Initial Hydrology Memorandum

Prepared for:

Flood Control District of Maricopa County

Prepared by:

URS Corporation

Registered Professional Engineer (Civil)
CERTIFICATE NO. 33656
ELLIOT SILVERSTON
Date Signed 10-2-08
ARIZONA, U.S.A.
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This report is based on data, site conditions and other information that is generally applicable as of 2008, and the conclusions and recommendations herein are therefore applicable only to that time frame.

This report is preliminary in nature and is not to be used as the sole basis for final design, construction or as a basis for major capital decisions. Further analysis of the study area should be performed prior to any designs or decisions.

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1.0 PURPOSE AND OBJECTIVE

Task 9.5 of the Rainbow Valley Area Drainage Master Plan (RVADMP) requires that an initial hydrology memorandum will be prepared documenting the concerns and discrepancies with hydrologic models created for the Waterman Wash Floodplain Delineation Study. The Floodplain Delineation Study was completed by Engineering and Environmental Consultants (EEC) in 2006.

In addition, this memorandum will document additional concerns and propose alternative methodologies for the hydrologic models that will be created as part of the RVADMP.

2.0 INTRODUCTION

There have been two hydrologic models, previously created for the Waterman Wash watershed. The first model was done by Cella Barr and Associates in 1988. The purpose of this model was to determine flows in Waterman Wash for floodplain delineation. This project included a detailed floodplain / floodway delineation for Waterman Wash from the Gila River upstream to the confluence of the east and west prong.

The second hydrologic model was the EEC model completed in 2006. This model expanded the hydrology previously done by Cella Barr and Associates so they could map approximately 165 miles of Zone A floodplains. These approximate floodplains included the upper reaches of Waterman Wash as well as Lum and Corgett Washes.

These two previous models were developed for existing conditions and used to delineate floodplains. They did not account for proposed development in the study area. Additional and more accurate data is available for the watershed. The goal is to develop an existing and future hydrologic model that can be used as a development guide for the study area.

3.0 WATERMAN WASH MODEL ISSUES

The hydrologic models and Floodplain Delineation Study prepared by EEC were reviewed to determine what information could be used in the hydrologic models that will be created for the RVADMP. The EEC study created three hydrologic models for the watershed. In the first model, the Union Pacific Railroad (UPRR) acts as a levee. The lower flows are routed through the railroad crossing structures while the excess flow is diverted east along the railroad embankment. The second model ignores the effect of the railroad, assuming that no flow is diverted along the

railroad embankment. The last model is for the outlying drainage basins that drain directly into the Gila River and not into Waterman Wash. The following sections detail the issues and concerns with the hydrologic models from the EEC study.

3.1 NEW DATA IMPACTS

3.1.1 NOAA 2 to NOAA 14 Precipitation

The EEC study used the National Oceanic and Atmospheric Administration (NOAA) 2 atlas data, which gives higher rainfall values for the project area than the updated NOAA 14 atlas. The EEC study used a value of 4.40 inches for the 100-year, 24-hour rainfall in the study area. The new NOAA 14 atlas shows values ranging from 3.20 inches to 3.70 inches for the 100-year, 24-hour rainfall. Eight points in the watershed were selected for comparison, and the results are shown in Table 1. The EEC study also used the NOAA 14 atlas in their hydrology models to determine the differences in flow throughout the watershed. These models were for comparison only, and were not used in the EEC floodplain delineations.

Table 1
NOAA 2 versus NOAA 14

Point ID	Location	Longitude	Latitude	NOAA 14 Rainfall 100-yr, 24-hr (inches)	NOAA 2 Rainfall 100-yr, 24-hr (inches)	Percent (%) Reduction
1	Estrella Mountain Ranch	-112.482	33.338	3.42	4.18	18.2
2	Plains in Basin A	-112.520	33.264	3.44	4.16	17.3
3	Northern Portion of the Estrella Mountains	-112.339	33.308	3.42	4.61	25.8
4	Watershed B just Upstream of Waterman Wash	-112.415	33.196	3.23	4.42	26.9
5	Upper Plains Between the Mountains in Basin G	-112.234	33.166	3.39	4.63	26.8
6	Maricopa Mountains in the Middle of Basin C	-112.397	33.083	3.40	4.43	23.3
7	Southern Portion of the Maricopa Mountains	-112.360	32.940	3.65	4.52	19.2
8	Booth Hills	-112.248	32.975	3.60	4.55	20.9

The average NOAA 14 rainfall for the Waterman Wash watershed is approximately 3.44 inches, which is approximately 22 percent less than the average NOAA 2 rainfall. The Flood Control

District will provide URS with the final NOAA 14 rainfall data to be used for the hydrologic model.

The NOAA 14 rainfall values are lower than in NOAA 2, and that could result in a reduction of discharges in some of the delineated floodplains. If this reduction is significant, the floodplain study may need to be updated to reflect current information. The project team will decide what percentage of reduction (if any) would necessitate a floodplain re-delineation.

An increase in discharges is possible, but unlikely. The updated split flow analysis could increase the estimated discharges at certain locations by increasing the diverted flow in that reach. Any increase in flows within a delineated floodplain should be identified, and the floodplain delineation may need to be updated.

3.1.2 Topography (Basin Delineations and Flow Paths)

Topography

New 2-foot and 4-foot contour interval topography was created for this RVADMP, but it does not cover the entire watershed. The EEC model used 10-foot contours to develop their models. Comparison between their basin delineations and flow paths to the updated mapping revealed areas that need to be updated. Where no new topography exists for an area, such as portions of the Sonoran Desert National Monument, the previous 10-foot contour map will be used.

The new topography did not capture the recent mass grading in southern portions of Estrella Mountain Ranch. Field investigation will assist in basin delineations for these areas. The new topography also did not capture the diversion berms along the UPRR. The EEC study completed a survey of the diversion berms, and this information will be used in the new analysis.

Basin Delineations/Flow paths

Several issues are presented concerning current delineations and flow paths from the EEC study. As stated earlier, the EEC study used 10-foot contour mapping to delineate the drainage basins, and the 2-foot contour mapping created for the RVADMP revealed several areas where the delineations appeared inaccurate. The aerial maps show flow paths crossing different basin boundaries in some areas and, in most cases, the actual flow path is longer than what was used in the EEC model. Additionally, the EEC study did not incorporate any of Estrella Mountain Ranch into the basin delineations. Examples of concerns with the basin delineations are shown in Figures 1 through 3. URS has created a shapefile for each major basin identifying the basin delineation and flow path discrepancies. These shapefiles will be provided to the District for their information.

3.1.3 Imagery/New Development/Land Use

Imagery/New Development

The June 2007 aerial maps developed for this RVADMP will be used to identify new development, not existing at the time of the EEC study, and update the existing conditions land use data. This information also will be used to better analyze split flow locations. The evidence of vegetation on these aerial maps typically indicates a flow corridor.

Review of Planned Developments

Two major planned developments, Amaranth and Vekol Valley, are located in the southeast portion of the project area, and another, Estrella Mountain Ranch, is being developed near the Gila River. URS conducted a cursory review of the existing condition hydrology model for the Drainage Master Plan Draft. The drainage master plan for the Amaranth development is near completion. When this report is complete, the preliminary design phase will begin in selected areas. Three issues exist with the Amaranth development; the first is that the split flows along the UPRR from the EEC study were updated using supplemental survey and data collected from the UPRR. The second concern is that this development did not account for any flow diverting into the watershed from Vekol Wash. At this time, it is not certain if there is flow diverting into the watershed. If there is diversion flow from Vekol Wash, that could affect the Amaranth design.

The third and final concern with the Amaranth development relates to routing cross sections that were used from the original EEC study. These routing reaches used vertical walls in the cross sections to contain flow, which reduces the attenuation and storage in the reach. The model created for the Amaranth development increased the Manning's "n" values in the routing to account for the sheet flow. The modelers believed the velocities in the routing reaches were too high for sheet flow conditions. The EEC study determined the Manning's "n" values based on field reconnaissance, ground photographs, and examination of the aerial photographs. The increased Manning's "n" values could further reduce the offsite flow, and this issue needs be further examined. The District will review the hydrology created for the Amaranth development.

The Vekol Valley development is in the planning stages, and no work has been done on a drainage master plan. It is assumed that any alternatives developed in this ADMP will be complete before this development begins the drainage master plan.

The Estrella Mountain Ranch development has been designed and portions are currently under construction. No improvements are planned to that development as part of this ADMP.

Land Use

The models created in the EEC study were for existing conditions. Existing and future condition models will be created as part of the ADMP. The future land use plans for Goodyear, Avondale, Buckeye, the Bureau of Land Management, and the Maricopa Association of Governments will be collected, and that information will be incorporated into the future condition models.

3.1.4 UPRR Improvements

The UPRR is replacing many of the trestle bridge crossings in the project area with culverts made of steel pipe. These culverts were designed so the same conveyance through the railroad would be achieved. However, the culverts will change the stage-storage curves used in the previous model. The updated models will use revised stage-storage curves based on the new culverts. The UPRR is also constructing an additional track just south of the current alignment. The UPRR will be modeled as one track and the culvert length will be based on the total length through all tracks and the low areas between the track at the crossing. This information will be included in the RVADMP models.

3.1.5 New Project Boundaries

There were three new areas that were added to the original study area as part of the RVADMP. They do not drain into Waterman Wash, but were included so they could be modeled. The boundaries of those new areas follow county lines and not drainage boundaries, creating many small basins along the county line that are unconnected and will not be studied. An example of a project boundary not following a drainage divide is shown in Figure 4.

Flow from Pinal County also enters the project boundary in some locations. These areas will not be included into the HEC-1 model. If these areas are to be included in the models, the project team will need to decide how they would be modeled. The team does not presently have topographic and soil mapping for these areas. An example of this is shown in Figure 5. These areas were not considered in the scope of work.

3.1.6 Vekol Wash

A breakout from Vekol Wash could enter the Waterman Wash watershed near the stock tank. The contributing area of Vekol Wash near this location was determined using U.S. Geological Survey 7.5 quadrangle maps and the flow was estimated using the USGS Southwest Regional Regression Equation for the area. The team visited this location to determine the amount of potential flow diversions to our project area. The team determined only a minor amount of flow

could enter the Rainbow Valley project area. The minutes from that field trip have been included as Appendix 1.

3.1.7 Other Models (Amaranth and Sonoran Parkway)

The hydrologic models created for the Amaranth development will not be incorporated into the models created for the RVADMP. However, common concentration points will be used where feasible so the results from the RVADMP model can be compared to the Amaranth model. The hydrologic model created for the Sonoran Parkway will not affect the models created for the RVADMP. The Sonoran Valley Parkway project is currently being reviewed by the Bureau of Land Management and will most likely be on hold for 18 months.

3.2 METHODOLOGY ISSUES

3.2.1 Routing (Unexpected Flow Results, Transmission Losses, Routing Cross Sections)

3.2.1.1 Unexpected Flow Results

Some drainage basins are producing runoff values greater than three cubic feet per second (cfs) per acre. These values are higher than values obtained from using the U.S.G.S. Regression Equation which has a maximum value of two cfs per acre when using one square mile. There is no justification for these high values. The basins have an average slope and soil parameters with no rock outcropping and the area is a desert type land use. The high runoff values do not seem valid. Table 2 shows the basins that are generating a larger than expected amount of flow.

