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ELM LANE DRAINAGE STUDY AND FLOODING REMEDIATION ALTERNATIVES DEVELOPMENT

City of Avondale

PREPARED FOR:
City of Avondale
November 18, 2005

Registered Professional Engineer (Civil)
CERTIFICATE NO.
30488
CRAIG S.
BOLZE
Date Signed 11/18/05
ARIZONA, U.S.A.

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1.0 INTRODUCTION AND SCOPE OF WORK

This report presents the results of a Drainage Study And Flooding Remediation Alternatives Development conducted by Landmark Engineering, Inc. ("LEI") at the request of the City of Avondale ("client") for a portion of Avondale, Arizona that has reported localized flooding during a recent storm event. This storm event occurred during the evening and early morning hours of August 2, 2005 and August 3, 2005.

This study has been conducted for the City of Avondale in order to quantify the extent of flooding problems within the study area and to develop alternative solutions to these problems. The purpose of this report is to provide a hydrologic and hydraulic evaluation for the study area and to present conceptual alternatives for remediation of localized flooding that has been experienced for the site. In order to provide data to assist in documenting and evaluating local drainage conditions, this study will describe the contributory area directing stormwater runoff to the study area, describe the physical characteristics of the study area and contributory area, calculate peak discharges for multi-frequency storm events using the rational method of analysis, and identify conceptual-level alternatives to remediate flooding in the study area.

1.1 Scope of Work and Limitations

This report is focused on providing practical design information, evaluation, and calculations for statistical flood events up to and including the 100-year frequency flood. The procedures used herein are derived from, and performed with, currently accepted engineering methodologies and practices. Additionally, the criteria for this evaluation are designed to conform to currently applicable ordinances, regulations, and policies effected by the appropriate jurisdictional regulatory authorities for the site.

The analysis presented herein focuses on developing design estimates of storm water runoff resulting from a statistical evaluation of storm events of particular duration and frequency up to and including a 100-year frequency event. A storm event exceeding the 100-year frequency event may cause or create the risk of greater flood impact than is addressed and presented herein. However, the scope of this assessment does not include, neither did the client request, evaluation of storm water runoff resulting from storm events exceeding the 100-year frequency event. Landmark Engineering, Inc. assumes no responsibility for actual flood damage, increased risks of flood damage, or increased construction or development cost resulting from or related to any such events. Nor shall Landmark Engineering, Inc. be responsible for any changes in, or additions to, regulatory requirements that may result from, or be related to, any such events or changes in hydrologic or hydraulic conditions within the watershed.

In performing the services contained herein, LEI has received or will receive information prepared or compiled by others. LEI, as engineering professionals, are not required to verify the information, but may rely on the information unless actual knowledge concerning the validity of the information is known or is obvious to the professional. Therefore, LEI is entitled to rely upon the accuracy and completeness of this information without independent evaluation or verification.

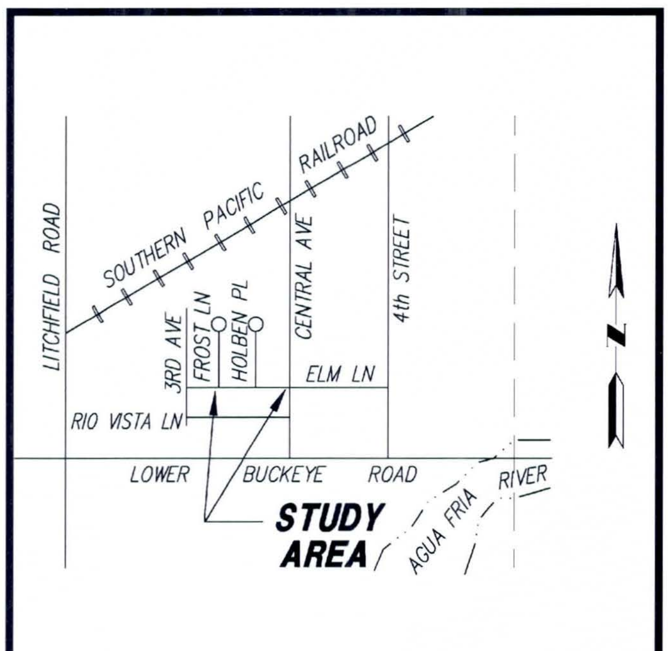


Figure 1: Site Vicinity Map

1.2 Study Area Location

The study area is situated within an existing single-family residential neighborhood in the City of Avondale, Arizona. The localized drainage concern is focused near the intersection of Elm Lane and Holben Place within this neighborhood as shown on the Site Vicinity Map (Figure 1). The study area consists of an existing single-family neighborhood situated on a local street known as Elm Lane in Avondale, Arizona. The study area is bounded on the east by Central Avenue and on the west by 3rd Avenue.

