacent to the Van Buren Street right-of-way. The trail could meander down into the channel bottom and back out to break up long, straight stretches. Maintenance and construction access will be from the Van Buren Street right-of-way.

The width of the open channel right-of-way corridor varies, depending on slope, and existing grades. Typically the channel corridor width ranges from 110 feet to approximately 190 feet.

Both alternate conveyances with reinforced box culvert and rectangular concrete channels would minimize right-of-way requirements. The first alternative conveyance option is a reinforced box culvert, ten feet wide by four feet tall with either four or five barrels, depending on location. The box culvert limits right-of-way acquisition to 80 feet wide. The box culvert is also buried so the right-of-way can be used for other uses, such as parking lots. The cost to install a box culvert is approximately three times more than an open channel.

The second alternative conveyance option is a rectangular concrete channel. The channel has the same foot print as the box culvert, but would remain open with no cover or internal walls. The cost savings over the box culvert is due to the fact that less concrete would be required by not installing the lid and divider walls. The cost is about twice as much as the open channel option.

Phase II pipes consist of 60-inch reinforced concrete pipe. The pipe will be installed at the northern edge of the Van Buren Street right-of-way or in a 20-foot drainage easement.

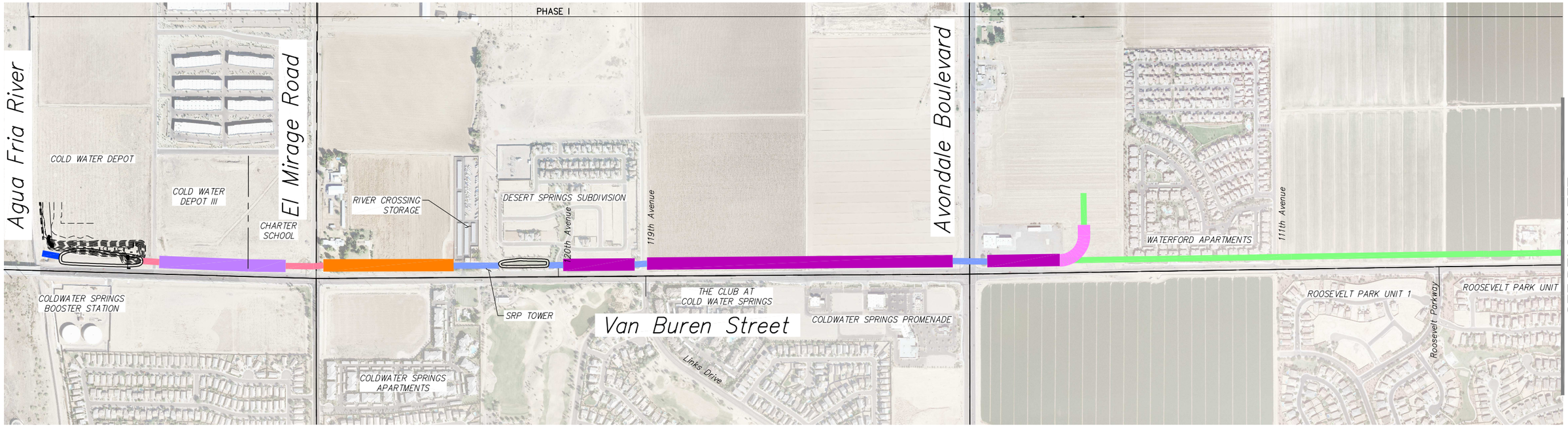
Pipe Only Alternative

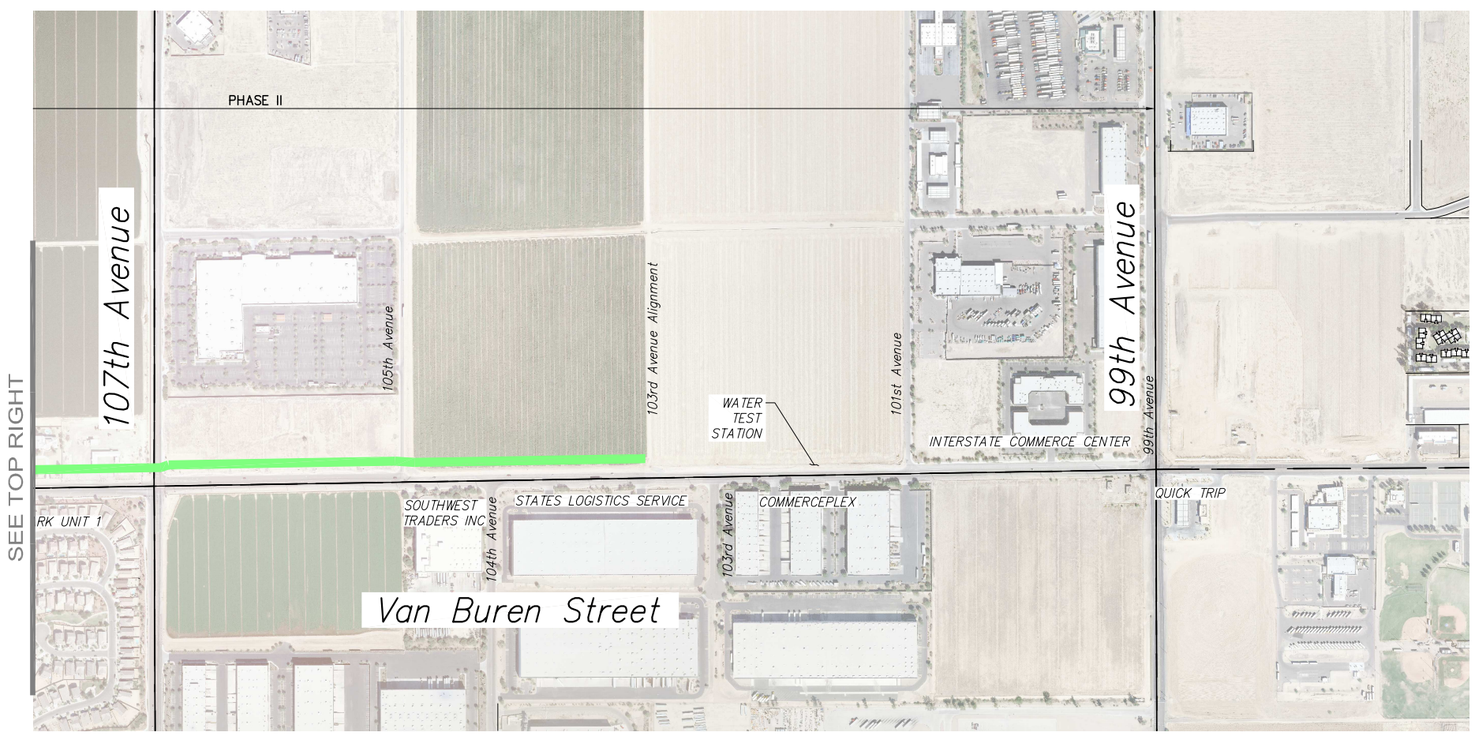
An "all pipe" conveyance alternative cost estimate was provided by the District. The all pipe alternative consists of reinforced concrete pipe for the entire length of the Alternative 1-3 alignment. Large pipe sizes are necessary to convey the required design flow. Maintaining a positive friction slope to the Agua Fria causes the top of pipe to daylight on the western end of the alignment. Therefore, this alternative was dismissed and is not a feasible option. See **Appendix H** for **Alternative Pipe Only Alternatives Analysis Cost Estimate**.

Alternative 3-2

Alternative 3-2 is a conveyance corridor that begins at the Agua Fria River and parallels the north side of the Van Buren Street right-of-way to 119th Avenue. The alignment then turns north on 119th Avenue to the future Fillmore Street alignment City Center West. In City Center East the alignment turns north on Park Avenue and then east to the Pierce Street alignment, then the alignment continues southeast to the half mile alignment and then east to 101st Avenue. See **Figure 2.2.3 – Alternative 3-2, 10-Year Event**.

The Alternative 3-2 alignment is not feasible for a number of reasons. First, the alignment through City Center would conflict with the proposed retention basin system and the channel size would be limited to the proposed median widths. Second the City of Avondale's vision for the channel is along Van Buren Street providing an overall corridor that is street, channel, and trail.





LEGEND

- AGUA FRIA OUTLET – 5' X 4' X QTY 6 RCB WITH FLAP GATES
- CHANNEL SECTION 3
- CHANNEL SECTION 2
- 60" REINFORCED CONCRETE PIPE
- REINFORCED CONCRETE BOX CULVERT – 4 BARREL 10' X 4'
- REINFORCED CONCRETE BOX CULVERT – 5 BARREL 10' X 4'
- CHANNEL SECTION 1B
- CHANNEL SECTION 1A

NORTH

SCALE
0 400' 800'
HORIZ: 1" = 400'

FIGURE 2.2.1 – ALTERNATIVE 1-3, 10-YEAR EVENT

PLAN VIEW

City of Avondale

Flood Control District of Maricopa County

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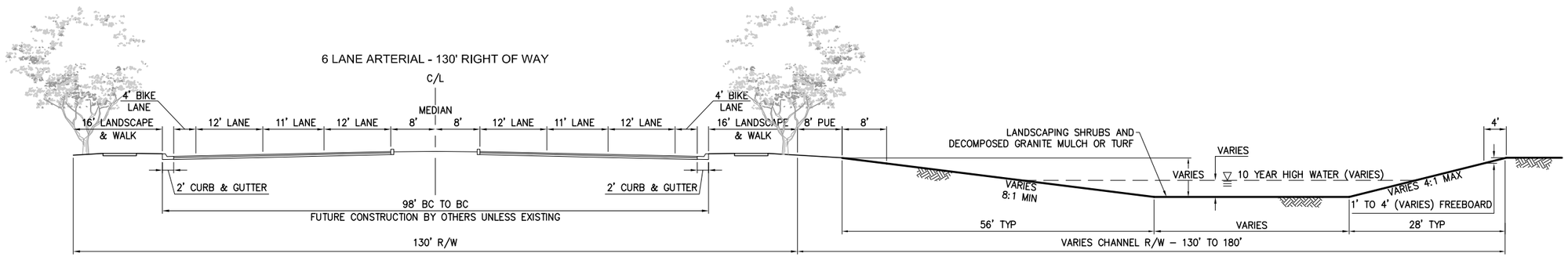
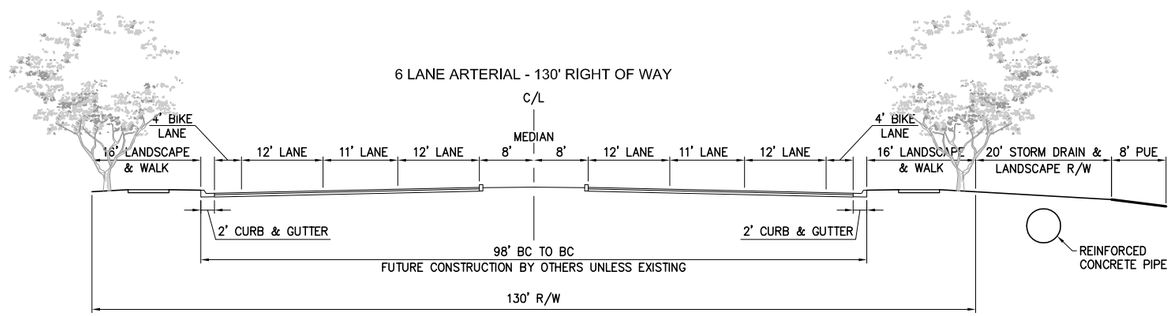


A
~
SECTION - VAN BUREN STREET
NOT TO SCALE
EL MIRAGE ROAD TO EAST OF 113TH AVENUE

CHANNEL DATA					
	SLOPE	DEPTH	BOTTOM	TYP TOTAL WIDTH	R/W WIDTH
CHANNEL 3	0.06%	3	90'	174'	180'
CHANNEL 2	0.21%	3	50'	134'	130'
CHANNEL 1B	0.45%	3	30'	114'	130', 150'
CHANNEL 1A	0.18%	2.2	10	94'	130'



B
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SECTION - ALTERNATE PIPE SECTION
NOT TO SCALE VAN BUREN
113TH AVENUE TO 103RD AVENUE

FIGURE 2.2.2 - ALTERNATIVE 1-3
CROSS SECTION

City of Avondale

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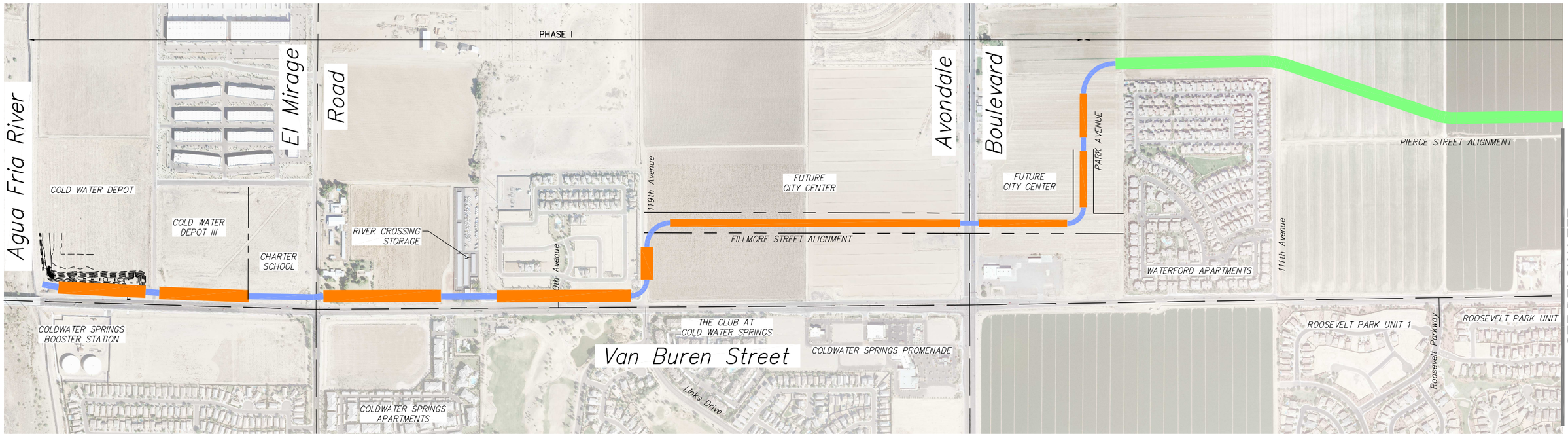