3.2.1.2 Transmission Losses

Transmission loss methodologies were reviewed to determine if they could be applied to the routes in the study area. It was decided that the transmission losses in the routes will not be considered in the modeling because we do not have enough soil information to develop the transmission losses and the gage history is not long enough to calibrate and validate the results.

3.2.1.3 Routing Cross Sections

The hydrologic models developed in the EEC study added high sloping almost vertical walls in the overbanks of the cross sections to contain the flow. This can reduce the storage capacity and reduce attenuation within the route. An analysis was done for these routes to ascertain the amount of attenuation lost to the vertical walls. There are seventeen routes that were selected based on an outer slope of 4 to 1 or less. The cross section was modified in the model using a gradual slope instead of a steeper slope. Table 3 shows the results of that analysis. The eight

point cross sections used in the revised model will use gradual slopes to better model attenuation within the routing reach.

Table 2

Larger than Expected Runoff

Basin ID	Avg Xksat	Landuse	Slope (ft/mile)	cfs/ac
C18	0.436	Desert	58.70	3.05
C25	0.700	Desert	49.10	2.95
C28	0.270	Desert	58.40	3.75
D46	0.270	Desert	34.30	3.72
H81	0.389	Desert	45.00	2.94
I03	0.400	Desert	74.00	3.44
I14	0.301	Desert, Row Crop	22.10	3.22
I57	0.302	Desert, VLDR	49.30	3.01
I61	0.277	Desert	85.20	3.58
I64	0.128	Desert	45.20	3.16
I62	0.301	Desert	84.81	2.83
I37	0.269	Desert	19.50	2.79

Table 3

Vertical Walls Versus Gradual Slope in Overbank Areas

Route	EEC Model Q (cfs)	EEC Top Width (ft)	Revised Model Q (cfs)	Revised Model Top Width (ft)	Decrease (cfs)	Percent Decrease (%)
RCPA10	831	153.8	750	303.7	81	9.7%
RCPE19	1335	112.6	1218	404.3	117	8.8%
RCPG15	2880	769.4	2490	984.2	390	13.5%
RCPI08	996	121.5	825	399.8	171	17.2%
RCPI10	1173	122.8	816	426.3	357	30.4%
RCPI12	1357	141.4	1243	414.7	114	8.4%
RCPI20	1601	192.6	1418	511.8	183	11.4%
RCPI21	1495	163.6	1240	497.5	255	17.1%
RCPI29	1046	88	862	350.1	184	17.6%
RCPI31	1116	113	804	416.3	312	28.0%
RCPI33	1217	114.8	775	449.8	442	36.3%
RCPI34	721	111.7	659	391.1	62	8.6%
RCPI35	1430	113.6	793	498.2	637	44.5%
RCPI46	1021	111.8	866	392.1	155	15.2%
RCPI47	1127	142.2	824	441.1	303	26.9%
RCPI48	1085	113.5	762	422.1	323	29.8%
RCPI49	1788	162.5	1407	479.9	381	21.3%

3.2.1.4 Route Attenuation Errors

Some routes in the HEC-1 models have negative attenuation or no attenuation. Normal depth calculations could have been calibrated to remove the negative attenuation from the models. However, the flow increase was less than one percent of the total flow in the route. It is possible to have no attenuation in shorter routes (less than ¼ mile) or routes with steep slopes (greater than 0.5%), but it is not expected in longer routes with average slopes. There are a few routes in areas with longer route lengths and average slopes that should attenuate flow, but do not. Table 4 shows these routes from the EEC model.

Table 4

Route Attenuation Errors

Route	Route Length (ft)	Route Slope (%)	Upstream Flow (cfs)	Upstream Time of Peak (hrs)	Downstream Flow (cfs)	Downstream Time of Peak (hrs)	Flow Reduction (cfs)	Attenuation Time (hrs)
RCPG33	340	0.3	9404	13.17	9435	13.17	-31	0
RCPB33	490	0.55	2215	12.5	2236	12.5	-21	0
RCPH16	1940	5.53	613	12.17	618	12.17	-5	0
RCPC29	520	0.52	917	12.83	921	12.83	-4	0
RCPD41	220	0.2	10825	14	10827	14	-2	0
RCPG37	1450	0.2	11054	13.67	10983	13.67	71	0
RCPD29	1640	0.26	9368	13	9289	13	79	0
RCPD32	2800	0.27	9657	13.17	9474	13.17	183	0
RCPA46	2250	0.29	28068	16.83	27974	16.83	94	0
RCPD40	2270	0.32	13001	14.17	12916	14.17	85	0
RCPG42	2400	0.5	14820	14.33	14785	14.33	35	0
RCPC27	1360	0.51	676	12.83	666	12.83	10	0
RCPC48	1420	0.72	9198	14.5	9182	14.5	16	0
RCPI48	2920	0.77	1125	12.83	1085	12.83	40	0
RCPC08	3060	0.99	874	12.33	739	12.33	135	0
RCPG08	1480	1	273	12.33	265	12.33	8	0
RCPJ20	1000	0.41	2395	12.5	2490	12.33	-95	-0.17
RCPJ33	2290	0.57	2367	12.33	2265	12.33	102	0
RCPJ34	880	0.69	2489	12.17	2507	12.33	-18	0.16

3.2.2 Flow Splits (EEC Methodology for Flow Distributions, Diversions, FLO-2D)

3.2.2.1 Split Flow Issues

The split flow locations were originally computed from the 10-foot contour mapping and will have to be recalculated using the new 2-foot contour mapping. The updated 2-foot contours and

aerials reveal that some of these locations might not have split flow or that the split flow location occurs further upstream or downstream. Some split flow locations will need to be moved to the actual split location, and some will need to be removed in areas where splits were modeled but none appear to exist. Examples of such instances are shown in Figures 6 through 9.

The split flow analysis also adds the entire contributing area upstream of the split flow locations to each side of the split so the area reduction would be applied to both sides. A more accurate method is to apply a percentage of the total contributing area to each side of the split based on the amount of flow in the split. If the total contributing area is applied to each side of the split, the downstream flow is less than the actual amount due to area reduction. Only a percentage of the contributing area should be applied to either side of the split. This percentage will be determined based on the ratio of flow in the split. If 20 percent of the upstream flow is routed through the reach, then 20 percent of the contributing area should be attributed to that split.

3.2.2.2 Split Flow and Alluvial Fan Methodology

As discussed in the previous section, the split flow analysis will be revised for the updated models. The attached flowchart (Figure 10) demonstrates the methodology that will be used to analyze the split flow locations. The first steps involve identifying the location as a split flow and determining if the flow splits to other drainage basins. If it remains in the same drainage basin, the entire flow will be routed to the downstream concentration point and the flow path will be determined by averaging up to three flow paths.

The next step in the split flow analysis is confirming if the downstream area will be developed. This will be done with the use of the future land use plan for the study area. If the downstream area will not be developed, then the split will be estimated using the normal depth methodology.

If downstream of the split is going to be developed, the next step is establishing if the split occurs on alluvial fan and if that fan was selected to be analyzed as part of the alluvial fan delineation, Task 11.3. If the fan is not going be studied in Task 11.3, the split will be evaluated in the next step of the flowchart If the alluvial fan is going to be studied, the steps for that analysis are included in the alluvial fan discussion.

If the split is not located on an alluvial fan, the next step is determining if the split flow will be analyzed as two dimensional flow (FLO-2D software). There are twenty locations that will be selected for FLO-2D modeling. That selection process is discussed in the next section. If the split is not one of the twenty selected for two dimensional modeling, it will also be estimated using the normal depth methodology or a simple HEC-RAS analysis using a lateral weir diversion(s).

3.2.2.3 Two-Dimensional Flow Analysis

The updated models will include a two-dimensional flow analysis for 20 split flow diversion locations that were ranked using the following four criteria: *flow magnitude, location, drainage size,* and *topography.* Because accurate flow distribution is most beneficial for larger *flow magnitudes,* split flow diversions with the greatest flow magnitudes were selected as potential candidates for two-dimensional flow analysis. Next, split flow diversions with *locations* in the Sonoran Desert National Monument or other areas not subject to development were excluded from further consideration. The resulting 20 locations were then ranked according to *drainage size* and *topography. Drainage size* was evaluated because a larger contributing drainage area increases the expected flow magnitude, necessitating the more accurate evaluation of flow distribution provided by two-dimensional analysis. *Topography* was considered because flatter areas, where backwaters can impact flow distribution, also benefit greatly from two-dimensional flow analysis.

This preliminary selection of split flow locations was discussed with the project team at a meeting at the Flood Control District. The minutes from the meeting have been included in Appendix A.

3.2.2.4 Alluvial Fans

JE Fuller is studying 25 alluvial fans as part of the Area Drainage Master Plan (Task 11.3). These alluvial fan locations have been determined by the District and are included as Attachment 2. The flow at the apex of these fans needs to be determined. The next step is concluding if the fans coalesce. If they do not, a percentage of the flow will be diverted based on the drainage divides on the alluvial fan. If the fans coalesce, the dominant fan will be decided. The flow from the dominant fan to the subordinate fan will be diverted to the subordinate fan while subtracting flow from the subordinate fan to the dominant fan.

3.2.3 Sheet Flow Areas (Infiltration Losses, Farmland Routing, Diversions)

Sheet Flow Areas

Sheet flow in the study area is very wide and shallow. It is difficult to determine where all the flow is conveyed. Some flow might divert to other drainage basins, which would reduce the actual flow amount.

Another issue concerning the sheet flow areas is how it is conveyed around or through future planned development. The current design standard is to collect and concentrate the sheet flow and route it through the development. This concentrated flow must then be returned to the

historic sheet flow characteristics as it exits the planned development. Returning concentrated flow to sheet flows is difficult in areas with mild slopes.

Storage in Farm Fields

It appears the EEC models did not account for potential storage in the farm fields because the contour interval used in EEC's topographic mapping made this difficult to analyze. This type of storage will not be considered in the revised models either because the storage is temporary in nature and can affect the storage requirements when the parcel is developed.

3.2.4 Regression Equation and Gage Data (Obtain Gage Data and then Decide Whether Adequate to Use in Statistical Analysis)

The results from the models created in the RVADMP will be compared to the U.S.G.S. Regression Equations. The Regression Equations were developed using Gage Data in Arizona and the southwest region and can be used to estimate flood magnitude-frequencies for watersheds in Maricopa County. The gage analysis at the Waterman Wash will be updated and a comparison of the regression data and the results of a Log Pearson Type III will be done at the gage. A comparison of the revised HEC-1 model versus the regression data and gage data will also be done at this location. The EEC study examined the gage records in Waterman Wash and concluded there was not enough data to determine the 100-year peak discharge in the wash.

3.3 CONCLUSIONS AND RECOMMENDATIONS

3.3.1 Conclusions

The current Waterman Wash hydrologic models developed in the EEC study were reviewed, and several issues were identified. The three most significant issues with the models are the negative attenuation shown by some routes, the unexpectedly large runoff values produced by some basins, and the potential magnitude of errors in basin delineation and flow paths. The updated delineations and split flow analysis will be more accurate than the EEC models because they will use the new 2-foot contour mapping and FLO-2D analysis.