1.3 Site Description

The site is irregular in shape and encompasses an existing single-family residential neighborhood in Avondale, Arizona. The neighborhood primarily consists of mobile homes situated on individual lots with corresponding lawns and driveways. Access to the lots is provided via paved local streets with curb, gutter, and sidewalks.

1.4 Regulatory Jurisdiction

The criteria used in the drainage design and analysis conducted for this study was established using the guidelines as described in the following:

- City of Avondale Engineering Design Standards, City of Avondale, June 1997 (Reference 1).
- Drainage Design Manual For Maricopa County, Arizona, Volume I, Hydrology (Reference 2).
- Drainage Design Manual For Maricopa County, Arizona, Volume II, Hydraulics (Reference 3).

2.0 PHYSICAL SETTING

2.1 Site Topography And Existing Conditions

The study area is situated in an area of relatively constant elevation of the type consistent with alluvial areas. A review of regional topographic mapping (Exhibits 1 and 2) identified the elevation of the contributory area to range from approximately 973 feet at the upstream end of the contributing watershed to less than 955 feet near the intersection of Elm Lane and Holben Place (References 4 and 5). Existing ground in the vicinity of the site generally slopes downward to the south, trending toward the Agua Fria River.

Visual reconnaissance was conducted for the site and surrounding area on August 5, 2005 and again on September 13, 2005 by Craig S. Bolze, P.E. of Landmark Engineering, Inc. in order to observe and record information concerning present development, use, and conditions for the site and surrounding area.

The study area is a developed urbanized residential neighborhood within the City of Avondale, Arizona. Local streets are paved with curb, gutter, and sidewalk (Photographs 1-4). The most common development within the study area is mobile homes. However, slab-on-grade construction was observed in isolated lots within the development. Finish floor elevations for

Photograph 1: Photograph taken from Elm Lane at its intersection with Central Avenue looking west. Photograph shows Elm Lane and Holben Place intersection and dip section in Elm Lane.

slab-on-grade construction were observed to be low with respect to the surrounding topography, typical of development occurring in the 1970s. The low finish floor elevations increase the potential for these properties to experience flooding during storm events. Finish floor elevations for mobile homes in the area are typically higher, commensurate with typical installation of these dwellings.

Photograph 2: Photograph taken looking east from the intersection of Elm Lane and 3rd Avenue showing dip section in Elm. Note sediment in roadway remaining from recent storms.

Elm Lane was observed to slope downward from both Central Avenue to the west and 3rd Avenue to the east, to a sump condition near its intersection with Holben Place (Photographs 2 and 3). Additionally, regional topographic mapping reviewed for this report (References 4, 5, and 6, Exhibits 1 and 2) also shows Elm Lane sloping to a sump near this intersection. Two catch basins were observed at the southeast and northeast corners of the intersection of Elm Lane and Holben Place (Photographs 3 and 4). Significant amounts of sediment and debris apparently resulting from the recent storm event were still evident in Elm Lane as well as the adjacent properties to the south (Photographs 3 and 4). The catch basins were observed to be small, not exceeding three-feet in length. Visual indications such as sediment deposition and local topography indicate that stormwater runoff from a recent storm event overtopped the curb and continued to the south, through the existing properties along the south side of Elm Lane (Exhibit 2, Photographs 3 and 4).

