

# 115<sup>th</sup> AVENUE AND UNION HILLS PROJECT ALTERNATIVES ANALYSIS REPORT PCN 450.07.31



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# 115<sup>th</sup> Avenue and Union Hills Project

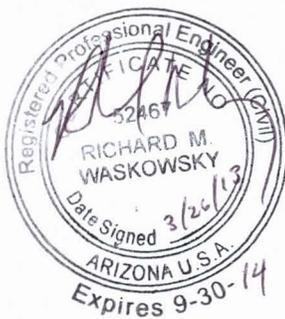
## Alternatives Analysis

by

The Flood Control District

of Maricopa County

March 22, 2013



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## Executive Summary

The Glendale/Peoria ADMPU – 107<sup>th</sup> Avenue and Union Hills Drive Design Concept Report (DCR) by Goodwin and Marshall included a recommendation for a channel and basin to handle the 100-year Beardsley Road Channel flows. This recommendation was costly, so a two-day Value Analysis Meeting was conducted which provided an alternative recommendation, but also recommended further review of some additional alternatives.

This Alternatives Analysis, performed by FCD's Engineering staff, further reviewed five alternatives for handling the Beardsley Channel Flow.

The recommended alternative from the Alternatives Analysis, using NOAA 14 and an unsteady HECRAS model, splits the Beardsley Channel flows at Beardsley Road and 115<sup>th</sup> Avenue, with most of the flows going south along 115<sup>th</sup> Avenue in storm drains that outlet to the Canyon Ridge Channel at Union Hills and 115<sup>th</sup> Avenue. The remaining Beardsley Channel peak flows will go west through the existing culverts and channels into the golf course and its existing basin. The recommended alternative includes the DCR's recommended storm drains along 107<sup>th</sup> Avenue and along Union Hills, and includes up-sizing the culverts in the Canyon Ridge Channel along 115<sup>th</sup> Avenue. The recommended alternative also includes a stilling basin at the northeast corner of 115<sup>th</sup> Avenue and Bell Road and improvements to the outfall channel south of Bell Road. The recommended alternative can be phased as follows:

Phase 1 – Improvements to Outlet Channel south of Bell Road; stilling basin at 115<sup>th</sup> Avenue and Bell Road; storm drains and catch basins to mitigate flows at the 115<sup>th</sup> Avenue and Union Hills Drive intersection, upsize culverts along 115<sup>th</sup> Avenue within Canyon Ridge Channel.

Phase 2 – Storm Drains along 107<sup>th</sup> Avenue, storm drains along Union Hills Drive from 107<sup>th</sup> Avenue to Canyon Ridge Channel, small channel or basin at northwest corner of Union Hills Drive and 111<sup>th</sup> Avenue.

Phase 3 – Improvements to Beardsley Channel from 111<sup>th</sup> Avenue to 115<sup>th</sup> Avenue, splitter structure at Beardsley Road and 115<sup>th</sup> Avenue, storm drains down 115<sup>th</sup> Avenue from Beardsley Road to Union Hills Drive.

### A. Introduction

This report has been prepared to review alternatives for handling stormwater runoff from the area between Beardsley Road and Bell Road and between 107<sup>th</sup> Avenue and 115<sup>th</sup> Avenue. A Draft Design Concept Report (DCR) was prepared in June 2011 that recommended routing the runoff from the Beardsley Road channel along an alignment of about 113<sup>th</sup> Avenue to Union Hills. The combined Union Hills and Beardsley flows would be routed along Union Hills to 115<sup>th</sup>

Avenue and then south to Bell Road. At Bell Road the 115<sup>th</sup> Avenue flows would be joined with Sun City Drain Flows from the east. The new combined flows would then flow through the Box Culverts at Bell Road to an existing regional drainage channel and south to the Aqua Fria River.

The design provided in the DCR was costly and had several utility conflicts. A Value Analysis (VA) was conducted that proposed alternative concepts. The District Engineering staff was asked to review the VA alternative concepts for routing the flows in this area and determine feasibility and provide cost estimates and pros/cons for each alternative.

### A.1 Basis of Cost Estimates

Cost estimates for pipes, channels and structures are based on recent bids received by the District from contractors for similar work.

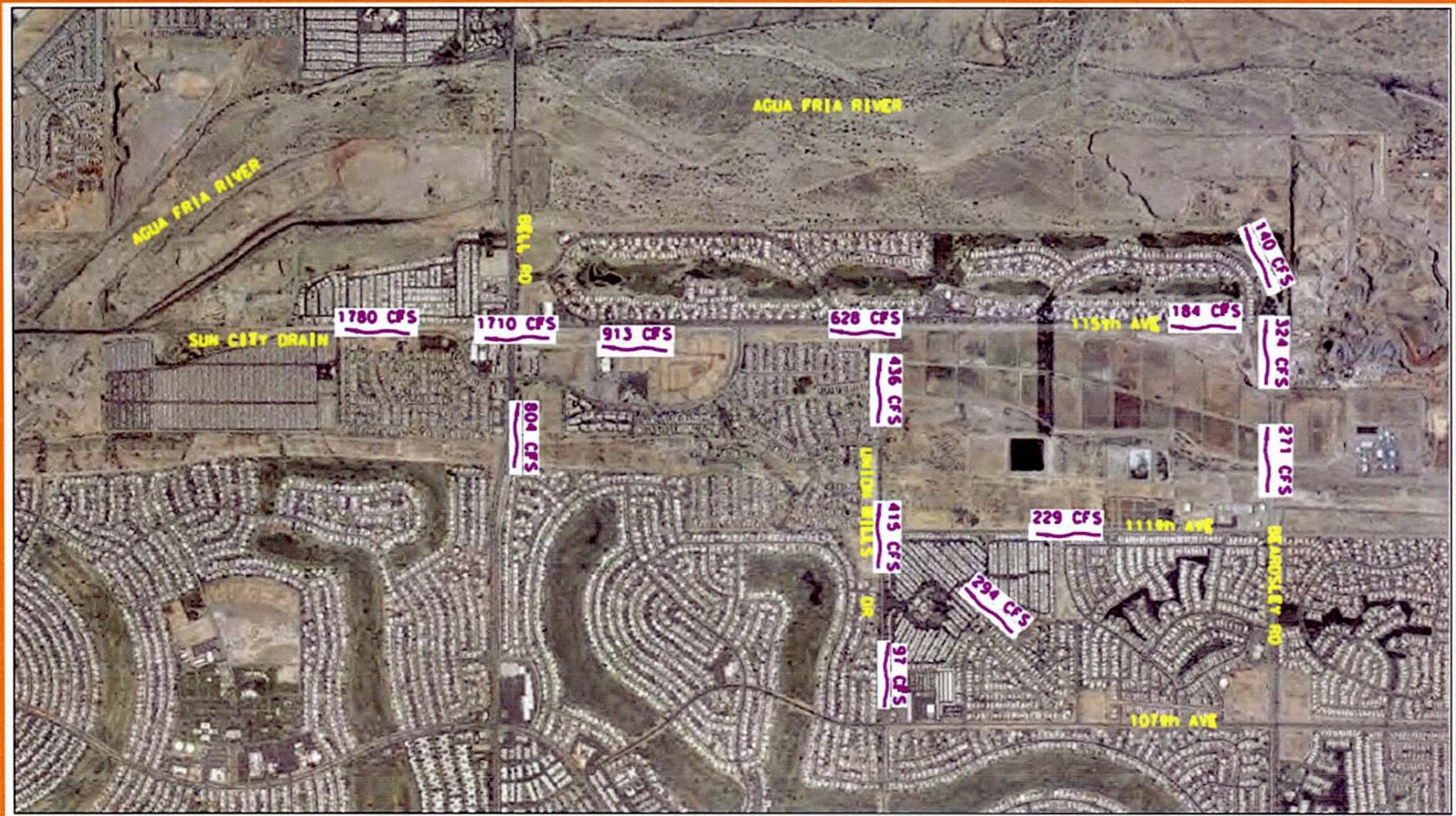
Cost estimates on land values are based on recent land appraisals (see Appendix I). The appraisals were preliminary and will need to be updated once an alternative is selected.

Cost estimates for mineral rights are based on in-house experience in negotiating quantities and unit costs.

### A.2 Hydrology

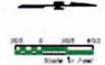
The existing conditions flows were calculated from the HEC-1 model, ex100-24.dat. The DCR used NOAA 2 for the hydrology model. The model for this report used the NOAA 14 100-year 24 hour rainfall in order to provide the most current rainfall data. The existing conditions flows are shown in Exhibit 1. The revised hydrology and hydrologic calculations are provided on the CD in Appendix H.

The DCR contained Exhibit 2 which shows areas of historical flooding north of Bell Road. Based on a preliminary HEC-RAS model, the areas of potential flooding south of Bell Road were estimated and provided in Exhibit 3.



**LEGEND:**

97 CFS NOAA14 FLOW (CUBIC FEET PER SECOND)



FLOOD CONTROL DISTRICT OF MARICOPA COUNTY  
ENGINEERING DIVISION  
107th AVE AND UNION HILLS DR  
DRAINAGE VALUES  
(EXISTING CONDITIONS)

Exhibit 1,  
Existing  
conditions  
100-year 24-  
hour flows  
based on  
NOAA-14  
with HEC-1  
routing.

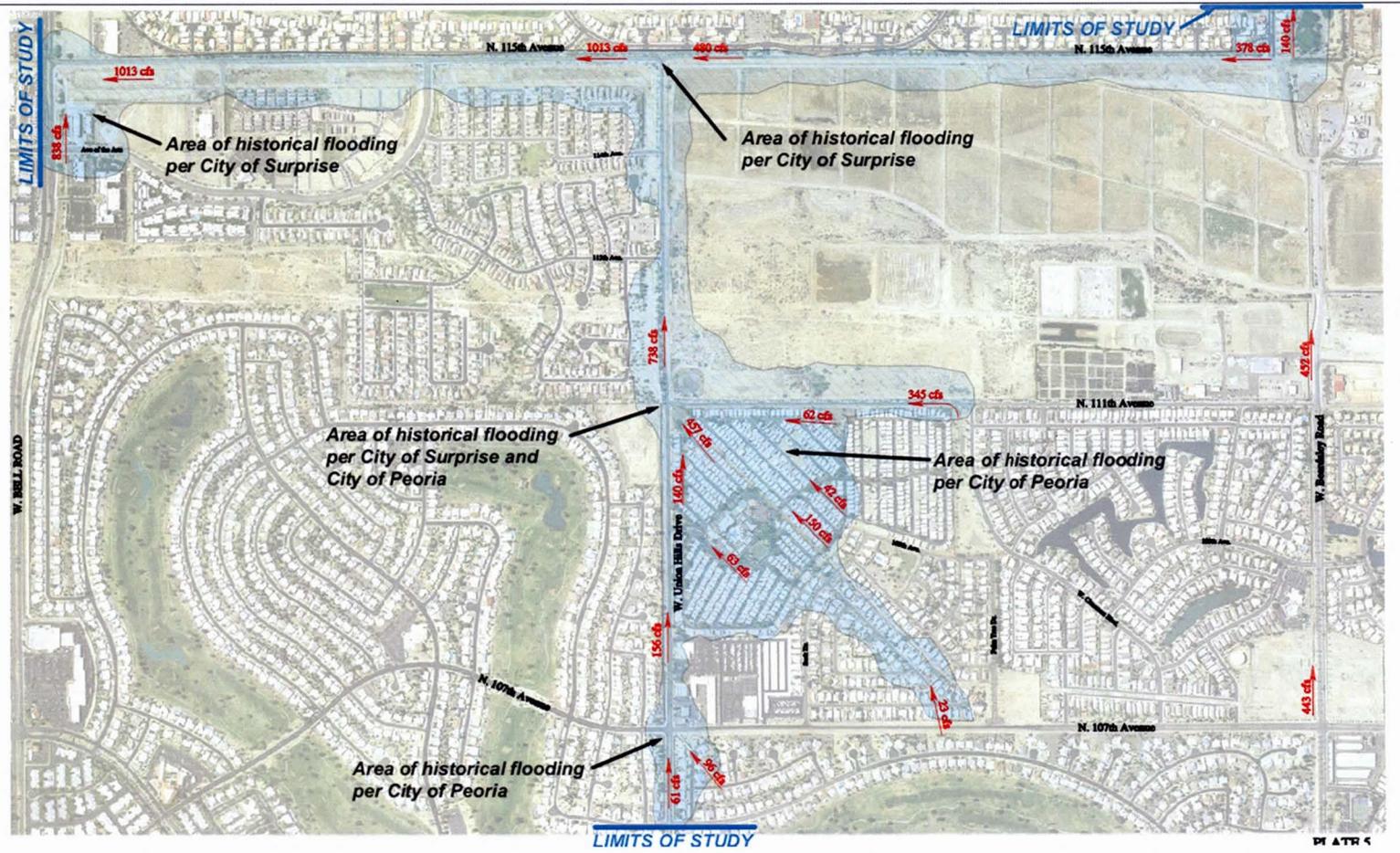


Exhibit 2, Areas of Historical Flooding North of Bell Road.



Exhibit 3, Potential Flooding South of Bell Road.

To obtain a more refined estimate of the attenuation in the Canyon Ridge Channel, two unsteady HEC-RAS models were developed. One model assumed the entire 324 cfs from the intersection of 115th Avenue and Beardsley Road was diverted south along 115th Avenue. The other model assumed the entire 324 cfs was diverted to the Agua Fria River. In this way, the effect of the Beardsley Road diversion could be seen at the Bell Road culvert. With the full 324 cfs diverted south, the flow at Bell Road was calculated to be 1360 cfs (as compared to 1710 cfs from HEC-1 in Exhibit 1). With the full 324 cfs diverted west, the flow at Bell Road was calculated to be 1250 cfs (as compared to 1710 cfs from HEC-1 in Exhibit 1). As a note, the 1710 cfs from HEC-1 used a partial (~2/3 south, ~1/3 west) diversion at Beardsley Road.

### A.3 Survey

Ground survey was obtained by the District's survey crew to ensure alternatives are feasible and to obtain additional information for the conceptual design. A copy of the survey data is included on the CD in Appendix H.

### A.4 Utility Conflicts

Maps of the alternatives were sent to utility companies to obtain input on possible conflicts. Scanned copies of the responses are included on the CD in Appendix H.

## B. Beardsley Channel Flows

### B.1 Existing Conditions

The existing peak flow as calculated using NOAA 14 100-year 24-hour data is 324 cfs in the Beardsley Road channel. The 100-year 24-hour data is being used as it has the greatest peak flows for this area.

The Beardsley Road channel on the south side of the road is concrete-lined east of 113th Avenue. It then flows through six 36-inch CMP Culverts to a dirt channel that drains to three 36-inch CMP culverts that connect to another dirt channel. The dirt ditch does not currently hold all of the 100-year flows. At about 115<sup>th</sup> Avenue some of the flows enter into two 36-inch CMP pipes that drain into the Coyote Lakes Golf Course. Based on Culvert Master analysis, the two 36-inch pipes will only allow about 55 cfs during a 100-year storm to pass into the Golf Course. The remaining flow ponds at the north end of 115<sup>th</sup> Ave and flows south along 115<sup>th</sup> Avenue causing roadway flooding.

A storm in January, 2010 resulted in the off-site flows filling the north portion of the golf course and overflowing into the adjacent sand and gravel pit causing headcutting and erosion at the golf course and the adjacent sand and gravel pit. As part of the repairs, the golf course increased the size of the retention basin in the north end of the golf course. The retention basin now has an approximate capacity of 9 acre-feet.

## B.2 Beardsley Road Channel Improvements from ~113<sup>th</sup> Ave to 115<sup>th</sup> Ave

There is a concrete lined channel east of the 113<sup>th</sup> Ave alignment on the south side of Beardsley Road that terminates in six 36-inch culverts under the private road access at the 113<sup>th</sup> Ave alignment. The 100-year 24hr flows are 324 cfs. West of the 113 Ave alignment the flow is conveyed by a dirt lined channel. The dirt-lined channel is poorly maintained and does not contain the 100-year flow.

The channel can be improved from the 113<sup>th</sup> Ave alignment to 115<sup>th</sup> Ave to hold the 100-year 24-hr flow by changing to a rip-rap lined trapezoidal channel with a 20-foot bottom, a depth of 4 feet and 3 to 1 side slopes (See Appendix A). The existing three 30-inch culverts at the crossing at the 114<sup>th</sup> Ave alignment would be replaced with six 42-inch RGRCP culverts. The cost estimate for these improvements is shown in Table 1.

### B.2.1 Land Ownership and Jurisdiction

From the 113<sup>th</sup> Ave crossing west for approximately 400 feet the channel is located in a public right-of-way that is partially in the jurisdiction of the City of Peoria and Maricopa County. It appears that the north half of the channel is located in the Maricopa County Jurisdictional area and the south half in Peoria.

To the west of the public right-of-way the property is owned by Arizona American Water Company (now EPCOR) to just east of the 114<sup>th</sup> Avenue crossing. This property is located in the County jurisdiction.

The crossing at 114<sup>th</sup> Avenue is owned by Hope Resources LLC and is in the County jurisdiction.

West of the 114<sup>th</sup> Avenue crossing the channel is in property owned by Coyote Lakes Joint Venture and is in the County jurisdiction.

Table 1 – Cost Estimate for Beardsley Channel Improvements from 113<sup>th</sup> Ave to 115<sup>th</sup> Ave

Item	Unit Cost	Unit Type	# of Units	Cost
Regrade Channel	\$2.50	SQFT	79200	\$198,000
Install 6" Rip Rap	\$50.00	CUYD	4400	\$220,000
Install 42" RGRCP Pipe	\$150.00	LF	450	\$67,500
Subtotal Cost				\$485,500
Design		LS		\$33,985
Mobilization		LS		\$14,565
Land Costs		LS		\$100,000
Project Management		LS		\$48,550
Total Cost				\$682,600

Pros:

- Keeps flows in channel
- Reduces maintenance costs
- Reduces inundation of Wastewater Infiltration Basins

Cons:

- None

### B.3 Beardsley Road at 115<sup>th</sup> Avenue

Several alternatives have been identified on how to manage the flows from the Beardsley Channel once they reach 115<sup>th</sup> Avenue. The alternatives are as follows:

B1 – Take flows west to the river

B2 – Take flows through golf course to new channel in existing 50-foot embankment easement.

B3 – Take flows to a proposed retention basin at Beardsley and 115<sup>th</sup> Avenue on the Sand and Gravel Mining property to the north of Beardsley.

B4 – Take flows south along 115<sup>th</sup> Avenue.

B5 – Take flows through the golf course to a basin just west of the golf course.

#### B.3.1 Alternative B1 – Take Flows West to the River

This alternative will take the 100-year flow west, in a 30-foot easement to be purchased along east and north property lines of the golf course and then west to the main channel of Agua Fria River across the Mining Property and State Lands (See Appendix B1). As the terrain is very flat, this option would require construction of 3150 linear feet of three 72" Diameter Concrete Pipe and the acquisition drainage easements over approximately 2.4 acres land plus the purchase of mineral rights for 1.05 acres of land.

The cost to purchase the mineral rights is highly variable both in quantity and price. An estimate is provided based on a 100-ft depth of minerals and 3 to 1 side slopes on either side of the 30-foot easement.

Table 2 presents the cost estimate for this option.

##### B.3.1.1 Land Ownership and Jurisdiction

The existing 36-inch pipes at the west end of the Coyote Lakes Venture parcel continue west through a public right-of-way that is partially owned by the County and partially by the City of Surprise.

The Golf Course property is owned by NTM Investments LLC and is located in the City of Surprise.

The route west of the golf course is owned by WAW LLC and ACAEL LLC until it gets to the State Land property. Both the WAW LLC and ACAEL LLC properties are located in the County's jurisdiction.

The final portion of the route is on State Land which is located in the County's jurisdiction.

Table 2 – Cost Estimate for Alternative B1

Item	Unit Cost	Unit Type	Qty	
Clear and Grub	\$5,000.00	Acre	2.32	\$11,600
Landscaping with Trees	\$7,500.00	Acre	0.88	\$6,600
Fill and Regrading	\$20,000.00	LS	1	\$20,000
Install 72" RGRCP Pipes	\$350.00	LF	9450	\$3,307,500
Headwalls	\$10,000.00	EA	2	\$20,000
Manhole Boxes	\$15,000.00	EA	5	\$75,000
Subtotal Cost				\$3,440,700
Design				\$240,849
Mobilization				\$103,221
Easement - Golf Course	\$60,000.00	Acre	0.88	\$52,800
Easement - S&G Lands	\$25,000.00	Acre	1.05	\$26,250
Easement - ALSD Lands	\$25,000.00	Acre	0.39	\$9,750
Mineral Rights Cost		2 CUYD	730000	\$1,460,000
Project Management				\$344,070
Total Cost				\$5,677,640

Pros:

- Shortest Path to River
- Decreases long term erosion impacts to Golf Course
- Utility conflicts unlikely

Cons:

- There are several trees along the property on the Golf Course side of the fence that will need to be removed to install the drainage pipe that will be hard, if not impossible, to replace
- There will be some interruption with Golf Course operations
- Costs of mineral rights are highly variable and could be higher than shown in cost estimate
- Pipes in the river may be sacrificed during major flooding event.
- Fill will be required to cover the pipe in west part of mining property which is located in Floodway which requires a 404 permit.
- Have to obtain easements from Golf Course, ASLD, and Mining Property Owners
- Water is being diverted to point in river where it does not go in existing conditions.
- Will have some temporary and some permanent impacts to Sand and Gravel Operations (i.e. crosses conveyor belt and access roads, limits mining depths and areas).
- There may be protracted legal issues with owners and operators of the sand and gravel mine.

### B.3.2 Alternative B2 – Flows Through Golf Course to New Channel in Existing 50-Foot Berm Maintenance and Access Easement along the East Side of Coyote Lakes

This Alternative takes flows from Beardsley Road through the golf course to a new drainage ditch located in a 50-foot embankment easement on the west side of Coyote Lakes (See Appendix B2). One alternative to get the water to the new drainage ditch will be to pipe the flows along the north and west property lines of the Golf Course in a new 30-foot easement using a design similar to that in Alternative B1.

Another alternative would be to route the water in a channel through the golf course to the 50-foot embankment easement on the west side of Coyote Lakes.