Estrella Mountain Ranch will be incorporated into the updated models, as well as the newly constructed UPRR culvert crossings and the additional southern line. Some information from the Amaranth drainage master plan may also be incorporated into updated models.

3.3.2 Recommendations

The major basin identifications used in the previous EEC study will be used in the updated models. Three new areas will be included in the updated models. The first area is the northeast portion of the project area, which includes the Phoenix International Raceway and parking lots, which will be the "X" drainage basin. The second area is along the eastern portion of the project area, between the original study area and the county line. This will be the "Y" drainage basin. The last area is in the southeastern portion of the study area and includes Vekol Wash; this will be the "V" drainage basin.

The split flow analysis will be updated using the new 2-foot and 4-foot contour mapping and will follow the split flow and alluvial fan methodology described in Section 3.2.2.. The contributing areas upstream of the splits should be updated to a percentage based on the amount of flow in the diversion.

The routing should be modified so there are no vertical walls in the cross sections unless it is an actual condition. A gradual slope in the routing cross-section overbanks would more accurately model attenuation and storage in the routing reach. The drainage basin delineations and flow routes in the updated models need to be revised with the new 2-foot contour mapping where possible and aerial imaging. Any storage in the existing agricultural fields will not be considered in the updated models because the storage is temporary in nature.

The small insignificant drainage basins (less than 80 acres) along the county line will not be studied in this project, because they constitute a small portion of a larger watershed and the results will have no affect on future designs or floodplain delineations. Any drainage basin draining into the study area from Pinal County will not be included in the hydrologic models because they do not flow into Waterman Wash and we don't have any topography or soils information for those areas.

The average NOAA 14 rainfall provided by the District will be used for the 100-year, 24-hour rainfall. The hydrologic models created for the RVADMP will be compared to results from the NOAA 14 models created in the EEC study for validation as well as portions of the models created for the Amaranth development.

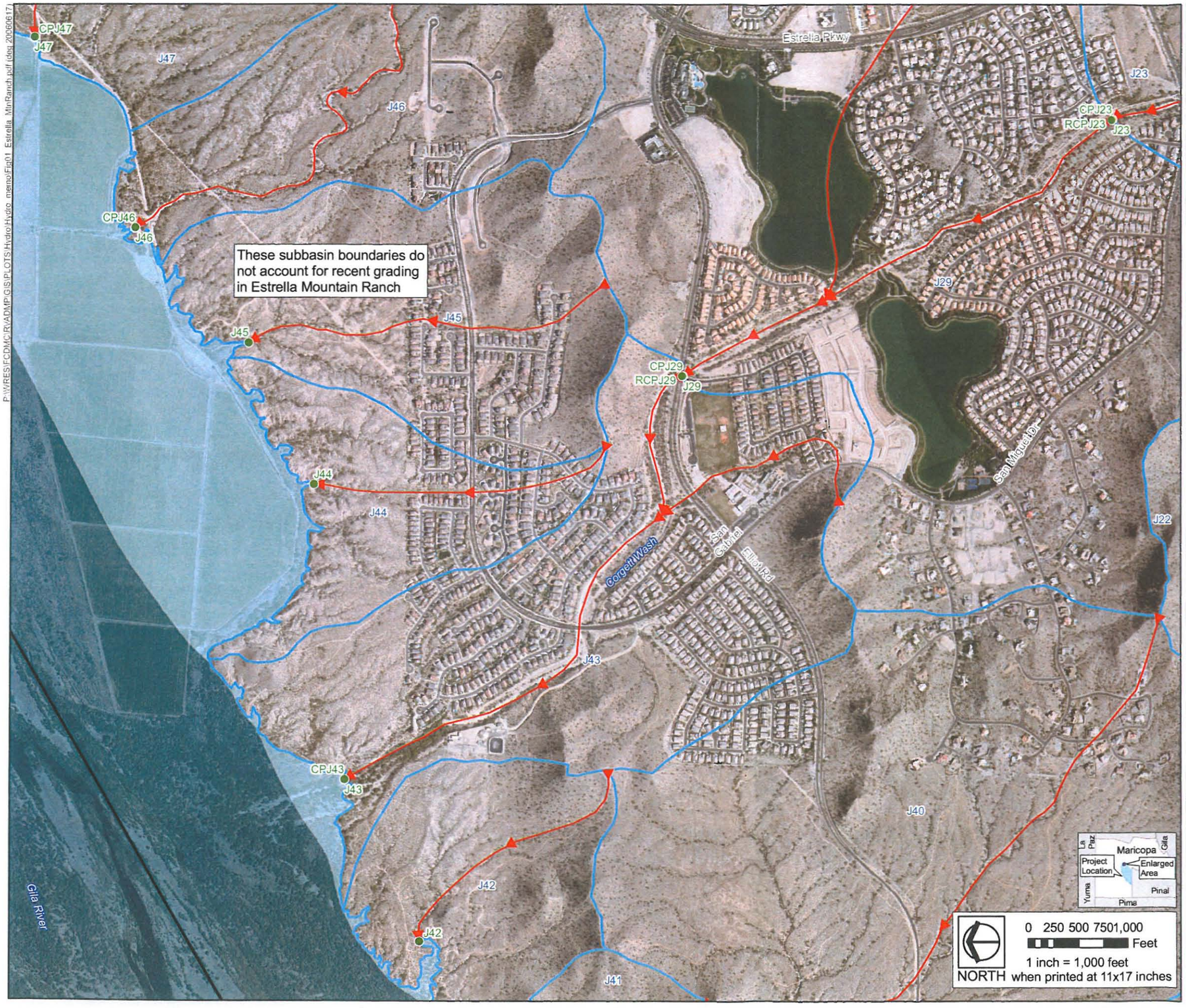
The revised model can be used to assist development in the study area, but the rainfall will need to be modified from an average rainfall for the entire watershed to point rainfall at the development site because there is a difference in those rainfall amounts. The revised model will document the need for this modification in the model description area.

Transmission Losses will not be included in the revised model because there is not enough gage data to calibrate the model. Any existing storage in the agricultural fields will be ignored because it is temporary in nature.

Split Flows will be determined using normal depth, lateral weirs (HEC-RAS), or two dimensional (FLO-2D) methods depending on complexity, downstream future land use and other topographic or land form conditions.

There are many assumptions that will be made in the revised model due to alluvial fans, split flow, and sheet flow. These assumptions will be documented in the model so anyone using this data is aware of the assumptions made. An exhibit will be prepared showing areas of uncertainty to assist the regulatory agencies in reviewing developments.

FIGURES



Rainbow Valley
Area Drainage Master Plan
Basin Delineation Concerns

Figure 1

Project Features

- Drainage Flow Path Point and Name
- Drainage Flow Path Line
- Drainage Sub-Basin Boundary and Name

FEMA Floodplains

- 1% Annual Chance Floodplain
- Floodway

Reference Features

- County Boundary
- Perennial Streams
- Rainbow Valley ADMP Boundary
- State Highways

Data Sources

Flood Control District of Maricopa County Base Data 2008
Flood Control District of Maricopa Aerial Images 2006-2007

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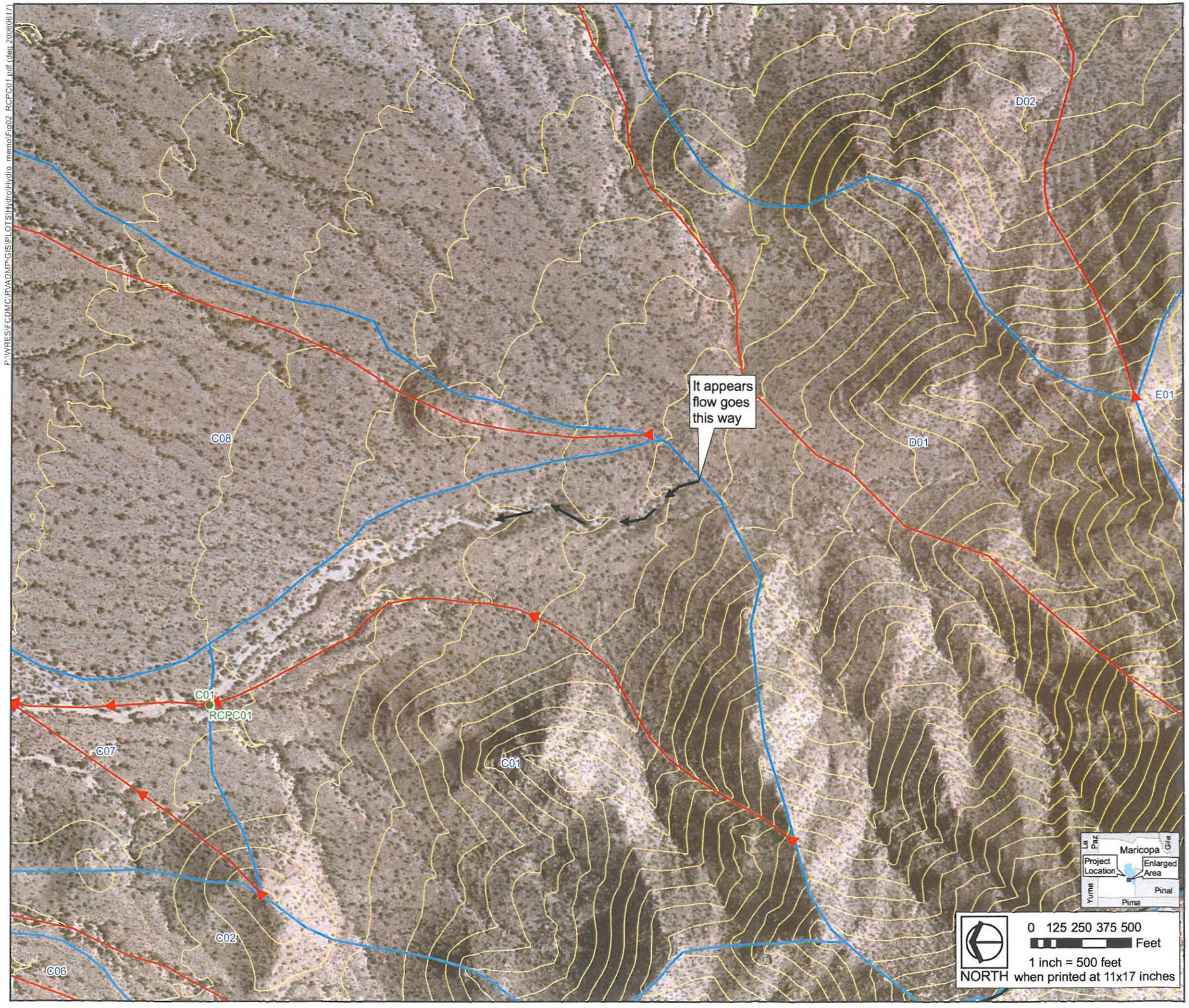