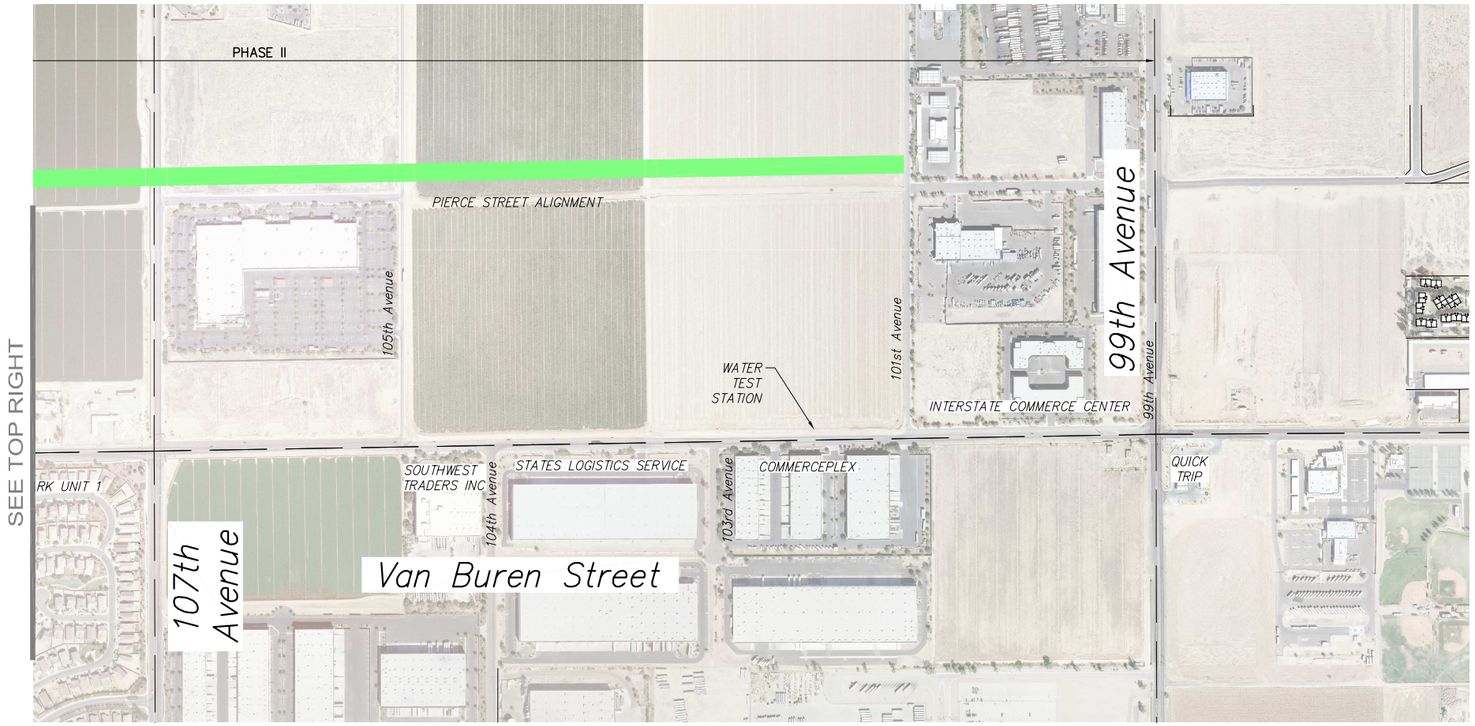

LEGEND

- SECTION – OPEN CHANNEL
- SECTION – REINFORCED CONCRETE PIPE
- REINFORCED CONCRETE BOX CULVERT – 50' X 4'

NORTH

SCALE 0 400' 800'

HORIZ: 1" = 400'

FIGURE 2.2.3 - ALTERNATIVE 3-2, 10-YEAR EVENT

PLAN VIEW

City of Avondale

Flood Control District of Maricopa County

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3 RECOMMENDED PLAN

The Recommended Plan is Alternative 1-3 with Phase I open channel, Phase II storm drain pipe, and four landscape themes. The alignment is on the north side of Van Buren Street, eliminating large utility crossings in Van Buren Street. The Recommended Plan was chosen as the preferred alignment as it minimizes construction conflicts, does not disrupt planned City Center drainage and keeps with the City's desires to have the conveyance parallel to Van Buren Street. See **Figure 2.2.1 – Alternative 1-3, 10-Year Event** for a plan view of the alignment. Also, see **Appendix B** for conceptual **15% Plan and Profile Drawings**.

The project is expected to be constructed in two phases. Phase I is the western portion from the Agua Fria River to 113th Avenue (approx. 1200 feet east of Avondale Boulevard). Phase II is 113th Avenue east to 99th Avenue.

The 10-year design flow rate is 600 cubic feet per second for Phase I and 100 cubic feet per second for Phase II.

3.1 Description

The Recommended Plan alignment is a conveyance corridor on the north side of Van Buren Street. The parallel alignment begins at the Agua Fria River and ends at 103rd Avenue. The alignment will be contiguous with the 65-foot ultimate right-of-way along Van Buren Street.

Conveyances

The conveyance for the Recommended Plan is an open channel from the Agua Fria River to 113th Avenue for Phase I with reinforced box culverts at roadway crossings and existing constrictions. Alternatives to the open channel conveyance are reinforced box culvert or an open top rectangular concrete channel. The Phase II conveyance is a 60-inch reinforced concrete pipe from 113th Avenue to 103rd Avenue. There is no need to extend the pipe all the way to 99th Avenue due to low flow rates in the initial reaches the pipe.

Phase I open channels will consist of a trapezoidal channel with side slopes varying from a maximum of four to one and a minimum of eight to one. The water depth is three feet, with freeboard varying from one to four feet depending on existing grades. One foot of free board is the minimum required. Inverts were set at seven feet deep at intersection crossings to accommodate culverts. At El Mirage Road the invert was set at six feet so a positive slope could be maintained to the Agua Fria River.

Varying side slopes will create a meandering bottom while leaving the right-of-way width and top of channel consistent. The side slopes will be covered with granite mulch and appropriate landscape plant material and trees.

The trail component will typically be on the south side of the channel adjacent to the Van Buren Street right-of-way. The trail could meander down into the channel bottom and back out to break up long, straight stretches. Maintenance and construction access will be from the Van Buren Street right-of-way.

The width of the open channel right-of-way corridor varies, depending on slope, and existing grades. Typically the channel corridor width ranges from 110 feet to approximately 190 feet.

Reinforced box culvert will be used at roadway crossings and existing constrictions. The reinforced box culverts allow flow to cross under crossing roadway or other existing conflict. The reinforced box culvert is ten feet wide by four feet tall with either three or four barrels, depending on location. The box culvert limits right-of-way acquisition to 80 feet wide. The box culvert is also buried so the right-of-way can be used for other uses, such as parking lots. The cost to install a box culvert is approximately three times more than that to install an open channel.

Phase II pipes consist of 60-inch reinforced concrete pipe. The pipe will be installed at the northern edge of the Van Buren Street right-of-way or in the proposed 20-foot drainage easement. The easement area will be landscaped with a trail that provides a continuous connection from the Agua Fria River to 99th Ave.

Direct storm water connections to the conveyance are not allowed. District standards require that all developed areas must at least retain the first flush prior to discharging to the system. Details have been developed for connections to the channel and the pipe. Van Buren Street runoff is conveyed to catch basins or scuppers. The catch basin or scupper conveys the runoff under the open channel or over the pipe to the adjacent retention basin that has been sized for the Van Buren half street flow. In addition, an "overflow box" is constructed in the basin with the grate at the high water level in the basin. The "overflow box" should have a snout or similar BMP to prevent oils and floating debris from entering the outgoing pipe. The catch basin is connected to the open channel or the pipe. When the basin volume exceeds the design volume it will drain to the channel or pipe. This will allow existing and future developments as well as Van Buren Street runoff to retain first flush prior to discharging into the system. See **Appendix F** for **Van Buren Channel Scupper and Catch Basin Connections**.

Land Acquisitions – Phase I

Land acquisition will be required for Phase I of the alignment. A majority of the alignment is undeveloped vacant land. Five parcels of the alignment are developed or are planned to be developed. These parcels are as follows:

1. Coldwater Depot – Coldwater Industrial Associates, LLC
   Coldwater Depot is located at the northwest corner Van Buren Street and 127th Avenue to Agua Fria River and is a proposed one million square foot distribution center. The development is planning a very large and deep retention basin along Van Buren Street. The retention basin would be used as a conveyance to the Agua Fria River. The retention basin invert is below the proposed channel invert. Channel inverts through the basin were set to have positive flow from east to west with the channel invert coming into the basin being higher than the one leaving the basin.

Coldwater Depot Site and Agua Fria River - Looking South

Box culverts are required to penetrate the existing Agua Fria River levee. The box culverts are proposed to have flap gates installed to prevent flow in the Agua Fria from entering the existing retention basin at the Coldwater Depot Site. A six (6) box culvert array is proposed, four culverts six inches above the invert of the Agua Fria River and two culverts two feet above the lower culverts. The upper culverts will provide an outlet for water should the lower culverts plug with sediment or river sediment builds up on the outside of the flap gate preventing them from opening.

Hydraulic calculations have been performed to estimate the water surface in the retention basin during the 100-year and 10-year event. Both hydraulic grade lines are below the finished floor level of the building. The 10-year hydraulic grade line level is near the proposed parking lot level.

2. Coldwater Depot III - Van Buren and El Mirage LLC
   Coldwater Depot III, a planned fourteen acre distribution center, is located at the northeast corner Van Buren Street and 127th Avenue to the existing charter school. The development is planning a building and parking within the proposed conveyance corridor. The developer will have to design the project to accommodate the base open channel right-of-way. The developer has the option to fund one of the two alternate conveyances.

3. Charter School – Charter School Fund Avondale
   The Charter School was constructed in 2011 and is located at the northwest corner of Van Buren Street and El Mirage Road. Its existing parking lot and retention basin are located in the conveyance corridor. However, the school is planning a future building expansion that will further limit the conveyance corridor. A Reinforced box culvert will be required to pass the channel under the existing parking lot and around the future building.

4. River Crossing Storage and RV – River Crossing LLC
   River Crossing Storage is located at Van Buren Street west of 120th Avenue. This existing storage facility has a parking lot, office, and private residence within the conveyance corridor. A box culvert array is possible under the parking lot, leaving the office building and home. However, the channel alignment is in conflict with the adjacent SRP tower. The SRP tower must be relocated. If relocation is not possible then the culvert must go through the office and home or go south into the Van Buren right-of-way where many utilities currently exist. Costs estimates provide costs for on relocating the SRP tower.

River Cross Storage - Looking Northeast

5. Desert Springs Village Subdivision – Ownership Varies
   Desert Springs Village Subdivision is located at Van Buren Street and 120th Avenue. Desert Springs is an existing subdivision with retention basins that front Van Buren Street in the conveyance corridor. The west basins are currently large enough to use for the proposed conveyance. However, the basins will have to be excavated approximately one foot to match the conveyance invert. In addition, a portion of the remaining retention basin will have to be closed off with a berm to separate the basin from the channel. The retention basin may also need further regrading to accommodate the relocation of the adjacent SRP tower.

Desert Springs West Retention Basin - Looking West

The east basin is approximately one to two feet deep and is narrower than the west basin. Twelve single family home lots adjoin the basin to the north. All twelve lots and the basin are within the conveyance corridor. The lots and the retention basin will have to be purchased for the conveyance corridor. The retention basin does not have conveyance capacity in its current condition, and will have to be re-graded to the selected conveyance section.

COA has already acquired the parcels needed for the project within the Desert Springs Village Subdivision.

El Mirage Traffic Interchange Improvements

The City is planning a traffic interchange at I-10 and El Mirage Road. The planned interchange improvements are planned for El Mirage Road from I-10 to Van Buren Street. The channel invert was set at six feet deep at this intersection to maintain positive slope to the Agua Fria River. The City, District, and Sunrise will work with the traffic interchange designers to facilitate raising the intersection to gain seven feet from pavement to invert.

Desert Springs East Retention Basin - Looking East

Land Acquisitions – Phase II

Land acquisition will be required for Phase II of the alignment. The Phase II conveyance corridor is a twenty-foot pipe and trail easement. The corridor can also fit within the right-of-way if necessary due to existing constrictions and avoids the need for the easement. The alignment is undeveloped except for the Waterford Apartment complex at approximately 112th Avenue. The existing retention basins at the Waterford Apartments were checked for conveyance capacity and not large enough, in their current condition, to convey the design flow. It is COA's choice to acquire the required easements as development occurs or they acquire them all at once.

Utility Relocations

Utility relocations will be required at all intersection and driveway crossings. In general, the inverts of the conveyance are within the typical utility depth zones of three to five feet deep.

COA ordered potholes to locate utilities at the intersection of Avondale Boulevard in June 2013. Eight utilities were located and this data has been added to the conceptual plan and profile drawings located in **Appendix B**.

Major utility relocations include:

1. SRP 230 Kilovolt Tower
   The SRP 230 kilovolt tower is located at Van Buren Street west of 120th Avenue. The SRP 230 kilovolt tower is a double circuit tower transmission line that crosses Van Buren Street north to south. The current tower foot print is over the Van Buren Street right-of-way and is in conflict with the proposed conveyance corridor. SRP typically requires a 50-foot clear and flat area around the tower legs and clear access parallel to the power lines. SRP was given detailed topographic survey information of the area and CAD drawings so they could provide a preliminary design and cost. SRP's design moves the tower north with a cost of $230,000 to $330,000. The final cost will depend on a more detailed 3D design for the tower type.

   The existing Desert Springs Subdivision retention basin will also have to be modified to accommodate the relocated tower.

2. SRP 69 Kilovolt Power Pole
   A SRP 69 kilovolt power pole is located near Van Buren Street west of 120th Avenue, immediately east of the SRP 230 kilovolt tower. This pole is currently in conflict and will have to be moved.

3. SRP 12 Kilovolt Power Poles
   SRP 12 kilovolt power poles are currently located along Van Buren Street from El Mirage Road to the SRP 230 kilovolt tower and City Center West. The existing 12 kilovolt poles are at the back of the current Van Buren Street right-of-way. These poles would typically be moved to the back of the future right-of-way when constructed, however, because the channel will be at the back of the right-of-way these poles will have to share an easement and be located within the right-of-way, PUE and channel right-of-way.

SRP 12 Kilovolt Power Pole - Looking East

4. Centurylink Fiber Optic
   Fiber optic cable is currently located along the north side of Van Buren Street and runs the entire length of the project. Centurylink will have to move their facilities to a new duct bank below the proposed channel invert, place the fiber and the copper into the new duct bank and then cut over to new ducts. The fiber cannot be cut at any point and can only be spliced where there is an existing splice which could be 2,000 feet or more. The cut over takes approximately two months to complete and additional time will be required for design and placing the copper and fiber. The fiber optic serves special customers which takes additional time for coordination of the cut over.

5. SRP 24-inch Irrigation Pipe
   A 24-inch irrigation pipe is located along 119th Avenue and will have to be lowered below the proposed culvert invert. The culvert will have approximately two to three feet of cover, therefore the irrigation pipe cannot be placed over the culvert. The possibility of relocating the existing pipe will need to be coordinated with SRP in order to determine any relocation design constraints.

6. SRP 36-inch Irrigation Pipe
   A 36-inch SRP irrigation pipe is currently located along Avondale Boulevard. This concrete irrigation pipe will have to be lowered below the proposed culvert invert. The culvert will need to have approximately two to three feet of cover, therefore the irrigation pipe cannot be placed over the culvert. Coordination with SRP will need to take place in order to determine any additional relocation design constraints.

SRP Tower and 69 Kilovolt Power Pole - Looking North

3.2 Landscape Themes

Four landscape character types were developed to create a cohesive landscape theme along the Van Buren Street drainage channel that will provide an aesthetic treatment of the drainage improvement as well as adding an attractive streetscape component and multi-use path amenity to the community. The four areas are referred to as the City Center (Urban), Residential (Desert Springs), Transitional (Industrial) and Trail (Channel Piped Underground) Character Type. The primary intent of the landscape concepts is to blend the drainage improvement into the adjacent land uses along Van Buren. Each character type is designed with the same enhanced desert themed landscape palette to provide uniformity to the channel; however, the density and layout of plant material differ for each area.