#### B.3.2.1 Land Ownership and Jurisdiction

The existing 36-inch pipes at the west end of the Coyote Lakes Venture parcel continue west through a public right-of-way that is partially owned by the County and partially by the City of Surprise.

The Golf Course property is owned by NTM Investments LLC and is located in the City of Surprise.

The property along the west side of Coyote Lakes is owned by WAW LLC. South of the WAW LLC property, the route is on State Land. The 50-foot embankment easement does not include drainage and prohibits the land owners from excavating in this area.

#### B.3.2.2 Alternative B2a- Piping Through the Golf Course

In order to maintain adequate cover over the pipes, it would take 3-72" RGRCP pipes to convey the entire flow to a new channel in the embankment easement.

Once in the embankment easement the runoff can flow in a dirt lined channel south to a point just north of Bell Road and then west to the main channel of the river.

Table 3 presents the cost estimate for this option.

Table 3 – Cost Estimate for Alternative B2a

Item	Unit Cost	Unit Type	Qty	
Clear and Grub	\$5,000.00	Acre	11.38	\$56,900
Landscaping - Golf Course	\$7,500.00	Acre	1.48	\$11,100
Landscaping - Desert	\$4,500.00	Acre	9.9	\$44,550
Install 72" RGRCP Pipes	\$350.00	LF	9450	\$3,307,500
Headwalls	\$10,000.00	EA	2	\$20,000
Manhole Boxes	\$15,000.00	EA	5	\$75,000
Channel Excavation	\$6.00	LF	10000	\$60,000
New Drainage Channel	\$25.00	LF	10000	\$250,000
Subtotal Cost				\$3,825,050
Design				\$267,754
Mobilization				\$114,752
Easement on Golf Course	\$60,000.00	Acre	2.18	\$130,800
Easement on Mining Prop	\$20,000.00	Acre	4.1	\$82,000
Easement on State Land	\$20,000.00	Acre	5.8	\$116,000
Project Management				\$382,505
Total Cost				\$4,918,860

Pros:

- Would have no or minimal impacts to sand and gravel mine operations
- Eliminates long term erosion impacts to Golf Course

Cons:

- There are several trees along the property on the Golf Course side of the fence that will need to be removed to install the drainage pipe that will be hard, if not impossible, to replace.
- There will be some temporary interruptions with Golf Course operations.
- Will require easement acquisition from the Golf Course, ASLD and Mining Land Owners

- Will discharge most of the runoff at a point upstream of where it goes now (i.e. most of the flows goes south of Bell Rd along 115<sup>th</sup> Avenue)
- Not supported by the City of Surprise due to golf course impacts

#### B.3.2.3 Alternative B2b- Channel through the Golf Course

This alternative would be to take all the flows into the golf course with some drainage channel improvements to convey the flows to golf course retention basin and from there to the 50-foot embankment easement. This alternative will require a public drainage easement over portions of the golf course.

The flows that currently get to the golf course flow through two 36" diameter pipes are limited by the size of the pipes. In order to make this alternative work, the 36" diameter pipes will need to be replaced by three 72" diameter pipes. The existing rip-rap lined channel from the west side of the 115<sup>th</sup> Avenue Right-of-Way (ROW) to the detention basin in the golf course as well as the golf course path crossings will need to be enlarged to contain the entire 324 cfs flow within the channel and the basin. A new channel will need to be constructed from the retention basin in the golf course to the 50-foot embankment easement along the west side of Coyote Lakes. This new channel will cross an existing grass fairway and should be designed with side slopes flatter than 6 to 1 and be grass lined to allow golfers access into and across the channel. In addition, at least two crossing points will be needed.

Once in the embankment easement the runoff can flow in a dirt lined channel south to a point just north of Bell Road and then west to the main channel of the river.

Table 4 presents the cost estimate for this option.

Table 4 – Cost Estimate for Alternative B2b

Item	Unit Cost	Unit Type	Qty	
Clear and Grub	\$5,000.00	Acre	4	\$20,000
Landscaping - Golf Course	\$7,500.00	Acre	4	\$30,000
Golf Course Channel	\$30.00	LF	1000	\$30,000
Golf Course Channel	\$20.00	LF	1000	\$20,000
Install 72" RGRCP Pipes	\$350.00	LF	950	\$332,500
Headwalls	\$10,000.00	EA	10	\$100,000
Channel Excavation	\$6.00	LF	10000	\$60,000
New Drainage Channel	\$25.00	LF	10000	\$250,000
Subtotal Cost				\$842,500
Design				\$58,975
Mobilization				\$25,275
Easement on Golf Course	\$60,000.00	Acre	4	\$240,000
Easement on Mining Prop	\$20,000.00	Acre	4.1	\$82,000
Easement on State Land	\$20,000.00	Acre	5.8	\$116,000
Project Management				\$84,250
Total Cost				\$1,449,000

Pros:

- Would have no or minimal impacts to sand and gravel mine operations
- Eliminates long term erosion impacts to Golf Course

Cons:

- There will be major interruption with Golf Course operations.
- Will require easement acquisition from Golf Course, ASLD and Mining Land Owners
- Will require a drainage easement over golf course and some major modifications to one of the fairways in the golf course.
- Will discharge most of the runoff at a point upstream of where it goes now (i.e. most of the flows goes south of Bell Rd along 115<sup>th</sup> Avenue)
- Not supported by the City of Surprise

### B.3.3 Alternative B3- Retention Basin at 115<sup>th</sup> Avenue and Beardsley

This alternative takes all flows to a new basin on the north side of the Beardsley Channel just east of the intersection of 115<sup>th</sup> Avenue and Beardsley Road. The basin would be designed to hold the entire 100-year flow without discharge. This would require the acquisition of approximately 6.6 acres of the mining property to build a retention basin to hold 57 acre-feet of runoff which is the entire flow from Beardsley Road during a 100-year 24-hr storm event (see Appendix B3 for calculations).

Most of the proposed basin area is currently leased for sand and gravel mining and is occupied by several trailers, some pieces of equipment (i.e. scale house), and is part of the access roads for an active sand and gravel mine. All of which would have to be relocated for the basin. The relocation of this operations site would also require some additional relocation of processing plants and conveyor systems in the plant. There is also a parcel on the south side of the proposed basin that is owned by Coyote Lakes Venture which may no longer exist. There are several years of back taxes due on the property. This parcel includes the existing dirt drainage channel and as built plans show an embankment that is part of the Coyote Lakes floodwall system.

The cost estimate presented in Table 5 includes the costs for the loss of mineral rights and assumes a depth of minerals of 100 feet. The cost of mineral rights is highly variable both in quantity and unit costs. The property owner has indicated that they believe there is at least 200 feet of minerals available for mining in this area. However, that assumption also depends on the mining company being able to get a permit to mine to that depth. The costs could be reduced by negotiating a reduced quantity or unit cost or by allowing the mining company the use of the aggregate removed. It may also be possible to allow the mining company to keep the mineral rights in exchange for handling the runoff within the mine area. The adjacent "grandfathered" pit has the potential to cause long term problems which could result in litigation. If the retention basin is part of the same operation or connected, it has the potential to involve the District or others in the litigation.

#### **B.3.3.1 Land Ownership and Jurisdiction**

The land is owned by Hope Resources LLC with the strip in the existing channel being owned by Coyote Lakes Joint Venture. The area is within the jurisdiction of the County.

Table 5 – Cost Estimate for Alternative B3

Item	Unit Cost	Unit Type	Qty	
Clear and Grub	\$6,000.00	Acre	6.6	\$39,600
Excavate Drainage Basin	\$10.00	CuYd	74536	\$745,360
Relocation of Equipment				\$500,000
Replace Landscape	\$5,000.00	Acre	2	\$10,000
Subtotal Cost				\$1,294,960
Design				\$90,647
Mobilization				\$38,849
Easement Costs	\$30,000.00	Acre	6.6	\$198,000
Mineral Rights Costs	\$2.00	CuYd	1064800	\$2,129,600
Project Management				\$129,496
Total Cost				\$3,881,552

Pros:

- Simple design
- Should be fast-draining since in river floodplain
- Eliminates long term erosion impacts to Golf Course

Cons:

- Could lead to long litigation with sand and gravel people over land’s value and mineral rights and costs of relocating facilities which could cause long delays and costs.
- The adjacent “grandfathered” pit has the potential to cause long term problems which could result in litigation. If the retention basin is part of the same operation or connected, it has the potential to involve the District or others in the litigation.

[B.3.4 Alternative B4- Take Flows South Along 115<sup>th</sup> Avenue](#)

There were two options with this alternative. One was to split the flows taking some south along 115<sup>th</sup> Avenue and some flows into the golf course. The other would be to take all of the flows south along the east side of 115<sup>th</sup> Avenue to Union Hills. The Golf Course can hold approximately nine acre-feet of runoff without over topping. There are two options for splitting flows. In both options only the peak flows would be diverted to the golf course. The remaining flows would be piped down 115<sup>th</sup> Avenue. One option to divert the peak flows would be to keep the existing 36-inch pipes in place which will allow approximately 50 cfs of flow through the pipes. This will result in approximately 269 cfs of flow down 115<sup>th</sup> Avenue.

The pipe size could be increased so that 7.5 acre-feet of the peak flows would be diverted to golf course. This amount is what the retention basin in the golf course can hold with a little bit of freeboard, the peak flows in the piped system would be reduced from a peak of 324 cfs to 175 cfs (see Appendix B4 for calculations).

#### B.3.4.1 Land Ownership and Jurisdiction

The route suggested for the pipes along 115<sup>th</sup> Avenue is just east of the existing pavement which will be in the ROW easement for a roadway belonging to MCDOT which is owned by Hope Resources LLC and Arizona-American Water Company. The road easement is located in the jurisdiction of the County. MCDOT has informed us that they are opposed to a channel within the easement, but a storm drain is acceptable. The golf course is owned by NTM Investments LLC and is in the City of Surprise's jurisdiction.

#### B.3.4.2 Split Flows at 115<sup>th</sup> Avenue and Beardsley without modifying the Golf Course

This alternative assumes that the flows are split at 115<sup>th</sup> Avenue and Beardsley with only the peak flows, approximately 50 cfs, flowing through the existing 36-inch culverts into the golf course. Approximately, 269 cfs will flow south along 115<sup>th</sup> Avenue.

One of the assumptions with this estimate is that the District would not have to purchase a drainage easement over the golf course, because the flows getting to the golf course would be significantly reduced and the drainage channel and basin in the golf course will not need to be improved. In addition, there would be no land costs for the pipe along 115<sup>th</sup> Avenue as the pipe will be located in a public Right-of-Way.

In addition, the pipes down 115<sup>th</sup> Avenue could just extend to the south end of the existing Sand & Gravel pit which is too close to the property line to allow the construction of a drainage channel. However, once beyond that point the flows could be placed in a new drainage channel until they get to Union Hills. They would then be piped under Union Hills to channel to south. However, MCDOT is not in favor of having a channel in their future Right-of-Way and would prefer to have runoff piped over the entire distance.

The pipes were sized at 54-inch diameter which is the design size that allows 269 cfs of flow, but only for a half-mile of pipe with the flows being conveyed in a drainage channel for the remaining distance to Union Hills. The estimate did not up size the pipe diameter as the straight short pipe run should have a minimum of head loss and there is enough freeboard for additional head at the pipe entrance to allow for the head loss. However, for this alternative to pipe the flows all the way to Union Hills would require the pipes to have 60-inch diameter. So to allow for future upgrades of the road and drainage system, the District recommends starting with 60-inch drainage pipes even for the shorter drainage pipe system. Table 6a presents the cost estimate for this alternative with pipes along the entire length of 115<sup>th</sup> Avenue. Table 6b

presents the cost estimate for this alternative using an open channel for half the length of 115<sup>th</sup> Avenue. Both costs are presented even though MCDOT has indicated that they will not approve a channel in their future Right-of-Way.

Table 6a – Alternative B4a – Split Flows on 115<sup>th</sup> Avenue (based on existing 36" pipes remaining, no channel on 115<sup>th</sup> Ave)

Item	Unit Cost	Unit Type	Qty	
Clear and Grub	\$2.50	SQYD	29222	\$73,056
Install 60" RGRCP Pipes	\$300.00	LF	9840	\$2,952,000
Box Manholes	\$15,000.00	LF	8	\$120,000
Headwall	\$10,000.00	EA	1	\$10,000
Spilter Structure	\$15,000.00	EA	1	\$15,000
Subtotal Cost				\$3,170,056
Design				\$221,904
Mobilization				\$95,102
Land Costs				\$0
Project Management				\$317,006
Total Cost				\$3,804,067

Table 6b – Alternative B4a – Split Flows on 115<sup>th</sup> Avenue (based on existing 36" pipes remaining with 115<sup>th</sup> Ave channel)

Item	Unit Cost	Unit Type	Qty	
Clear and Grub	\$2.50	SQYD	29222	\$73,056
Install 60" RGRCP Pipes	\$300.00	LF	4920	\$1,476,000
Drainage Channel	\$31.00	LF	4920	\$152,520
Box Manholes	\$15,000.00	LF	4	\$60,000
Headwall	\$10,000.00	EA	1	\$10,000
Spilter Structure	\$15,000.00	EA	1	\$15,000
Subtotal Cost				\$1,786,576
Design				\$125,060
Mobilization				\$53,597
Land Costs				\$0
Project Management				\$178,658
Total Cost				\$2,143,891

Pros:

- No additional right-of-way needed
- Avoids impacts to golf course operations
- This option could be phased to allow only the flooding at Union Hills and 115<sup>th</sup> Avenue to be drained with the rest of the drainage system being installed sometime in the future.
- Eliminates long term erosion impacts to Golf Course
- Keeps flows to the river in the approximate current location

Cons:

- The new channel in 115<sup>th</sup> Avenue would have to be replaced in the future if 115<sup>th</sup> Avenue is widened.
- Would require the City of Surprise to annex the eastside of 115<sup>th</sup> Avenue between Beardsley and Union Hills as MCDOT will not allow a channel in their Right-of-Way.

#### B.3.4.3 Split Flows at 115<sup>th</sup> Avenue and Beardsley Modifying the Golf Course Flows

A second alternative is to split the flows such that the volume of runoff getting to the golf course is less than 9 acre-feet, the volume of the retention basin in the golf course. This would reduce the flows from 269 cfs in alternative B4a to 175 cfs which then allows the use of 54-inch pipes for both the short (with channel) and complete pipe run between Beardsley and Union Hills. However, it would require that improvements be made to golf course channel and pipes between 115<sup>th</sup> Avenue and the retention basin. The cost estimate in Table 6c presents the costs for the short run option and Table 6d presents the costs for the complete pipe run between Beardsley and Union Hills.

Table 6c – Alternative B4b – Split Flows on 115<sup>th</sup> Avenue (based on retention volume w/o 115<sup>th</sup> Ave channel)

Item	Unit Cost	Unit Type	Qty	
Clear and Grub	\$2.50	SQYD	29222	\$73,056
Install 54" RGRCP Pipes	\$250.00	LF	9840	\$2,460,000
Install 42" RGRCP Pipes	\$200.00	LF	500	\$100,000
Box Manholes	\$15,000.00	LF	8	\$120,000
Golf Course Channel	\$30.00	LF	1000	\$30,000
Headwall	\$10,000.00	EA	5	\$50,000
Spilter Structure	\$15,000.00	EA	1	\$15,000
Subtotal Cost				\$2,848,056
Design				\$199,364
Mobilization				\$85,442
Land Costs	\$60,000.00	ACRE	3.1	\$186,000
Project Management				\$284,806
Total Cost				\$3,603,667

Table 6d – Alternative B4b – Split Flows on 115<sup>th</sup> Avenue (based on retention volume with 115<sup>th</sup> Ave channel)

Item	Unit Cost	Unit Type	Qty	
Clear and Grub	\$2.50	SQYD	29222	\$73,056
Install 54" RGRCP Pipes	\$250.00	LF	4920	\$1,230,000
Install 42" RGRCP Pipes	\$200.00	LF	500	\$100,000
Drainage Channel	\$31.00	LF	4920	\$152,520
Box Manholes	\$15,000.00	LF	4	\$60,000
Golf Course Channel	\$30.00	LF	1000	\$30,000
Headwall	\$10,000.00	EA	5	\$50,000
Spilter Structure	\$15,000.00	EA	1	\$15,000
Subtotal Cost				\$1,710,576
Design				\$119,740
Mobilization				\$51,317
Land Costs	\$60,000.00	ACRE	3.1	\$186,000
Project Management				\$171,058
Total Cost				\$2,238,691

Pros:

- This option could be phased to allow only the flooding at Union Hills and 115<sup>th</sup> Avenue to be drained with the rest of the drainage system being installed sometime in the future.
- Eliminates long term erosion impacts to Golf Course

Cons:

- The new channel of 115<sup>th</sup> Avenue would have to be replaced in the future if 115<sup>th</sup> Avenue is widened
- It will temporarily impact golf course operations and require an easement from the golf course
- Would require the City of Surprise to annex the eastside of 115<sup>th</sup> Avenue between Beardsley and Union Hills as the MCDOT will not allow a channel in their Right-of-Way.

In both alternative B4a and B4b the pipe costs would double if the pipes were extended all the way to Union Hills, but the drainage channel costs would be eliminated. It would cost approximately \$250 more in pipe costs between Alternative B4a and B4b for the complete

run, because of the difference in pipe size requirements. For the short run Alternative B4a is less expensive than Alternative B4b by approximately \$95,000. However, for the complete run, Alternative B4a is more expensive than Alternative B4b by about \$150,000.

#### B.3.4.4 All Flows at 115<sup>th</sup> Avenue and Beardsley Being Piped Down 115<sup>th</sup> Avenue

The final alternative would be pipe all of the flows down 115<sup>th</sup> Avenue and let none of the flows go into the golf course. Table 7 presents the cost estimate for this alternative.

Table 7 – Alternative B4c – All Flows on 115<sup>th</sup> Avenue

Item	Unit Cost	Unit Type	Qty	
Clear and Grub	\$2.50	SQYD	29222	\$73,056
Install 60" RGRCP Pipes	\$300.00	LF	9840	\$2,952,000
Box Manholes	\$15,000.00	LF	8	\$120,000
Headwall	\$10,000.00	EA	2	\$20,000
Subtotal Cost				\$3,165,056
Design				\$221,554
Mobilization				\$94,952
Land Costs				\$0
Project Management				\$316,506
Total Cost				\$3,798,067

#### Pros:

- This option could be phased to allow only the flooding at Union Hills and 115<sup>th</sup> Avenue to be drained with the rest of the drainage system being installed sometime in the future.
- Avoids impacts to golf course operations
- Eliminates long term erosion impacts to Golf Course

#### Cons:

- None

#### B.3.5 Alternative B5 – Flows Through Golf Course to Existing Mine Pit West of Golf Course

This will take the 100-year flow west, in a 30-foot easement to be purchased along east and north property lines of the golf course and then discharge the flows into the existing sand and gravel pit located just west of the golf course which would serve as a retention basin with no

outfall. This would require construction of 1980 linear feet of 3-72" Diameter Concrete Pipes and the acquisition drainage easements over approximately 0.88 acres land (see Appendix B5 for calculations).

The existing pit covers an area of about 20 acres. In order for the mining company to manage the runoff in the pit, a drainage easement over the entire pit will be required. However, as the mining company could be allowed to mine the pit while managing the runoff in the pit, we have included an estimate for the mineral rights only over the approximately 5 acres where the outfall will be located and only to a depth of 50 feet. The final cost will have to be negotiated with both the mining company and the land owner.

Table 8 presents the cost estimate for this alternative.

#### [B.3.5.1 Land Ownership and Jurisdiction](#)

The existing 36-inch pipes at the west end of the Coyote Lakes Venture parcel continue west through a public right-of-way that is partially owned by the County and partially by the City of Surprise.

The Golf Course property is owned by NTM Investments LLC and is located in the City of Surprise.

The mining area west of the golf course is owned by WAW LLC which is all located in the County's jurisdiction.

Table 8 – Alternative B5 –Flows Through Golf Course to Existing Mine Pit West of Golf Course

Item	Unit Cost	Unit Type	Qty	
Clear and Grub	\$2.50	SQYD	79200	\$198,000
Landscaping	\$5.00	SQYD	79200	\$396,000
Install 72" RGRCP Pipes	\$350.00	LF	5940	\$2,079,000
Headwalls	\$10,000.00	EA	1	\$10,000
Outfall Structure	\$20,000.00	EA	1	\$20,000
Manhole Boxes	\$15,000.00	EA	3	\$45,000
Subtotal Cost				\$2,748,000
Design				\$192,360
Mobilization				\$82,440
Easement - Golf Course	\$60,000.00	Acre	0.88	\$52,800
Easement - Mining Pit	\$25,000.00	ACRE	20	\$500,000
Mineral Rights Cost	\$2.00	CUYD	403333	\$806,667
Project Management				\$274,800
Total Cost				\$4,657,067

Pros:

- Shortest Path to River

Cons:

- Have to obtain easement from mining company which will need to include costs for long term maintenance of the flows in the Sand and Gravel Pit.
- Requires negotiation with both mine operator and land owner
- All of the water would be diverted to a point in the river where it does not go in existing conditions.

**C. Coyote Lakes Homes**

Floodwaters from Beardsley Channel currently pond at the intersection of Beardsley Road and 115<sup>th</sup> Avenue, and some water enters the Coyote Lakes development at its north entry. Water

moving down 115<sup>th</sup> Avenue may also pond at the southern Coyote Lakes development entry. It was not known if homes would flood at these locations, or if the floodwaters would move into the golf course without flooding homes; therefore, a study was performed to determine if homes have the potential to be flooded during a 100-year storm event. A survey was completed to determine if any homes at these locations would be susceptible to flooding. The District has received reports that intersection at 115<sup>th</sup> Avenue and Coyote Parkway floods, but there have been no reports of flood waters getting into the homes.

The survey results (included in Appendix G and on CD in Appendix H) indicated that none of the homes would be flooded in the 100-year 24-hour storm event. The water would pond at the intersection Coyote Lakes Parkway and 115<sup>th</sup> Avenue, but flow towards the south along 115<sup>th</sup> Avenue. The home located on the northwest corner of Coyote Lakes Parkway and 115<sup>th</sup> Avenue could become flooded if the waters flowing south on 115<sup>th</sup> Avenue were restricted as the finished floor of the house is lower than the top of curb adjacent to the golf course 250 feet west of the house. A curb cut or scupper in this area would eliminate the potential for flooding this home.