Rainbow Valley
Area Drainage Master Plan
Basin Delineation Concerns

Figure 2

Project Features

- Drainage Flow Path Point and Name
- Proposed Flow Path Direction
- Drainage Flow Path Line
- Drainage Sub-Basin Boundary and Name

Reference Features

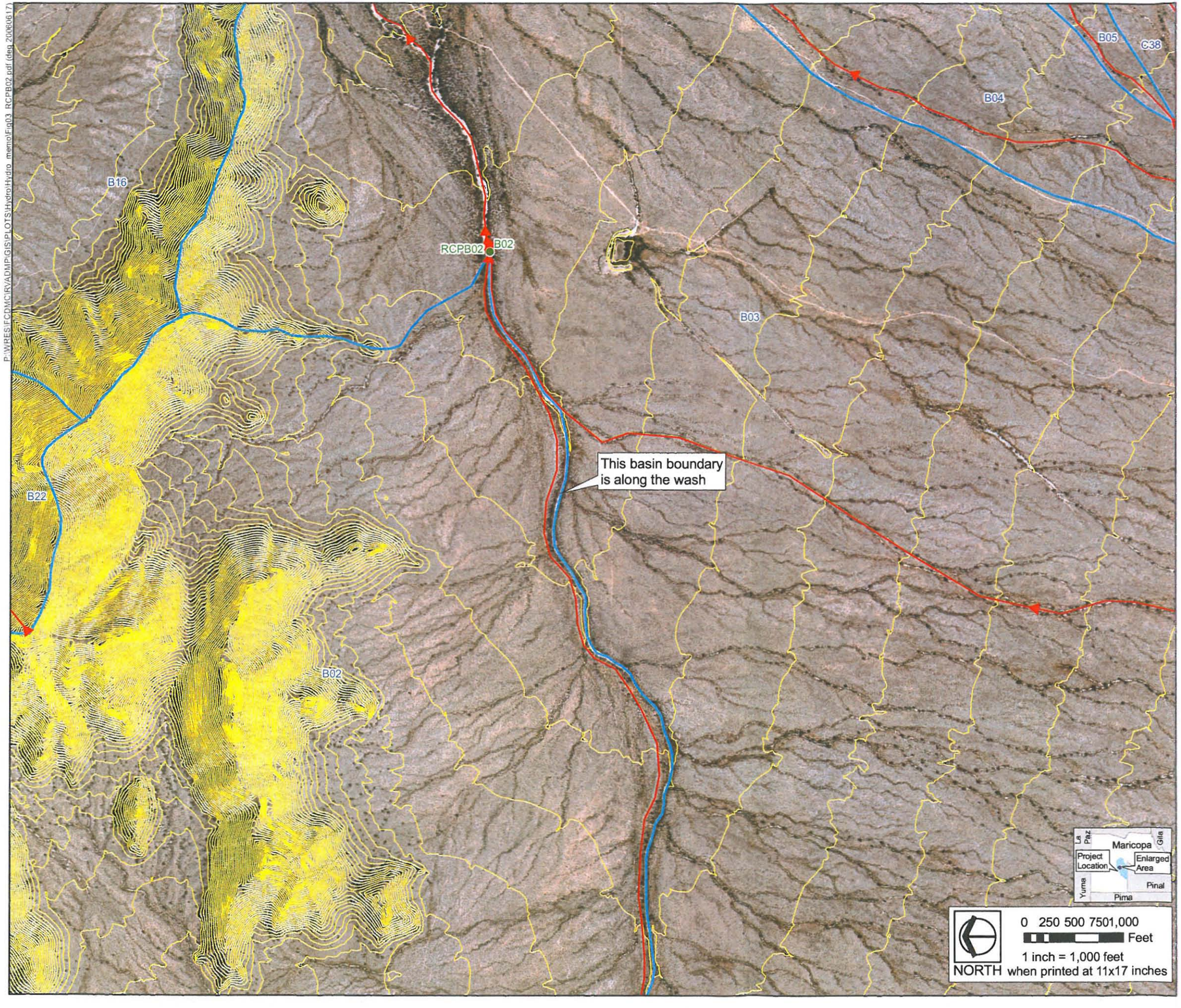
- County Boundary
- Rainbow Valley ADMP Boundary
- State Highways
- Perennial Streams
- Elevation Contours (Contour Interval = 50 feet)

Data Sources

Flood Control District of Maricopa County Base Data 2008
Flood Control District of Maricopa Aerial Images 2006-2007

Rainbow Valley
Area Drainage Master Plan
Basin Delineation Concerns

Figure 3



Project Features

- Drainage Flow Path Point and Name
- Drainage Flow Path Line
- Drainage Sub-Basin Boundary and Name

Reference Features

- County Boundary
- Perennial Streams
- Rainbow Valley ADMP Boundary
- Elevation Contours (Contour Interval = 10 feet)
- State Highways

Data Sources

Flood Control District of Maricopa County Base Data 2008
Flood Control District of Maricopa Aerial Images 2006-2007

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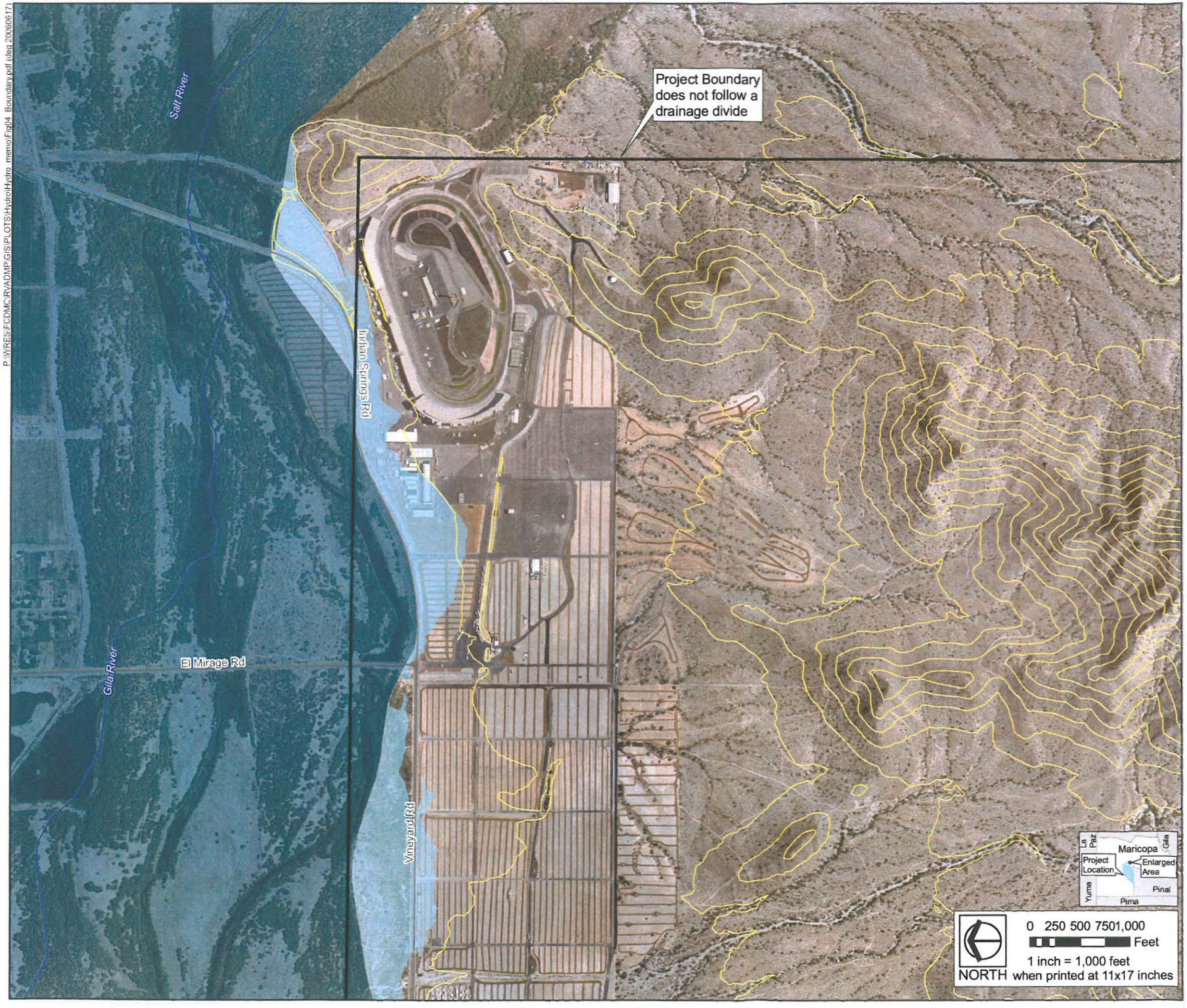


Rainbow Valley
Area Drainage Master Plan
No Drainage Boundary

Figure 4

Project Features

FEMA Floodplains

- 1% Annual Chance Floodplain
- Floodway

Reference Features

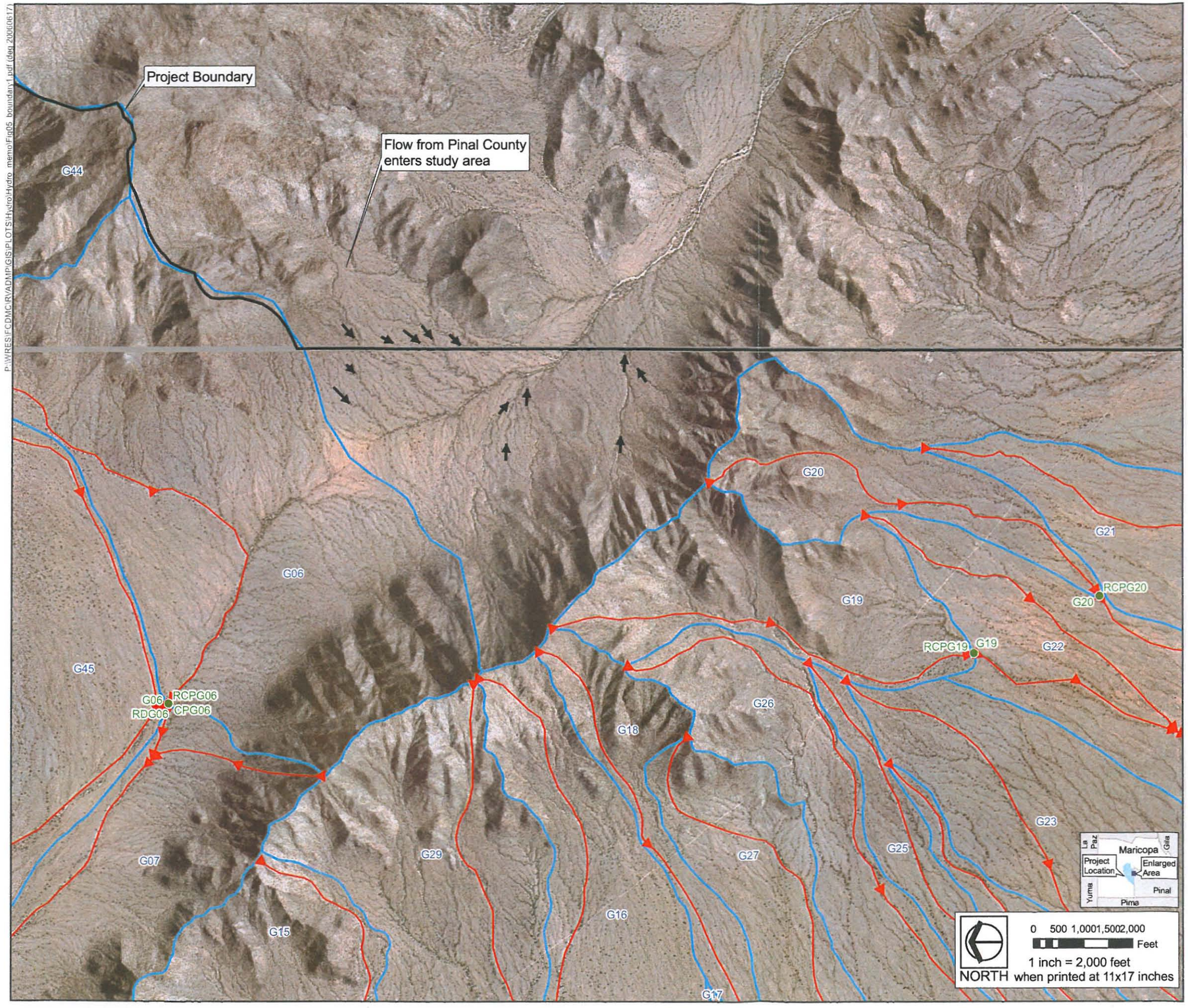
- County Boundary
- Rainbow Valley ADMP Boundary
- State Highways
- Perennial Streams
- Elevation Contours (Contour Interval = 50 feet)