The overall plant palette for the project consists of low allergenic, seasonally colorful, desert adapted plants that are sustainable in a low maintenance environment. All the plants being used are container grown nursery plants, drought tolerant, and can grow in local soil conditions that will require little water after the plant has been established. Each plant was selected for ease of regular maintenance and hardiness. Cultivars of the Native Mesquite and Palo Verde were selected to eliminate thorns and seed pods. Different sizes of rock are being used in the landscape areas for aesthetic purposes and dust/erosion control. One-half inch screened rock mulch has been selected for the perimeter landscape areas and streetscapes. Larger angular rock is recommended in the basins to provide texture to the landscape surface and to minimize erosion and sedimentation. A dark tan (Tanner Gold) color of rock has been selected to blend the landscape with the surrounding farming and natural areas.
The four landscape character types are described below:

City Center Character Type

The City Center theme is designed with a higher density and formality to blend the channel into the urbanized character within this portion of the project area adjacent to the City Center. The side slopes of the channel are terraced with gabion walls to strengthen the geometry of the adjacent landscape. The landscape outside the channel is designed in formal massing laid out in rows of evergreen shrubs, grasses, and cacti accents. Each type of plant material is separated by concrete banding that is orientated perpendicular to the channel. Even though the density of plant material is higher than the other character type areas, the simplicity of the layout of the plant material is readable from larger vantage points. To provide greater pedestrian opportunities the channel is designed with shaded seating areas, small passive lawn areas, and larger event lawn areas. See **Figure 3.2.1 – City Center Character Type.**

City Center Park Avenue Linear Retention Basin – Looking North

Residential Character Type

The Residential theme is located adjacent to the Desert Springs Community residential area. The landscape is designed with a large passive turf open space that can be utilized by the neighborhood for recreation. Larger evergreen shade trees are placed near seating nodes and along the perimeter of the open space to provide a "park type" appearance. The landscape along Van Buren Street is consistent with the City Center and Transitional concepts to maintain a uniform streetscape theme. Colorful shrub massing and cacti accents are located along Van Buren Street as part of the overall streetscape theme and to buffer the recreational amenities from the street. Overall, the simplicity and massing of plant material are consistent with the City Center theme, yet the overall quantities have been reduced to match the context of the neighborhood. See **Figure 3.2.2– Residential Character Type.**

Transitional Character Type

The Transitional theme layout and quantity of the understory plants have a more naturalistic approach typical to the Sonoran Desert landscape than the other landscape character types. Even though the plant palette does not change, there is a greater quantity of boulders, angular rock, and cacti accents and less seasonally colorful shrubs. The massing of plant material is greater with regard to the tree layout in order to screen the industrial areas located north of the channel. See **Figure 3.2.3 – Transitional Character Type.**

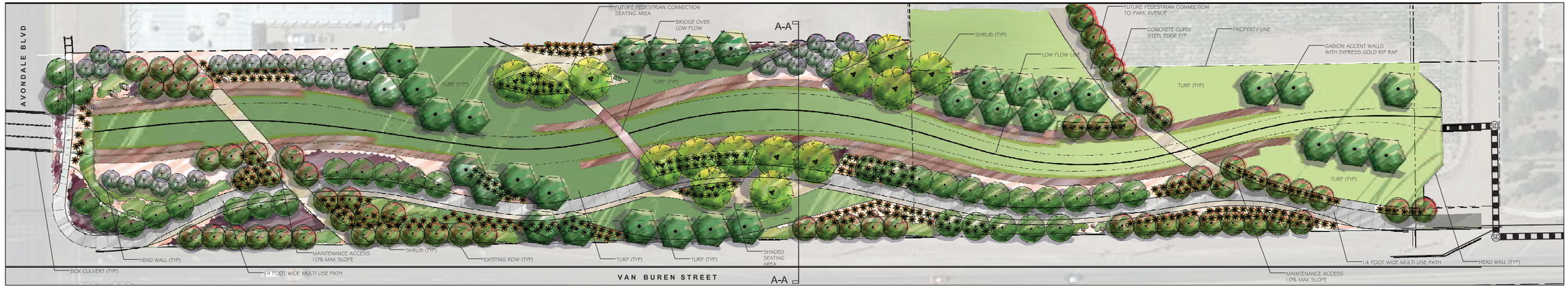
Desert Springs East Retention Basin - Looking East

Trail Character Type

The Trail theme occurs within the Phase II areas where the channel is piped underground. The landscape concept is consistent with the characteristics of the Transitional concept, utilizing a similar layout and quantity of the understory plants as well as the boulders and cacti modified to accommodate the narrow sections. Even though the plant palette does not change, the massing of plant material will continue to pronounce the banding and the tree layout will provide dense shade along the meandering multi-use path. See **Figure 3.2.4 – Trail Character Type.**

Van Buren Street 99th to Agua Fria River

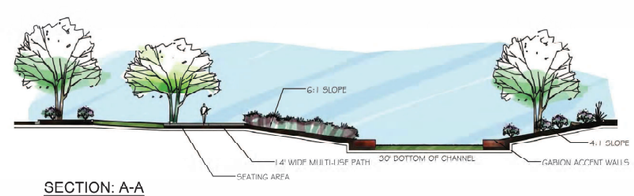
City Center Concept Plan



SYMBOL	BOTANICAL NAME	COMMON NAME
TREES		
	PARKINSONIA x 'SONORAN EMERALD'	THORNLESS SONORAN EMERALD PALO VERDE
	OLNEYA TESOTA	IRONWOOD
	PROSOPIS x 'PHOENIX'	HYBRID PHOENIX MESQUITE
	DALBERGIA SISSOO	SISSOO TREE
	PITHECELLOBIUM FLEXICAULE	TEXAS EBONY
	VITEX AGNUS CASTUS	CHASTE TREE
	ACACIA FARNESIANA	SWEET ACACIA
	CHILOPSIS LINEARIS	DESERT WILLOW
	PISTACIA x 'RED PUSH'	CHINESE PISTACHE

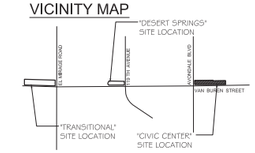
SYMBOL	BOTANICAL NAME	COMMON NAME
SHRUBS		
	BOUGAINVILLEA SPP.	BOUGAINVILLEA
	DODONAEA VISCOSA	HOP BUSH
	EREMOPHILA MACULATA 'VALENTINE'	VALENTINE EMU BUSH
	JUSTICIA SPICIGERA	MEXICAN HONEYSUCKLE
	MUHLENBERGIA CAPILLARIS 'REGAL MIST'	REGAL MIST
	NOLINA MICROCARPA	BEAR GRASS
	RUELLIA BRITTONIANA	BRITISH RUELLIA
	TECOMA STANS 'GOLD STAR'	GOLD STAR YELLOW BELLS
ACCENTS		
	AGAVE SPP.	AGAVE
	ALOE VERA	MEDICINAL ALOE
	DASYLIRION WHEELERI	DESERT SPOON
	HESPERALOE PARVIFLORA	RED YUCCA
	ECHINOCACTUS GRUSONII	GOLDEN BARREL CACTUS
	OPUNTIA BASILARIS	BEAVERTAIL PRICKLY PEAR
	PACHYCEREUS MARGINATUS	MEXICAN FENCE POST

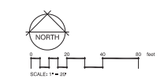
SYMBOL	BOTANICAL NAME	COMMON NAME
GROUND COVERS		
	ACACIA REDOLENS 'DESERT CARPET'	TRAILING ACACIA
	DALEA CAPITATA	LEMON DALEA
	TETRANEURIS ACAULIS	ANGELITA DAISY
	LANTANA 'GOLD MOUND'	GOLD MOUND LANTANA
	LANTANA MONTEVIDENSIS 'TRAILING PURPLE'	PURPLE LANTANA
INERT MATERIALS		
	BOULDER, PEVRUN, ANGULAR FACES	
	ROCK MULCH , 3/4" MINUS	EXPRESS GOLD
	ANGULAR RIP RAP SIZED BY CIVIL	EXPRESS GOLD



SECTION: A-A

VICINITY MAP





CHARACTER IMAGES

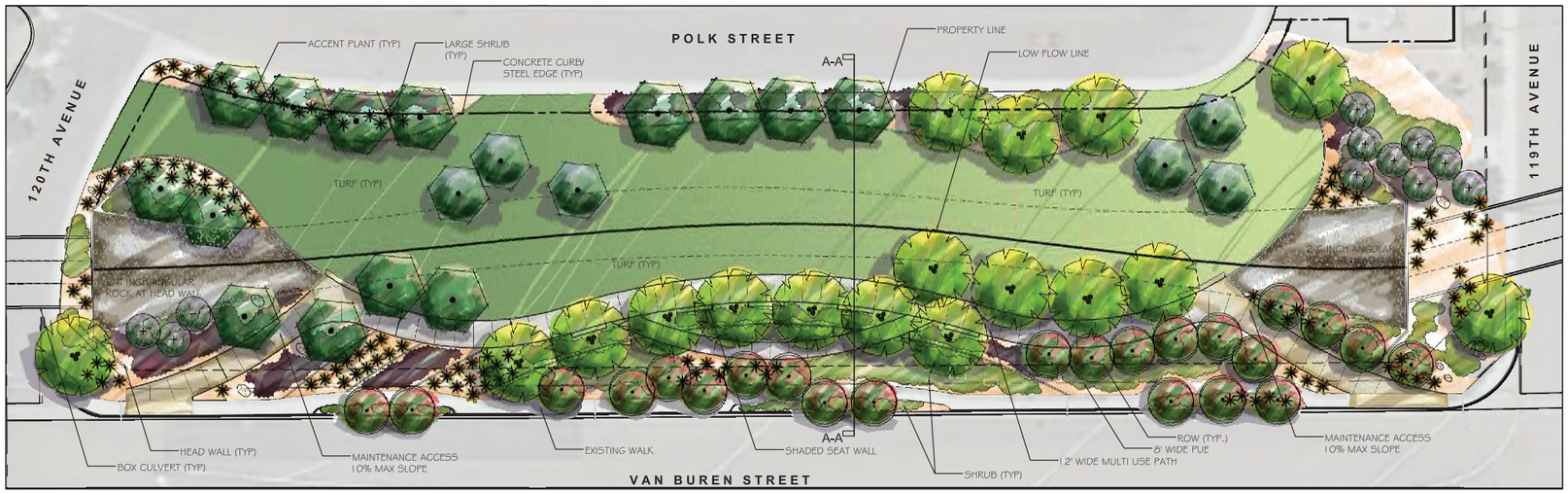
LOGAN SIMPSON DESIGN INC.

SUNRISE ENGINEERING

FIGURE 3.2.1 - CITY CENTER CHARACTER TYPE

Van Buren Street 99th to Agua Fria River

Residential Concept Plan



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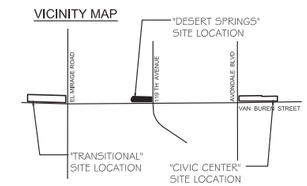
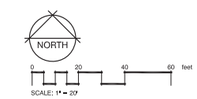




TREES

SYMBOL	BOTANICAL NAME	COMMON NAME
	PARKINSONIA x 'SONORAN EMERALD'	THORNLESS SONORAN EMERALD PALO VERDE
	OLNEYA TESOTA	IRONWOOD
	PROSOPIS x 'PHOENIX'	HYBRID PHOENIX MESQUITE
	DALBERGIA SISSOO	SISSOO TREE
	PITHECELLOBIUM FLEXICAULE	TEXAS EBONY
	VITEX AGNUS CASTUS	CHASTE TREE
	ACACIA FARNESIANA	SWEET ACACIA
	CHILOPSIS LINEARIS	DESERT WILLOW
	PISTACIA x 'RED PUSH'	CHINESE PISTACHE

SHRUBS

SYMBOL	BOTANICAL NAME	COMMON NAME
	BOUGAINVILLEA SPP.	BOUGAINVILLEA
	DODONAEA VISCOSA	HOP BUSH
	EREMOPHILA MACULATA 'VALENTINE'	VALENTINE EMU BUSH
	JUSTICIA SPICIGERA	MEXICAN HONEYSUCKLE
	MUHLENBERGIA CAPILLARIS 'REGAL MIST'	REGAL MIST
	NOLINA MICROCARPA	BEAR GRASS
	RUELLIA BRITTONIANA	BRITTISH RUELLIA
	TECOMA STANS 'GOLD STAR'	GOLD STAR YELLOW BELLS

ACCENTS

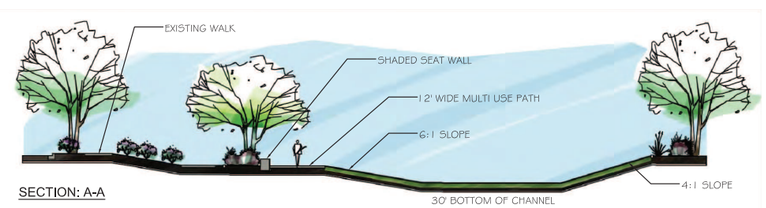
SYMBOL	BOTANICAL NAME	COMMON NAME
	AGAVE SPP.	AGAVE
	ALOE VERA	MEDICINAL ALOE
	DASYLIRION WHEELERI	DESERT SPOON
	HESPERALOE PARVIFLORA	RED YUCCA
	ECHINOCACTUS GRUSONII	GOLDEN BARREL CACTUS
	OPUNTIA BASILARIS	BEAVERTAIL PRICKLY PEAR
	PACHYCEREUS MARGINATUS	MEXICAN FENCE POST

GROUND COVERS

SYMBOL	BOTANICAL NAME	COMMON NAME
	ACACIA REDOLENS 'DESERT CARPET'	TRAILING ACACIA
	DALEA CAPITATA	LEMON DALEA
	TETRANEURIS ACAULIS	ANGELITA DAISY
	LANTANA 'GOLD MOUND'	GOLD MOUND LANTANA
	LANTANA MONTEVENDENSIS "TRAILING PURPLE"	PURPLE LANTANA

INERT MATERIALS

SYMBOL	BOTANICAL NAME	COMMON NAME
	BOULDER, PIT-RUN, ANGULAR FACES	
	ROCK MULCH , 3/4" MINUS	EXPRESS GOLD
	ANGULAR RIP RAP SIZED BY CIVIL	EXPRESS GOLD



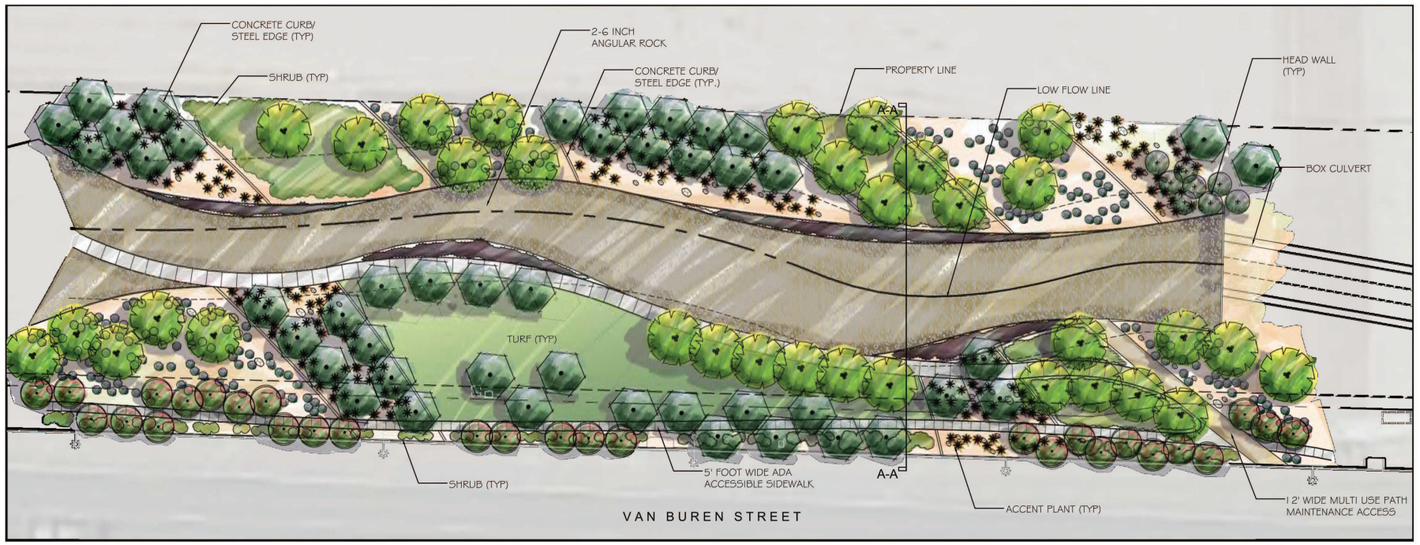
SECTION: A-A

CHARACTER IMAGES

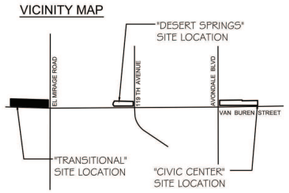
FIGURE 3.2.2 - RESIDENTIAL CHARACTER TYPE