## **D. Union Hills**

### **D.1 Existing Conditions**

“Union Hills Drive from 107th Avenue to 111th Avenue utilizes an existing earthen channel located along the south side of the existing pavement to convey storm water flows west to the Canyon Ridge Channel. The channel currently has a maximum capacity of 362 cfs near the 107th Avenue intersection and ending with a capacity of 10 cfs near the 111th Avenue intersection. The existing conditions hydrology model indicates that approximately 160cfs is conveyed along Union Hills Drive in the controlling 100-year 6 hour event. In events that exceed the capacity of the existing channel storm water flows enter the Canyon Ridge Channel, the existing retention basin at the northwest corner of Union Hills Drive and 111th Ave. or continue west along Union Hills Drive. Union Hills Drive from 111th Avenue to 115th Avenue conveys storm water west via curb and gutter. Scuppers are located at intervals along the southern curb where storm water is captured and conveyed south into the Canyon Ridge Channel system.”  
(Excerpt from DCR, GM2010)

### **D.2 Proposed Drainage Design**

With the use of NOAA 14 rainfall, the peak flow rates have been reduced from the original DCR rates, and it was thought that the pipe sizes could be reduced from the DCR. However, due to the presence of a natural gas line that crosses Union Hills Road at 111th Avenue, it is recommended that the original DCR concept be used for the flow upstream of 111th Avenue,

but basin "A" can be replaced by a drainage channel because there is enough volume in the Canyon Ridge existing channel based on the unsteady HEC-RAS model (see Appendix C).

Table 9a presents the cost estimate for the Union Hills and 107<sup>th</sup> Avenue improvements as discussed above, except for the intersection improvements at Union Hills and 115<sup>th</sup> Ave.

Table 9a – Union Hills & 107<sup>th</sup> Ave Improvements from DCR

Item	Unit Cost	Unit Type	Qty	
Install 36" RGRCP Pipes	\$160.00	LF	2900	\$464,000
Install 30" RGRCP Pipes	\$140.00	LF	2640	\$369,600
8'X4' Box Culvert	\$488.89	LF	250	\$122,222
Concrete Channel	\$125.00	LF	800	\$100,000
Inlets/Headwalls	\$10,000.00	EA	8	\$80,000
Subtotal Cost				\$1,135,822
Design				\$79,508
Mobilization				\$34,075
Project Management				\$113,582
Total Cost				\$1,362,987

Pros:

- Resolves flooding problems on Union Hills and 107<sup>th</sup> Avenue

Cons:

- Will require drainage easements to install

### D.3 Union Hills and 115<sup>th</sup> Avenue Drain

In order to control ponding at the intersection of the 115<sup>th</sup> Avenue and Union Hills, a couple of curb inlets could be installed to drain the intersection into the Canyon Ridge Channel. These inlets could be installed independent of other improvements or as part of the Beardsley Road drainage Alternative B4. This installation would be entirely within the road right-of-way.

Table 9b presents the cost estimate for the improvements at the intersection of 115<sup>th</sup> Avenue and Union Hills.

Table 9b – Union Hills Intersection Drains

Item	Unit Cost	Unit Type	Qty	
Install 60" RGRCP Pipes	\$300.00	LF	500	\$150,000
Install 24" RGRCP Pipes	\$140.00	LF	100	\$14,000
Headwalls	\$10,000.00	EA	1	\$10,000
Inlets	\$10,000.00	EA	2	\$20,000
Subtotal Cost				\$194,000
Design				\$13,580
Mobilization				\$5,820
Project Management				\$19,400
Total Cost				\$232,800

#### D.4 Canyon Ridge Channel

In general, the Canyon Ridge Channel has capacity for all the flows with and without the flows from Beardsley Road. However, there are some areas that need improvement. These locations are at the power pole towers where larger culverts will need to be installed. These berms will have to be modified to allow for a better flow conveyance while maintaining the power company's access to their towers. Both of these modifications have been modeled in the unsteady state HEC-RAS flow model for this channel. Please see the calculations in the CD for the models.

##### D.4.1 Land Ownership and Jurisdiction

The Canyon Ridge Channel parcels are owned by Canyon Ridge West Master Association, 115<sup>th</sup> & Bell, LLC and Sterns Bank National Association. In addition, to the drainage easement there is a powerline easement and some utility and road easements on these parcels.

Table 9c presents the costs estimate for the improvements on the Canyon Ridge Channel.

Table 9c – Canyon Ridge Channel

Item	Unit Cost	Unit Type	Qty	
Install 24" RGRCP Pipes	\$140.00	LF	875	\$122,500
Regrading Areas	\$50,000.00	LS	1	\$50,000
Subtotal Cost				\$172,500
Design				\$12,075
Mobilization				\$5,175
Project Management				\$17,250
Total Cost				\$207,000

Pros:

- Improves flows

Cons:

- May require easements and/or agreements from HOA and Power Company.

## **E. Bell Road and 115<sup>th</sup> Avenue**

### **E.1 Existing Conditions**

The existing regional drainage channel south of Bell Road, along the 115<sup>th</sup> Avenue alignment, was constructed by Del Webb when the area was first developed and is located in unincorporated Maricopa County. Del Webb established a 40-foot private drainage easement for the channel and later sold the properties to various entities. The private drainage easement remains on the parcels. The channel is owned, and should be maintained by the landowners but it appears no one is maintaining the channel. It is currently overgrown in places and the channel lining is in disrepair. The capacity is insufficient in some locations. The channel in its current condition appears to have the capacity to handle 850 cfs without overtopping. However, the flows reaching the channel during a 100-year 24 hour storm event are about 1400 cfs using unsteady state HEC-RAS routing which would cause overtopping of the channel and potentially flood the mobile home park to the west which is in the City of Surprise (see exhibit 3).

There are several storm drain pipes and scuppers that discharge into the regional drainage channel south of Bell Road. They drain the storm water from the surrounding subdivisions and commercial properties.

The flow in the Sun City Drain channel north of Bell and east of 115<sup>th</sup> Avenue parallels Bell Road and makes a 90 degree bend to flow through the box culvert under Bell Road. The velocity of the flow is so high that the water jumps out of the channel and flows over Bell Road during a 100-year 24-hour storm flow event. In order to reduce the flow velocity in the existing Sun City Drain channel so that the flows will pass through the Bell Road box culverts, a stilling basin will need to be constructed. The box culverts are capable of passing the 1400 cfs reaching them without overtopping Bell Road provided flow velocities are reduced so that the flows stay within the channels north of Bell Road.

### **E.2 Regional Drainage Road Channel**

The original DCR recommendation was to reconstruct about 900 feet of the existing regional drainage channel, to keep water within the channel. However the recommended channel reconstruction did not include improvements to any parts of the channel that are in disrepair or overgrown. A public drainage easement would likely need to be acquired, on top of the existing private drainage easement in order to accomplish these improvements.

The DCR determined that the existing channel could handle 850 cfs. However, the flows getting to the channel during a 100-year event are approximately 1400 cfs which exceeds the capacity of the channel. Once the flows from the Sun City Drain along Bell Road and the flows from

115<sup>th</sup> Avenue reach the box culvert, there are three options being considered as part of this study to manage the flows at Bell Road and 115<sup>th</sup> Avenue, to upgrade the existing regional drainage channel south of Bell Road, to split some of the flows and divert them to river to west along the north side of Bell Road, or to construct a detention basin north of Bell Road to reduce the flows to capacity of the existing channel.

### E.2.1 Existing Regional Drainage Channel Option

The existing channel can be upgraded to handle all of the flows from north of Bell Road. This would require the installation of a stilling basin north of Bell Road and east of 115<sup>th</sup> Avenue in order to safely pass the flows through the existing box culverts under Bell Road. The stilling basin can be used to reduce the energy in the flows prior to them flowing under Bell Road reducing the peak flow to prevent flooding of Bell Road.

In order to pass the entire 1400 cfs through the channel south of Bell Road, the existing regional drainage channel will need to be reconstructed into a re-enforced concrete lined channel with drop structures placed to keep the flow sub-critical. In addition, the existing drain pipes and scuppers will need to be connected to the new channel and agreements made with adjacent property owners concerning maintenance of the drains.

#### E.2.1.1 Land Ownership and Jurisdiction

Immediately south of Bell road the channel is located on property owned by Avenue of Arts LLC and is in unincorporated Maricopa County. The access road for the channel on the west side of the channel is located in public right-of-way that is part of the City of Surprise. The rest of the properties are in the jurisdiction of Maricopa County.

South of the Avenue of Arts LLC property, the channel is located on property owned by the Citrus Point Community Association with the access road within private drainage easement on the west.

South of there the private drainage easement widens to include most of the channel and access road with channel shifting east onto property owned by Sun City RV Compound Inc. The channel and access road are entirely on the Sun City RV Compound Inc. property until just before entering the Aqua Fria River.

The channel then flows through property owned by CALMAT Co. and into the Aqua Fria River on property owned by Arizona Sand and Rock Company.

**Table 9 – Existing Channel Upgrade**

Item	Unit Cost	Unit Type	Qty	
Remove Existing Liner	\$10.00	LF	5700	\$57,000
Regrade Channel	\$5.00	LF	5700	\$28,500
Reinforce Concrete	\$254.63	LF	5700	\$1,451,389
Stilling Basin	\$45,000.00	Each	1	\$45,000
Drop Structures	\$5,000.00	Each	10	\$50,000
Replace Landscape	\$5,000.00	Acre	2.617	\$13,085
Subtotal Cost				\$1,644,974
Design				\$115,148
Mobilization				\$49,349
Easement Costs	\$283,140.00	Acre	1.5	\$424,710
Easement Costs	\$108,900.00	Acre	1.7	\$185,130
Easement Costs	\$65,340.00	Acre	1.9	\$124,146
Easement Costs	\$25,000.00	Acre	14.1	\$352,500
Project Management				\$164,497
Total Cost				\$3,060,455

Pros:

- Existing Path to River
- Has dedicated outfall
- Eliminates flooding at Bell Road
- Eliminates flooding in subdivisions south of Bell Road

Cons:

- Ownership and maintenance of the channel could become District's or one of the Cities.

**E.2.2 New Channel west to Aqua Fria along north side of Bell Road.**

In the current condition, all water that reaches the intersection of Bell Road and 115<sup>th</sup> Avenue flow south to the existing regional drainage channel south of Bell Road with some flowing over Bell Road. An alternative to having all of the flows making it to the intersection of Bell Road and 115<sup>th</sup> Avenue would be to build a new drainage system to take part of the water west to the river.

**Table 10 – New channel on North Side of Bell Road to Aqua Fria River**

Item	Unit Cost	Unit Type	Qty	
Clear and Grub	\$2.50	SQYD	79200	\$198,000
Stilling Basin	\$45,000.00	Each	1	\$45,000
Road Crossings	\$10,000.00	Each	3	\$30,000
Utility Relocation	\$20,000.00	LS	3	\$60,000
Install 8'X6' Box Culverts	\$611.11	LF	4000	\$2,444,444
Replace Landscape	\$50.00	SQYD	450	\$22,500
Subtotal Cost				\$2,799,944
Design				\$195,996
Mobilization				\$83,998
Easement Costs	\$304,920.00	Acre	0.27	\$82,328
Easement Costs	\$263,750.00	Acre	0.46	\$121,325
Easement Costs	\$25,000.00	Acre	5.4	\$135,000
Project Management				\$279,994
Total Cost				\$3,698,587

Pros:

- Shortest Path to River
- Reduces flooding along regional channel.
- Eliminates flooding Bell Road

Cons:

- High potential for conflicts with utilities – this could increase costs
- The culvert will be located under commercial property restricting use of the property.
- The runoff is being diverted to a point in the river upstream of its current discharge point.

**E.2.3 Detention Basin “C”**

Detention Basin “C” was planned to be installed just north of the Bell Road culverts in order to reduce the flows going south so that the existing channel south of Bell Road could pass the flows without overtopping. This would require reducing flows from 1400 cfs to 850 cfs, and there is insufficient acreage available to reduce the flows enough to make this option viable.

## F. Conclusions and Recommendations

Table 11 is a summary of the results of this analysis.

**Table 11 – Alternative Summary**

Area	Alternative	Description	Cost	Pros	Cons
Beardsley Road Improvements		Improve channel between 113 <sup>th</sup> Ave and 115 <sup>th</sup> on the south side of Beardsley	\$582,600	<ul style="list-style-type: none"> <li>Keeps runoff in channel</li> <li>Reduces Maintenance Costs</li> <li>Reduces inundation of infiltration basins</li> </ul>	<ul style="list-style-type: none"> <li>None</li> </ul>
115th Avenue and Beardsley Road	B1	Beardsley flows directly to river	\$5,677,640	<ul style="list-style-type: none"> <li>Shortest Path to river</li> <li>Decreased erosion to golf course</li> <li>Utility conflicts unlikely</li> </ul>	<ul style="list-style-type: none"> <li>Trees in golf course would be difficult remove and to replace</li> <li>Interruption to golf course activities</li> <li>Costs of mineral rights are highly variable</li> <li>Sacrificial during 100-year event</li> <li>Fill required in mine area with 404 implications</li> <li>Requires easement from the Golf Course, ASLD and Mining Land Owners</li> <li>Water is diverted upstream of current flows</li> <li>May impact S&amp;G operations</li> <li>May have protracted legal issues with mine owners and operators</li> </ul>
	B2a	Beardsley flows through golf course (w/culverts) and 50' easement	\$4,918,860	<ul style="list-style-type: none"> <li>Minimal impacts to S&amp;G operations</li> <li>Eliminates erosion to golf course</li> </ul>	<ul style="list-style-type: none"> <li>Trees in golf course would be difficult to remove and to replace</li> <li>Interruption to golf course activities</li> <li>Requires easement from the Golf Course, ASLD and Mining Land Owners</li> <li>Water is diverted upstream of current flows</li> <li>Not supported by the City of Surprise</li> </ul>

	B2b	Beardsley flows through golf course (w/open channel) and 50' easement	\$1,449,000	<ul style="list-style-type: none"> <li>Supported by S&amp;G</li> <li>Eliminates erosion to golf course</li> </ul>	<ul style="list-style-type: none"> <li>Major Interruption to golf course activities</li> <li>Requires easement from the Golf Course, ASLD and S&amp;G land owners</li> <li>Requires drainage easement and some modification to Golf Course</li> <li>Not supported by City of Surprise due to Golf Course impacts</li> <li>Water is diverted upstream of current flows</li> </ul>
Area	Alternative	Description	Cost	Pros	Cons
115th Avenue and Beardsley Road	B3	Retention basin on S&G property	\$3,881,552	<ul style="list-style-type: none"> <li>Simple design</li> <li>Basin should be fast draining</li> <li>Eliminates erosion to golf course</li> </ul>	<ul style="list-style-type: none"> <li>Could lead to litigation with S&amp;G over land value and mineral rights</li> <li>May involve County/City in litigation over adjacent problems with "grandfathered" pit in future</li> </ul>
	B4a	Partial Beardsley flows down 115th Ave (no changes to 36" pipes or golf course)	\$3,804,067 (\$2,143,891 w/ Channel)	<ul style="list-style-type: none"> <li>Keeps 100-year flows in the approximate current location</li> <li>Avoids impacts to Golf Course</li> <li>No additional ROW needed</li> <li>Allows the project to be phased</li> <li>Eliminates long-term erosion impacts to golf course</li> </ul>	<ul style="list-style-type: none"> <li>The new channel on 115<sup>th</sup> Avenue would need to be replaced with pipe if road is widened.</li> <li>MCDOT does not support a channel</li> <li>City of Surprise will have to annex road to implement channel option</li> </ul>
	B4b	Partial Beardsley flows down 115th Ave (change pipes and golf course channel)	\$3,603,667 (\$2,238,691 w/Channel)	<ul style="list-style-type: none"> <li>Allows the project to be phased</li> <li>Eliminates long-term erosion impacts to golf course</li> </ul>	<ul style="list-style-type: none"> <li>The new channel on 115<sup>th</sup> Avenue would need to be replaced with pipe if road is widened.</li> <li>MCDOT does not support a channel</li> <li>City of Surprise will have to annex road to implement channel option</li> <li>Requires modifications to golf course</li> </ul>

115th Avenue and Beardsley Road	B4c	All Beardsley flows down 115th Ave	\$3,798,067	<ul style="list-style-type: none"> <li>No modification to golf course</li> <li>Eliminates long-term erosion impacts to golf course</li> <li>Allows the project to be phased</li> </ul>	<ul style="list-style-type: none"> <li>None</li> </ul>
	B5	Beardsley flows through golf course to S&G pit	\$4,657,067	<ul style="list-style-type: none"> <li>Shortest path to river</li> </ul>	<ul style="list-style-type: none"> <li>Need to obtain easement from S&amp;G to include costs of long term maintenance</li> <li>Requires negotiation with S&amp;G owners and operators on cost of easement, mineral rights, and management</li> <li>Diverts water to a location that historically does not receive flows</li> <li>Temporary impacts to golf course</li> </ul>
<b>Area</b>	<b>Alternative</b>	<b>Description</b>	<b>Cost</b>	<b>Pros</b>	<b>Cons</b>
Union Hills & 107 <sup>th</sup> Ave Improvements	Modified DCR Option	Pipes flows to new and existing channels, no basins	\$1,362,987	<ul style="list-style-type: none"> <li>Resolves flooding problems on Union Hills &amp; 107<sup>th</sup> Ave</li> </ul>	<ul style="list-style-type: none"> <li>None</li> </ul>
Canyon Ridge Channel	Minor upgrades to channel flows	Add some improved drain pipes and swales	\$207,000	<ul style="list-style-type: none"> <li>Improves flows</li> </ul>	<ul style="list-style-type: none"> <li>None</li> </ul>
115th Avenue and Bell Road	South	Upgrade existing regional drainage channel south of Bell Road	\$3,060,455	<ul style="list-style-type: none"> <li>Existing path to river</li> <li>Has dedicated outfall</li> <li>Eliminates flooding along regional drainage channel</li> <li>Eliminates overtopping at 115<sup>th</sup> Avenue and Bell Road</li> </ul>	<ul style="list-style-type: none"> <li>Probably need to take ownership (and possibly maintenance) of Sun City Drain</li> </ul>
	West	Split flows to west with new channel and keep regional drainage south of Bell Road in current condition	\$3,698,587	<ul style="list-style-type: none"> <li>Shortest path to river</li> <li>Reduces flooding along regional drainage channel</li> <li>Eliminates overtopping at 115<sup>th</sup> Avenue and Bell Road</li> </ul>	<ul style="list-style-type: none"> <li>The culvert will be located under commercial property restricting use of the property Diverts water to a location that historically does not receive flows</li> <li>Possible utility conflicts</li> </ul>

If 100% of the flows from Beardsley Road were routed south to Bell Road, it would only increase the flows at Bell Road by approximately 100 cfs (1300 cfs to 1400 cfs). Therefore, the solution to the flooding and erosion problems from the Beardsley Road runoff is technically independent of the solution for the outfall.

One of the primary concerns is the flooding at Bell Road. The Bell Road flooding can be eliminated by constructing a stilling basin on the north side of the Bell Road Culverts. This basin will take the flows from the Sun City Drain to the east and flows from the Canyon Ridge Channel to the north and slow them down so they can pass through the Bell Road Culverts without overtopping the road. The existing Bell Road Culverts will pass the entire 100-year 24-hour storm runoff of 1400 cfs.

The regional drainage channel south of Bell Road is so badly deteriorated that it can only pass an estimated 850 cfs without overtopping (from DCR, GM 2011). Of the three options considered for handling the flows at Bell Road, repairing and upgrading the channel south of Bell Road to the Aqua Fria River is the most viable and cost effective option. In addition, there is already an existing drainage easement over most of the channel and the channel currently receives the existing flows.

The DCR had a design for Union Hills that works even with the change in flows using NOAA 14. The detention basins are not needed to manage the flows along Union Hills to 115<sup>th</sup> Avenue. There is some ponding that takes place at the intersection of Union Hills and 115<sup>th</sup> Avenue. This ponding can be eliminated by adding a couple of curb inlets to pick up the flows and discharge them into the Canyon Ridge Channel.

Of the options for managing the flows on Beardsley Road, alternatives B1, B3 and B5 are too costly and will possibly require costly litigation with the mining company (La Farge) and land owners and are not recommended. Options B2b, B4a, B4b and B4c are feasible. Option B2b which directs the flows through the golf course to a 50 foot easement along the west side of the Coyote Lakes erosion protection berm south to a point just north of Bell Road and then out to the river appears to be the most cost effective option. However, there is a lot of uncertainty with this option and it requires getting permission to modify the existing golf course plus to get easements from Home Owners Association and the sand and gravel land owners. Therefore, it is not being recommended at this time. Option B2a which allows for split flows at Beardsley and 115<sup>th</sup> Avenue without requiring any modification of the golf course is the recommended solution as the easiest to design and construct.

The Coyote Lakes survey and drainage analysis indicates that the Coyote Lakes homes are probably not in danger of flooding during a 100-year 24-hour storm event. The one house that has potential for flooding could be protected by building a simple curb inlet to allow the flood

waters to flow into the golf course about 300 feet west of the northeastern most house in the Coyote Lakes Subdivision. A “do nothing” alternative could also be considered here. The primary impacts would be that the intersection of 115<sup>th</sup> Avenue and Beardsley would flood for brief periods of time and there is a potential that the golf course would flood and overflow into the adjacent sand and gravel pit to the west which could cause additional erosion in the pit and on the golf course similar to what happened most recently in the January 2010 storm. The erosion repairs from the January 2010 storm were repaired in a few days by the sand and gravel pit operators and the retention basin in the golf course was enlarged.