Data Sources

Flood Control District of Maricopa County Base Data 2008
Flood Control District of Maricopa Aerial Images 2006-2007

Rainbow Valley
Area Drainage Master Plan
Basin Delineation Concerns

Figure 5



Project Features

- Drainage Flow Path Point and Name
- Proposed Flow Path Direction
- Drainage Flow Path Line
- Drainage Sub-Basin Boundary and Name

Reference Features

- County Boundary
- Perennial Streams
- Rainbow Valley ADMP Boundary
- State Highways

Data Sources

Flood Control District of Maricopa County Base Data 2008
Flood Control District of Maricopa Aerial Images 2006-2007

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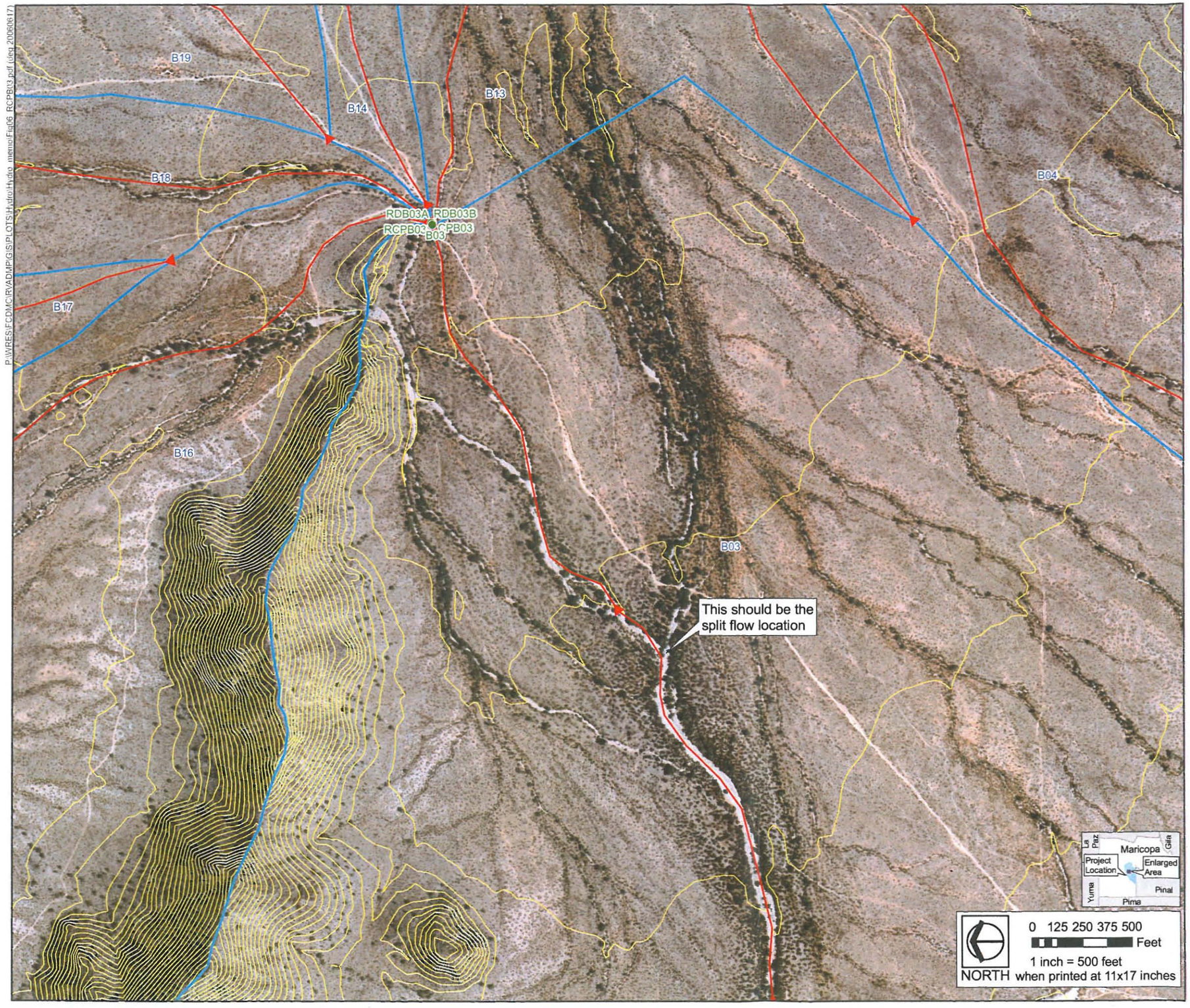

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Rainbow Valley
Area Drainage Master Plan
Split Flow Inaccuracy

Figure 6

Project Features

- Drainage Flow Path Point and Name
- Drainage Flow Path Line
- Drainage Sub-Basin Boundary and Name

Reference Features

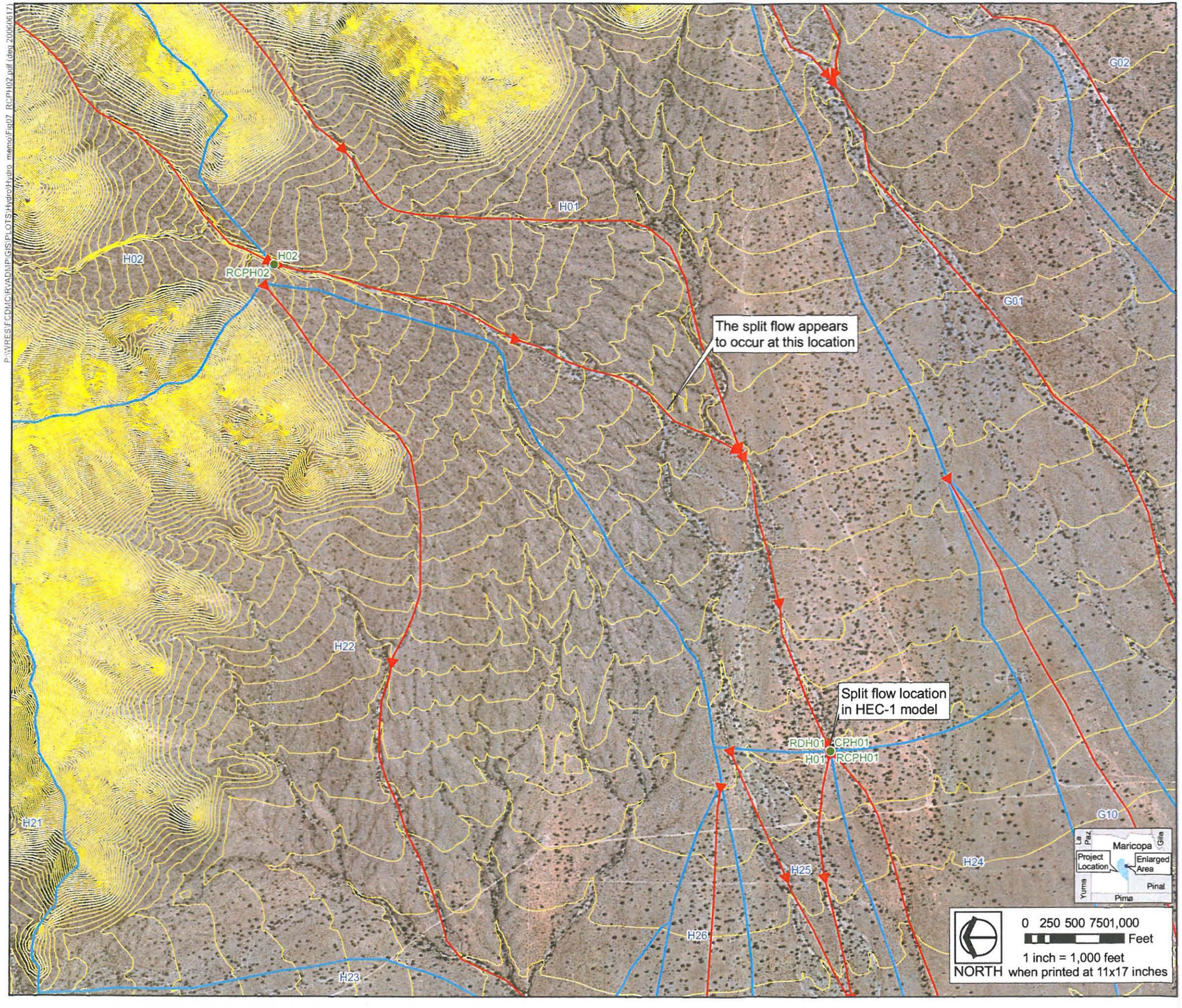
- County Boundary
- Rainbow Valley ADMP Boundary
- State Highways
- Perennial Streams
- Elevation Contours (Contour Interval = 10 feet)

Data Sources

Flood Control District of Maricopa County Base Data 2008
Flood Control District of Maricopa Aerial Images 2006-2007

Rainbow Valley
Area Drainage Master Plan
Split Flow Inaccuracy

Figure 7



Project Features

- Drainage Flow Path Point and Name
- Drainage Flow Path Line
- Drainage Sub-Basin Boundary and Name

Reference Features

- County Boundary
- Rainbow Valley ADMP Boundary
- State Highways
- Perennial Streams
- Elevation Contours (Contour Interval = 10 feet)

Data Sources

Flood Control District of Maricopa County Base Data 2008
Flood Control District of Maricopa Aerial Images 2006-2007