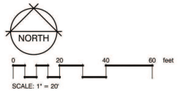
Van Buren Street 99th to Agua Fria River

Transitional Concept Plan



VICINITY MAP





TREES	SYMBOL	BOTANICAL NAME	COMMON NAME
		PARKINSONIA x 'SONORAN EMERALD'	THORNLESS SONORAN EMERALD PALO VERDE
		OLNEYA TESOTA	IRONWOOD
		PROSOPIS x 'PHOENIX'	HYBRID PHOENIX MESQUITE
		DALBERGIA SISSOO	SISSOO TREE
		PITHECELLOBIUM FLEXICAULE	TEXAS EBONY
		VITEX AGNUS CASTUS	CHASTE TREE
		ACACIA FARNESIANA	SWEET ACACIA
		CHILOPSIS LINEARIS	DESERT WILLOW
		PISTACIA x 'RED PUSH'	CHINESE PISTACHE

SHRUBS	SYMBOL	BOTANICAL NAME	COMMON NAME
		BOUGAINVILLEA SPP.	BOUGAINVILLEA
		DODONAEA VISCOSA	HOP BUSH
		EREMOPHILA MACULATA 'VALENTINE'	VALENTINE EMU BUSH
		JUSTICIA SPICIGERA	MEXICAN HONEYSUCKLE
		MUHLENBERGIA CAPILLARIS 'REGAL MIST'	REGAL MIST
		NOLINA MICROCARPA	BEAR GRASS
		RUELLIA BRITTONIANA	BRITISH RUELLIA
		TECOMA STANS 'GOLD STAR'	GOLD STAR YELLOW BELLS
ACCENTS			
		AGAVE SPP.	AGAVE
		ALOE VERA	MEDICINAL ALOE
		DASYLIRION WHEELERI	DESERT SPOON
		HESPERALOE PARVIFLORA	RED YUCCA
		ECHINOCACTUS GRUSONII	GOLDEN BARREL CACTUS
		OPUNTIA BASILARIS	BEAVERTAIL PRICKLY PEAR
		PACHYCEREUS MARGINATUS	MEXICAN FENCE POST

GROUND COVERS	BOTANICAL NAME	COMMON NAME
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	ROCK MULCH , 3/4" MINUS	EXPRESS GOLD
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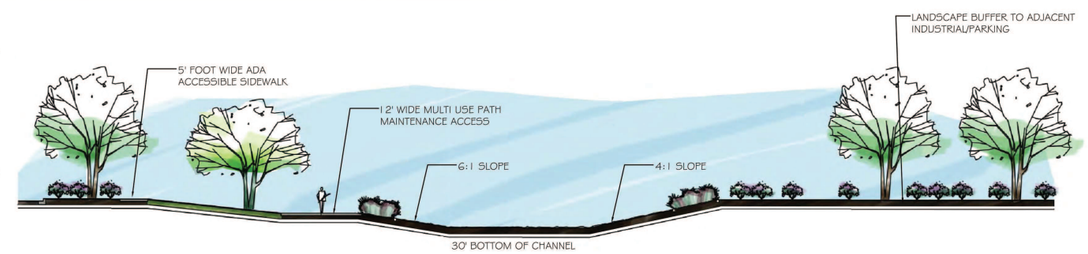

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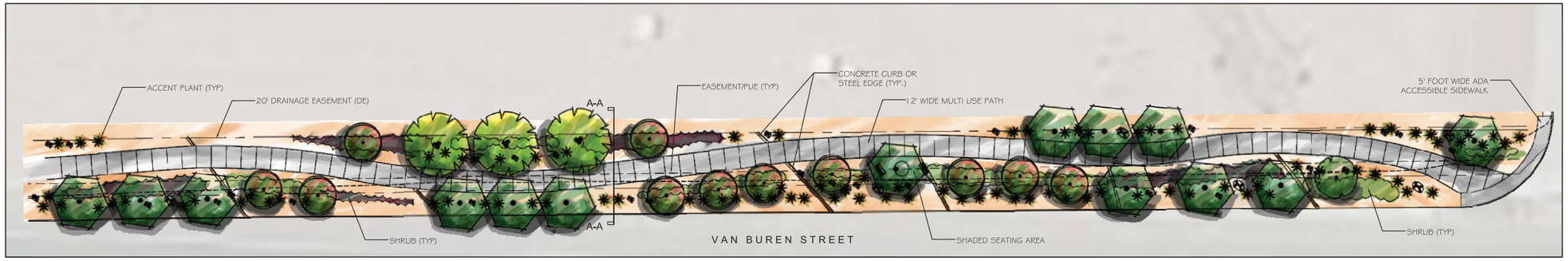
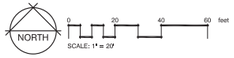
CHARACTER IMAGES

FIGURE 3.2.3 - TRANSITIONAL CHARACTER TYPE

Van Buren Street 99th to Agua Fria River

Trail Concept Plan





TREES	SYMBOL	BOTANICAL NAME	COMMON NAME
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		OLNEYA TESOTA	IRONWOOD
		PROSOPIS x 'PHOENIX'	HYBRID PHOENIX MESQUITE
		DALBERGIA SISSOO	SISSOO TREE
		PITHECELLOBIUM FLEXICAULE	TEXAS EBONY
		VITEX AGNUS CASTUS	CHASTE TREE
		ACACIA FARNESIANA	SWEET ACACIA
		CHILOPSIS LINEARIS	DESERT WILLOW
		PISTACIA x 'RED PUSH'	CHINESE PISTACHE

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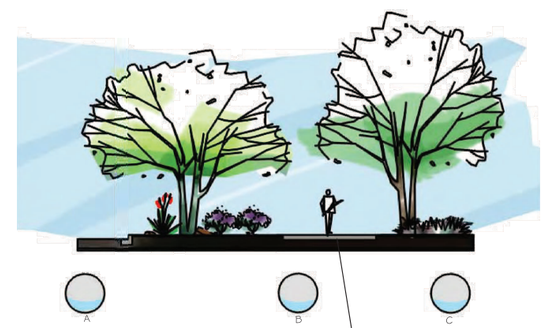
		JUSTICIA SPICIGERA	MEXICAN HONEYSUCKLE
		MUHLENBERGIA CAPILLARIS 'REGAL MIST'	REGAL MIST
		NOLINA MICROCARPA	BEAR GRASS
		RUELLIA BRITTONIANA	BRITISH RUELLIA
		TECOMA STANS 'GOLD STAR'	GOLD STAR YELLOW BELLS
ACCENTS			
		AGAVE SPP.	AGAVE
		ALOE VERA	MEDICINAL ALOE
		DASYLIRION WHEELERI	DESERT SPOON
		HESPERALOE PARVIFLORA	RED YUCCA
		ECHINOCACTUS GRUSONII	GOLDEN BARREL CACTUS
		OPUNTIA BASILARIS	BEAVERTAIL PRICKLY PEAR
		PACHYCEREUS MARGINATUS	MEXICAN FENCE POST

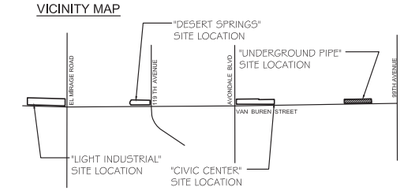
GROUND COVERS	BOTANICAL NAME	COMMON NAME
	ACACIA REDOLENS 'DESERT CARPET'	TRAILING ACACIA
	DALEA CAPITATA	LEMON DALEA
	TETRANEURIS ACAULIS	ANGELITA DAISY
	LANTANA 'GOLD MOUND'	GOLD MOUND LANTANA
	LANTANA MONTEVENDENSIS 'TRAILING PURPLE'	PURPLE LANTANA
INERT MATERIALS		
	BOULDER, PIT-RUN, ANGULAR FACES	
	ROCK MULCH , 3/4" MINUS	EXPRESS GOLD
	ANGULAR RIP RAP SIZED BY CIVIL	EXPRESS GOLD



SECTION: A-A

STORM DRAIN LOCATION
A - UNDER PAVEMENT
B - PARWAY BETWEEEN CURB & ROW (TREES/PATH IN DE)
C - IN DE (PLACE TREES IN PARKWAY)

VICINITY MAP



CHARACTER IMAGES

FIGURE 3.2.4 - TRAIL CHARACTER TYPE

3.3 Public and COA Council Meetings

The project was presented at a public meeting addressed to the public, COA Parks and Recreation Board, and the COA City Council. The public meeting was held at COA City Hall on March 20, 2013 and the project was presented in an open house format. Generally the public reception of the project has been excellent. The public likes the idea of the trail connectivity. The trail provides the benefit of walking from their homes to the trail then to City Center or other destination.

The project was presented to the COA Parks and Recreation Board on April 10, 2013. The Parks and Recreation Board was also enthusiastic of amenities the landscape components of the project will bring to the City.

Lastly the project was presented to the COA City Council work session meeting on May 13, 2013. The City Council as whole likes the project. Nonetheless, there are questions and concerns regarding funding for the project. These concerns were calmed by advising the Council that grant money could be applied for and used for the project.

3.4 Agua Fria Levee Design & Construction

The project proposes penetration of the Agua Fria River levee. There are two federal processes the project will need to go through due to the proposed penetration of the levee.

The U.S. Army Corps of Engineers (COE) will review the project plans because the District is in the COE's Rehabilitation and Inspection Program. The COE should be informed of and given the opportunity to review levee modifications between periodic inspections.

FEMA will also need to review the project and an analysis of flooding on the land side of the levee. The District certifies the levee and will re-certify the levee for this project. FEMA accredits the levee for flood protection on the land side and will modify the accreditation based on the project plans and "interior drainage" analysis.

The "interior drainage" analysis demonstrates that during a 100-year flow in the Agua Fria River, the flooding on the land side (interior) is not worse for a 100-year event. This will require a delineation of flooding in the pre-project or existing condition and an analysis of the project for the in place condition (assuming ultimate development) with the flaps gates closed during the Agua Fria flooding event. Since the existing condition involves overflows onto Van Buren Street at various locations and at the pedestrian culvert under Van Buren Street, the project in place condition would involve overflows at the same locations, but with some anticipated differences due to re-direction of flows by the channel and no retention in the City Center. A successful project would show that with the project in place, the interior flooding impacts are not worse than existing conditions.

The final design process should include a scope that:

1. Procures flown topo along Van Buren Street for the project design as well as the interior drainage analysis. Current GIS topo may be adequate south of Van Buren Street, but this would need to be verified.
2. Provides for an existing condition 100-year flooding analysis to determine a benchmark for comparison. (for FEMA)
3. Provides for a project-in-place 100-year flooding and existing conditions analysis assuming no or limited flows into the Agua Fria River. (for FEMA)
4. Provides for a project-in-place 100-year flooding and ultimate conditions analysis assuming no or limited flows into the Agua Fria River. (for internal use)
5. Provides for a staged approach:
    a. preliminary design completed based on the new topo
    b. existing condition interior drainage analysis based on the new topo
    c. project-in-place interior drainage analysis
    d. comparison of b and c results
    e. design revision, if necessary to mitigate any adverse impacts of project-in-place 100-year flooding with existing conditions and re-analyze, or
    f. submit to FEMA existing condition and project-in-place 100-year flooding with existing conditions if no adverse impacts are identified
    g. proceed with final design if FEMA approves interior drainage analysis

3.5 Cost Estimate

The Recommended Plan costs have been estimated for the project. The costs were estimated from quantity take offs of the conceptual plan and profile drawings. Unit prices are recent bid prices provided by the District and COA. The unit prices reflect actual bidding and are the median costs of those bids.

Utility relocation costs were estimated by unit quantity to be relocated based on the size of the utility or lump sum fee. The unit pricing is from current bid pricing. Lump sum fee relocations were provided by the District and COA based on previous utility relocation experience. The utility relocation costs assumed relocations can been made within 100-feet of the conflict. The SRP tower relocation cost of $250,000 is an estimate from SRP.

Right-of-way costs were estimated by plan take off. There are three right-of-way line items, channel/trail, road, Coldwater Depot and Desert Springs West basin. All right-of-way from Van Buren Street 65-foot to the required channel/trail width are included in the channel/trail line item.

Road right-of-way is required to be purchased where the existing Van Buren Street right-of-way is not at ultimate 65-foot width. The road right-of-way quantity, quantifies the purchase from the existing right-of-way to the ultimate right-of-way.

Coldwater Depot and Desert Springs West Basin right-of-way estimated by quantity take off. These two areas are existing retention basins that will be converted into channel. The estimated right-of-way is the land required to be purchased. COA has already acquired the Desert Springs area that includes the west basin. Although already purchased the Desert Springs basin is still included in the cost estimates.

Landscape costs have also been integrated into the cost estimate. The landscape costs are based on estimates by LSD. LSD provided estimates for the four theme areas. Landscape costs were prorated from the theme estimates and applied to the actual channel areas.

To facilitate landscape cost sharing, that channel liner quantities have been divided into conveyance and non-conveyance areas. Conveyance area was found via plan takeoff. The conveyance area was added as a separate line item in the channel and subtracted from the landscape estimate proration.

A 20% construction contingency has been included to account for any unforeseen items that occasionally occur during construction. A 5% professional services contingency has been included for final engineering, permitting fees, administration, and other professional services. Other professional services can include but not be limited to representation, real-estate fees, land appraisals, etc.

The estimated project grand total is $18.6 million, with a Phase I cost of $13.4 million and a Phase II cost of $5.2 million. The cost estimate has been summarized by phase, sheet, construction costs, land costs, and utility relocation costs, see **Figure 3.5.1 - Grand Total by Section**. See **Figure 3.5.2 - Grand Total** for quantities of the entire project. See **Figures 3.5.3 and 3.5.4 - Grand Total Phase I** and **Grand Total Phase II.** See **Appendix A** for quantities and totals by plan sheet.