Based on costs and complexity, the following three phased approach is recommended:

1. Build the stilling basin at 115<sup>th</sup> Avenue and Bell Road north of the Bell Road Culverts to keep the flows from the Sun City Drain in the channel and prevent the flooding of Bell Road. Re-build and upgrade the regional drainage channel south of Bell Road to manage all of the flows from the north as well as the existing flows into the drain. The channel will need to be lined with reinforced concrete and have several drop structures to maintain sub-critical flow in the channel. Add some drainage culverts and some minor grading to the high ground separating the Canyon Ridge Basins to facilitate flows. Construct some new drainage inlets at the intersection of the Union Hills Road and 115<sup>th</sup> Avenue to remove runoff that ponds in this area.
2. Construct the drainage system recommended in the DCR for Union Hills and 107<sup>th</sup> Avenue. Detention Basin B is deleted. Detention Basin A may no longer be needed and may become a channel segment.
3. Construct the channel improvements on the south side of Beardsley Road between 113<sup>th</sup> Avenue and 115<sup>th</sup> Avenue (see section B2 of this report) and construct the split flow improvements to route the water south on 115<sup>th</sup> Avenue while leaving the existing 36-inch drains into the golf course in place (alternative B4a).

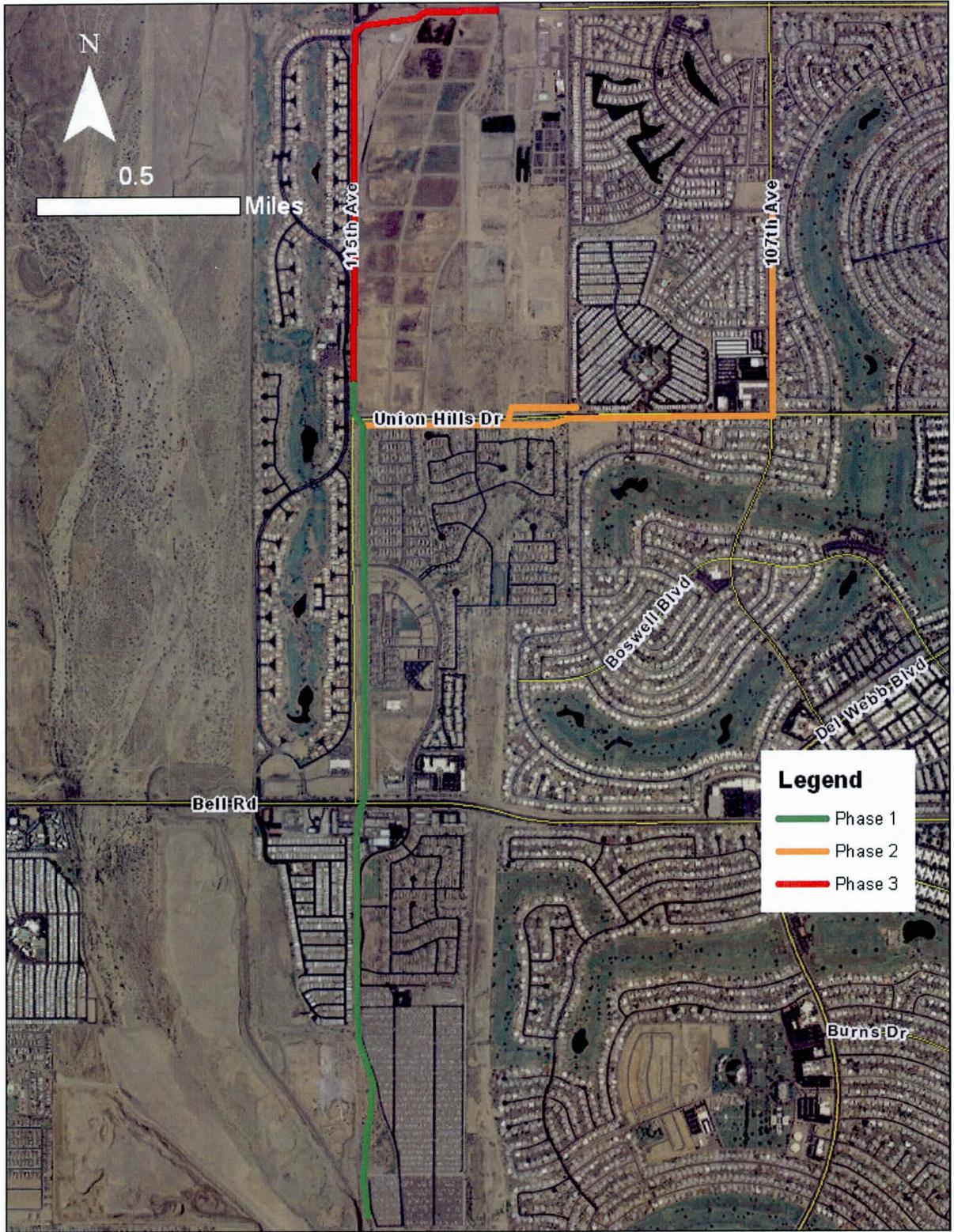


Exhibit 2 – Phasing Plan

Table 12 – Phase I Cost Estimate

Item	Cost
Outfall Channel Improvements	\$3,060,455
Union Hills & 115th Intersection	\$232,800
Canyon Ridge Channel Improvements	\$207,000
Total Cost	\$3,500,255

Table 13 – Phase II Cost Estimate

Item	Cost
Union Hills Rd/107th Ave Improvements	\$1,274,280
Total Cost	\$1,274,280

Table 14 – Phase III Cost Estimate

Item	Cost
Beardsley Road Improvements	\$582,600
115th Ave Improvements	\$3,804,067
Total Cost	\$4,386,667

Table 15 – Total Project Cost Estimate

Item	Cost
Phase I	\$3,500,255
Phase II	\$1,274,280
Phase III	\$3,862,327
Total Cost	\$8,636,862

**APPENDIX A – BEARDSLEY ROAD CHANNEL IMPROVEMENTS**

## Beardsley Road Channel (~113<sup>th</sup> Avenue to 115<sup>th</sup> Avenue)



Figure 1. Location (in red) of Beardsley Road channel upstream of 115<sup>th</sup> Avenue.

Design Flow: 324 cfs (from existing conditions HEC-1 model, EX100-24.dat)

Slope: 0.005 ft/ft

Length: ~1800 ft

Channel Shape: Trapezoidal (see Figure 2)

Channel Lining: 6-inch D50 riprap. If concrete is used, the flow is supercritical.

Channel Depth: ~4 ft (including freeboard)

Estimated Velocity: 3.6 ft/s at the 100-year design flow

Drop Structures: Yes, can be incorporated into the culvert that is circled in green in Figure 1. The drop height is 2.5 ft.

Culverts: At the location circled in green a six 42" CMPs would be needed.

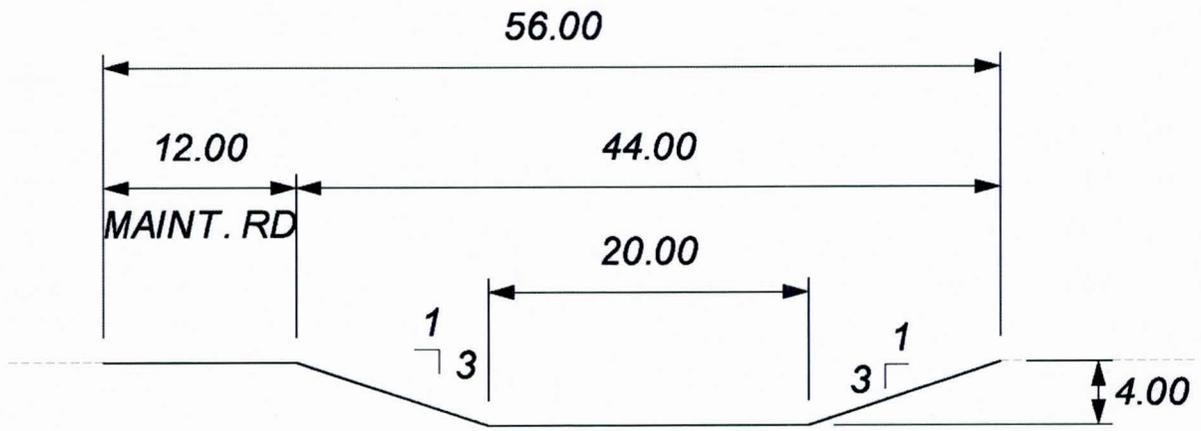


Figure 2. Typical section of the Beardsley Road channel.

**APPENDIX B1 – BEARDSLEY ALTERNATIVE B1**

## Storm Drain to Agua Fria



Figure 3. Location of the proposed storm drain (in red) from existing Beardsley channel to the Agua Fria River.

Assumptions: Headwater kept below elevation of 1192 ft (NAVD 88)

Culvert size: three 72" circular concrete pipes (calculated for 60" but upsized to account for clogging)

Design Flow: 324 cfs (from existing conditions HEC-1 model, EX100-24.dat)

Slope: 0.0016 ft/ft (u/s invert 1185 ft, d/s invert 1180 ft NAVD 88, u/s invert 5 ft below invert of existing invert of 36" pipes in Beardsley Road channel)

Length: ~3150 ft (from alignment in Figure 3)

Culvert size: three 72" circular concrete pipes (calculated for 60" but upsized to account for clogging)

Cons: Some areas will require fill to provide 2 ft of cover over pipes (see Figure 4).

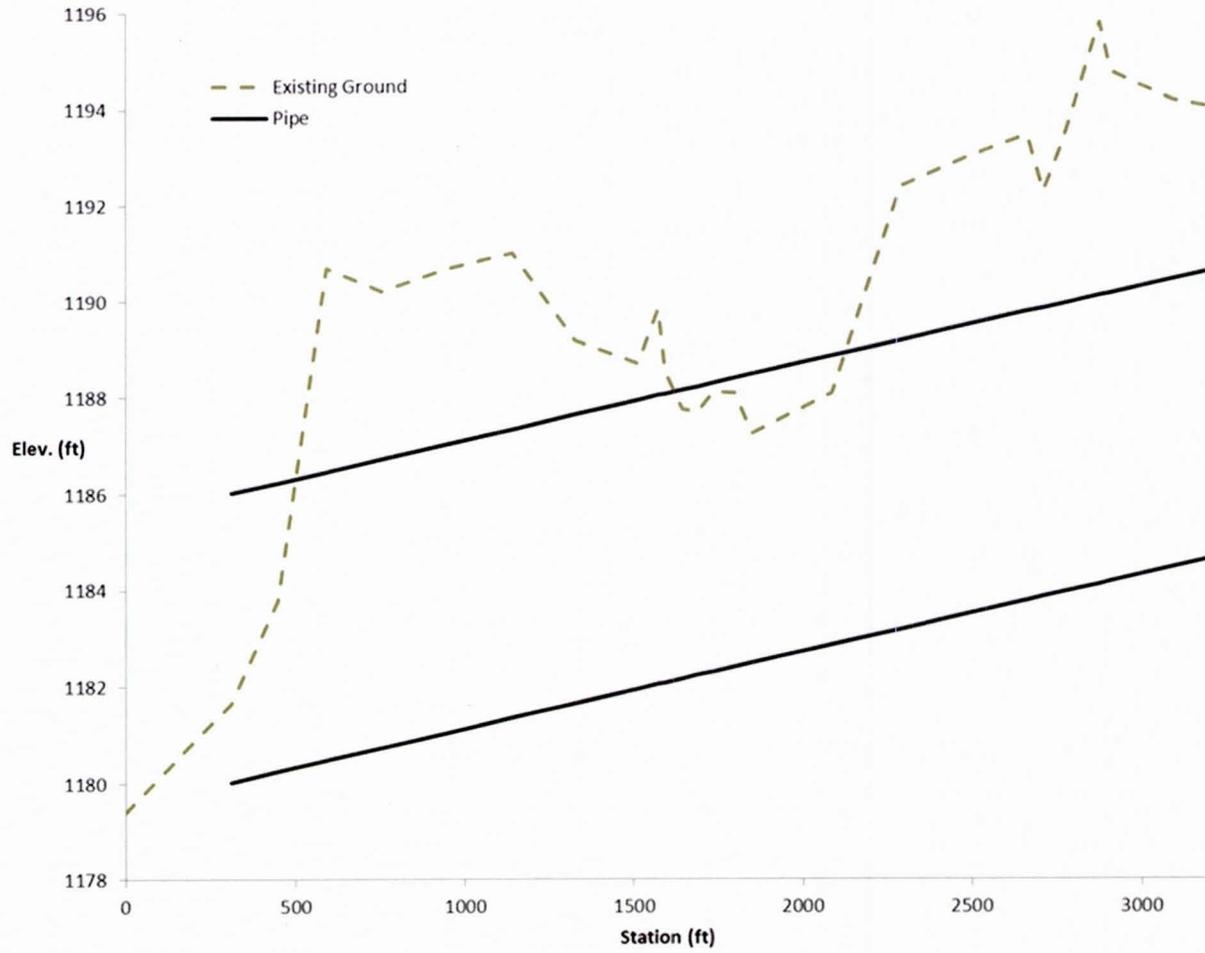


Figure 4. Profile of proposed storm drain from Beardsley Road to Agua Fria

**APPENDIX B2 - BEARDSLEY ALTERNATIVE B2**

## Channel Along the west side of Coyote Lakes

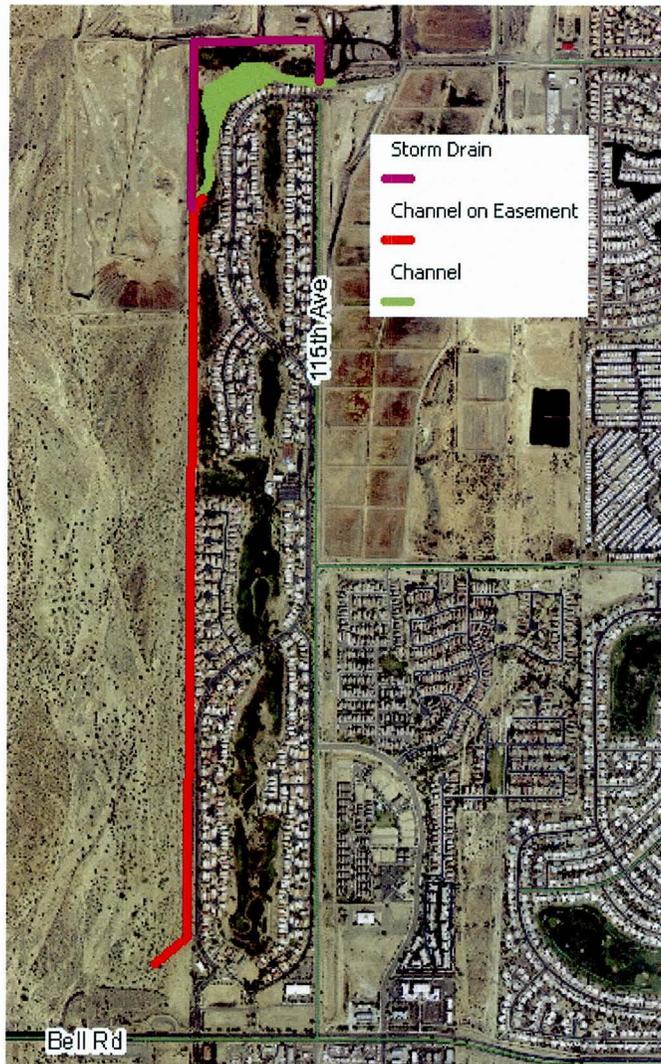


Figure 5. General location of the proposed channel (in red) along the west side of Coyote Lakes, the Storm Drain around golf course in purple, and the channel through the golf course in green.

Assumptions: Along the west side of the Coyote Lakes development, there is a 50-ft easement. This easement is assumed to be the location of the channel. However, the channel should have a top width of 30 ft

Design Flow: 324 cfs (from existing conditions HEC-1 model, EX100-24.dat)

Slope: 0.0025 ft/ft (based on alignment in Figure 5), 0.003 in general from Beardsley Road to Bell Road

Length: ~8400 ft (from outlet of Coyote Lakes golf course to a braid of the Agua Fria River south of Union Hills alignment, see Figure 5)

Channel Shape: Trapezoidal

Channel Lining: Natural

Channel Depth: 5 ft (~4.6 ft including freeboard and 2:1 side slopes).

Estimated Velocity: 5.27 ft/s

Cons: 1) Side slopes steeper than 3:1.

2) Unlined channel with velocity slightly greater than 5 ft/s

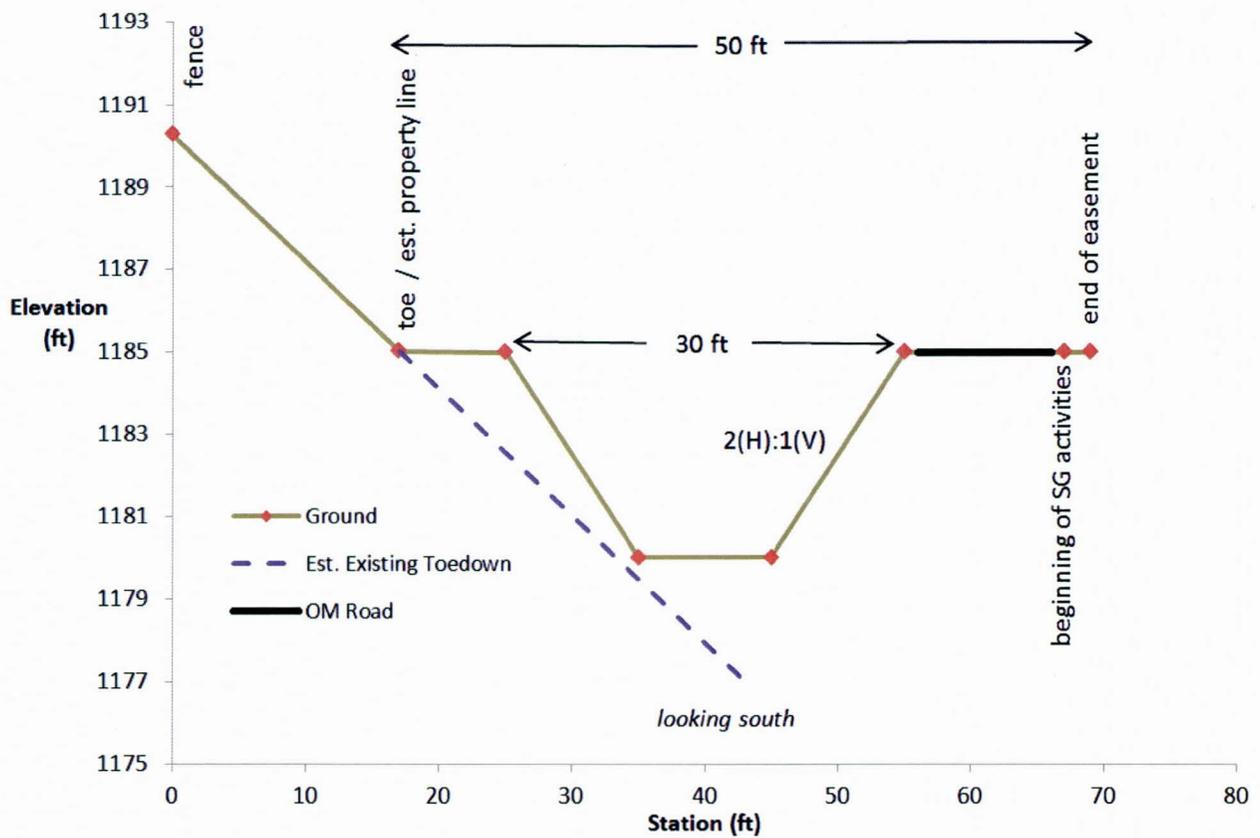


Figure 6. Cross-section of typical channel as it relates to existing 50 ft easement and estimated location of toe down of existing berm.

## Volume of Basin in Coyote Lakes Golf Course

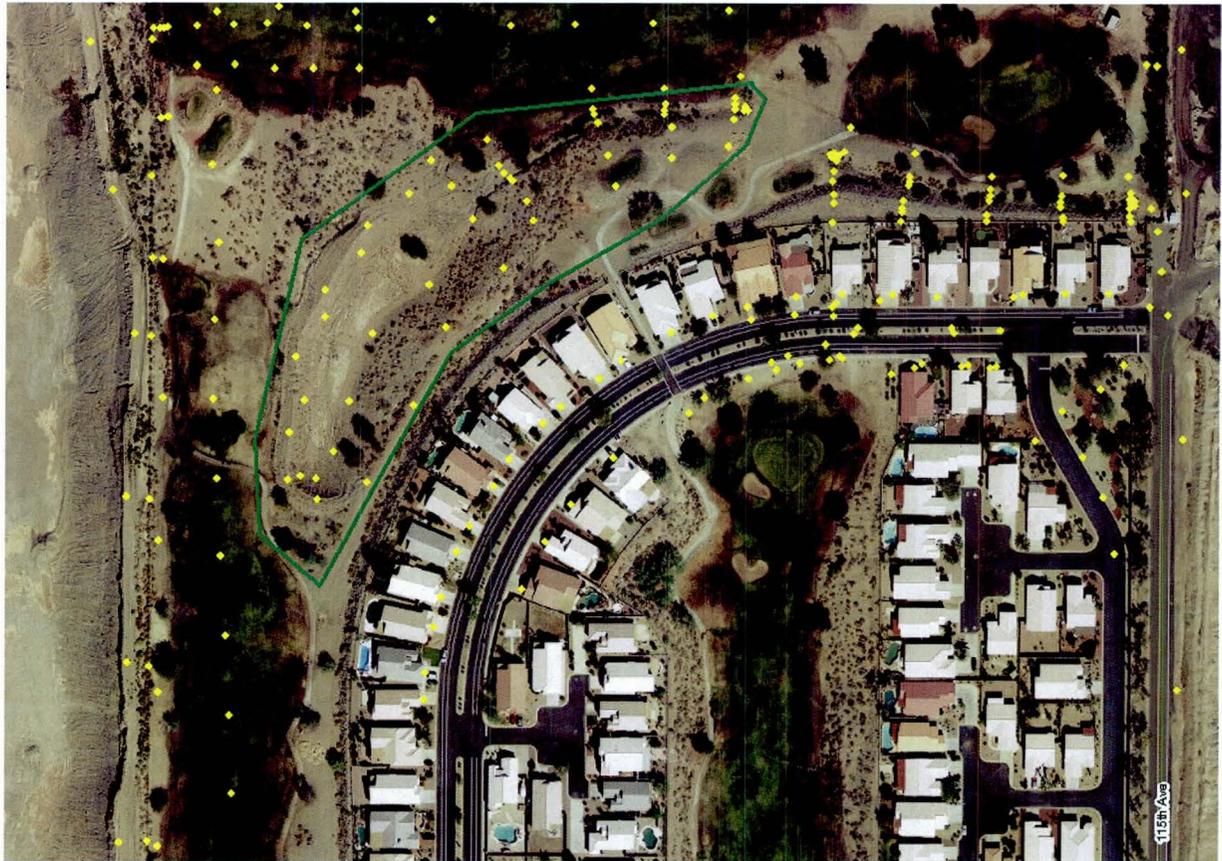


Figure 7. Location of existing basin (circle in green) in the northern section of the Coyote Lakes golf course. The locations of the spot elevations are shown as yellow points.