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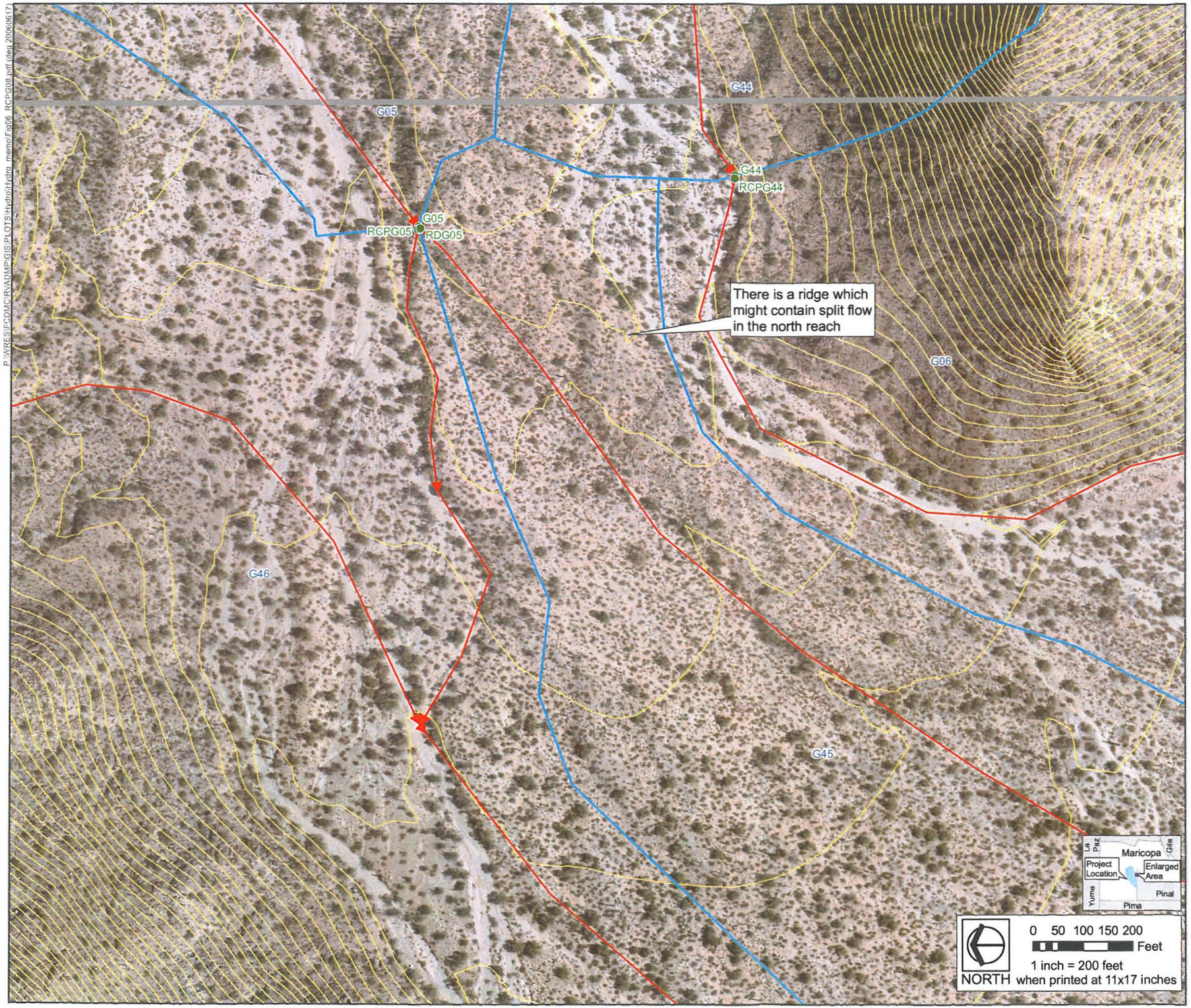
Rainbow Valley
Area Drainage Master Plan
Split Flow Inaccuracy

Figure 8



Project Features

- Drainage Flow Path Point and Name
- Drainage Flow Path Line
- Drainage Sub-Basin Boundary and Name

Reference Features

- County Boundary
- Rainbow Valley ADMP Boundary
- State Highways
- Perennial Streams
- Elevation Contours (Contour Interval = 10 feet)

Data Sources

Flood Control District of Maricopa County Base Data 2008
Flood Control District of Maricopa Aerial Images 2006-2007

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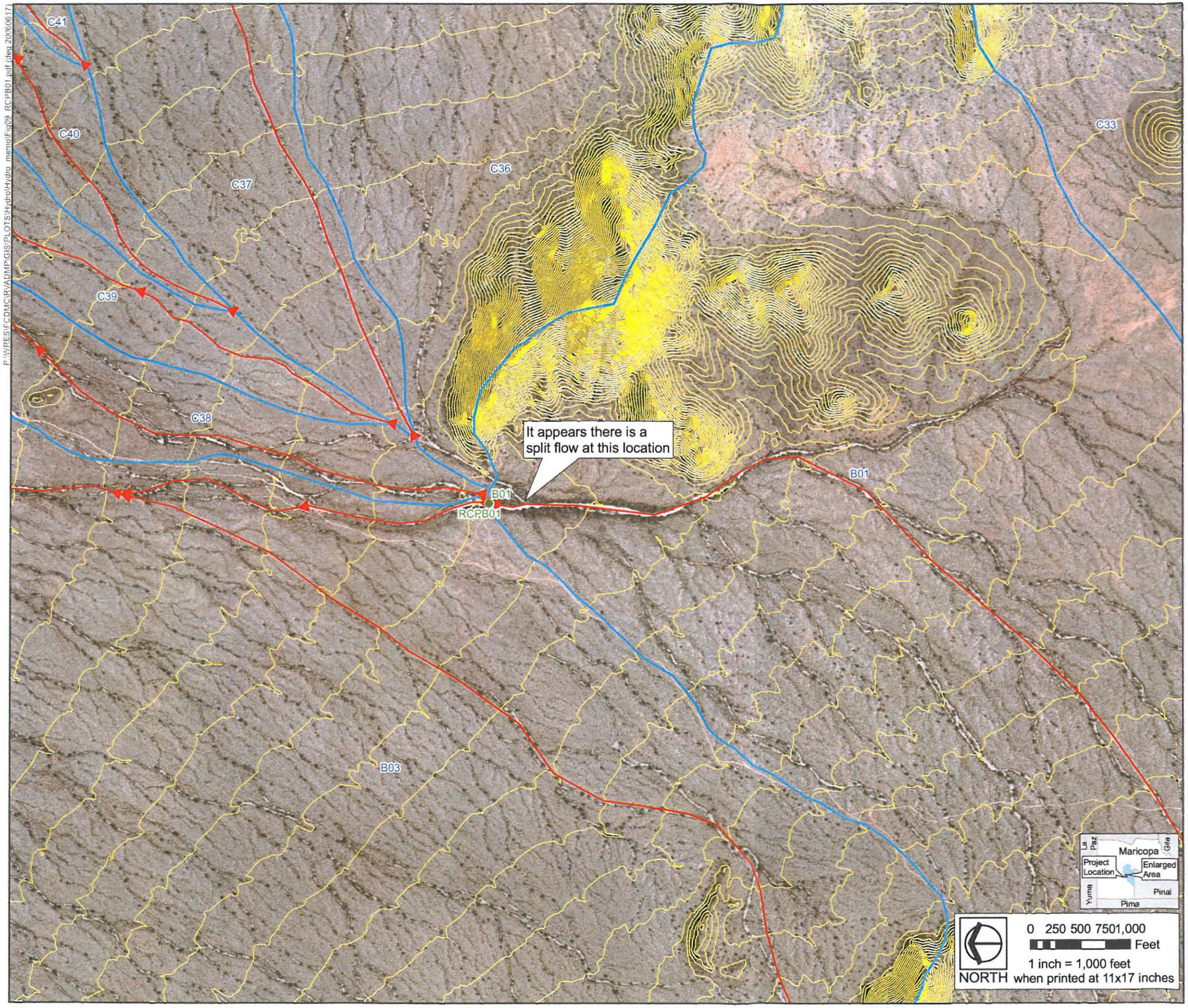


Rainbow Valley
Area Drainage Master Plan
Split Flow Inaccuracy

Figure 9

Project Features

- Drainage Flow Path Point and Name
- Drainage Flow Path Line
- Drainage Sub-Basin Boundary and Name

Reference Features

- County Boundary
- Perennial Streams
- Rainbow Valley ADMP Boundary
- Elevation Contours (Contour Interval = 10 feet)
- State Highways

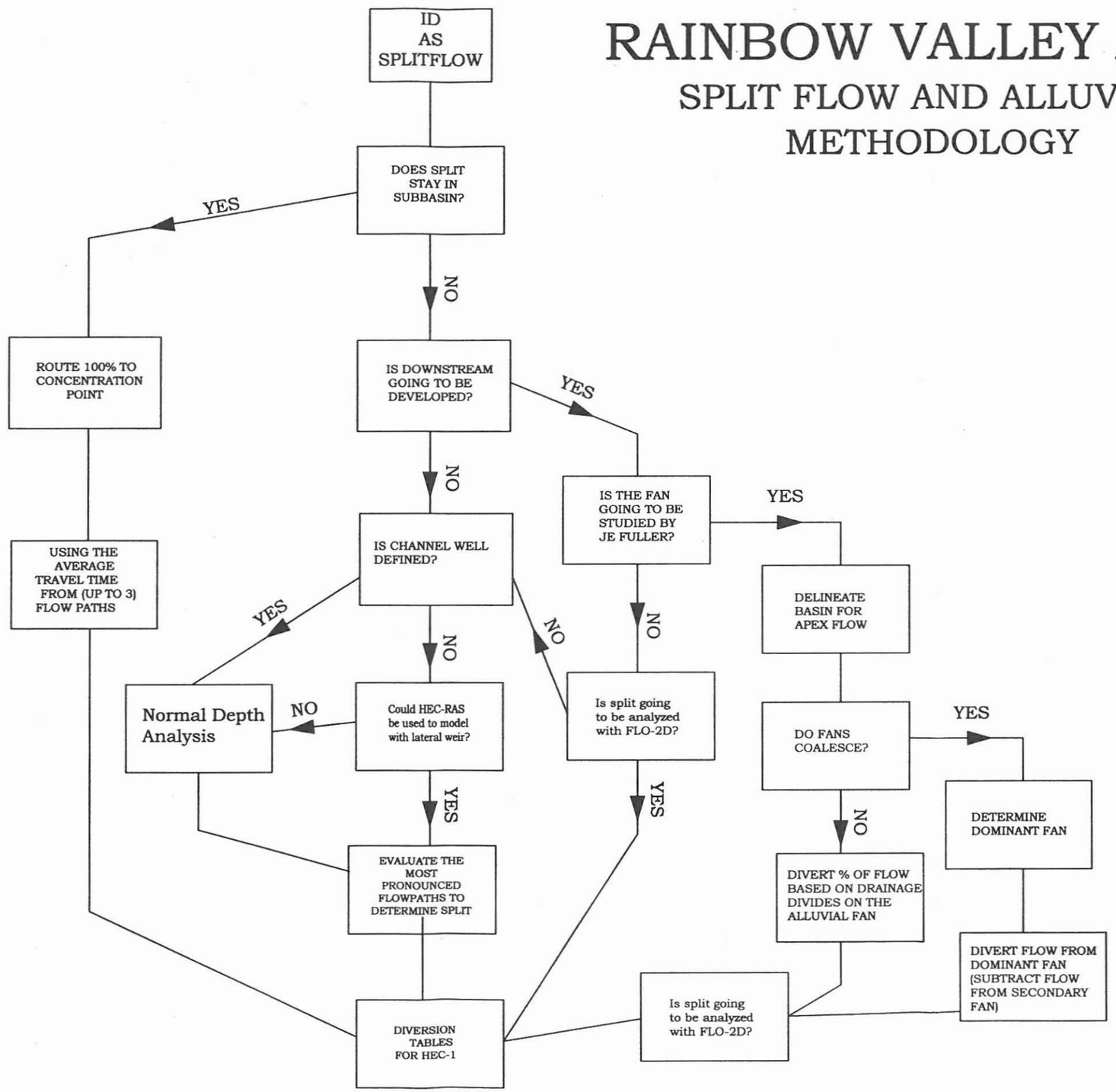
Data Sources

Flood Control District of Maricopa County Base Data 2008
Flood Control District of Maricopa Aerial Images 2006-2007