Reference costs estimates for the 10-yr Alternatives Analysis are included in **Appendix G** and pipe only alternative is included in **Appendix H.**

SUNRISE ENGINEERING

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Tel: (480) 768-8600 Fax: (480) 768-8609

Engineer's Opinion of Probable Cost *

Project: Van Buren DCR
Reach: Total Project Summary (40+00 to 193+00)
Owner: FCDMC & COA
Prepared By: RMP

7/19/13

No.	Item Description				Total
	Phase I	(40+00 to 135+00, 1.8 miles)	LF	$/FT	
	Construction-	Sheet P1 - Agua Fria River to El Mirage Rd (40+00 to 60+00)	1,328	$1,304.92	$1,732,793
	Land-	Sheet P1 - Agua Fria River to El Mirage Rd (40+00 to 60+00)			$869,591
	Utilities-	Sheet P1 - Agua Fria River to El Mirage Rd (40+00 to 60+00)			$13,603
	Construction-	Sheet P2 - El Mirage Rd to Desert Springs Village (60+00 to 85+00)	2,091	$1,244.44	$2,602,111
	Land-	Sheet P2 - El Mirage Rd to Desert Springs Village (60+00 to 85+00)			$452,101
	Utilities-	Sheet P2 - El Mirage Rd to Desert Springs Village (60+00 to 85+00)			$502,483
	Construction-	Sheet P3 - Desert Springs Village to Fresh n Easy (85+00 to 110+00)	2,503	$596.54	$1,493,087
	Land-	Sheet P3 - Desert Springs Village to Fresh n Easy (85+00 to 110+00)			$860,471
	Utilities-	Sheet P3 - Desert Springs Village to Fresh n Easy (85+00 to 110+00)			$503,406
	Construction-	Sheet P4 - Fresh n Easy to Versante (110+00 to 127+50)	1,743	$726.39	$1,266,259
	Land-	Sheet P4 - Fresh n Easy to Versante (110+00 to 127+50)			$572,105
	Utilities-	Sheet P4 - Fresh n Easy to Versante (110+00 to 127+50)			$307,275
				Phase Subtotal Construction	$7,094,250
				Phase Subtotal Land	$2,754,269
				Phase Subtotal Utilities	$1,326,767
				15 % Contingency	$1,676,293
				5% Professional Services	$558,764
				Phase I Total	**$13,400,000**
	Phase II	(135+00 to 193+00, 1.1 miles)			
	Construction-	Sheet P4 & P5 - Versante to Roosevelt Park (127+50 to 160+00)	3,470	$467.62	$1,622,674
	Land-	Sheet P4 & P5 - Versante to Roosevelt Park (127+50 to 160+00)			$196,200
	Utilities-	Sheet P4 & P5 - Versante to Roosevelt Park (127+50 to 160+00)			$59,320
	Construction-	Sheet P6 - Roosevelt Park to 104th Ave (160+00 to 185+00)	2,523	$467.46	$1,179,625
	Land-	Sheet P6 - Roosevelt Park to 104th Ave (160+00 to 185+00)			$148,657
	Utilities-	Sheet P6 - Roosevelt Park to 104th Ave (160+00 to 185+00)			$38,065
	Construction-	Sheet P7 - 104th Ave to 103rd Ave (185+00 to 210+00)	751	$885.39	$664,625
	Land-	Sheet P7 - 104th Ave to 103rd Ave (185+00 to 210+00)			$192,855
	Utilities-	Sheet P7 - 104th Ave to 103rd Ave (185+00 to 210+00)			$0
	Construction-	Sheet P8 - 103rd Ave to 99th Ave (210+00 to 218+50)	890	$182.70	$162,600
	Land-	Sheet P8 - 103rd Ave to 99th Ave (210+00 to 218+50)			$40,050
	Utilities-	Sheet P8 - 103rd Ave to 99th Ave (210+00 to 218+50)			$0
				Phase Subtotal Construction	$3,629,525
				Phase Subtotal Land	$577,761
				Phase Subtotal Utilities	$97,385
				15 % Contingency	$645,701
				5% Professional Services	$215,234
				Phase II Total	**$5,200,000**
				Grand Total	**$18,600,000**

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Figure 3.5.1 Grand Total by Section

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Tel: (480) 768-8600 Fax: (480) 768-8609

Engineer's Opinion of Probable Cost *

Project: Van Buren DCR
Reach: Total Project - Construction Quantities (40+00 to 193+00)
Owner: FCDMC & COA
Prepared By: RMP

7/19/13

No.	Item Description	Total	Unit	Unit Price	Total	Notes
	Construction					
	Excavation - Channel	105,568	CY	$6.00	$633,409	Includes excavation and export haul costs.
	Excavation - Box Culvert and/or 60" RGRCP	31,680	CY	$9.80	$310,468	Includes excavation and export haul costs.
	Concrete - Box Culvert	6,063	CY	$430.00	$2,607,245	Includes concrete and steel reinforcement.
	Concrete - Headwalls	248	CY	$430.00	$106,464	Includes concrete and steel reinforcement.
	Concrete - Multi-Use Path (no existing VB path)	136,640	SF	$6.00	$819,840	
	Remove and Replace Asphalt Road	12,402	SY	$22.00	$272,847	
	60" RGRCP	6,744	LF	$190.00	$1,281,404	Includes pipe and bedding.
	Flap Gates	6	EA	$8,000.00	$48,000	
	CLSM Backfill	8,584	CY	$45.00	$386,276	
	Storm Drain Manhole - MAG 521	18	EA	$4,500.00	$81,000	
	Channel Liner - Conveyance Turf (Sod w/ Irrigation)	308,250	SF	$1.25	$385,313	
	Channel Liner - Rock Mulch	330,670	SF	$0.30	$99,201	
	Angular Rock (3"-8" Rip Rap @ 12" Deep)	128,950	SF	$0.90	$116,055	
	Landscape Construction					
	Landscape Theme - City Center	603,330	SF	$1.19	$719,108	
	Landscape Theme - Residential (Desert Springs)	143,500	SF	$0.78	$111,473	
	Landscape Theme - Desert Garden (Lt. Industrial)	521,870	SF	$1.12	$584,287	
	Landscape Theme - Trail Only	394,680	SF	$1.58	$624,331	
	Concrete - Multi-Use Path	71,640	SF	$6.00	$429,840	
	Concrete - Maintenance Path	36,240	SF	$6.00	$217,440	
	Concrete - Pedestrian Path	840	SF	$6.00	$5,040	
	Concrete - Cut-Off Walls	292	CY	$430.00	$125,450	Includes concrete and rebar.
	Surface Treatment - Turf (Sprigs w/ Irrigation)	124,389	SF	$0.85	$105,730	
	Surface Treatment - Rock Mulch	505,010	SF	$0.30	$151,503	
	Lighting	335	EA	$1,500.00	$502,050	
				SubTotal	$10,723,774	
	Land					
	Land Acquisition - Channel / Trail	1,042,502	SF	$2.25	$2,345,630	
	Land Acquisition - Road	195,900	SF	$2.25	$440,775	
	Land Acquistion - CW Depot & DS West Basin	242,500	SF	$2.25	$545,625	
				SubTotal	$3,332,030	
	Utility Relocation					
	Water 8"-16"	747	LF	$105.00	$78,383	Includes an additional 10' before and after the structure.
	Water 18" and up	0	LF	$510.00	$0	Includes an additional 10' before and after the structure.
	Reclaimed Water	77	LF	$105.00	$8,103	Includes an additional 10' before and after the structure.
	Reclaimed Water Vault	0	EA	$5,000.00	$0	
	Fire Hydrant	1	EA	$5,500.00	$5,500	
	Sewer Manholes	0	LF	$4,500.00	$0	Includes an additional 10' before and after the structure.
	Sewer Mains	354	LF	$80.00	$28,313	Includes an additional 10' before and after the structure.
	Storm Drain Structures	2	LF	$2,500.00	$5,000	Includes an additional 10' before and after the structure.
	Storm Drain Pipes	92	LF	$95.00	$8,764	Includes an additional 10' before and after the structure.
	Concrete Irrigation Ditch	0	LF	$20.00	$0	Includes an additional 10' before and after the structure.
	Irrigation Relocation	5	LS	$150,000.00	$750,000	
	Gas 6" Relocation	3	LS	$25,000.00	$75,000	
	Gas 20" Relocation	1	LS	$55,000.00	$55,000	
	Electric	738	LF	$130.00	$95,940	Includes an additional 10' before and after the structure.
	Electrical Pole	6	EA	$7,000.00	$42,000	
	Others (Telephone, Cable, Etc.)	343	LF	$50.00	$17,150	Includes an additional 10' before and after the structure.
	Street Lights	2	EA	$2,500.00	$5,000	
	Traffic Signals	0	EA	$150,000.00	$0	
	Traffic Conduit	0	EA	$1,000.00	$0	
	SRP Tower	1	EA	$250,000.00	$250,000	
				Subtotal	$1,424,152	
				CONSTRUCTION TOTAL	**$10,723,774**	
				LAND TOTAL	**$3,332,030**	
				UTILITY RELOCATION TOTAL	**$1,424,152**	
				15% CONTINGENCY	**$2,321,993**	
				5% PROFESSIONAL SERVICES	**$773,998**	
				PROJECT TOTAL	**$18,600,000**	

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Figure 3.5.2 Grand Total

SUNRISE ENGINEERING

SUNRISE ENGINEERING, INC.
2152 S. Vineyard, Suite 123
Mesa, Arizona 85210
Tel: (480) 768-8600 Fax: (480) 768-8609

Engineer's Opinion of Probable Cost *

Project: Van Buren DCR
Reach: Total Project Phase I- Construction Quantities (40+00 to 127+50)
Owner: FCDMC & COA
Prepared By: RMP

7/19/13

No.	Item Description	Total	Unit	Unit Price	Total	Notes
	Construction					
	Excavation - Channel	105,568	CY	$6.00	$633,409	Includes excavation and export haul costs.
	Excavation - Box Culvert and/or 60" RGRCP	18,192	CY	$9.80	$178,281	Includes excavation and export haul costs.
	Concrete - Box Culvert	6,063	CY	$430.00	$2,607,245	Includes concrete and steel reinforcement.
	Concrete - Headwalls	225	CY	$430.00	$96,840	Includes concrete and steel reinforcement.
	Concrete - Multi-Use Path (no existing VB path)	82,460	SF	$6.00	$494,760	
	Remove and Replace Asphalt Road	7,906	SY	$22.00	$173,932	
	60" RGRCP	0	LF	$190.00	$0	Includes pipe and bedding.
	Flap Gates	6	EA	$8,000.00	$48,000	
	CLSM Backfill	0	CY	$45.00	$0	
	Storm Drain Manhole - MAG 521	0	EA	$4,500.00	$0	
	Channel Liner - Conveyance Turf (Sod w/ Irrigation)	308,250	SF	$1.25	$385,313	
	Channel Liner - Rock Mulch	330,670	SF	$0.30	$99,201	
	Angular Rock (3"-8" Rip Rap @ 12" Deep)	128,950	SF	$0.90	$116,055	
	Landscape Construction					
	Landscape Theme - City Center	603,330	SF	$1.19	$719,108	
	Landscape Theme - Residential (Desert Springs)	143,500	SF	$0.78	$111,473	
	Landscape Theme - Desert Garden (Lt. Industrial)	521,870	SF	$1.12	$584,287	
	Landscape Theme - Trail Only	0	SF	$1.58	$0	
	Concrete - Multi-Use Path	18,180	SF	$6.00	$109,080	
	Concrete - Maintenance Path	33,600	SF	$6.00	$201,600	
	Concrete - Pedestrian Path	840	SF	$6.00	$5,040	
	Concrete - Cut-Off Walls	292	CY	$430.00	$125,450	Includes concrete and rebar.
	Surface Treatment - Turf (Sprigs w/ Irrigation)	124,389	SF	$0.85	$105,730	
	Surface Treatment - Rock Mulch	221,652	SF	$0.30	$66,496	
	Lighting	155	EA	$1,500.00	$232,950	
				SubTotal	$7,094,250	
	Land					
	Land Acquisition - Channel / Trail	890,619	SF	$2.25	$2,003,894	
	Land Acquisition - Road	91,000	SF	$2.25	$204,750	
	Land Acquistion - CW Depot & DS West Basin	242,500	SF	$2.25	$545,625	
				SubTotal	$2,754,269	
	Utility Relocation					
	Water 8"-16"	565	LF	$105.00	$59,273	Includes an additional 10' before and after the structure.
	Water 18" and up	0	LF	$510.00	$0	Includes an additional 10' before and after the structure.
	Reclaimed Water	77	LF	$105.00	$8,103	Includes an additional 10' before and after the structure.
	Reclaimed Water Vault	0	EA	$5,000.00	$0	
	Fire Hydrant	1	EA	$5,500.00	$5,500	
	Sewer Manholes	0	LF	$4,500.00	$0	Includes an additional 10' before and after the structure.
	Sewer Mains	276	LF	$80.00	$22,073	Includes an additional 10' before and after the structure.
	Storm Drain Structures	2	LF	$2,500.00	$5,000	Includes an additional 10' before and after the structure.
	Storm Drain Pipes	66	LF	$95.00	$6,294	Includes an additional 10' before and after the structure.
	Concrete Irrigation Ditch	0	LF	$20.00	$0	Includes an additional 10' before and after the structure.
	Irrigation Relocation	5	LS	$150,000.00	$750,000	
	Gas 6" Relocation	2	LS	$25,000.00	$50,000	
	Gas 20" Relocation	1	LS	$55,000.00	$55,000	
	Electric	530	LF	$130.00	$68,900	Includes an additional 10' before and after the structure.
	Electrical Pole	5	EA	$7,000.00	$35,000	
	Others (Telephone, Cable, Etc.)	133	LF	$50.00	$6,625	Includes an additional 10' before and after the structure.
	Street Lights	2	EA	$2,500.00	$5,000	
	Traffic Signals	0	EA	$150,000.00	$0	
	Traffic Conduit	0	EA	$1,000.00	$0	
	SRP Tower	1	EA	$250,000.00	$250,000	
				Subtotal	$1,326,767	

CONSTRUCTION TOTAL	**$7,094,250**
LAND TOTAL	**$2,754,269**
UTILITY RELOCATION TOTAL	**$1,326,767**
15% CONTINGENCY	**$1,676,293**
5% PROFESSIONAL SERVICES	**$558,764**
PHASE I TOTAL	**$13,400,000**

*In providing opinions of probable construction cost the Client understands that the Engineer has no control over costs or the price of labor, equipment or materials, or over the Contractor's method of pricing, and that the opinion of probable construction cost provided herein is made on the basis of the Engineer's qualifications and experience. The Engineer makes no warranty, expressed or implied, as the accuracy if such opinions compared to bid or actual costs.