To determine the best alternative, the volume of the existing basin on the northern section of the Coyote Lakes golf course needed to be determined. The location of this basin is shown in Figure 7. To facilitate this task, a TIN surface (shown in Figure 8) was created from the spot elevations in Figure 7. The volume below the outlet elevation of the basin was determined from the ArcGIS tool, Surface Volume, in the 3D Analyst tool set. The storage versus elevation curve of the existing basin is shown in Figure 9. The inflow hydrograph to this basin was then extracted, and the cumulative volume was calculated at each ordinate. Based on this analysis, the volume of the basin would be filled before the second peak of the hydrograph passes (see Figure 10). Therefore, the channel that outlets this basin should conservatively be designed to carry the full inflow of 324 cfs, since at the second peak of 298 cfs the cumulative volume is 19.3 ac-ft. However, during final design, the inflow/outflow characteristics of this system can be optimized to more efficiently use the volume of this basin.

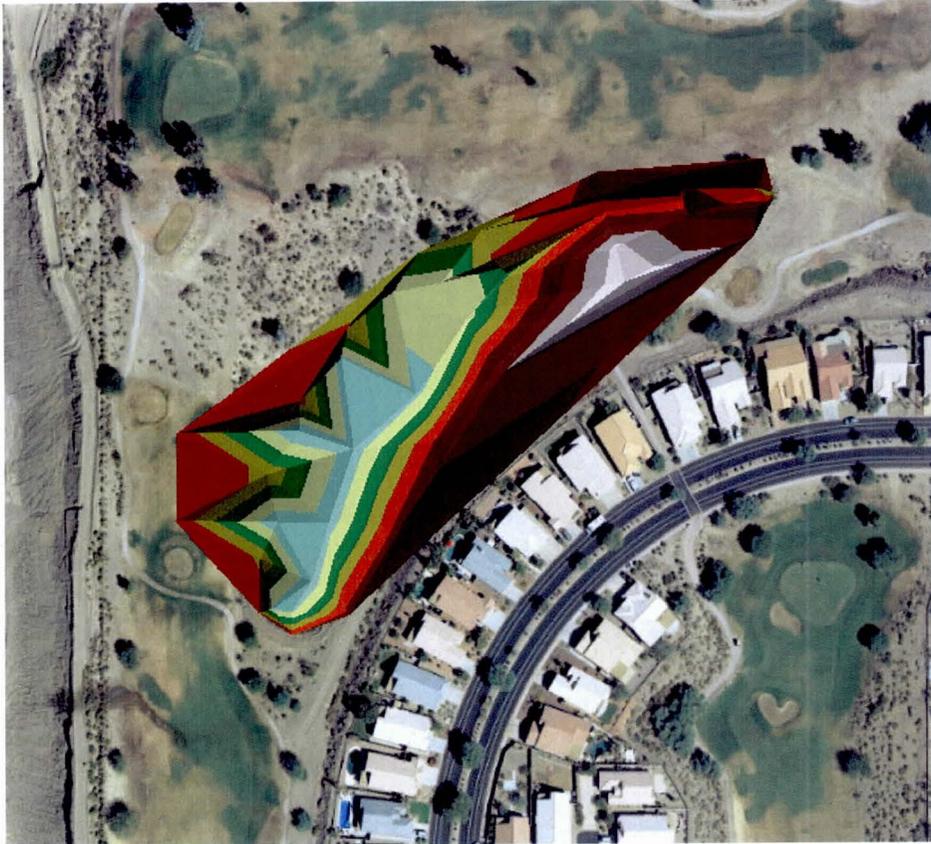


Figure 8. TIN surface that was created to represent the Coyote Lakes Basin.

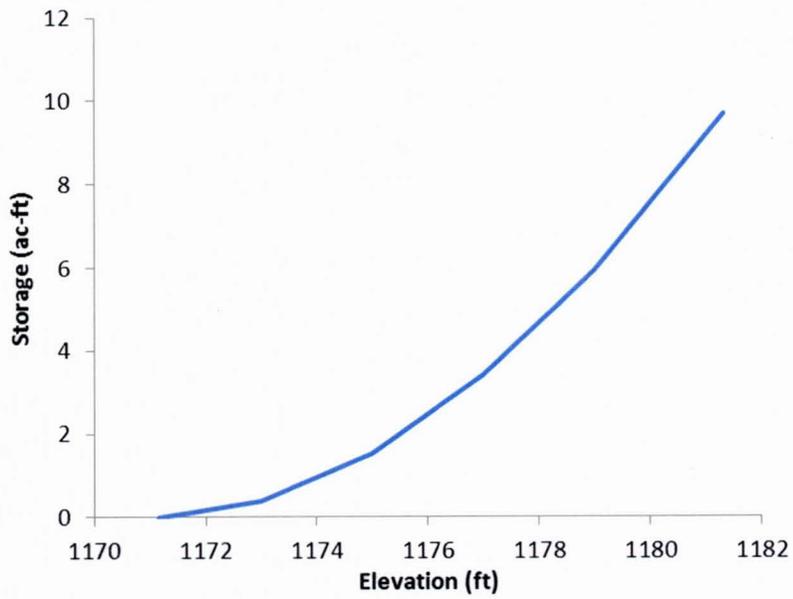


Figure 9. Storage-Elevation curve of existing basin of Figure 7.

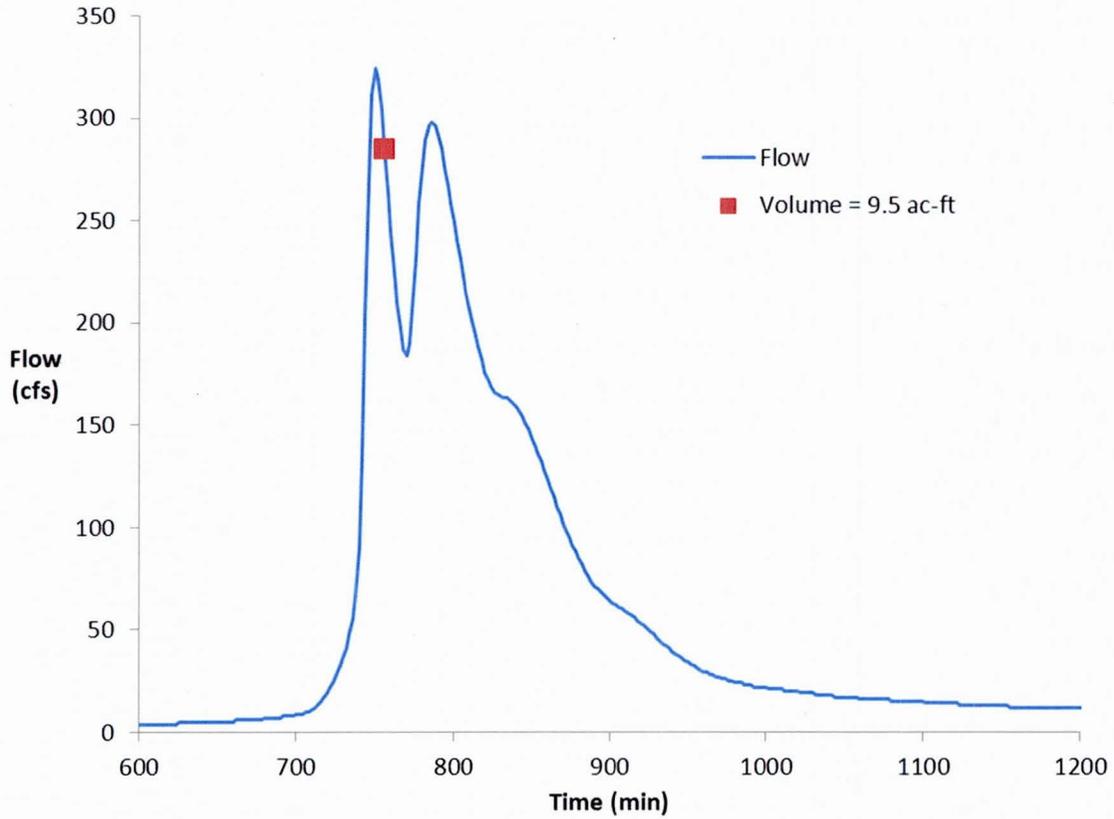


Figure 10. Plot of full hydrograph at 115<sup>th</sup> Avenue and Beardsley Road. The time when the inflow reaches a cumulative volume of 9.5 ac-ft is highlighted with a red square.

**APPENDIX B3 – BEARDSLEY ALTERNATIVE B3**



Figure 11. Proposed retention basin for Alternative B3. The retention basin is 10 feet deep with 3 to 1 side slopes except on the west side it has 6 to 1 side slopes to facilitate access. Total Volume is 57 acre-feet. Total Acreage is 6.6 acres.

**APPENDIX B4 - BEARDSLEY ALTERNATIVE B4**

## Storm Drain along 115<sup>th</sup> Avenue

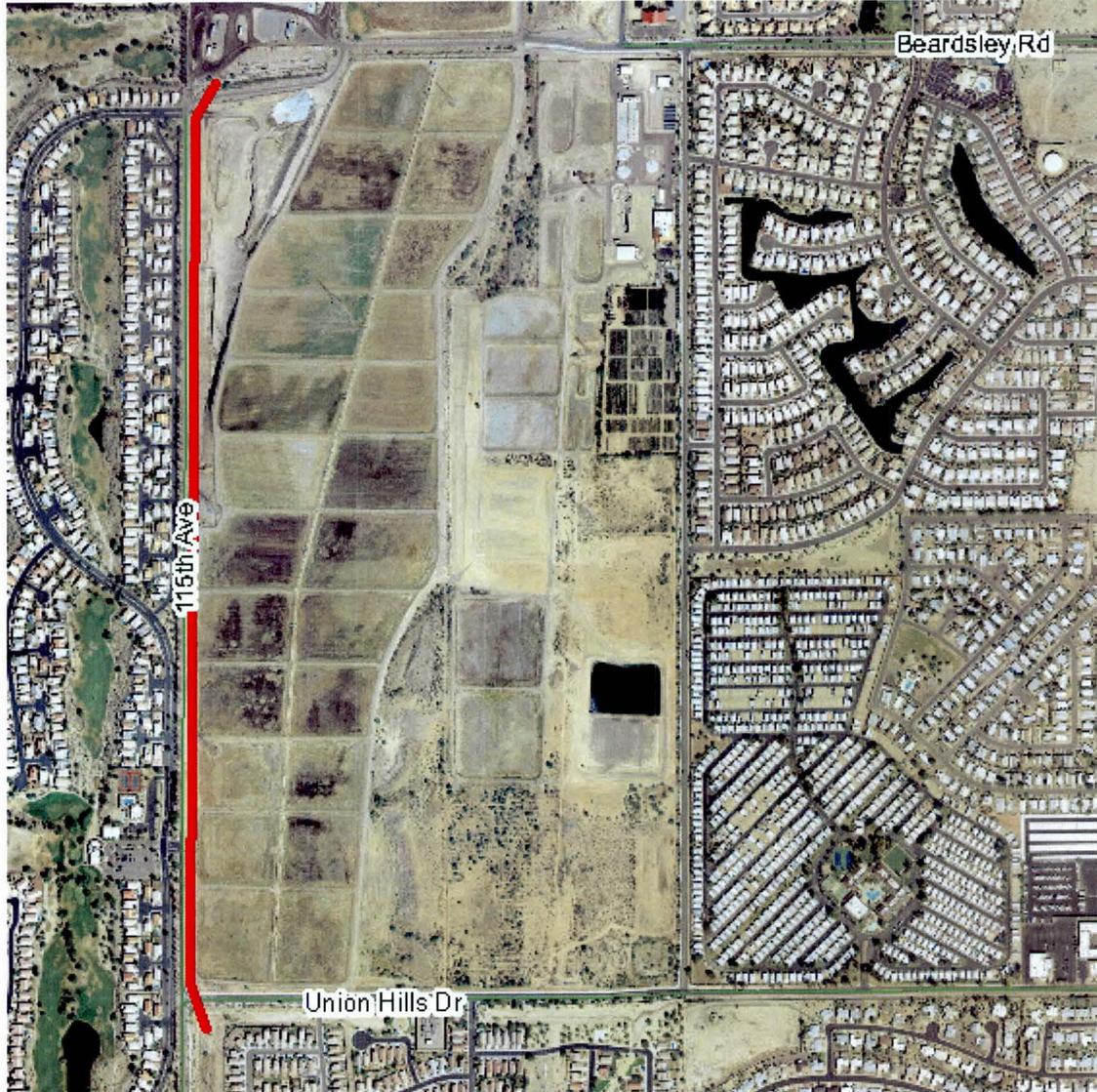


Figure 12. Location of the proposed storm drain (in red) along 115<sup>th</sup> Avenue.

Assumptions: Headwater kept below elevation of 1192 ft (NAVD 88)

Design Flow: 324 cfs (from existing conditions HEC-1 model, EX100-24.dat)

Slope: 0.0026 ft/ft (u/s invert 1182 ft, d/s invert 1168 ft NAVD 88, u/s invert 8' below road grade at 115<sup>th</sup> and Beardsley)

Length: ~5300 ft (from alignment in Figure 12)

Culvert size: three 72" circular concrete pipes (calculated for 60" but upsized to account for clogging)

## Storm Drain along 115<sup>th</sup> Avenue (with splitter structure)

Assumptions: Headwater kept below elevation of 1192 ft (NAVD 88) and peak flows allowed to spill to golf course but kept below a total volume of 9 ac-ft (the volume of golf course basin)

Design Flow: 175 cfs (from split flow conditions HEC-1 model, Down115.dat)

Slope: 0.0026 ft/ft (u/s invert 1182 ft, d/s invert 1168 ft NAVD 88, u/s invert 8' below road grade at 115<sup>th</sup> and Beardsley)

Length: ~5300 ft (from alignment in Figure 12)

Culvert size: two 54" circular concrete pipes (calculated for 48" but upsized to account for clogging)

Using the design assumption of 175 cfs for the flow down 115<sup>th</sup> Avenue, the volume of the flow that still enters the golf course is 7.51 ac-ft.

However, the current 36" culverts do not have the capacity to pass that much flow to the golf course. From my analysis, they can only pass about 55 cfs. If we left the pipes to the golf course alone, the flow down 115<sup>th</sup> Avenue would be much higher, around 269 cfs, which would require the pipes down 115<sup>th</sup> Avenue to be increased in size to 60-inch diameter.

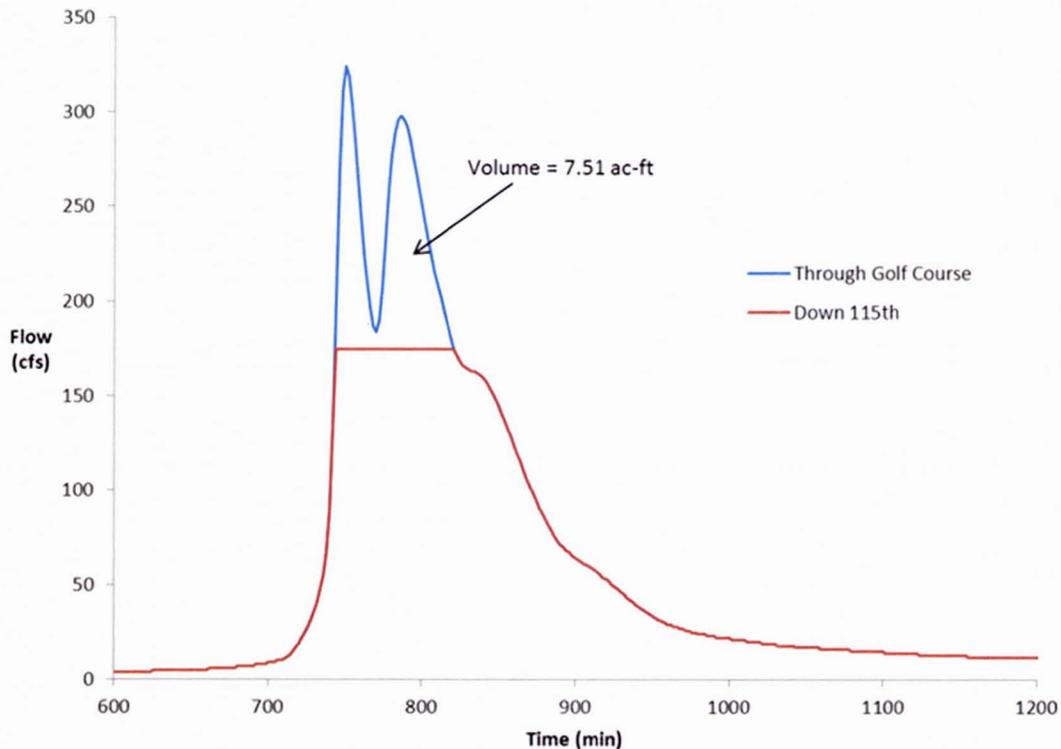


Figure 13. Hydrograph for allowing 7.51 ac-ft of runoff into the golf course.

For the 150 cfs through the golf course, a length of 900 ft (from US end of existing culverts to the basin) was used. From the CulvertMaster analysis, two 42" pipes would work.

With the 55 cfs to the golf course, the volume to the golf course is 1 ac-ft (0.94 ac-ft).

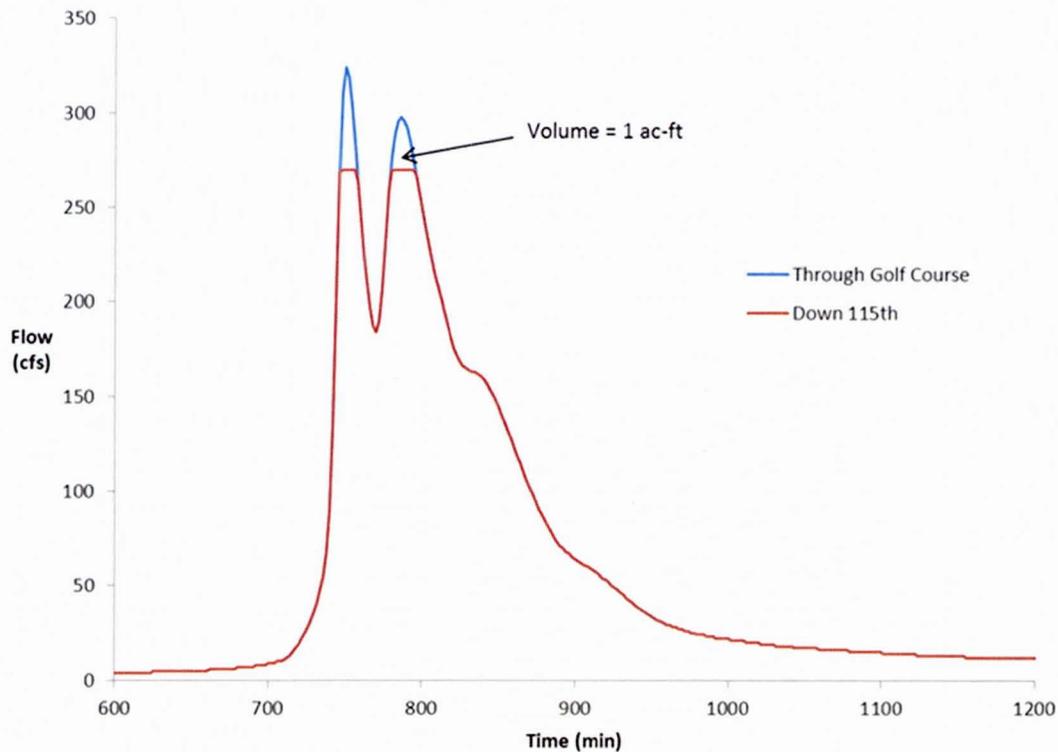


Figure 14. Hydrograph for limiting into the golf course based on existing 36" pipe flows during peak events.

Using a flow of 270 cfs (55 cfs through golf course), two 54" pipes would work for the flow down 115<sup>th</sup> Avenue.

For a channel, the bottom width would be 10 feet and the top width 40 feet (including freeboard) with 3:1 side slopes. A cross-section for 324 cfs is shown below. With the 270 cfs, the only difference would be that the depth would be 4.5 feet rather than 5 feet (both including freeboard). The calculations used a Manning's n value of 0.033, and the velocity was below 5 ft/s. Therefore, it appears riprap wouldn't be needed.

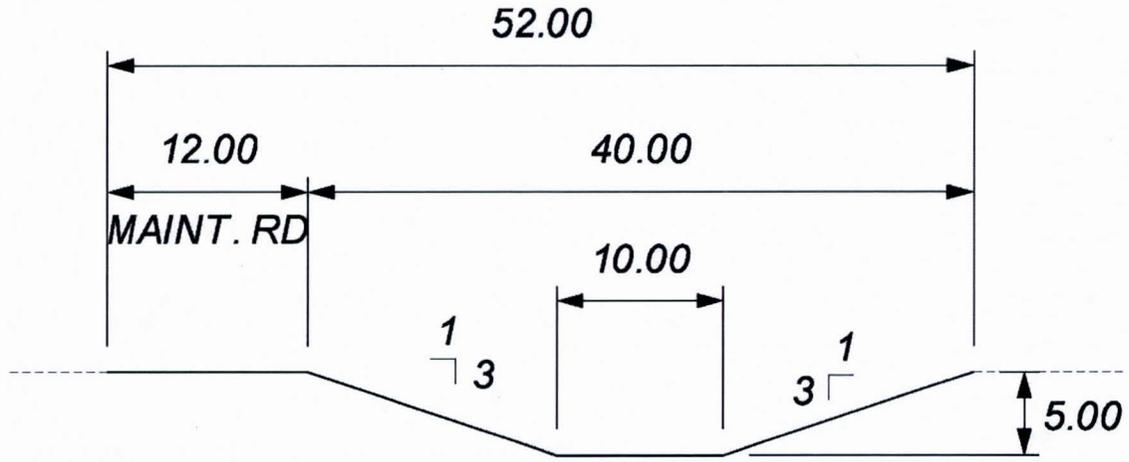


Figure 15. 115<sup>th</sup> Ave channel rather than pipes.