FIGURE 10

RAINBOW VALLEY ADMP

SPLIT FLOW AND ALLUVIAL FAN METHODOLOGY



RAINBOW VALLEY
AREA DRAINAGE MASTER PLAN

VEKOL WASH – UPRR FIELD REVIEW
AUGUST 20, 2008

Introduction: Amir Motamedi (District), Marc McIntosh and Elliot Silverston (URS) performed a field review on August 20, 2008 in the Rainbow Valley ADMP study area. The goals of the field review were to field evaluate the extent of inter-basin diversion of flow between Vekol Wash and Waterman Wash in the stock pond areas sections 2, 3, 10, and 11, Township 6 South, and Range 1 East, sections 25, 26, 35, and 36, Township 5 South, Range 1 East, and Section 30, Township 5 South Range 2 East in Maricopa County, Arizona. We also drove the UPRR track alignment parallel to Maricopa Road in the study area to review the progress on culvert and bridge improvements and the construction of the second track. The following are some of the observations from the field review.

Observations:

Vekol Wash – Waterman Wash Diversion

- Access to Vekol Wash occurs from the Vekol Road exit on I-8 (southern access). Existing aerial maps provide adequate images that are passable to the study sites.
- The Vekol Wash channel bed can be crossed because it is comprised of coarse sands, gravel and cobbles. There is adequate dry whether access to drive to the area between Waterman and Vekol washes with a four wheel drive vehicle without trespassing on signed private property. At the time of the trip no gates were locked (impassable).
- The stock pond in Section 10, Township 6 South, Range 1 East was designed to store water from a northern tributary to the main Vekol Wash channel blocking flow to Vekol Wash. Low areas in the stock pond had standing water on the day of the field review. There is a 54 inch CMP outlet pipe that discharges flow to the north east (see Field Map). Looking from the downstream end into the pipe you cannot see daylight. The pipe inlet is blocked with debris on the upstream end. The drainage from the outlet pipe does not flow directly into Vekol Wash. The stock pond berm is high (15-20 feet) at the outlet and can detain a significant volume of flow, but probably not a 100-year flood. At this time a significant volume of water will not be detained because there is a large breach in the stock pond embankment. It is located at the southeast side of the berm. Based on observed vegetation and erosion in and around the breach it appears that the dam failure is not recent, large palo verde trees are growing on the breach embankments. This breach may have been caused by the plugged outlet structure. The discharges from the breach will flow to Vekol Wash. In addition, it was observed that the flow from the breach location could not flow into Waterman Wash due to the higher elevation of the topography between the breach flowpath and Waterman Wash.

- A BLM marker – Vekol Dam – SE ¼ Section 10, T6S, R1E, 1986 was located along the stock pond berm.
- We followed a road northeast between the outflow channel to the stock pond and the Waterman Wash watershed. There were no signs that the flows would be conveyed to Waterman Wash through defined channels. The wash appeared to flow towards other stock ponds to the northeast. Any flow between Waterman Wash and Vekol Wash in this area has been through sheetflow and would be difficult to estimate. The amount of flow from Vekol Wash to Waterman Wash could be on the order of a few hundred cubic feet per second. However, it is questionable whether the washes would have simultaneous peak flows so we probably can practically assume that the diversion is zero.
- We next back tracked towards the original stock pond. Down stream from the outlet the outlet wash splits (1,500 feet). Previously we followed the left fork which had riparian vegetation and was most likely to have some flow divert to Waterman Wash. Instead we followed a road that led us to a location that showed the potential for the outlet wash to split. The left split was vegetated and the right split was not. At the split we found a berm that blocked flow to the right branch, diverting flow to the left branch. This observation showed the reason for the lack of vegetation.
- We next drove to the stock ponds located in sections 25, 35 and 36, Township 5 South, Range 1 East and Section 30, Township 5 South, Range 2 East. There are 9 stock pond berms in this location. Runoff flows from the south west to the north east. The berms detain the flow. The stock ponds have relatively small diameter outlets that allow flows to be conveyed to the next downstream stock pond. There is no apparent flow pattern that shows conveyance from the stocks ponds to Waterman Wash. Therefore we assume that the general flow pattern is to Vekol Wash with a significant portion of the flow infiltrating to the ground or being lost to evapotranspiration.

UPRR Bridge and Culvert Replacements

- We next followed the UPRR alignment along Maricopa Road. Most of the drainage structures were replaced. New track was placed along the entire corridor. Survey would show whether the track embankment was raised. Some of the embankments for the second rail line are in place, but this was sporadic.
- URS has data on many of the wash crossings. We need to determine where data is missing. The data we have is for the proposed design and not as-built. Each drainage crossing has its own local datum (top of track). We need to tie the data to a single vertical datum (NAVD88).
- There is a berm on the upstream (south) side of the track that protects the track embankments from standing water and directs runoff to the culverts and bridges under the track.
- There are locations where new ballast has been used on the rail embankments.
- Riprap is used to protect the washes downstream from the railroad.

URS

MEETING NOTES

Project Name: Rainbow Valley Area Drainage Master Plan (RVADMP)

Project No.: 23445383.09500 (FCD 2006C029)

Meeting Date: September 8, 2008

Location: Flood Control District of Maricopa County (District)
Time: 1:00 P.M.
Agenda: Attached
Sign-In Sheet: Attached

Attendees:		
	Burke Lokey	District
	Amir Motamedi	District
	Tom Loomis	District
	Esperanza Foreman	District
	Richard Harris	District
	Apu Borah	District
	Elliot Silverston	URS
	Marc McIntosh	URS
	Patrick Wolf	URS
	Jeremy Laipple	Dibble

The purpose of this meeting was to select the split flow locations that will be analyzed with FLO-2D as part of the RVADMP. The Scope of Work included twenty locations that could be selected for this analysis. The project team reviewed all the potential candidates and ranked them on significance.

Selection Criteria

The first discussion item was the selection criteria developed by the URS team. There were three main criteria used to select the preliminary recommended FLO-2D locations. The first selection criterion was the flow magnitude upstream of the split flow location. This flow magnitude was taken from the previous hydrology developed by the EEC study. The split flow locations were sorted from the largest flow magnitude to the smallest.

The second selection criteria involved whether or not the split flow location was an alluvial fan that will be studied by JE Fuller. There are twenty five alluvial fans that will be studied by JE

URS Corporation
7720 North 16th Street, Suite 100
Phoenix, Arizona 85020
Tel: 602.371.1100
Fax: 602.371.1615
www.urscorp.com

Fuller, so they wouldn't need a FLO-2D analysis.

The last selection criteria examined downstream conditions at the split flow location. If the area downstream of the split was not going to be developed, based on the MAG future land use plan, it would not be included as a potential candidate. If the split flow location was at the Union Pacific Railroad, it would not be a potential candidate because this type of split would be better analyzed using other methodologies. The last consideration reviewed was whether downstream of the split flow location the split rejoins. If the split rejoins itself before it drains into Waterman Wash, it would not be considered a potential candidate.

Grid Size

The next discussion item was the grid size to be used in FLO-2D analysis. If we use a larger grid size, we could analyze more of the split flow area. The Scope of Work was based on using a grid size of 15 to 20 feet. Task 9.7.2 proposes an average model area of 800-ft x 1200-ft (or 22 acres) for each split flow location. The District believes that a grid size of 40-feet or 30-feet was too large and would miss some of the smaller washes. A 15-foot grid size was too small and could cause modeling issues during the FLO-2D analysis. The District recommended a grid size of 25-feet.

Preliminary Recommended Locations

The majority of the meeting involved reviewing each preliminary recommended split flow location and ranking them based on the District's and URS's preference for the FLO-2D Analysis. The highest preference split flow location would have an "A" ranking and the lowest preference would have an "F" ranking. This ranking was based on whether the split flow location would benefit from a FLO-2D analysis, or if other methodologies (such as HEC-RAS or normal depth analysis) would be sufficient. The FLO-2D Ranking Table (attached) includes this ranking as well as other pertinent information.

This review resulted in six split flow locations receiving an "A" or "B" ranking that should be analyzed with FLO-2D. These splits can be analyzed in four FLO-2D models as shown in the accompanying figures. The analysis area of these locations is much larger than the combined area for the 20 models included in the Scope of Work. If the team uses the recommended 25-

foot grid size for these four areas, we would be over the total analysis area in the Scope of Work, as shown in the table below. The four models would provide greater benefit to the goals of the overall hydrologic model. The URS team believes this can be done within the budget.

Revised Analysis Area

Split ID	Analysis Area (ac)	Number of 25-foot Grid Points
CPH17 & CPH31	974	68,000
CPB03 & CPB13	395	28,000
CPE05	80	5,600
CPG31 & CPG47	842	58,000
Total	2,291	159,600
Scope of Work	440	86,000

Hydrology and Model Iterations

The last discussion items were related to the hydrology used for the split flow locations and the number of iterations to be done to the revised hydrology model. The flow expected in the revised hydrology model will be less than the EEC model because the rainfall has decreased in the watershed. The EEC model should be revised with the new NOAA 14 rainfall and that information should be used in the initial FLO-2D analysis. This would reduce the amount of iterations needed in the FLO-2D analysis. Reducing the amount of iterations in the FLO-2D analysis and revised hydrology model is paramount so that the schedule can be maintained. The team decided that the revised hydrology model could be completed with only one or two iterations, but we would need to focus on the connectivity of the split flow locations.

Conclusions

The preliminary recommended split flow locations were reviewed and ranked by the project team. There are six split flow locations that received a high rank and should be analyzed with FLO-2D. These six split flow locations can be analyzed with four models. The analysis area of these locations is much larger than the 20 model locations with 22-acres for each location discussed in the Scope of Work. These locations can be analyzed within the original budget.