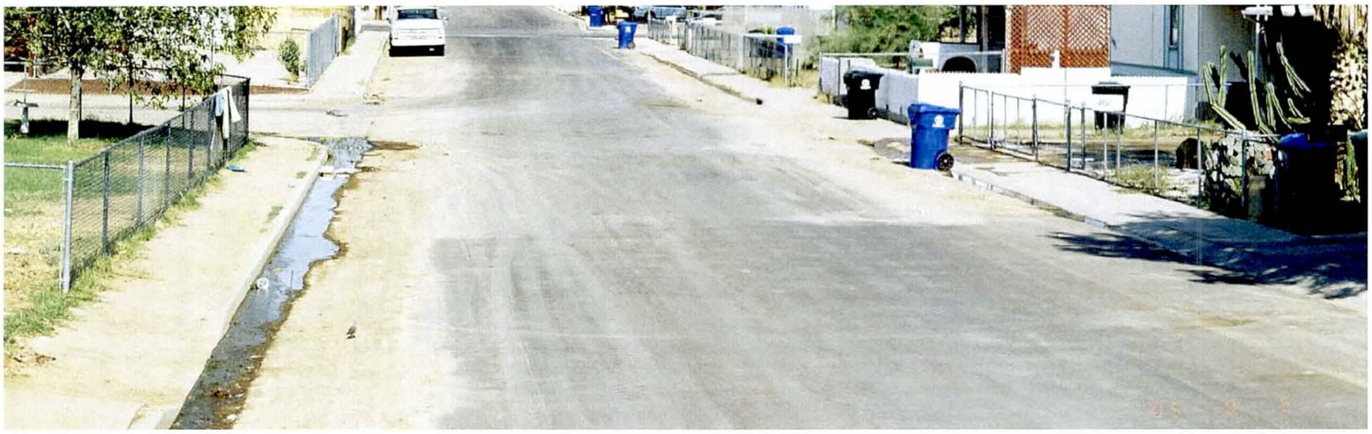
The residents of this area have reported experiencing localized flooding during storm events and have reported water ponding at the intersection of Holben Place and Elm Lane at depths as much as two (2) to three (3) feet. The most recent storm to cause this kind of event occurred during the period of August 2, 2005 through August 3, 2005.

2.2 Regional Hydrology

The study area is situated within the Agua Fria River watershed. Regional hydrologic conditions for the site and surrounding area have been described in the hydrologic analysis for this watershed as characterized in the White Tanks/Agua Fria Area Drainage Master Study and revisions. Historically, stormwater runoff has been directed to the Agua Fria River via local and regional watercourses. Historic stormwater runoff flow patterns have been altered by agricultural use, increasing urbanization in the watershed, and the construction of the Agua Fria River levees and bank stabilization structures. Development upstream of the site, such as the Southern Pacific railroad embankment, has served to concentrate and convey stormwater runoff in the vicinity of the study area.

3.0 EXISTING DATA AND REPORTS

No previous reports for the study area were reviewed for this study and none have been provided by the City of Avondale for review. As referenced in section 2.2, Regional Hydrology, the study area is situated within the Agua Fria River watershed. Regional



Photograph 3: Photograph taken looking east from Elm Lane between Holben Place and Frost Lane. Note sediment near catch basins situated at the southeast corner of Holben and Elm.

hydrologic conditions for the site and surrounding area have been described in the hydrologic analysis for this watershed as characterized in the White Tanks/Agua Fria Area Drainage Master Study and revisions (Reference 8).

Rain gage data for Flood Control District of Maricopa County was reviewed for two nearby rain gages. These rain gages are identified as Agua Fria River at Buckeye Road (Station ID 5400) and Gila River at 116th Avenue (Station ID 6845). Historical records for these rain gages as well as data for the storm event of August 2, 2005 through August 3, 2005 is presented in Appendix A.

Mapping for the study area and associated watershed was assembled by LEI using data supplied by the Flood Control District of Maricopa County (Reference 5). The resulting mapping is shown on the *Study Area and Watershed Boundaries Map* (Exhibit 2) assembled for this report.

4.0 HYDROLOGIC ANALYSIS

Hydrologic analysis was undertaken for the study area in order to characterize the drainage setting for the site and to provide data to assist in evaluating existing and proposed drainage conveyance and storage facilities. Additionally, hydrologic analysis for this report was developed using regional topographic mapping (Reference 4, Exhibit 1), mapping developed from the Flood Control District of Maricopa County (FCDMC) (Reference 5, Exhibit 2), site reconnaissance activities, and visual observations made during this assessment for the site and surrounding area, along with existing regional hydrologic analysis.