Down 115<sup>th</sup> Avenue using a maximum headwater of 1195 ft (no upsizing has been included):

Half length

175 cfs – two 54" pipes

270 cfs – two 54" pipes

324 cfs – two 60" pipes

Full length

175 cfs – two 54" pipes

270 cfs – two 60" pipes

324 cfs – two 60" pipes

The previous analyses used a maximum headwater of 1192 ft and included upsizing. 1192 was taken as just below the elevation of the circled point in Figure 16.



Figure 16. Elevations at the existing Beardsley Road channel. The green circle shows the low point on south channel wall which was used for headwater calculation.

**APPENDIX B5 - BEARDSLEY ALTERNATIVE B5**

**Storm Drain from Beardsley to Sand and Gravel Pit**



Figure 17. Location of the proposed storm drain (in red) from existing Beardsley channel to the sand and gravel pit.

This alternative is basically the same as alternative B1, but the pipe run goes to the northeast corner of the existing sand and gravel pit and is piped down to the bottom.

**APPENDIX C – UNION HILLS DESIGN**

## Union Hills Storm Drain (upstream of 111<sup>th</sup> Avenue and intersection of 111<sup>th</sup> Avenue and Union Hills)



Figure 18. Location of Union Hills and 107<sup>th</sup> Avenue storm drains (in red).

With the use of NOAA 14 rainfall, the peak flow rates have been reduced from the original DCR, and it was thought that the pipe sizes could be reduced from the DCR. However, due to the presence of a natural gas line that crosses Union Hills Road at 111<sup>th</sup> Avenue, it is recommended that the original DCR concept be used for the flow upstream of 111<sup>th</sup> Avenue.

Recommendation: Use original DCR configuration, but basin "A" from the DCR can probably be changed to a channel because there is enough volume in the Canyon Ridge existing channel based on an unsteady HEC-RAS model to handle the peak flows (assuming minor changes in the Canyon Ridge Channel are allowed).

The DCR for the proposed solution at 111<sup>th</sup> and Union Hills included the following items:

2640 feet of 30" RCP

2900 feet of three 36" RCP

100 feet of road crossing of two 8'x4' RCB

150 feet of road crossing of two 8'x4' RCB

Basin A can be replaced with ~800 feet of channel. A rough estimate of channel would be 10' bottom width with 3:1 side slopes and a depth of 5 feet (with freeboard). The slope is fairly steep so 6-in D50 riprap will be needed as a minimum for erosion protection.

**APPENDIX D – BELL ROAD WEST CHANNEL**

## Storm Drain to Agua Fria along Bell Road

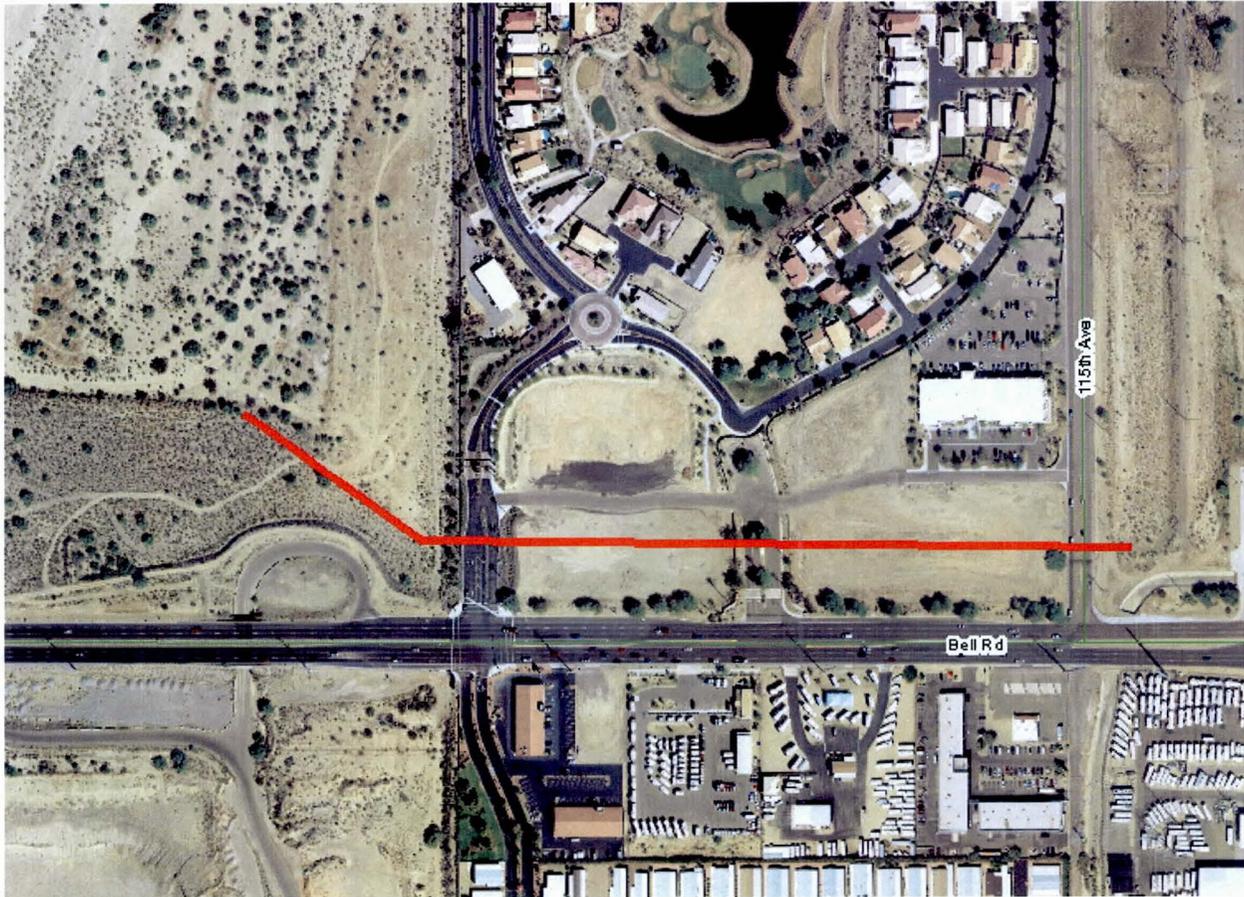


Figure 19. Location of the proposed storm drain (in red) from Canyon Ridge channel along Bell Road to the Agua Fria River.

Assumptions: 7-ft headwater depth maximum (max depth in Canyon Ridge channel)

Design Flow: 600 cfs (from unsteady conditions HEC-RAS model for Canyon Ridge, the model includes full flow from 115<sup>th</sup> Avenue and Beardsley Road and Sun City Drain flow, diversion of 600 cfs maintains Sun City Drain at 800 cfs south of Bell Road)

Slope: 0.00175 ft/ft (based on alignment in Figure 19, Outlet Invert = 1154 ft NGVD 29, 1156 ft NAVD 88, Inlet Invert = 1157.5 ft NAVD 88)

Length: ~2000 ft (from alignment in Figure 19)

Culvert size: three cells 8'(S)x 6'(H) box, or three 90" circular concrete pipes

Cons: 1) Will require basin to hold increased flows to this location in Agua Fria River

2) If culverts are used, a drop inlet will be needed to lower the invert of the culvert. Based on existing topography, there is not enough depth to provide the necessary cover for a 6' high box culvert (see Figure 20)

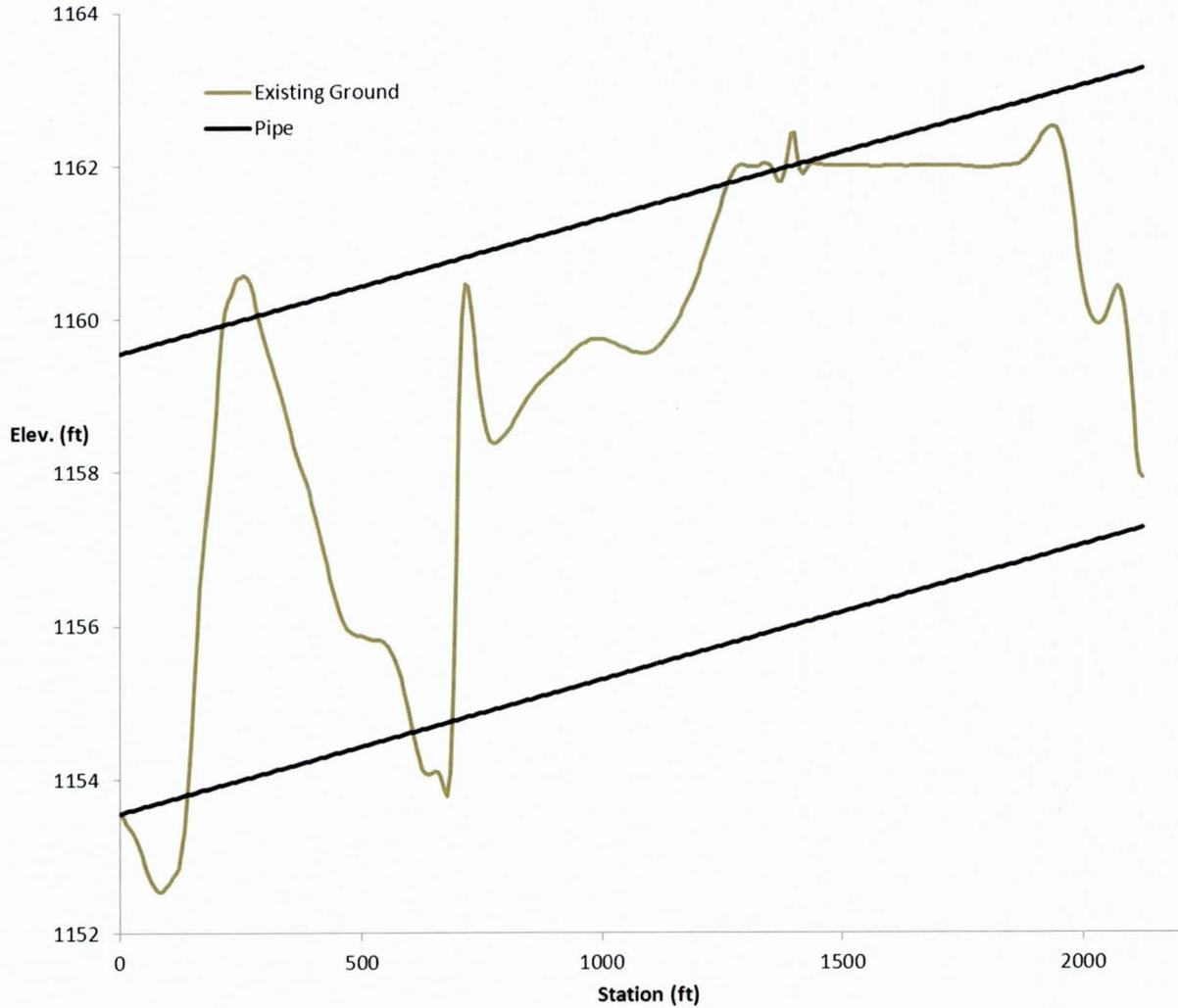


Figure 20. Profile of existing topography along the alignment of Figure 19.

**APPENDIX E – REGIONAL DRAINAGE CHANNEL SOUTH OF BELL ROAD**

Sun City Drain South of Bell Road

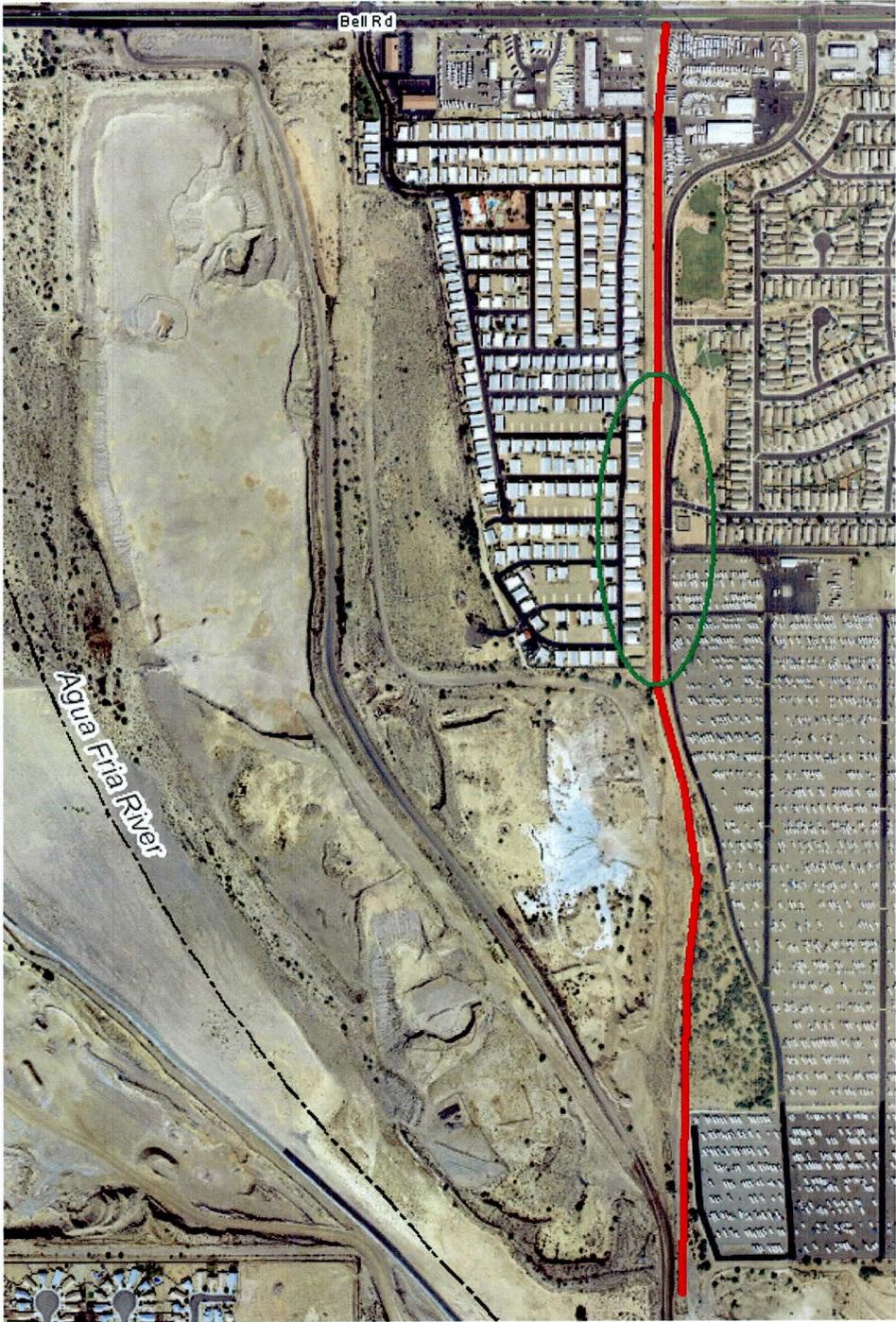


Figure 21. Location of existing Sun City Drain south of Bell Road. Areas of definite overtopping are circled in green.

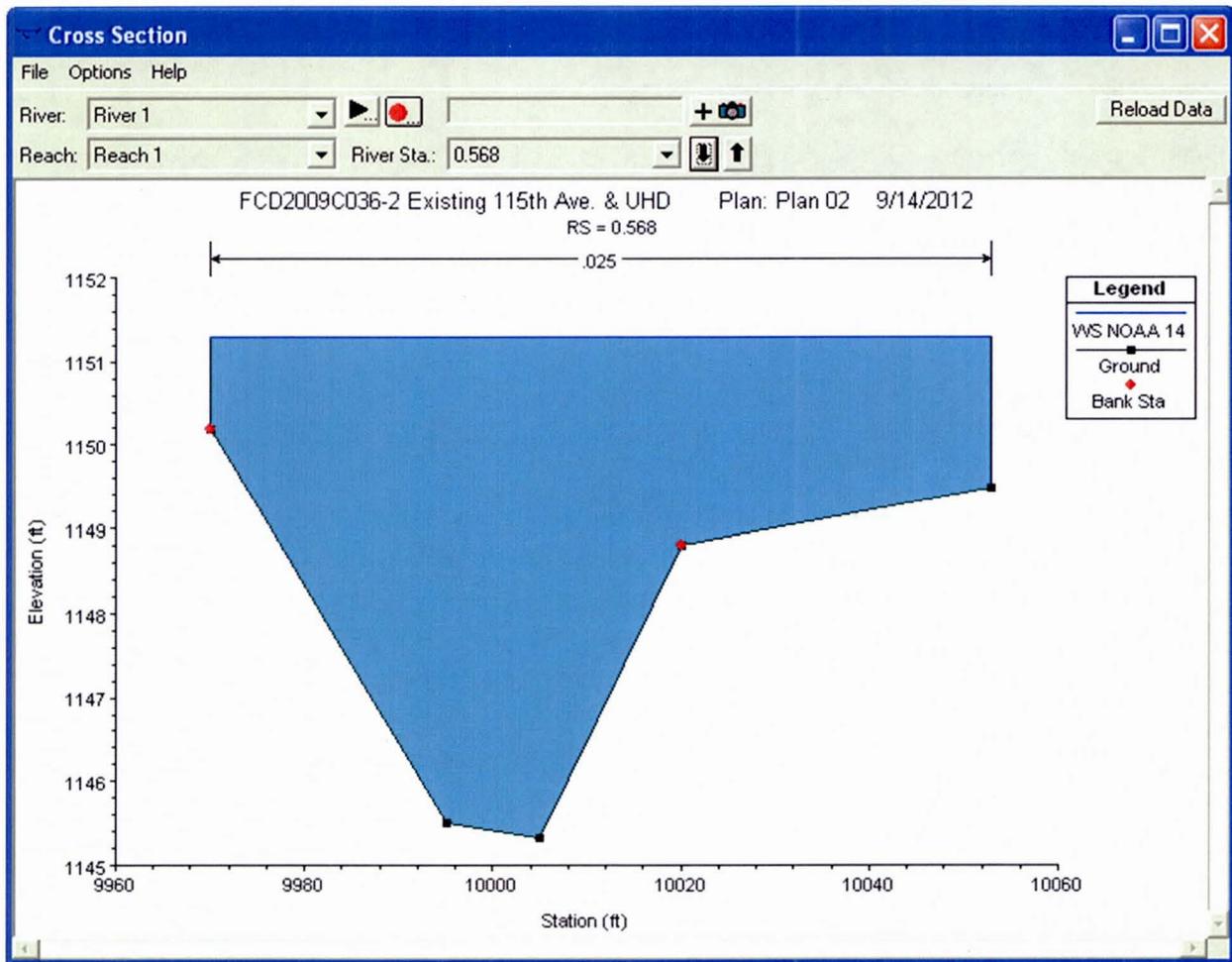


Figure 22. Cross-section 0.568 of the existing conditions HEC-RAS model of the Sun City Drain. The water surface elevation is from the existing conditions NOAA 14 100-year 24 hour HEC-1 model.

Problem: In the existing conditions, the channel does not have adequate capacity to pass the 100-year storm. From a review of the existing conditions, the 100-year NOAA 14 flows overtop the west bank and flow through the mobile home park. The area where this overtopping occurs is circled in green in Figure 21. Figure 22 is a plot of the cross-section where the worst overtopping occurs. As a note, a flow of 800 cfs would be contained with the  $n$  value of 0.025 in the cross-section that is shown in Figure 22.

Assumptions: The full flow that was determined from the unsteady HEC-RAS model of Canyon Ridge were used to design the channel. Because of local drainage in the southern subbasins, the peak flows increase as the channel approaches the Agua Fria River.

Design Flow: 1400 cfs (from unsteady conditions HEC-RAS model for Canyon Ridge)

Slope: 0.0055 ft/ft (from Goodwin & Marshall existing conditions HEC-RAS supercritical), 0.0007 subcritical

Length: ~5700 ft (from alignment in Figure 21)

Channel Shape: Trapezoidal (shown in Figure 23)

Channel Lining: Concrete

Channel Depth: ~5 ft (4.7 ft including freeboard) supercritical, ~6.0 ft (5.8 ft including freeboard) supercritical

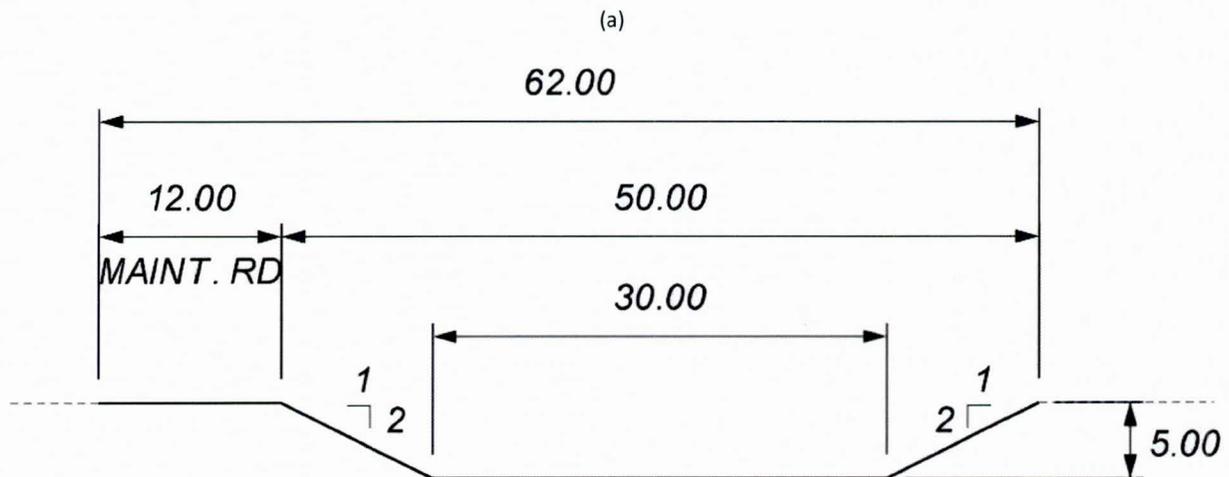
Estimated Velocity: 14.65 ft/s supercritical, 3.22 ft/s subcritical

Cons: 1) Based on the above slope, a concrete channel produces a supercritical flow. Reducing the slope to 0.004 ft/ft by including a long sloped drop structure still produces a supercritical channel.