Figure 3.5.3 Grand Total Phase I

SUNRISE ENGINEERING

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2152 S. Vineyard, Suite 123
Mesa, Arizona 85210
Tel: (480) 768-8600 Fax: (480) 768-8609

Engineer's Opinion of Probable Cost *

Project: Van Buren DCR
Reach: Total Project Phase II - Construction Quantities (127+50 to 193+00)
Owner: FCDMC & COA
Prepared By: RMP

7/19/13

No.	Item Description	Total	Unit	Unit Price	Total	Notes
	Construction					
	Excavation - Channel	0	CY	$6.00	$0	Includes excavation and export haul costs.
	Excavation - Box Culvert and/or 60" RGRCP	13,488	CY	$9.80	$132,187	Includes excavation and export haul costs.
	Concrete - Box Culvert	0	CY	$430.00	$0	Includes concrete and steel reinforcement.
	Concrete - Headwalls	22	CY	$430.00	$9,623	Includes concrete and steel reinforcement.
	Concrete - Multi-Use Path (no existing VB path)	54,180	SF	$6.00	$325,080	
	Remove and Replace Asphalt Road	4,496	SY	$22.00	$98,915	
	60" RGRCP	6,744	LF	$190.00	$1,281,404	Includes pipe and bedding.
	Flap Gates	0	EA	$8,000.00	$0	
	CLSM Backfill	8,584	CY	$45.00	$386,276	
	Storm Drain Manhole - MAG 521	18	EA	$4,500.00	$81,000	
	Channel Liner - Conveyance Turf (Sod w/ Irrigation)	0	SF	$1.25	$0	
	Channel Liner - Rock Mulch	0	SF	$0.30	$0	
	Angular Rock (3"-8" Rip Rap @ 12" Deep)	0	SF	$0.90	$0	
	Landscape Construction					
	Landscape Theme - City Center	0	SF	$1.19	$0	
	Landscape Theme - Residential (Desert Springs)	0	SF	$0.78	$0	
	Landscape Theme - Desert Garden (Lt. Industrial)	0	SF	$1.12	$0	
	Landscape Theme - Trail Only	394,680	SF	$1.58	$624,331	
	Concrete - Multi-Use Path	53,460	SF	$6.00	$320,760	
	Concrete - Maintenance Path	2,640	SF	$6.00	$15,840	
	Concrete - Pedestrian Path	0	SF	$6.00	$0	
	Concrete - Cut-Off Walls	0	CY	$430.00	$0	Includes concrete and rebar.
	Surface Treatment - Turf (Sprigs w/ Irrigation)	0	SF	$0.85	$0	
	Surface Treatment - Rock Mulch	283,359	SF	$0.30	$85,008	
	Lighting	179	EA	$1,500.00	$269,100	
				SubTotal	$3,629,525	
	Land					
	Land Acquisition - Channel / Trail	151,883	SF	$2.25	$341,736	
	Land Acquisition - Road	104,900	SF	$2.25	$236,025	
	Land Acquistion - CW Depot & DS West Basin	0	SF	$2.25	$0	
				SubTotal	$577,761	
	Utility Relocation					
	Water 8"-16"	182	LF	$105.00	$19,110	Includes an additional 10' before and after the structure.
	Water 18" and up	0	LF	$510.00	$0	Includes an additional 10' before and after the structure.
	Reclaimed Water	0	LF	$105.00	$0	Includes an additional 10' before and after the structure.
	Reclaimed Water Vault	0	EA	$5,000.00	$0	
	Fire Hydrant	0	EA	$5,500.00	$0	
	Sewer Manholes	0	LF	$4,500.00	$0	Includes an additional 10' before and after the structure.
	Sewer Mains	78	LF	$80.00	$6,240	Includes an additional 10' before and after the structure.
	Storm Drain Structures	0	LF	$2,500.00	$0	Includes an additional 10' before and after the structure.
	Storm Drain Pipes	26	LF	$95.00	$2,470	Includes an additional 10' before and after the structure.
	Concrete Irrigation Ditch	0	LF	$20.00	$0	Includes an additional 10' before and after the structure.
	Irrigation Relocation	0	LS	$150,000.00	$0	
	Gas 6" Relocation	1	LS	$25,000.00	$25,000	
	Gas 20" Relocation	0	LS	$55,000.00	$0	
	Electric	208	LF	$130.00	$27,040	Includes an additional 10' before and after the structure.
	Electrical Pole	1	EA	$7,000.00	$7,000	
	Others (Telephone, Cable, Etc.)	211	LF	$50.00	$10,525	Includes an additional 10' before and after the structure.
	Street Lights	0	EA	$2,500.00	$0	
	Traffic Signals	0	EA	$150,000.00	$0	
	Traffic Conduit	0	EA	$1,000.00	$0	
	SRP Tower	0	EA	$250,000.00	$0	
				Subtotal	$97,385	

CONSTRUCTION TOTAL	**$3,629,525**
LAND TOTAL	**$577,761**
UTILITY RELOCATION TOTAL	**$97,385**
15% CONTINGENCY	**$645,701**
5% PROFESSIONAL SERVICES	**$215,234**
PHASE II TOTAL	**$5,200,000**

*In providing opinions of probable construction cost the Client understands that the Engineer has no control over costs or the price of labor, equipment or materials, or over the Contractor's method of pricing, and that the opinion of probable construction cost provided herein is made on the basis of the Engineer's qualifications and experience. The Engineer makes no warranty, expressed or implied, as the accuracy if such opinions compared to bid or actual costs.

Figure 3.5.4 Grand Total Phase II

4 HYDROLOGY

The hydrology model used for this study is based on the Hydrology Technical Memorandum dated September 2010, completed for the Van Buren DCR. The Hydrology Technical Memorandum extracted the project study area from the Durango Area Drainage Master Plan (Durango ADMP) by Dibble & Associates, 2001. The existing HEC-1 model input data files including slt4dur6.dat (100-year 6-hour event) and sltdur24.dat (100-year 24-hour event) were provided by the District. These models were generated for the Durango ADMP and later updated by the District using the Aspen routing.

4.1 Van Buren DCR 100-Year Hydrologic Models

The September 2010 Hydrology Technical Memorandum HEC-1 models for the 100-year storm event were extracted from the existing Durango ADMP HEC-1 models. The extracted areas of the models include the study area shown as Area 1, the extended study area shown as Area 2, and an offsite contributing area, as shown in **Figure 1.1.1 – Study Area**. These areas include 39 Durango ADMP sub-watersheds: RA through RE (Area 1), KA, KD, LE, OB, OF and OG (Area 2), RF and RG (extended study area), and RH through RJ, SA through SH, TA and TB, UA through UD, VA through VD, WA through WD, and XA (offsite contributing area). Minor adjustments were made in the models to match the existing model results.

The point rainfall depths of the 100-year 6-hour and 100-year 24-hour events used in the September 2010 Hydrology Technical Memorandum models were 3.23 and 3.99 inches respectively. These rainfall depths were obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 2 for Arizona. These values are the same as the rainfall depths used in the Durango ADMP.

Soil data used in the September 2010 Hydrology Technical Memorandum models is the same as the Durango ADMP, which was determined from the SCS Soil Survey of Maricopa County (SCS, 1997).

Land uses were updated for both current and future condition land uses and retention volumes. Current land uses were obtained using current aerial photography of the study area. The future land uses were determined using the City of Avondale's General Plan. Retention volumes for the future land use were computed using City of Avondale and Maricopa County Drainage Design Standards and NOAA Atlas 2 rainfall depths. Eighty-five percent of the retention required volume was accounted for by diverting the required volume out of the model. Note the District standard is 80%. Eighty-five percent was used as the City code requires retention basins as part of its development process, so the team agreed to use 85% retention rate.

The Agriculture S-graph was used for all the five sub-watersheds in Area 1 in the Durango ADMP models. Based on the updated current land uses, the Agriculture S-graph was used for sub-watersheds RB and RC, while the Phoenix Valley S-graph was used for RA, RD and RE due to the recent development in these areas. In future condition models, Phoenix Valley S-graph was used for all the sub-watersheds in Area 1.

The channel routing procedures as related in the Durango ADMP were used in the Van Buren DCR models. The number of routing steps (NSTPS) for each channel routing was calculated by using an interactive process described in the Maricopa County Hydrology Manual. Runoff discharges cross Van Buren Street at several locations and enter the DROP channel located south of Area 1.

See the Van Buren DCR Hydrology Technical Memorandum for additional details of the current and future conditions models.

4.2 Hydrologic Model Update

Alternatives Analysis for the 10-year conveyance was built upon the September 2010 Hydrology Technical Memorandum models (base models). The HEC-1 model data sheets are included in **Appendix C**.

Effective August 6, 2003, the NOAA Atlas 2 has been superseded by Atlas 14 for Arizona and other western states. Consequently, the following point rainfall depths were obtained from NOAA Atlas 14 (NOAA 2006) and used in this study:

$D_{10\text{-year},6\text{-hour}}$ = 1.71 inches;
$D_{10\text{-year},24\text{-hour}}$ = 2.19 inches;
$D_{100\text{-yea,r }6\text{-hour}}$ = 2.62 inches; and
$D_{100\text{-year},24\text{-hour}}$ = 3.41 inches.

Soil data is the same as the base models.

Land uses were further updated for both current and future condition land uses according to the most recent data. The required retention volumes were recalculated accordingly. The District standard of 80% retention volume of the required volume was entered into the model by diverting the required volume out of the model. Because the retention volume captures most of the flow for sub-watersheds RA, RC, RD and RE, the DI and DQ cards in the models were adjusted to allow a smaller portion (~5%) of the flow to bypass the retention area until the 80% capacity is reached, as recommended by the District. First flush runoff was retained in the City Center areas that are and/or will be located in sub-watersheds RB and RC.

S-graphs were revised for both current and future condition models accordingly.

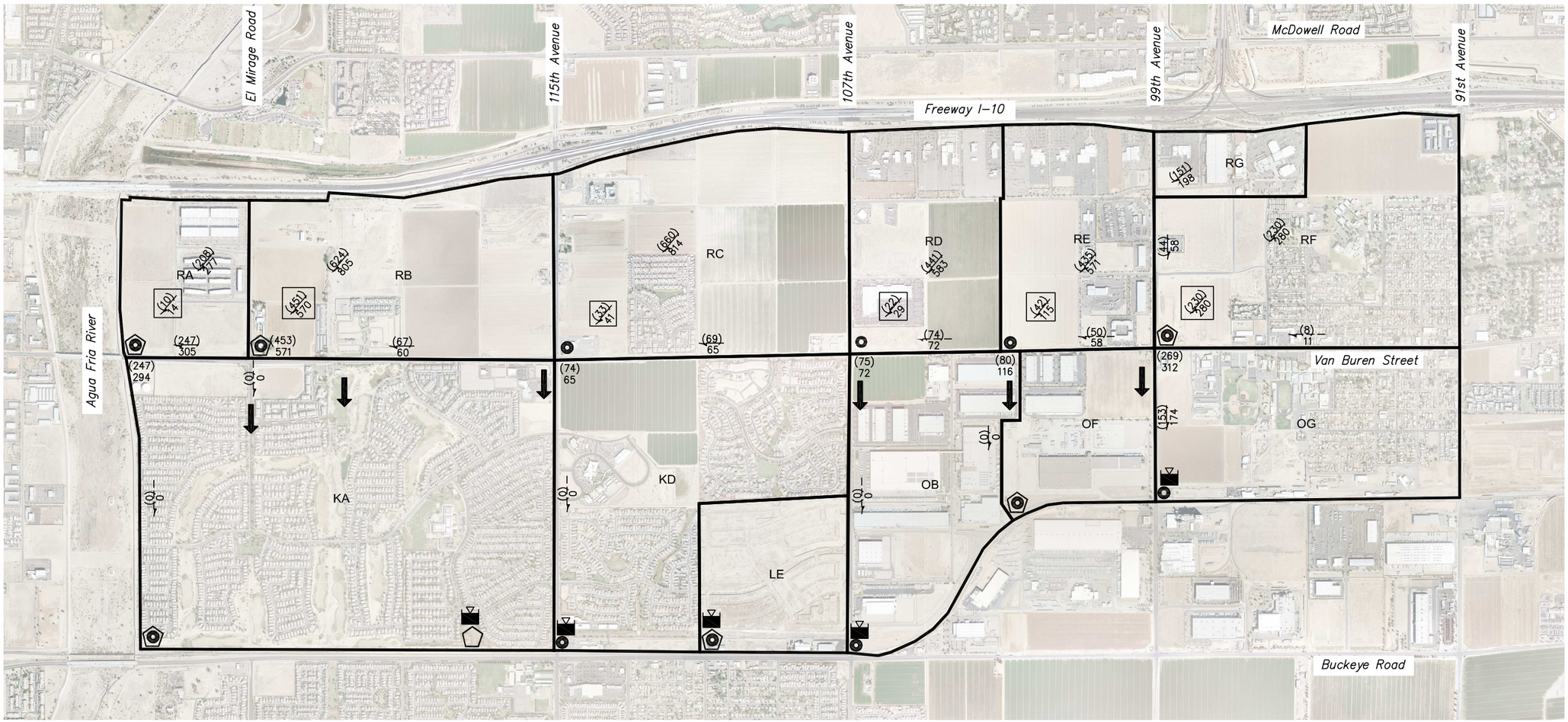
To ensure a conservative flow in the first reach of the storm drain system, the District and City requested that the 10-year, 6-hour peak flow of the initial 160 acres of sub-watershed RE be calculated with the rational method. The higher discharge generated in the initial 160 acres of RE between the 10-year rational peak and the HEC-1 10-year peak should be used in the 10-year, 6-hour future condition alternative analysis model (see **Section 4.3**). DDMSW was used to calculate a rational peak flow for the 10-year event of 386.2 cubic feet per second. The peak flow of the 10-year event modeled using HEC-1 is 382 cubic feet per second. Consequently, the rational 10-year peak discharge should be used. This was reduced down to the initial flow rate of 77.2 cubic feet per second by assuming 80% of the water was retained in retention basins in sub-watershed RE (386.2 cubic feet per second (cfs) × 20% = 77.2 cfs).

For the 10-year, 6-hour future condition alternative analysis model, the hydrograph for the entire RE area was modeled, the portion of the initial 160 acres removed, and the rational peak flow of 77.2 cubic feet per second, was added back in for a composite hydrograph for RE. The retention values in RE were than adjusted to reflect the composite peak flow rate of 115 cubic feet per second at the concentration point RETRE. The recommended plan models (see **Section 4.4**) used the same retention volume but, the peak was not adjusted to 115 cubic feet per second. No retention volume adjustments were necessary as the flow was added as an extra to ensure the 10-year future condition channel would have flow in the upper reaches.

All hydrographs were routed west along Van Buren Street through a conceptual channel and a conceptual storm drain pipe connected to the channel upstream. Existing flow splits to the south were also routed west. Existing flow splits, per the City, for Van Buren Street go south at 103rd Avenue, 107th Avenue, 111th Avenue, 113th Avenue, Cold Water Springs Golf Course, and El Mirage Road.

4.3 Alternatives Analysis Models

Ten-year 6-hour and 24-hour storm events (NOAA Atlas 14) were modeled for future conditions. These models were designated as "alternative analysis models". Based on the preliminary model results, a conceptual channel was sized using Flow Master. A channel routing was performed by using the conceptual channel. The model input data and results were submitted to the District for review. Based on the review comments, the models were modified and recomputed. The outputs from the modified models are included on a compact disc that is included with this DCR. **Figure 4.3.1 - HEC-1 Alternative Analysis Model Results – 10 Year Peak Flows of Future Condition Routing West through Conceptual Channels,** shows the peak flow values generated in sub-watersheds, routed or diverted, and at the hydrograph combining and diverting locations.



LEGEND

- SUB-BASIN RUNOFF BEFORE RETENTION
- SUB-BASIN RUNOFF AFTER RETENTION
- FLOW ROUTING
- DIVERT ROUTING
- HYDROGRAPH COMBINE POINT
- FLOW DIVERSION
- HYDROGRAPH COMBINE & DIVERSION POINT
- PROPOSED DETENTION BASIN
- NON-CONTRIBUTING AREA
- ADMP BASIN
- (222) 24 HOUR PEAK FLOW
  328 6 HOUR PEAK FLOW
- EXISTING FLOW SPLIT

MODELING NOTES:

1. ALL FLOWS ALONG VAN BUREN WERE MODELED WITH ROUTING TO WEST. ALL OVER FLOWS WERE ASSUMED TO CONTINUE WEST.
2. PER CITY OF AVONDALE, EXISTING CONDITION IS FLOWS SPLITS AT VAN BUREN DIVERT FLOW SOUTH AT 103RD, 107TH, 111TH AND 113TH AVENUES, COLD WATER SPRINGS GOLF COURSE AND EL MIRAGE ROAD. ACTUAL DISCHARGE TO SPLITS ARE UNKNOWN.

FIGURE 4.3.1 - HEC-1 ALTERNATIVE ANALYSIS MODEL RESULTS - 10-YEAR PEAK FLOWS OF FUTURE CONDITION
ROUTING WEST THROUGH CONCEPTUAL CHANNELS

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P:\FCDMC\03700.001\VanBuren III\Dwg\Exhibits\Exhibit 4.2 - HEC-1 Model Results - 10-Year Peak Flows-Future 1.dwg Jul 19, 2013 12:45pm hpowell

4.4 Recommended Plan Models

Recommended Plan models were ran to verify that the installed channel does not adversely affect the study other than the 10-year future build-out. Based on the alternative analysis model results (10-year events) and the available Van Buren Street survey data, three sections of a conceptual trapezoidal channel (10-year event channel) and a section of reinforced concrete pipe (10-year event pipe) were sized by using an open channel computer program, Flow Master. Side slopes of the channel are between 8:1 and 4:1 (horizontal: vertical).