The historic watershed directing stormwater runoff to the site is shown on the *USGS Topographic Map* (Exhibit 1) and the *Study Area and Watershed Boundaries Map* (Exhibit 2). This watershed has extended from a ridge situated roughly along what is now the Litchfield Road alignment on the west to another low ridge along what is now roughly the 2nd

Photograph 4: Photograph taken from Elm Lane looking east at its intersection with Holben Place. Note the existing catch basins in the left and right sides of photograph.

Street alignment on the east. Stormwater runoff from this watershed has historically been concentrated and conveyed to the south in a low area watercourse that passed through the area immediately west of what is now the intersection of Holben Place and Elm Lane as shown on the *USGS Topographic Map* (Exhibit 1) in the area of what is currently identified as the Elm Lane sump. Stormwater runoff then continued to the south, to the Agua Fria River.

This watershed has been altered significantly due to urbanization of this area. The most significant upstream feature is the railroad and MC 85 trending southwest to northeast north of the site (Photograph 5). For the purpose of this study, this roadway is understood to form the north boundary of the watershed and contributory area. Local streets within the study area serve to concentrate and convey stormwater runoff. Slopes and grade breaks of local streets within the watershed were visually noted during site reconnaissance activities in order to clarify current drainage patterns within the watershed. These drainage patterns within the watershed are shown on the *Study Area and Watershed Boundaries Map* (Exhibit 2).

Within the watershed, Central Avenue serves as a significant conveyance corridor for stormwater runoff. Local streets in the eastern portion of the watershed direct stormwater runoff westerly to Central Avenue where it is directed south to Lower Buckeye Road and then overland to the Agua Fria River. Because of this, a significant portion of the eastern watershed has been removed from the contributory area directing stormwater runoff to the study area. Similarly, local streets north of the study area direct stormwater runoff easterly to Central Avenue, removing this area from the contributory area directing stormwater runoff to the study area. Based on these field observations and review of mapping used for this study, a contributory area that currently directs stormwater runoff to the study area has been defined and is shown on *Study Area and Watershed Boundaries Map* (Exhibit 2).

The contributory area directing stormwater runoff to the site extends to the north encompassing approximately 29.5 acres as shown on the *Study Area and Watershed Boundaries Map* (Exhibit 2). Stormwater runoff from the upstream contributory area is directed to Frost Lane and Holben Place via sheet flow that is concentrated and conveyed in local streets to the low point at the intersection of Elm Lane and Holben Place.

Although Central Avenue generally serves to concentrate and convey stormwater southerly and away from the study area, low-frequency storm events likely exceed the conveyance capacity of Central Avenue. As a result, stormwater runoff that has been directed to Central Avenue may impact the study area during low-frequency storm events. To provide data to assist in assessing this occurrence, hydrologic calculations have also been performed for the contributory area directing stormwater runoff to Central Avenue.

A significant portion of the contributory area directing stormwater runoff to the study area consists of a vacant lot situated in the upstream portion of the contributory area

Photograph 5: Photograph taken from railroad looking east. Showing elevated rail-bed that forms the northern boundary of the watershed. For orientation, Central Avenue is in he background and MC85 is in the background in the far right-hand side of the photograph.

as shown on the *Study Area and Watershed Boundaries Map* (Exhibit 2). This lot comprises approximately 11 acres of the contributory area. In order to assess the effect of removing this area from the contributory area directing stormwater runoff to the study area, hydrologic calculations were undertaken excluding this area.

The Rational Method of hydrology as described in the Drainage Design Manual for Maricopa County, Volume I was used in developing peak storm discharges for use in characterizing stormwater runoff directed to the study area. The contributory area directing stormwater runoff to the site was delineated using regional topographic mapping supplied by FCDMC (Reference 5). The delineated sub-basins were given unique identifiers corresponding to their location in the watershed as follows:

XY
X – Watershed identifier (W)
Y-Sub-basin identifier (A, B, C)
A-Contributory area (Study Area)
B-Contributory area without vacant lot
C- Central Avenue contributory area

A conservative, weighted, runoff coefficient, "C-value" was used for all calculations. The results of this analysis are presented Appendix B.