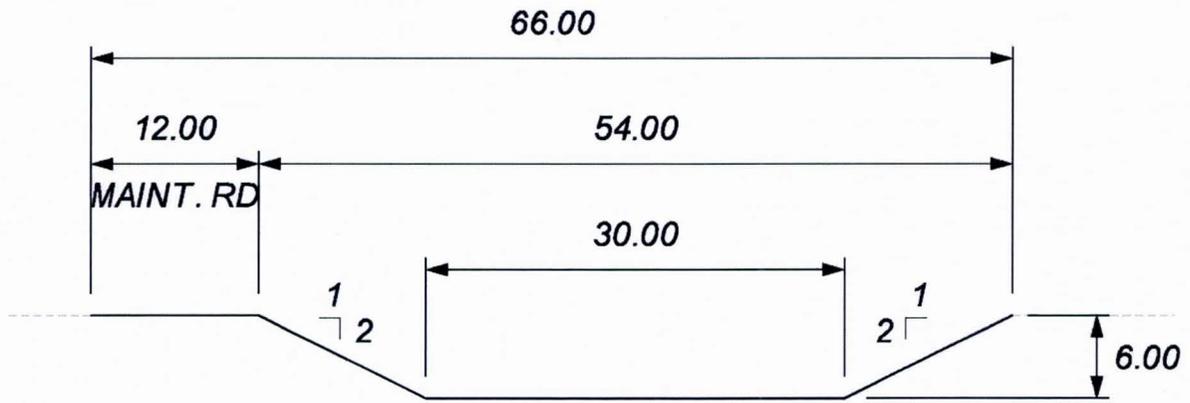
2) To reduce the flow velocity until the Froude number is less than 0.86, the slope would need to be reduced to 0.001 ft/ft. This would require multiple drop structures and earthwork. Figure 24 shows the existing profile of the Sun City Drain channel.

3) Existing 40 ft drainage easement would have to be expanded.

Pros: 1) Improving this channel would provide a designated outfall for the entire project.



(b)



) Figure 23. Schematic of (a) proposed supercritical trapezoidal channel and of (b) proposed subcritical trapezoidal channel.

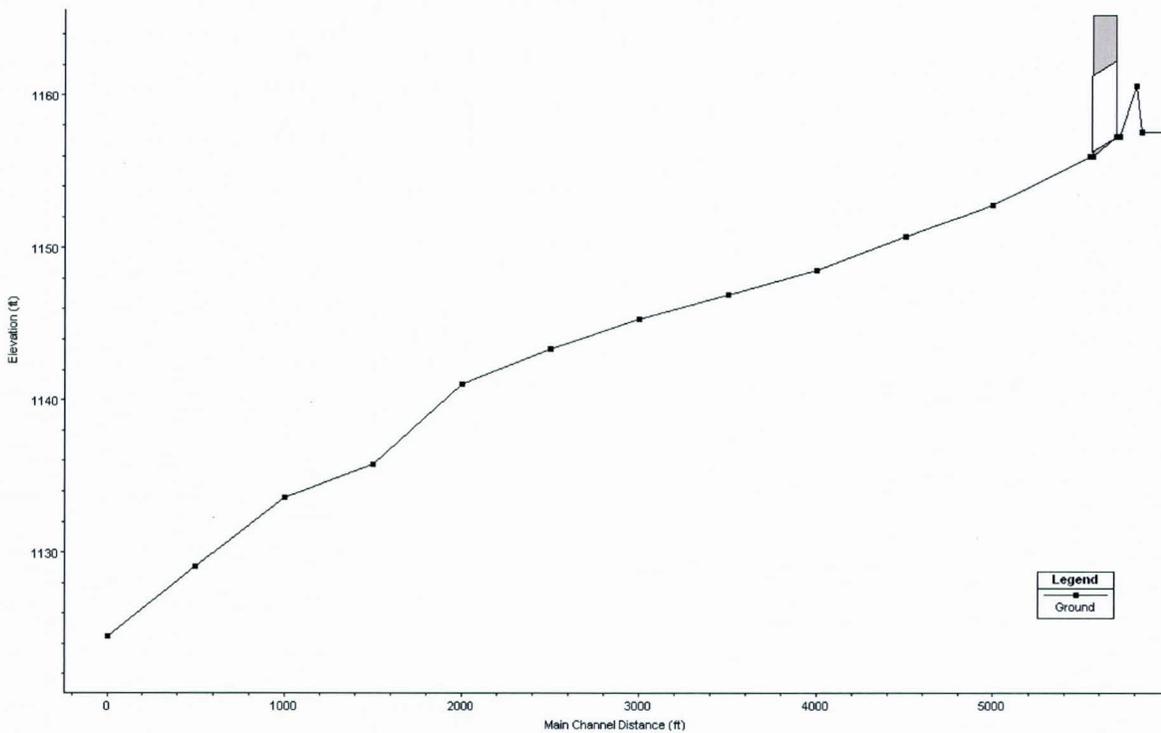


Figure 24. Profile of existing Sun City Drain south of Bell Road. The culvert in the figure is the Bell Road culvert.

**APPENDIX F – DETENTION BASIN “C”**

## Attenuating the Flows through Basin C



Figure 25. Location of basin C. The top of the basin is outlined in red while the bottom is shown in orange. The spot elevations shown with yellow dots along Bell Road.

Design Goal: To size the basin such that the outflow to the existing Sun City Drain channel south of Bell Road is less than 800 cfs

Methodology: A simple HEC-1 model was developed using the inflow hydrographs from the unsteady HEC-RAS model for Canyon Ridge Channel for the inflow of the existing Sun City Drain to the east and the outflow from Canyon Ridge to the north. A rating curve for a potential outflow pipe from the basin was developed using the maximum flow of 800 cfs. The volume-elevation curve for the potential basin was also developed using the areas shown above and a depth of 6 feet. The depth was developed using 1164 ft minus 1158 ft, where 1164 ft is taken as 1 ft below the elevation of 115<sup>th</sup> Avenue (illustrated by the spot elevation at the lower left of Figure 25). 1158 ft was taken as just above the invert (1157.18 ft) of the existing culverts under Bell Road.

**APPENDIX G – COYOTE LAKES FLOODING**

**Flooding at Northeast Corner of Coyote Lakes Development**



**Figure 26. Spot elevations at the northeast corner of Coyote Lakes**

To help determine if the houses near the Beardsley Road channel (shown in Figure 26) and 115<sup>th</sup> Avenue are subject to flooding, spot elevations were taken at key locations at this location. The spot elevations are shown in Figure 26. From this figure, it can be seen that the house nearest to 115<sup>th</sup> Avenue has an elevation that is lower than the top of curb at the golf course. If water were to pond to this level, it appears that this house may get wet.

Using Goodwin & Marshall’s existing conditions HEC-RAS for the Beardsley Road Channel, the sport elevations and a CulvertMaster model of the existing two 36” culverts, the maximum flow through the culverts at a headwater elevation equal to the top of existing channel is 55 cfs. At the peak flow of 324 cfs (from existing conditions HEC-1 model, EX100-24.dat), a value for the amount of overflow to this area of Coyote Lakes was estimated to be 269 cfs. A cross-section was determined along the red line in Figure 27. The slope between the two spot elevations (circled in green in Figure 28) near the centerline of 115<sup>th</sup> Avenue was determined to be 0.0048. Using a slightly more conservative slope of 0.004 ft/ft, the flow depth in the cross-section at 259 cfs would be 1.36 ft, which would result in an elevation of 1191.73 ft (NAVD 88). This elevation is below the 1192.286 ft (NAVD 88) of the nearest house. Only when the slope is flattened to 0.0009 ft/ft (~5 ft/mile) would the normal depth calculation result in an elevation equal to the nearest house. From this normal depth analysis, it appears that the house will not get inundated.

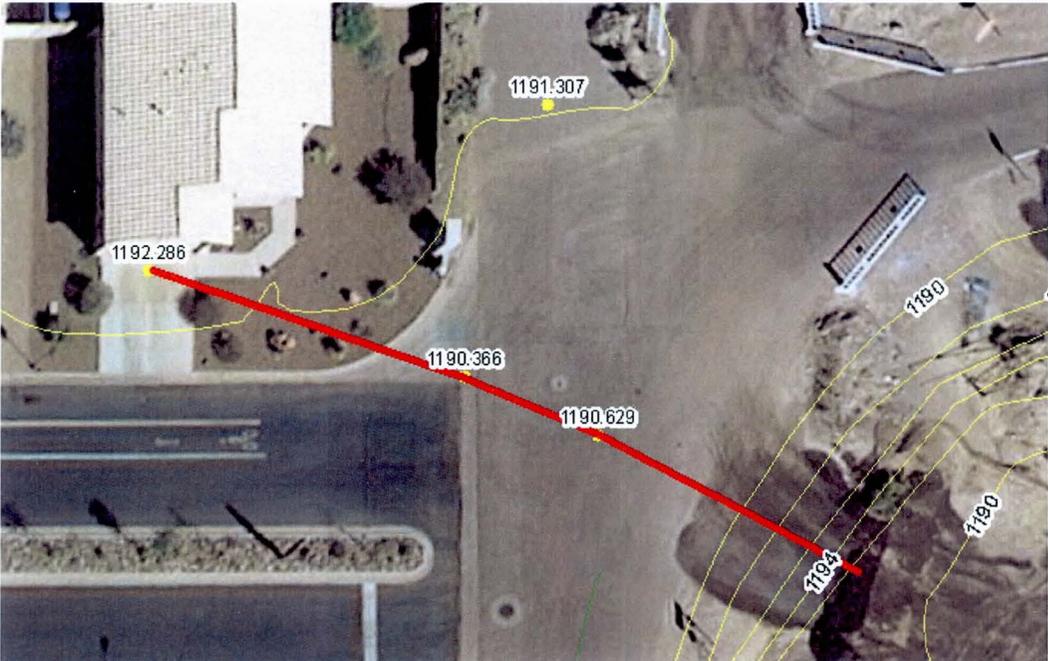


Figure 27. Cross-section (in red) location to determine flooding potential at Coyote Lakes. The point elevations are in NAVD 88, while the contours are in NGVD 29. The conversion is NAVD 88 – NGVD 29 = 1.96 ft.

However, based on the potential for ponding mentioned above, it is recommended that an inlet (through the curb of the sidewalk) to the golf course be designed to reduce the ponding potential. This inlet appears feasible because other areas of the Coyote Lakes development were designed to take the full 100-year 24 hour onsite rainfall to the golf course (according to the design report for *Coyote Lakes Unit 1 Replat*).

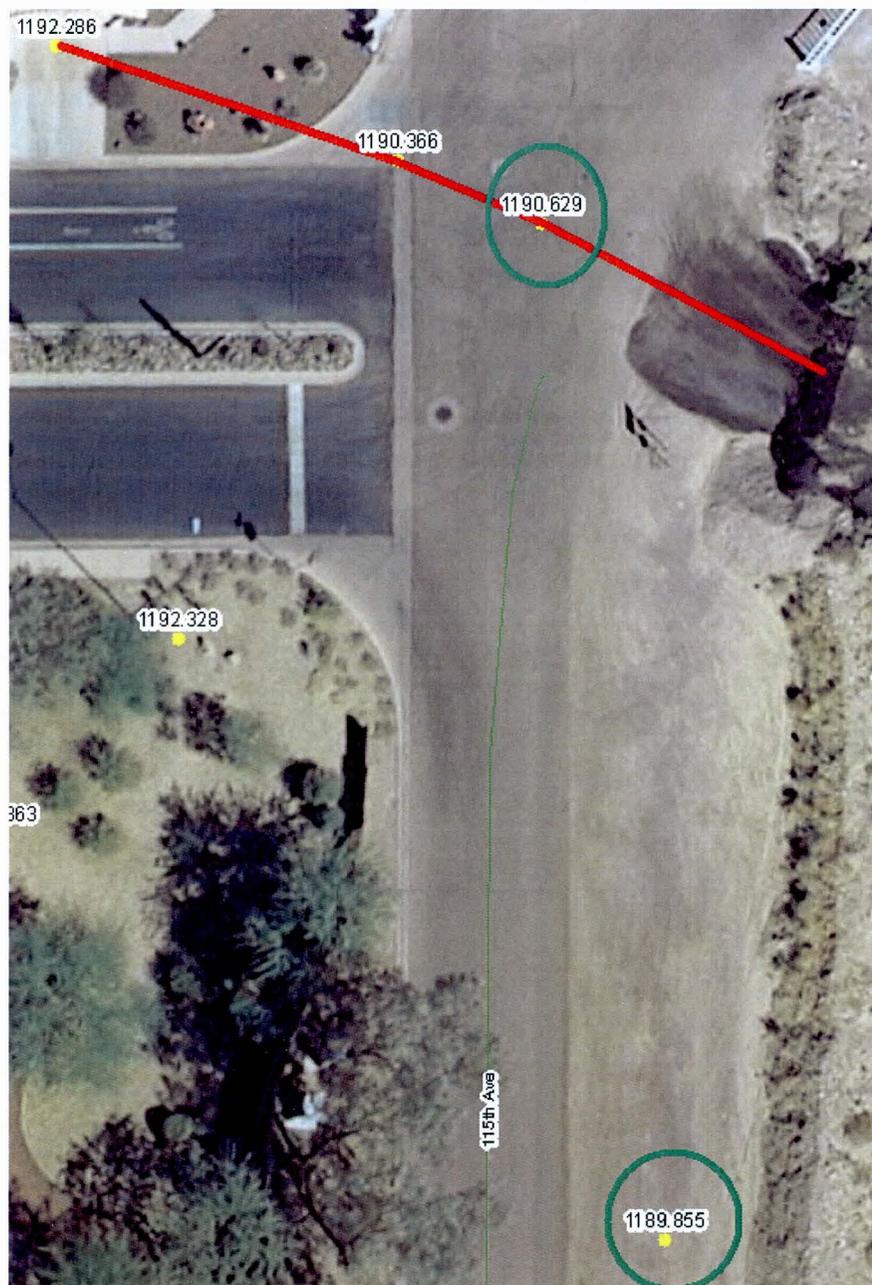
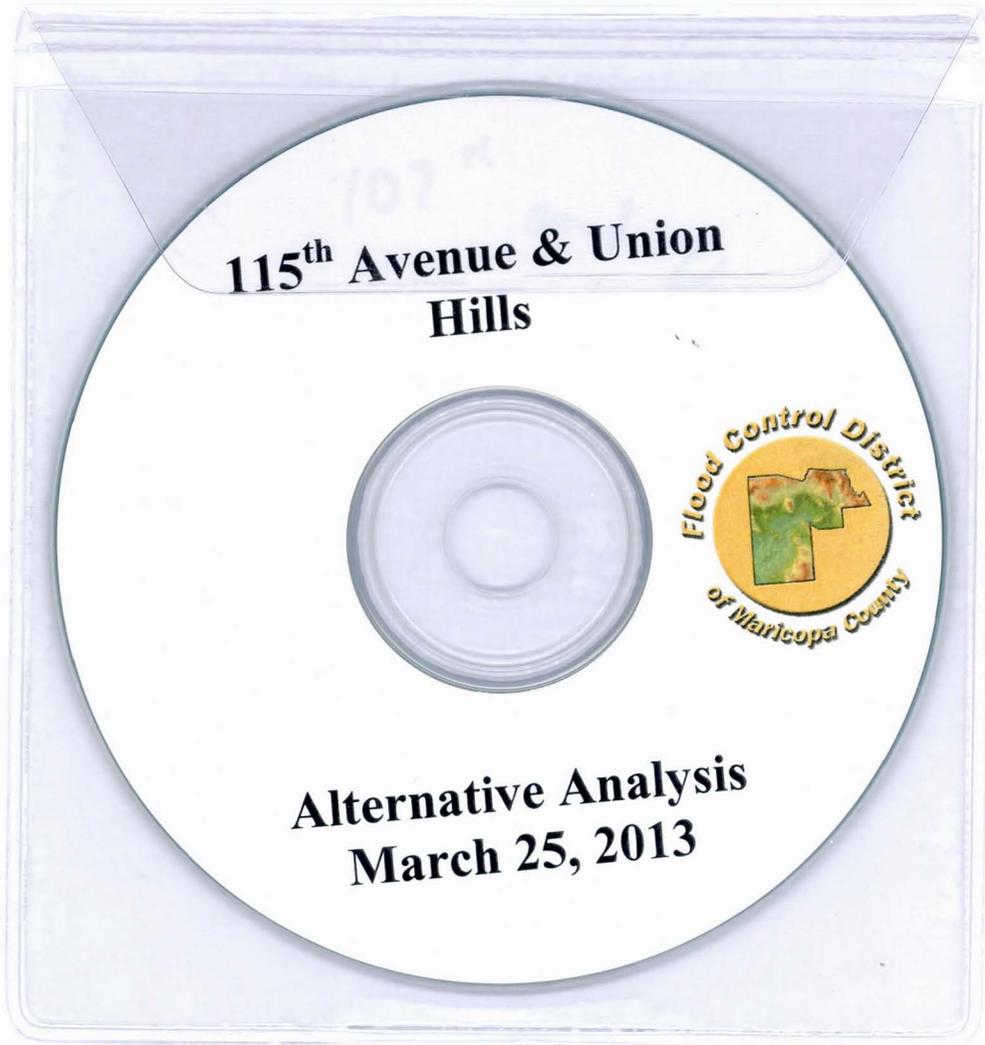


Figure 28. Points used to determine slope.

APPENDIX H - CALCULATIONS CD

# CD

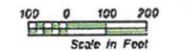


APPENDIX I – LAND COST EXHIBITS

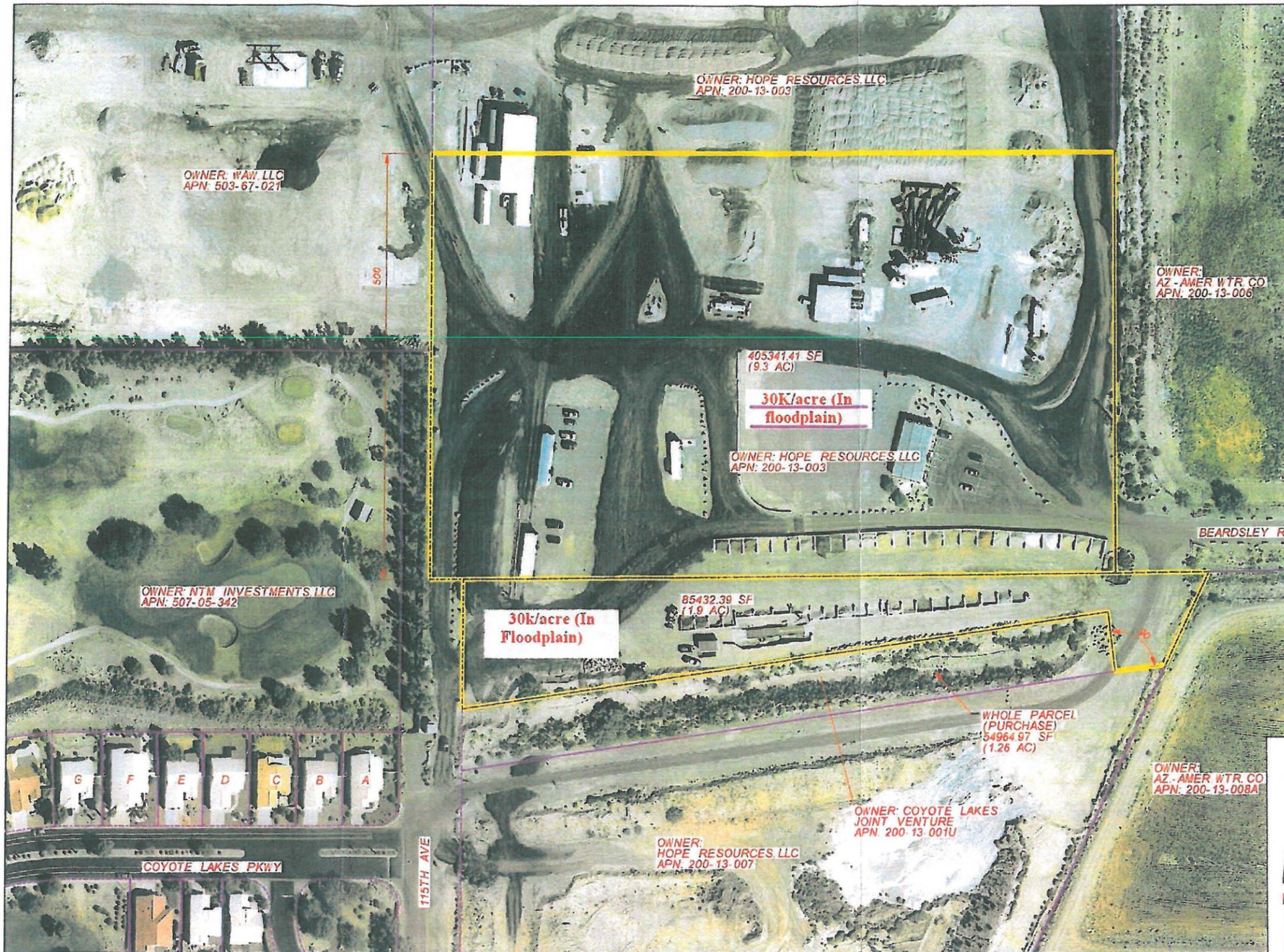


PARCEL A: 0.08 AC DRAINAGE EASEMENT IN ROAD R.O.W.  
 PARCEL B: 0.88 AC DRAINAGE EASEMENT ALONG GOLF COURSE  
 PARCEL C: 0.46 AC DRAINAGE EASEMENT - WAW, INC (INCLUDES MINERAL RIGHTS)  
 PARCEL D: 0.59 AC DRAINAGE EASEMENT - WAW, INC (INCLUDES MINERAL RIGHTS)  
 PARCEL E: 0.39 AC DRAINAGE EASEMENT ON A.S.L.D.