The "recommended plan models" were built up using the updated rainfall, land use, retention data, and 10-year channel. The base model was the 10-year future conditions model from **Section 4.3**. The following four models were run:

Model 1: 10-year, 6 & 24-hour events, updated current condition;
Model 2: 10-year, 6 & 24-hour events, updated future condition, modified retention in Coldwater Depot, School, and Desert Springs;
Model 3: 100-year, 6 & 24-hour events, updated current condition;
Model 4: 100-year, 6 & 24-hour events, future condition

The normal-depth channel routing and kinematic wave channel routing methods were respectively used for the channel and pipe. The model outputs are included on a compact disc that is included with this DCR. See the following figures for the peak flow values generated in sub-watersheds, routed or diverted, and at the hydrograph combining and diverting locations, as well as the channel routing conveyances for the modeled conditions:

Figure 4.4.1 – HEC-1 Recommended Plan Model Results – 10-Year Peak Flows of Updated Current Condition Routing West Through Conceptual Channels and RCP's

Figure 4.4.2 – HEC-1 Recommended Plan Model Results – 10-Year Peak Flows of Future Condition – Modified Retention Routing West Through Conceptual Channels

Figure 4.4.3 – HEC-1 Recommended Plan Model Results – 100-Year Peak Flows of Updated Current Condition Routing West Through Conceptual Channels and RCP's

Figure 4.4.4 – HEC-1 Recommended Plan Model Results – 100-Year Peak Flows of Future Condition Routing West Through Conceptual Channels and RCP's

Models 1, 3 and 4 were run to evaluate potential adverse effects of the proposed channel in different storm events or scenarios other than what it was designed for. Models 1, 3 and 4 assumed all flow was routed to the west even if the channel was not large enough to convey the flow. Refer to the exhibits previously mentioned for a table of the conveyance flow rate versus design flow rate to see where over topping of the channel occurs. Generally the channel depths given are seven feet except in a select location where the plans shows only a four and one-half-foot depth which is possible due to low existing grades. Generally the 10-year events do not over top. In some select locations the 100-year event over tops the channel.

Existing flow splits, per the City, for Van Buren Street go south at 103rd Avenue, 107th Avenue, 111th Avenue, 113th Avenue, Cold Water Springs Golf Course, and El Mirage Road. With the channel installed, there will be less flow within Van Buren Street. If over topping of the channel for a greater than 10-year event occurs, flow will enter Van Buren Street and continue in its historic path at a lower flow rate than currently occurs.

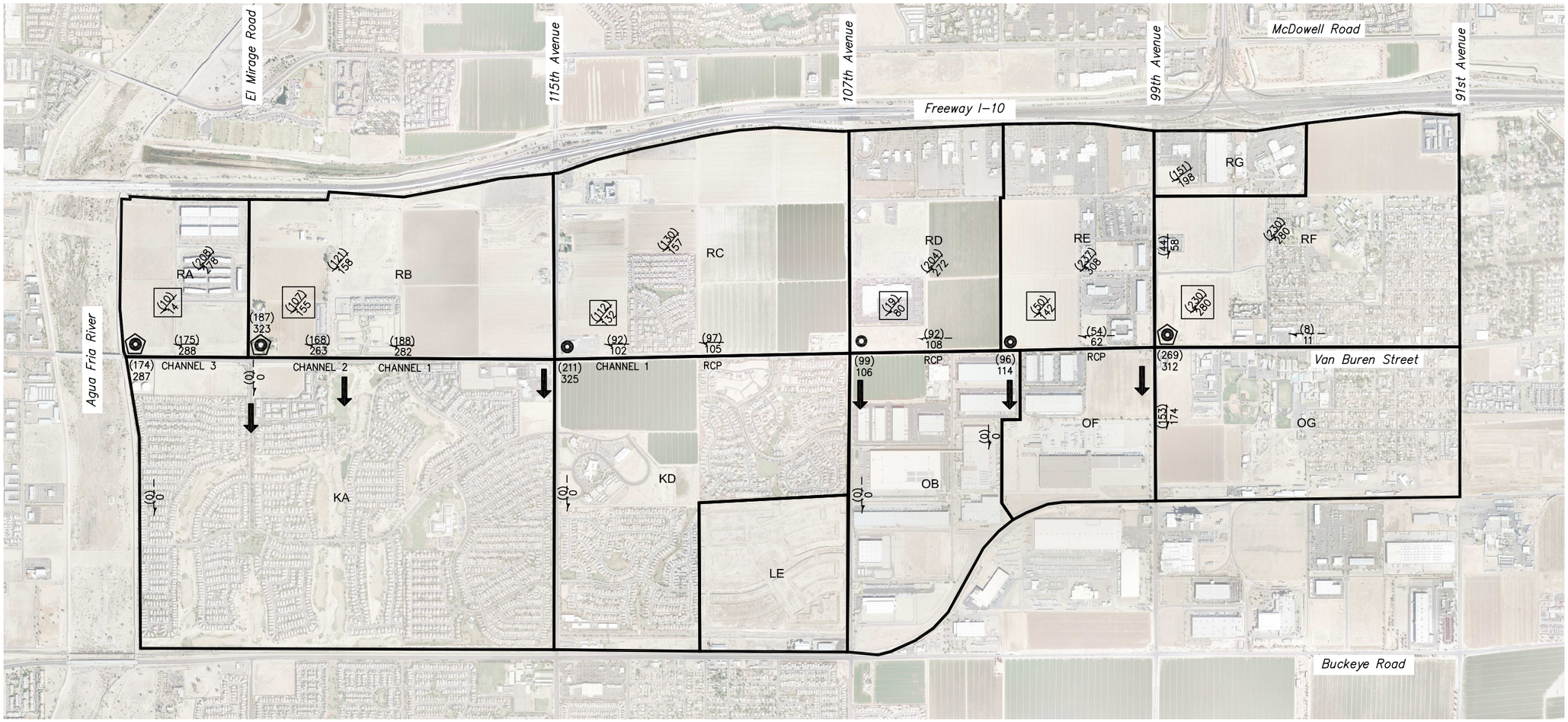
4.5 Retention

All Recommended Plan hydrology models assumed the developed conditions (except for the City Center) have retention basins that provide a least a 100-year, 2-hour retention volume except for the future 10-year. The future 10-year no retention model assumed certain existing developments would not be required to retain all volume required.

In the models with retention, the volume retained was reduced to 80% per the District standards. In the City Center, first flush was modeled as the volume provided. The volume provided was also applied to the five developed or soon to be developed parcels that will have their basins converted to channel by this project. Models 1, 3 and 4 assumed the five parcels would have to find retention elsewhere on their parcels and not discharge into the channel.

Model 2, the future 10-year no retention model assumed lesser retention volumes from Coldwater Depot, the charter school, and Desert Springs subdivision. All these projects are existing or under construction with retention basins in the proposed channel alignment. Reduced volumes provided were estimated for each site by subtracting the plan or as-built volume from the estimated total volume required. The revised lower volumes were entered into the model.

Agua Fria River - Looking South at Van Buren Street Bridge



LEGEND

- SUB-BASIN RUNOFF BEFORE RETENTION
- SUB-BASIN RUNOFF AFTER RETENTION
- FLOW ROUTING
- DIVERT ROUTING
- HYDROGRAPH COMBINE POINT
- FLOW DIVERSION
- HYDROGRAPH COMBINE & DIVERSION POINT
- NON-CONTRIBUTING AREA
- (222) 24 HOUR PEAK FLOW
  328 6 HOUR PEAK FLOW
- EXISTING FLOW SPLIT

CHANNEL ROUTING CONVEYANCES

	SLOPE	DESIGN CAPACITY (10-YR CFS)	DESIGN DEPTH, FT	FULL FLOW CAPACITY, CFS	FULL FLOW DEPTH, FT	BY PASS FLOW, CFS
60" RCP	0.2%	100	3.7	119	5	0
CHANNEL 1	0.45%	600	3.0	1,337	4.5	0
CHANNEL 2	0.21%	600	3.0	1,926	5.5	0
CHANNEL 3	0.06%	600	3.2	1,630	5.5	0

MODELING NOTES:

1. ALL FLOWS ALONG VAN BUREN WERE MODELED WITH ROUTING TO WEST. ALL OVER FLOWS WERE ASSUMED TO CONTINUE WEST.
2. PER CITY OF AVONDALE, EXISTING CONDITION IS FLOWS SPLITS AT VAN BUREN DIVERT FLOW SOUTH AT 103RD, 107TH, 111TH AND 113TH AVENUES, COLD WATER SPRINGS GOLF COURSE AND EL MIRAGE ROAD. ACTUAL DISCHARGE TO SPLITS ARE UNKNOWN.

FIGURE 4.4.1 - HEC-1 RECOMMENDED PLAN MODEL RESULTS - 10-YEAR PEAK FLOWS OF UPDATED CURRENT CONDITION
ROUTING WEST THROUGH CONCEPTUAL CHANNELS AND RCP'S

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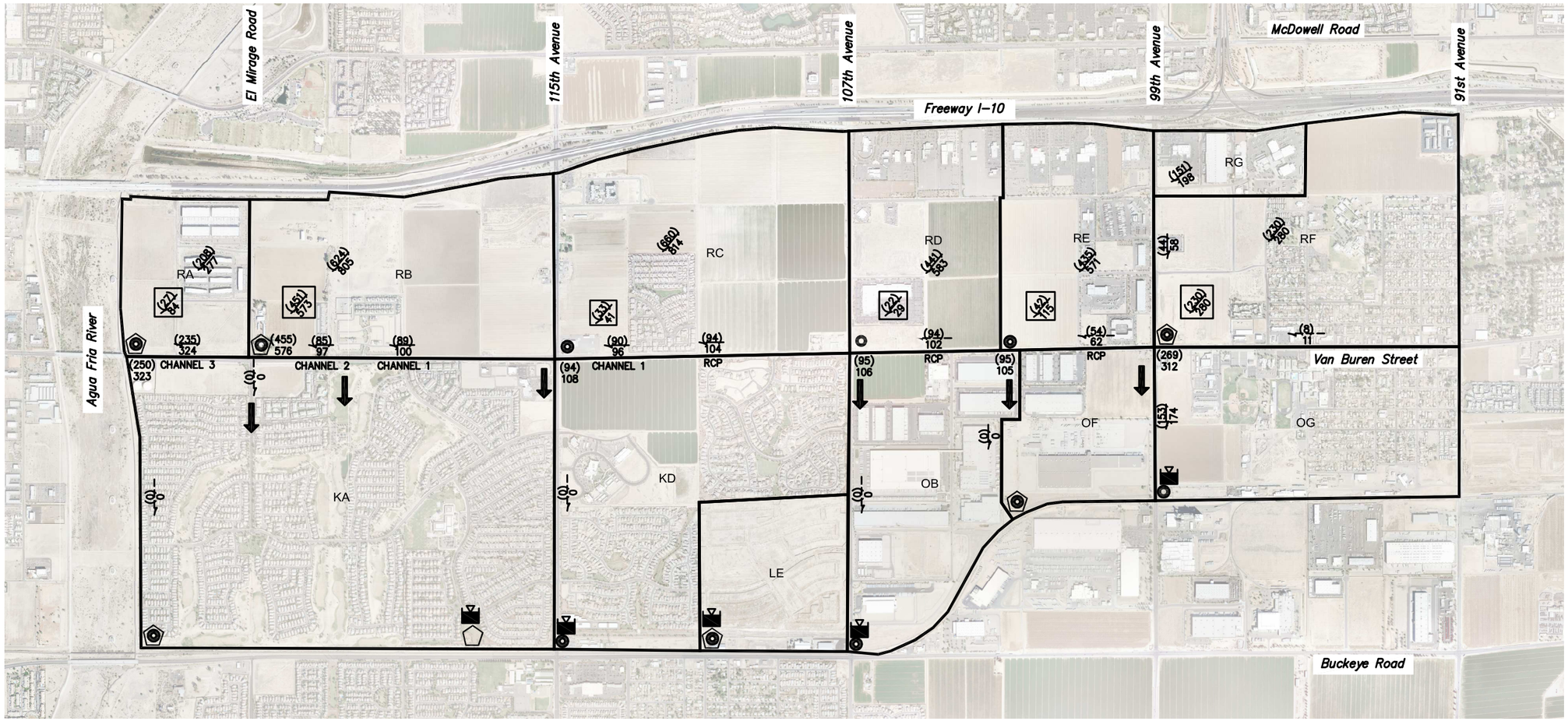
P:\FCDMC\03700.001VanBuren III\Dwg\Exhibits\Figure 4.4.1 - HEC1 Recommended Plan Results-10-Yr Pk Flows-Current Condition.dwg Jul 19, 2013 8:11am hpswell



LEGEND

- SUB-BASIN RUNOFF BEFORE RETENTION
- SUB-BASIN RUNOFF AFTER RETENTION
- FLOW ROUTING
- DIVERT ROUTING
- HYDROGRAPH COMBINE POINT
- FLOW DIVERSION
- HYDROGRAPH COMBINE & DIVERSION POINT
- PROPOSED DETENTION BASIN
- NON-CONTRIBUTING AREA
- ADMP BASIN
- (222) 24 HOUR PEAK FLOW
  328 6 HOUR PEAK FLOW
- EXISTING FLOW SPLIT

MODELING NOTES:

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2. PER CITY OF AVONDALE, EXISTING CONDITION IS FLOWS SPLITS AT VAN BUREN DIVERT FLOW SOUTH AT 103RD, 107TH, 111TH AND 113TH AVENUES, COLD WATER SPRINGS GOLF COURSE AND EL MIRAGE ROAD. ACTUAL DISCHARGE TO SPLITS ARE UNKNOWN.
3. THIS MODEL RUN REDUCES RETENTION PROVIDED FOR COLDWATER DEPOT (RA), COLDWATER DEPOT III (RA), SCHOOL (RA), AND DESERT SPRINGS (RB). THE REDUCTION IN RETENTION IS DUE TO RETENTION BASIN BEING CONVERTED TO CHANNEL BY THE PROJECT.