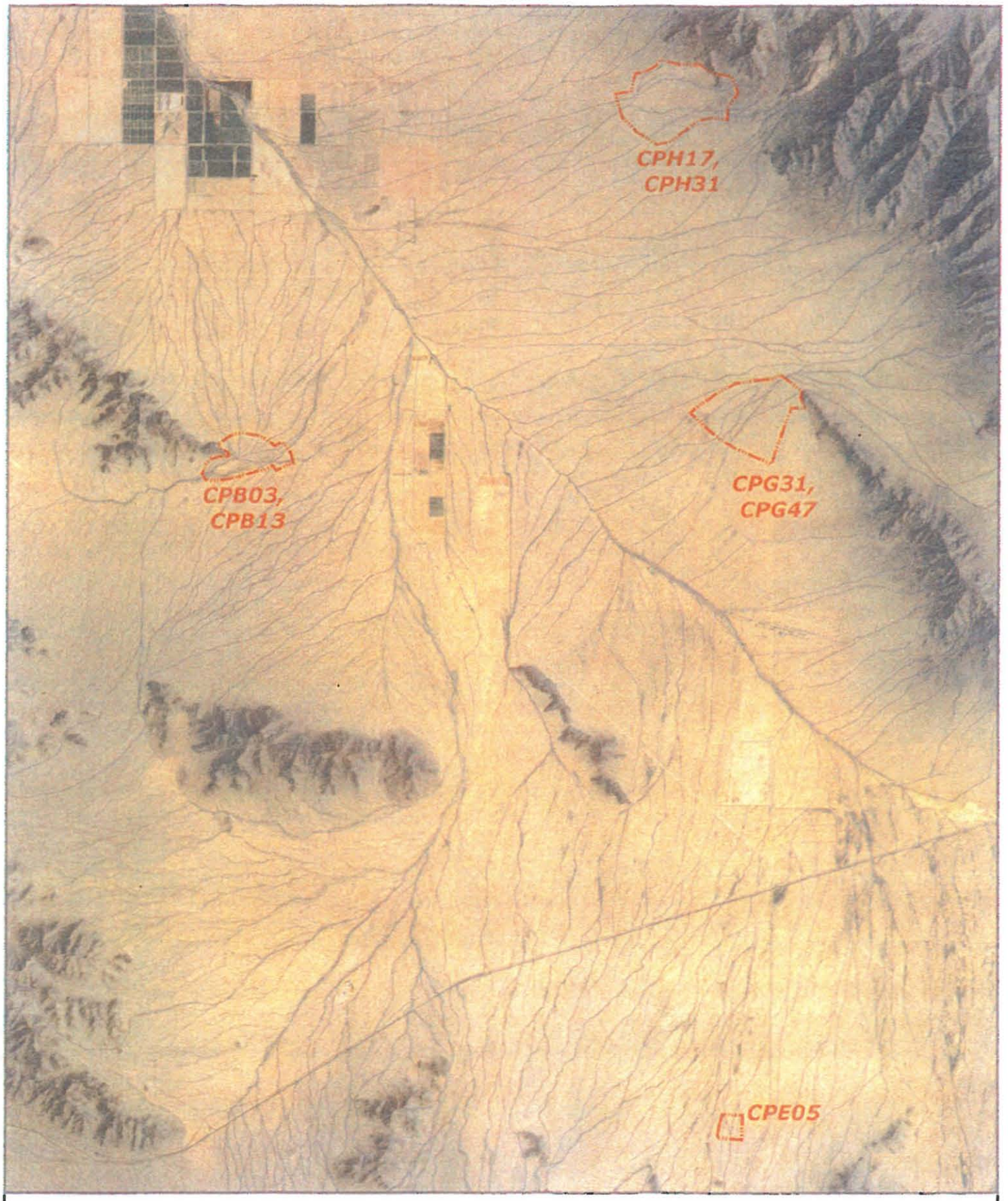
Action Items

1. URS will prepare the meeting minutes.
2. Prepare exhibits for "A" and "B" locations.
3. The District will review and approve the selected split flow locations.

Please Note: These notes summarize the directives, conclusions and assignments of the above referenced meeting. Please review these notes and notify URS Corporation in writing with any revisions or amendments. If URS Corporation does not receive any correspondence addressing adjustments within seven (7) days, these notes will stand as the accurate record of the meeting.

FLO-2D Ranking Table

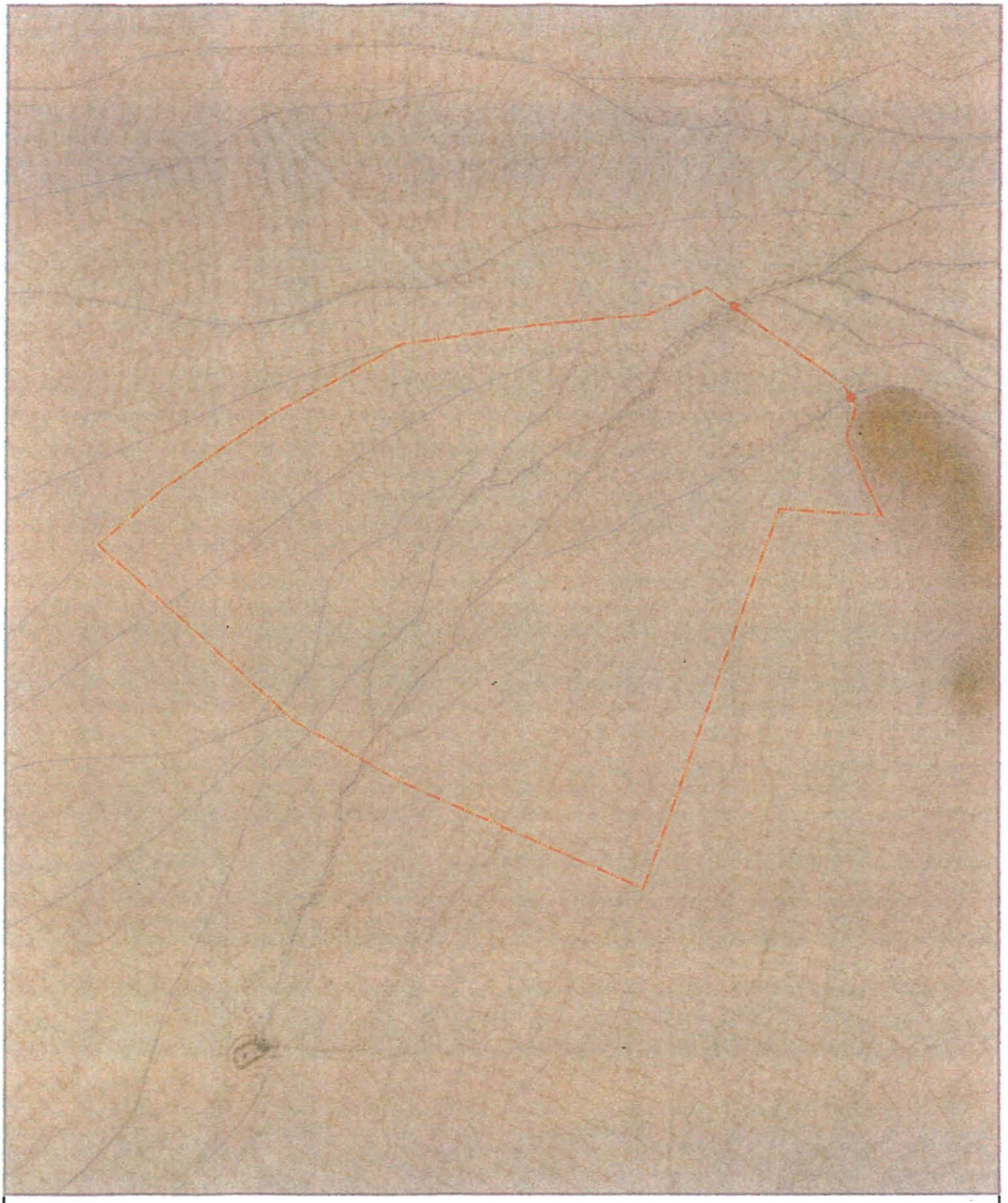
Split ID	Ranking	Upstream Concentration Point	Upstream Flow (cfs)	Notes
DB03A	A	CPB03	7922	This area needs supplemental survey upstream.
DB13	A	CPB13	3789	This should be combined with the split at CPB03.
DH17	A	CPH17	1562	Move analysis area south and further upstream to capture JEF #20.
DE05	B	CPE05	2355	Extend analysis area west, only 4-foot contour information in this area.
DG31	B	CPG31	5039	Analysis area needs to be increased.
DH31	B	CPH31	1658	The analysis area needs to be increased to capture upstream and downstream splits.
DA02A	C	CPA02	3587	JEF #23, not too much 2-foot contour information upstream.
DA08	C	CPA08	1636	This split is more defined and normal depth analysis would be sufficient.
DA10	C	CPA10	1703	This split is more defined and normal depth analysis would be sufficient.
DA11	C	CPA11	1359	This split is more defined and normal depth analysis would be sufficient.
DA21	C	CPA21	1529	This split is more defined and normal depth analysis would be sufficient.
DA64	C	CPA64	1674	This split is more defined and normal depth analysis would be sufficient.
DE16	C	CPE16	3608	Not enough 2-foot contours
DE19	C	CPE19	2147	Not enough 2-foot contours
DF19	C	CPF19	1894	Increase the size of the analysis area.
DG06	C	CPG06	2676	An identified alluival fan, not too much development
DG11	C	CPG11	6630	It appears only a small portion would be diverted and it is close to Waterman Wash.
DH01	C	CPH01	4064	Not enough upstream drainage basins to determine inflow hydrographs.
DH33	C	CPH33	1506	Sheet flow area.
DI03	C	CPI03	1895	JEF #11, sheet flow area.
DC07	D	CPC07	1952	This is open space until it hits the RR.
DD01	D	CPD01	2195	This is open space until it hits the RR.
DD05	D	CPD05	1891	This is open space until it hits the RR.
DD13	D	CPD13	1656	This is open space until it hits the RR.
DF18	D	CPF18	1498	Sheet flow area and only 4-foot contour information.
DG47	D	CPG47	2356	This split flows into open space and then into Waterman Wash.
DH59	D	CPH59	1626	This split converges.
DH63	D	CPH63	4228	Sheet flow area.
DF25	D	DRF27	1779	This Split is at RR, we can use Normal Depth.
DE11	D	E11	1744	This area has 4-foot contour information only.
DE25	F	CPE25	2415	This Split is at RR, we can use Normal Depth.
DE38	F	CPE38	2619	This Split is at RR, we can use Normal Depth.
DH07	F	CPH07	1634	This split converges.
DH39	F	CPH39	1730	This split converges.
DG05	F	G05	1389	Not enough 2-foot contour information.
DC24	F	PNDC01	1382	This Split is at RR, we can use Normal Depth.
DF27	F	PNDF01	2256	This Split is at RR, we can use Normal Depth.



Dibble Engineering

FLO-2D Split Flow Analysis Locations

Key Map



Dibble Engineering

FLO-2D Split Flow
Analysis Locations

CPG31, CPG47

Dibble Engineering

FLO-2D Split Flow
Analysis Locations

CPE05

Dibble Engineering

FLO-2D Split Flow
Analysis Locations

CPB03, CPB13

Dibble Engineering

FLO-2D Split Flow
Analysis Locations

CPH17, CPH31