150 SIGNS HAVE  
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 BLUE STAKE



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NO	REVISION	BY	DATE
 <b>FLOOD CONTROL DISTRICT OF MARICOPA COUNTY</b> <b>ENGINEERING DIVISION</b> <b>107th ave AND UNION HILLS DR</b> <b>FCD PROJECT NO. ---</b> <b>CONTRACT FCD 2011C0XX</b>			
PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING	DESIGNED	MJ	07/12
	DRAWN	FDK	08/12
	CHECKED	JRR	09/12
<b>107th ave AND UNION HILLS DR</b> <b>EASEMENT LOCATIONS</b>			
DRAWING NO.	EXHIBIT 1	SHEET OF 1	



DESCRIPTION:  
ACQUIRE 11.2 ACRES FROM  
HOPE RESOURCES, INC  
FOR STORM WATER BASIN.  
WILL REQUIRE PURCHASE OF  
MINERAL RIGHTS & RELOCATION  
OF EXISTING FACILITIES

- A) OWNER: LAURA LOCARANO  
APN: 507-05-161
- B) OWNER: THOMAS STACK  
APN: 507-05-160
- C) OWNER: JEANETTE WINTERS  
APN: 507-05-159
- D) OWNER: JOSE MEDINA  
APN: 507-05-158
- E) OWNER: WENDY KUNKEL/MICHEAL STEWART  
APN: 507-05-157
- F) OWNER: CHARLES CRAWFORD/DOMINICA MARIE  
APN: 507-05-156
- G) OWNER: NICHOLAS WILSON  
APN: 507-05-155

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FLOOD CONTROL DISTRICT  
OF MARICOPA COUNTY  
ENGINEERING DIVISION

107th ave AND UNION HILLS DR  
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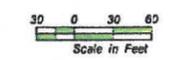
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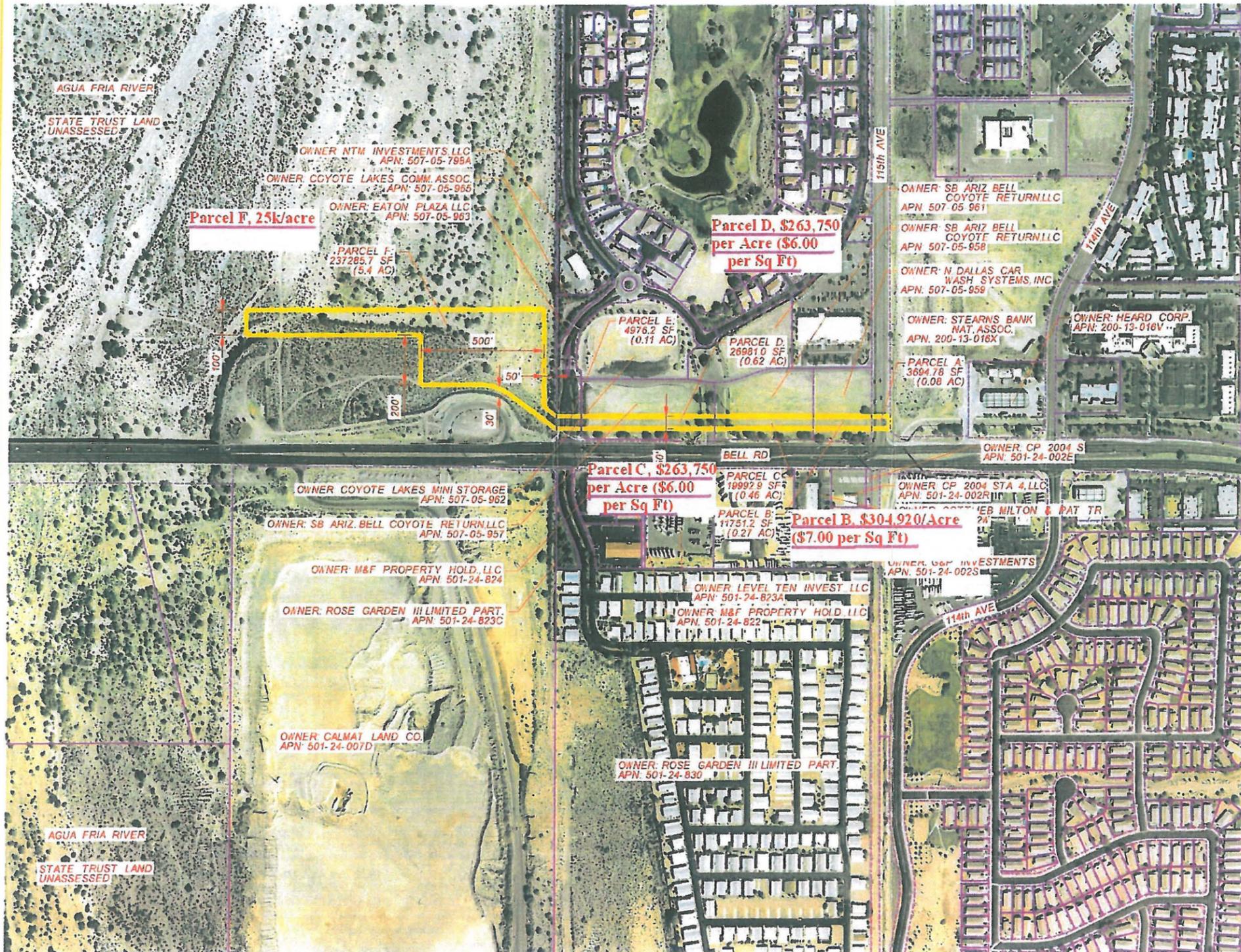
PRELIMINARY  
NOT FOR  
CONSTRUCTION  
OR  
RECORDING

107th ave AND UNION HILLS DR  
EASEMENT LOCATIONS

DRAWING NO.	EXHIBIT 2	SHEET OF 1
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1400 N. 20TH AVE  
SUITE 100, PHOENIX, AZ 85016  
602-263-1100  
BLUE STAKE



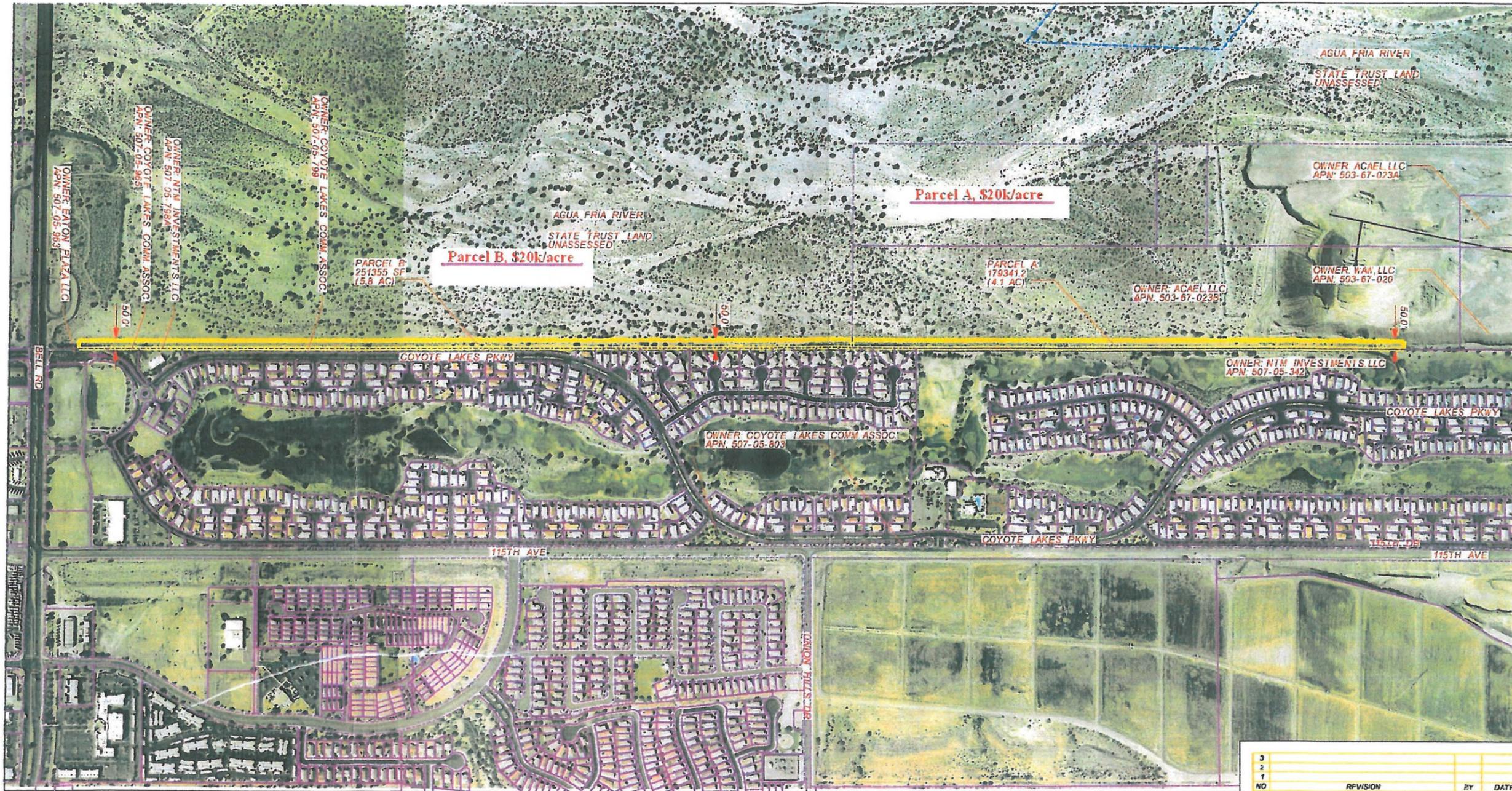


- PARCEL A: 0.08 AC  
ACQUIRE DRAINAGE PERMIT FOR CROSSING PUBLIC ROAD R.O.W.
- PARCEL B: 0.27 AC  
ACQUIRE DRAINAGE EASEMENT FOR BOX CULVERT
- PARCEL C: 0.46 AC  
ACQUIRE DRAINAGE EASEMENT FOR PRIVATE ROAD R.O.W. FOR BOX CULVERT
- PARCEL D: 0.62 AC  
ACQUIRE DRAINAGE EASEMENT FOR PRIVATE ROAD R.O.W. FOR BOX CULVERT
- PARCEL E: 0.11 AC  
ACQUIRE DRAINAGE EASEMENT FOR PRIVATE ROAD R.O.W. FOR BOX CULVERT
- PARCEL F: 5.4 AC  
ACQUIRE DRAINAGE EASEMENT FOR CHANNEL AND RETENTION BASIN



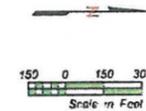
TOP SURVEY MAP  
 602-263-1100  
 BLUE STAKE

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PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING	DESIGNED DRAWN CHECKED	MJ FDK JRR	DATE 07/12 08/12 09/12
DRAWING NO.	107th ave AND UNION HILLS DR EASEMENT LOCATIONS		SHEET CF 1



DESCRIPTION:  
**PARCEL A:**  
 50' WIDE DRAINAGE EASEMENT WITHIN  
 EXISTING HOA ACCESS AND MAINTENANCE  
 EASEMENT ON MINING PROPERTY. (4.1 AC)

**PARCEL B:**  
 50' WIDE DRAINAGE EASEMENT WITHIN  
 EXISTING HOA ACCESS AND MAINTENANCE  
 EASEMENT ON STATE LAND. (5.8 AC)



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**107th ave AND UNION HILLS DR  
 FCD PROJECT NO. ---  
 CONTRACT FCD 2011C0XX**

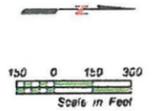
PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING	DESIGNED	BY	DATE
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	FDK		08/12
	JRR		09/12

**107th ave AND UNION HILLS DR  
 EASEMENT LOCATIONS**

DRAWING NO.		SHEET OF
	EXHIBIT 4	1

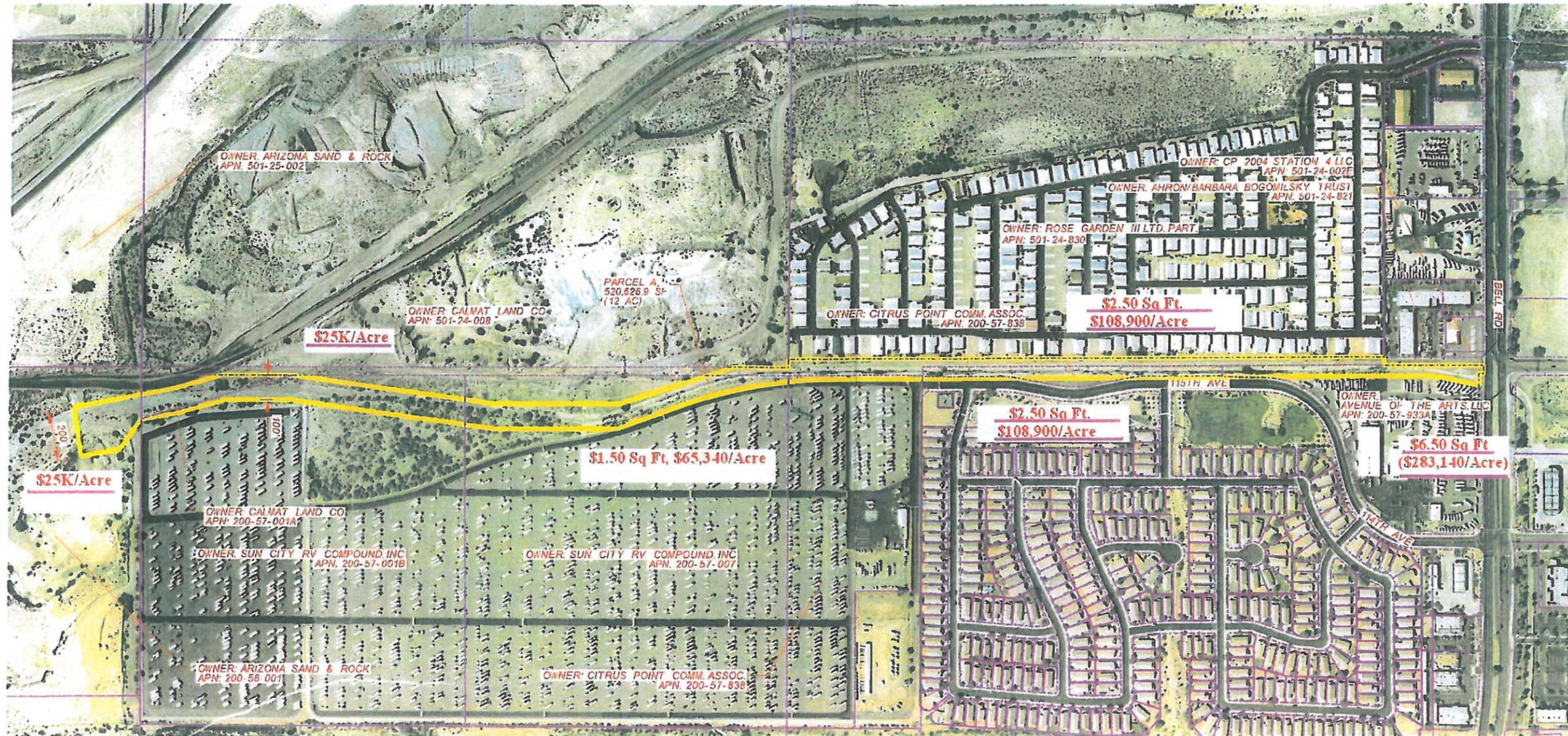


DESCRIPTION:  
 30' WIDE DRAINAGE EASEMENT WITHIN  
 EXISTING RIGHT-OF-WAY FOR 115th AVENUE.  
 LENGTH: 5,184FT FOR 3.57 ACRES

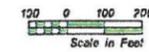


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	107th ave AND UNION HILLS DR FCD PROJECT NO. --- CONTRACT FCD 2011C0XX		
		BY	DATE
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NOT FOR	DRAWN	FDK	08/12
CONSTRUCTION	CHECKED	JRR	09/12
OR			
RECORDING	107th ave AND UNION HILLS DR EASEMENT LOCATIONS		
DRAWING NO.	EXHIBIT 5		SHEET OF 1



PARCEL A:  
12 AC - OBTAIN DRAINAGE AND MAINTENANCE EASEMENT  
OVER EXISTING DRAINAGE EASEMENT FROM  
MULTIPLE PROPERTY OWNERS



MAP & CIVILS IMPS  
SERV. YOU DO OK.  
602-263-1100  
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FLOOD CONTROL DISTRICT  
OF MARICOPA COUNTY  
ENGINEERING DIVISION

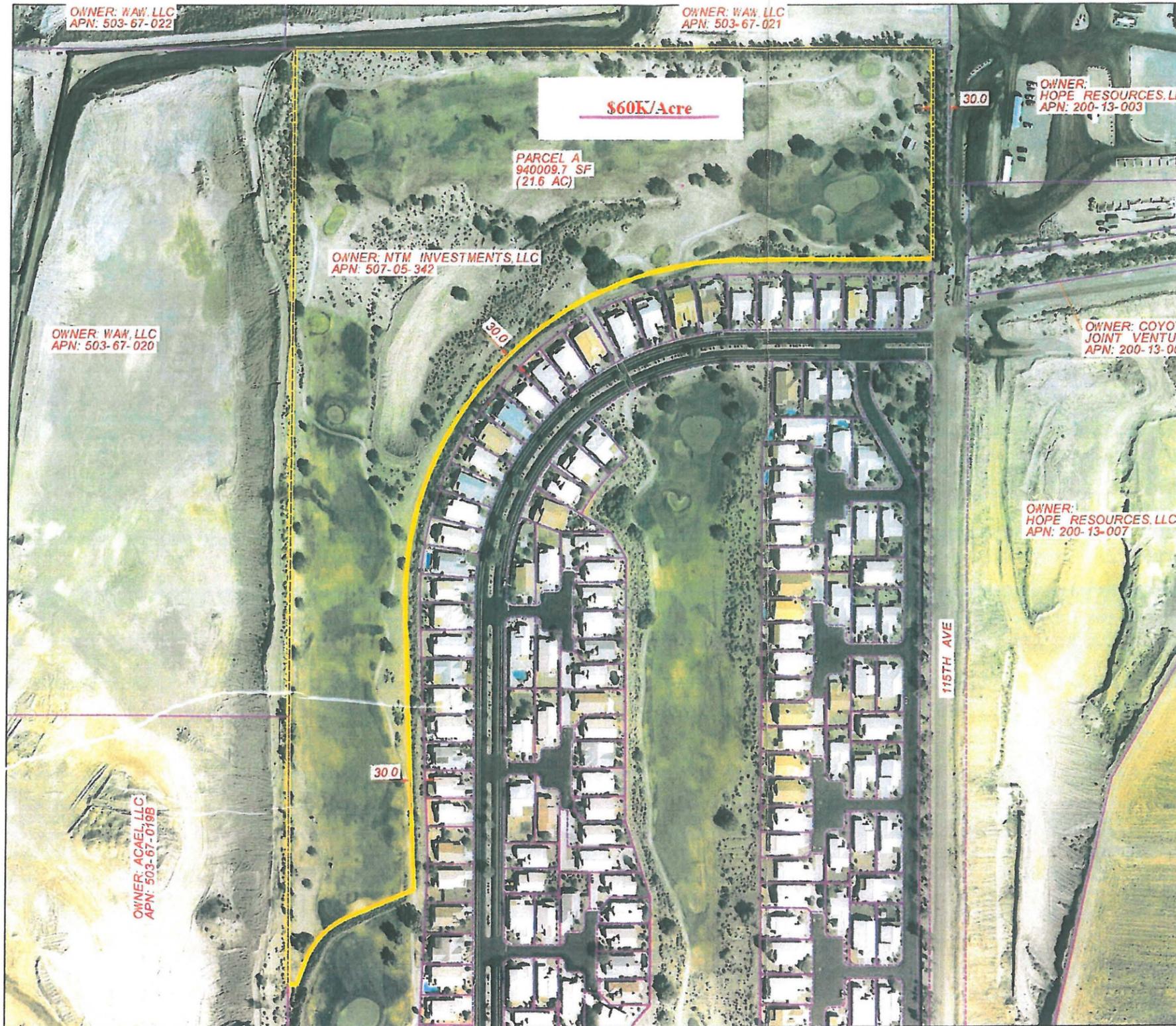
107th ave AND UNION HILLS DR  
FCD PROJECT NO. ---  
CONTRACT FCD 2011C0XX

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CHECKED	JRR	09/12

PRELIMINARY  
NOT FOR  
CONSTRUCTION  
OR  
RECORDING

107th ave AND UNION HILLS DR  
EASEMENT LOCATIONS

DRAWING NO.		SHEET OF
	EXHIBIT 6	1



OWNER: WAW, LLC  
APN: 503-67-022

OWNER: WAW, LLC  
APN: 503-67-021

**\$60K/Acre**

PARCEL A  
940009.7 SF  
(21.6 AC)

OWNER: NTM INVESTMENTS, LLC  
APN: 507-05-342

OWNER: HOPE RESOURCES, LLC  
APN: 200-13-003

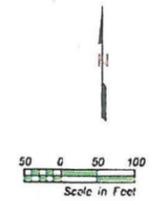
OWNER: WAW, LLC  
APN: 503-67-020

OWNER: COYOTE LAKES  
JOINT VENTURE  
APN: 200-13-001U

OWNER: HOPE RESOURCES, LLC  
APN: 200-13-007

OWNER: ACAEL, LLC  
APN: 503-67-0199

PARCEL A:  
DRAINAGE EASEMENT OVER  
GOLF COURSE (21.6 AC)



602-263-1100  
BLUE STAKE

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NOT FOR	DRAWN	FDK	08/12
CONSTRUCTION	CHECKED	JRR	09/12
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107th ave AND UNION HILLS DR EASEMENT LOCATIONS			
DRAWING NO.	LXHIBIT 7		SHEET OF 1