FIGURE 4.4.2 - HEC-1 RECOMMENDED PLAN MODEL RESULTS - 10-YEAR PEAK FLOWS OF FUTURE CONDITION - MODIFIED RETENTION ROUTING WEST THROUGH CONCEPTUAL CHANNELS

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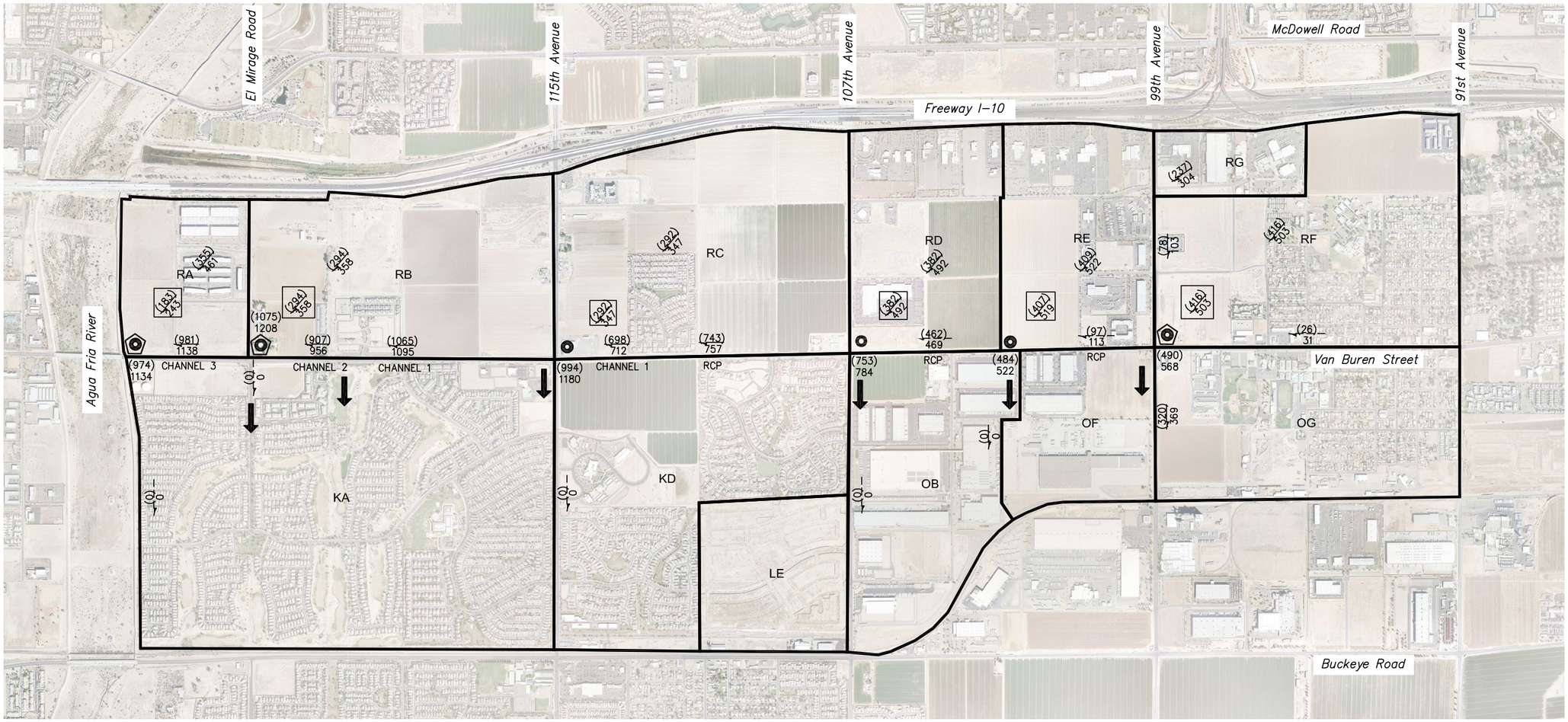
P:\FCDMC\03700.001VanBuren III\Dwg\Exhibits\Figure 4.4.2 - HEC-1 Recommended Plan Model Results - 10-Year Peak Flows-Future - Modified Retention.dwg Jul 19, 2013 7:52am hpowell



LEGEND

- SUB-BASIN RUNOFF BEFORE RETENTION
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- FLOW ROUTING
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- NON-CONTRIBUTING AREA
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  328 6 HOUR PEAK FLOW
- EXISTING FLOW SPLIT

CHANNEL ROUTING CONVEYANCES

	SLOPE	DESIGN CAPACITY (10-YR CFS)	DESIGN DEPTH, FT	FULL FLOW CAPACITY, CFS	FULL FLOW DEPTH, FT	BY PASS FLOW, CFS
60" RCP	0.2%	100	3.7	119	5	784-119=665
CHANNEL 1	0.45%	600	3.0	1,337	4.5	0
CHANNEL 2	0.21%	600	3.0	1,926	5.5	0
CHANNEL 3	0.06%	600	3.2	1,630	5.5	0

MODELING NOTES:

1. ALL FLOWS ALONG VAN BUREN WERE MODELED WITH ROUTING TO WEST. ALL OVER FLOWS WERE ASSUMED TO CONTINUE WEST.
2. PER CITY OF AVONDALE, EXISTING CONDITION IS FLOWS SPLITS AT VAN BUREN DIVERT FLOW SOUTH AT 103RD, 107TH, 111TH AND 113TH AVENUES, COLD WATER SPRINGS GOLF COURSE AND EL MIRAGE ROAD. ACTUAL DISCHARGE TO SPLITS ARE UNKNOWN.

FIGURE 4.4.3 - HEC-1 RECOMMENDED PLAN MODEL RESULTS - 100-YEAR PEAK FLOWS OF UPDATED CURRENT CONDITION ROUTING WEST THROUGH CONCEPTUAL CHANNELS AND RCP'S

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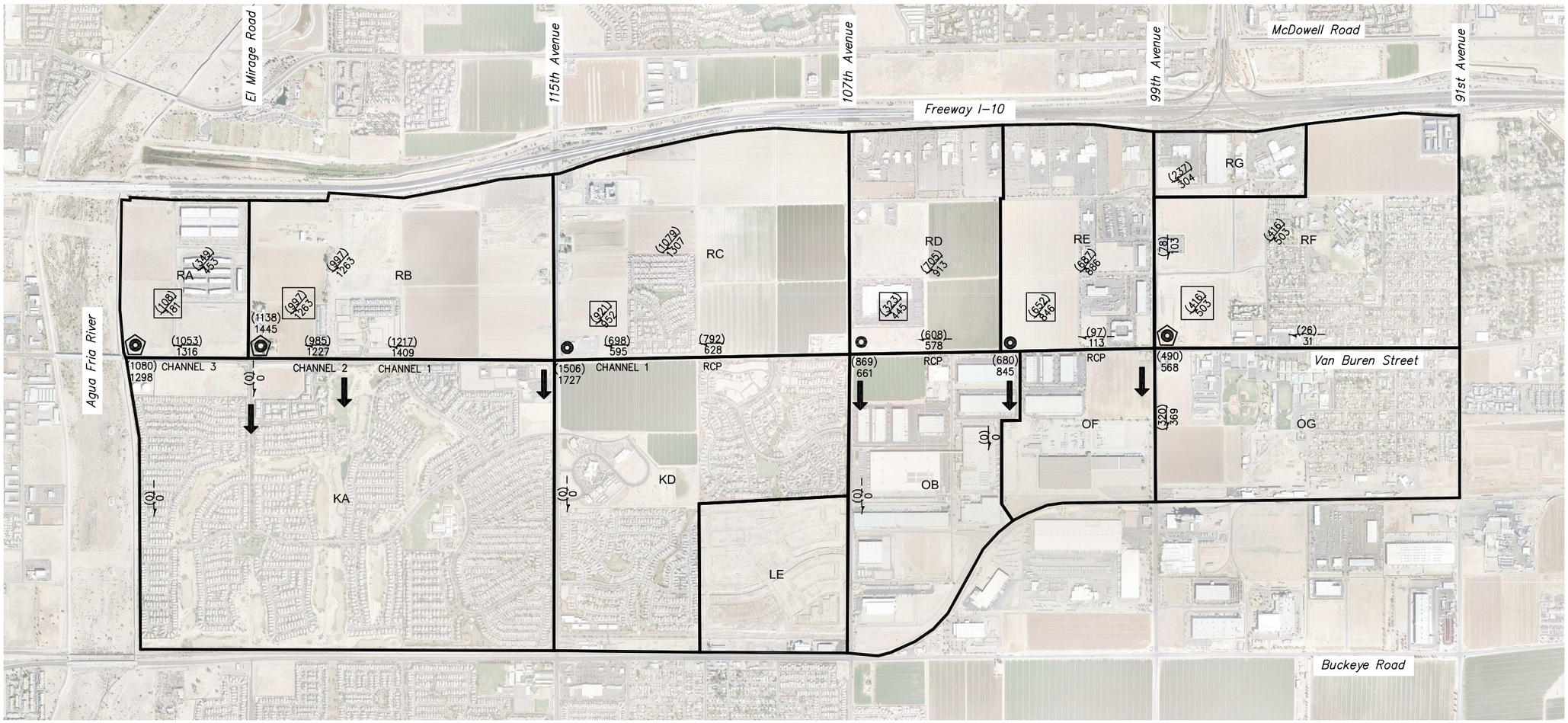
P:\FCDMC\03700.001VanBuren III\Dwg\Exhibits\Figure 4.4.3 - HEC-1 Recommended Plan Results-100-Yr Pk Flows-Current Condition Routing.dwg Jul 19, 2013 8:09am hpowell



LEGEND

- SUB-BASIN RUNOFF BEFORE RETENTION
- SUB-BASIN RUNOFF AFTER RETENTION
- FLOW ROUTING
- DIVERT ROUTING
- HYDROGRAPH COMBINE POINT
- FLOW DIVERSION
- HYDROGRAPH COMBINE & DIVERSION POINT
- NON-CONTRIBUTING AREA
- (222) 24 HOUR PEAK FLOW
- 328 6 HOUR PEAK FLOW
- EXISTING FLOW SPLIT

CHANNEL ROUTING CONVEYANCES

	SLOPE	DESIGN CAPACITY (10-YR CFS)	DESIGN DEPTH, FT	FULL FLOW CAPACITY, CFS	FULL FLOW DEPTH, FT	BY PASS FLOW, CFS
60" RCP	0.2%	100	3.7	119	5	869-119=750
CHANNEL 1	0.45%	600	3.0	1,337	4.5	1727-1337=390
CHANNEL 2	0.21%	600	3.0	1,926	5.5	0
CHANNEL 3	0.06%	600	3.2	1,630	5.5	0

MODELING NOTES:

1. ALL FLOWS ALONG VAN BUREN WERE MODELED WITH ROUTING TO WEST. ALL OVER FLOWS WERE ASSUMED TO CONTINUE WEST.
2. PER CITY OF AVONDALE, EXISTING CONDITION IS FLOWS SPLITS AT VAN BUREN DIVERT FLOW SOUTH AT 103RD, 107TH, 111TH AND 113TH AVENUES, COLD WATER SPRINGS GOLF COURSE AND EL MIRAGE ROAD. ACTUAL DISCHARGE TO SPLITS ARE UNKNOWN.

Flood Control District of Maricopa County

FIGURE 4.4.4 - HEC-1 RECOMMENDED PLAN MODEL RESULTS - 100-YEAR PEAK FLOWS OF FUTURE CONDITION
ROUTING WEST THROUGH CONCEPTUAL CHANNELS AND RCP'S

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P:\FCDMC\03700.001VanBuren III\Dwg\Exhibits\Figure 4.4.4 - HEC-1 Recommended Plan Results-100-Yr Pk Flows of Future Condition.dwg Jul 19, 2013 8:14am hpowell

5 HYDRAULICS

Hydraulic calculations were performed to size various conveyance system components. Normal depth calculations were performed for open channel flow. Culvert calculations were performed for culverts.

5.1 Open Channel Flow

The computer program, FlowMaster, was used to solve for normal depth using the Manning's equation. An n-value of 0.040 was used for granite mulch lined open channels and a value of 0.013 was used for concrete pipes.

The flow capacity of the retention basins at Desert Springs subdivision and Waterford Apartments were checked using FlowMaster. Surveyed cross section data of the existing retention was entered into FlowMaster and the normal depth solved for these areas. An n-value of 0.030 was used for the existing grass. See **Section 3.0** for discussion on use of existing retention basins as channels. See **Appendix D** for hydraulic calculations.

5.2 Culvert Flow

The computer program, CulvertMaster, was used to solve for headwater depth at culverts. Tail water conditions for the culvert calculations are the normal depth of the downstream section. An n-value of 0.013 was used for concrete, and a Ke of 0.5 for head walls was utilized.

Culvert calculations were performed for the proposed culverts at the Agua Fria River levee penetration. These culverts will have flap gates installed on the downstream end to prevent back water from the Agua Fria River from entering the culverts. The flap gates impede the flow of water through the culvert. This is measured and reported as a head loss from factory specifications. A head loss of six inches was added to the calculated headwater elevation.

Tail water conditions for the culverts were the water surface of the Agua Fria River. Per the District the Agua Fria tail water conditions are 100-year design flow for Van Buren channel, use 10-year flow in the Agua Fria, if 10-year design flow, use 100-year flow in Agua Fria. The District provided updated Agua Fria River water surface elevations for the Recommended Plan Analysis. The new Agua Fria TDN estimated the 100-year water surface elevation at 971.78 feet (NAVD88) and the 10-year water surface at 968.07 feet (NAVD88).

The Agua Fria River Levee culverts are a six box array of five-foot by four-foot reinforced box culverts. Four boxes are proposed to be six inches above the Agua Fria River bottom and two boxes are proposed two feet higher. The headwater elevation for the 10-year and 100-year events were calculated using the CulvertMaster computer program. CulvertMaster allows multiple flow components at different sizes and inverts. The program calculates a rating curve for all the flow components and then calculates the headwater elevation for the given flow. The expected headwater elevation in the channel was calculated at the 10-year flow with 100-year water level in the Agua Fria, and the 100-year flow with 10-year flow in the Agua Fria. See **Appendix E** for culvert calculations.

5.3 Flap Gates

Flap gates will be installed on the outlets of the Agua Fria culverts. The flap gates specified are heavy duty high head rated gates by Hydrogate. See **Appendix E** for manufacturer's information, pamphlet and head loss curves. The flap gates have head loss associated with the flow impendence they impose on the outflowing water. The manufacturer provides empirical head loss curves for the gates with different pipe sizes. Peak head loss for a 60-inch pipe (area equivalent to the culvert) is approximately 0.26 feet for 80 cubic feet per second. Maximum flow rate of the culvert is approximately 120 cubic feet per second per barrel which equates to a head loss of 0.20 feet. A conservative head loss of 0.5 feet was added to culvert headwater calculations.

The flap gates are designed to prevent backwater from entering the pipe. Flow in the positive direction will occur as long as the water level on the backside of the gate is higher than the front side of the gate. In the case of the Agua Fria River (front side of gate), if the river is flowing high enough to cover the flap gates, then water from the channel will not flow into the Agua Fria River. Flow into the Agua Fria River will occur when the channel water level rises higher than the Agua Fria River. The calculated headwater plus flap gate head loss for the 10-year and 100-year events show positive flow occurs into the Agua Fria River.

Hydrogate provided a letter stating this application is the intended use for the flap gates. They point out that the heavy duty gates specified are for high head applications and a low head gate can be used. It is our opinion that the heavy duty gate is needed more for the maintenance and to deter vandalism. See **Appendix E** for the Hydrogate letter.

6 CONCLUSION

The Van Buren DCR Recommended Alternative is a storm water conveyance that provides the area north of Van Buren Street a direct connection to the Agua Fria River. The conveyance will reduce runoff in Van Buren Street and allow reduced retention requirements in the City Center area. Phase I is an open channel from Avondale Boulevard to the Agua Fria River with a design flow of 600 cubic-feet per second. Phase II is a 60-inch storm drain pipe form Avondale Boulevard east to 103rd Street. Both alignments are on the north side of Van Buren Street and will be enhanced with one of four landscape themes developed for the project. The landscape theming provides a continuous trail connection from the Agua Fria River to 99th Street. The estimated total cost with landscape enhancements is $18.6 million.

The Recommended Alternative was chosen based on two different Alternative Analyses that were conducted for the project. The first Alternative Analysis investigated 100-year level conveyances on three different alignments from 99th Street to the Agua Fria River. The second Alternative Analysis analyzed 10-year level conveyances. The 100-year level conveyances were determined to be too costly and the second analysis was conducted.

An IGA will be entered into by the District and COA for final design and construction of the project. The District will provide a cost share of 40% of the design for Phases I and II, Phase I right-of-way-acquisition, utility relocations and construction. COA will be expected to contribute 60% of the cost for the final design, Phase I right-of-way, utility relocations and construction. COA will be responsible for 100% of Phase II construction costs. It is also understood COA will be the lead agency for design, right-of-way acquisition, utility relocations and construction. COA will also be responsible for operation and maintenance. District funding is available to COA for up to 15 years.

It is recommended during final design that the benefits to the DROP be documented. This will require detailed topographic survey to determine flow splits to the south at intersections. The detailed flow splits can be entered into the model to quantify the proposed flow to the south that works its way to the DROP. The existing and proposed flows in the DROP should be quantified to determine if the DROP is adversely affected or conversely determine that additional conveyance capacity is available within other projects.

7 REFERENCES

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