5.0 EXISTING DRAINAGE PATTERNS AND CONVEYANCE FACILITIES

Stormwater runoff is currently directed from the upstream contributory area as shown on the *Study Area and Watershed Boundaries Map* (Exhibit 2) via sheet flow. Stormwater runoff is then concentrated and conveyed south in Frost Lane and Holben Place and directed to the sump in Elm Lane situated at the intersection, and immediately west of the intersection of Elm Lane and Holben Place. The Elm Lane storm drain conveys stormwater runoff to a discharge point situated on the south side of Lower Buckeye Road at its intersection with Central Avenue. No retention, detention, or other stormwater storage facilities were observed within the contributory area during this study. Additionally, no other means of stormwater conveyance from the study area was observed during this study or is known to exist.

5.1 Elm Lane Storm Drain

Stormwater runoff directed to the study area is conveyed away from the study area via catch basins and storm drain situated in Elm Lane. This storm drain conveys stormwater east in Elm Lane to a similar storm drain line in Central Avenue that continues to convey stormwater south to an outlet south of Lower Buckeye Road.

Storm drain and half street improvement plans for Elm Lane and the storm drain extension along Central Avenue were supplied by the City of Avondale for review during this study (Reference 6) These plans are presented in Appendix C of this report.

These plans show half-street improvements including storm drain facilities for the north-half of Elm Lane only. The abutting property to the south is shown as unsubdivided on these drawings. This indicates that

Photograph 6: Storm drain outlet at Lower Buckeye Road and Central Avenue. Note heavy vegetation growth and sedimentation at the outlet. The outlet is a 24-inch diameter pipe.

Photograph 7: Photograph taken from the rear yards of Rio Vista Lane facing north showing the block walls, out-buildings and other structures that exacerbate the ponding condition on Elm Lane. Stormwater runoff from Elm Lane ponds until it overtops to the left and continues south through these rear yards and lots and is discharged to Rio Vista Lane where it is directed to Central Avenue.

the most affected properties that abut the south side of Elm Lane were constructed in a subsequent phase of the same project or as a separate project. Maricopa County Assessor's records identify the lots to the south as Wigwam Country Estates and the lots to the north as Ambrose Estates (Reference 7), corresponding to the improvement plans. At the time of construction of the improvements shown on these plans, stormwater runoff exceeding the capacity of the catch basins and storm drain would have overtopped the roadway and continued south in its historic drainage pattern. Subsequent development in the south-half of Elm Lane has cut off this historic flow path and has resulted in ponding and flooding as reported by the local residents.

The Elm Lane storm drain plans show that the Elm Lane storm drain consists of an 18-inch diameter R.G.R.C.P. (concrete pipe) that conveys stormwater east to another 18-inch diameter concrete pipe located in Central Avenue, continuing south to a 24-inch diameter pipe outlet on the south side of Lower Buckeye Road. Hydraulic analysis conducted for this system as part of this study indicates that this system is capable of conveying peak discharges slightly exceeding 7 cfs. Hydraulic analysis for the storm drain is presented in Appendix D. This calculated capacity of the existing storm drain system is significantly less than the calculated peak stormwater runoff discharge resulting from the 10-year frequency storm event of approximately 55 cfs (Appendix B).

5.2 Existing Drainage Patterns

Stormwater runoff directed to Elm Lane is conveyed away from the study area via the Elm Lane storm drain system. When the capacity of this storm drain system is exceeded stormwater ponds within the study area. Study area residents have reported ponding to depths of up to three (3) feet. This ponding occurs because subsequent development that has occurred on the south side of Elm Lane does not allow stormwater runoff to continue south in its historic flow path. Grading on lots, the construction of houses and ancillary buildings, and the construction of screen walls have all served to inhibit stormwater conveyance to the south and exacerbate ponding within the study area.

Field observations during site reconnaissance and conversations with local residents (Al Busbee, Personal Communication) indicate that when the ponded stormwater runoff has reached a sufficient depth, it overflows to the south and flows through abutting lots to the south that are situated along the north side of Rio Vista Lane (Photograph 7). The stormwater runoff is then conveyed to the east in Rio Vista Lane to Central Avenue where it ponds and continues south to the vacant land south of Lower Buckeye Road and the Agua Fria River.

In extreme storm events, stormwater runoff being conveyed to the south in Central Avenue may spill into Elm Lane to the west and be directed to the Elm Lane sump. In the event of this occurrence, water would continue to pond in the Elm Lane sump until

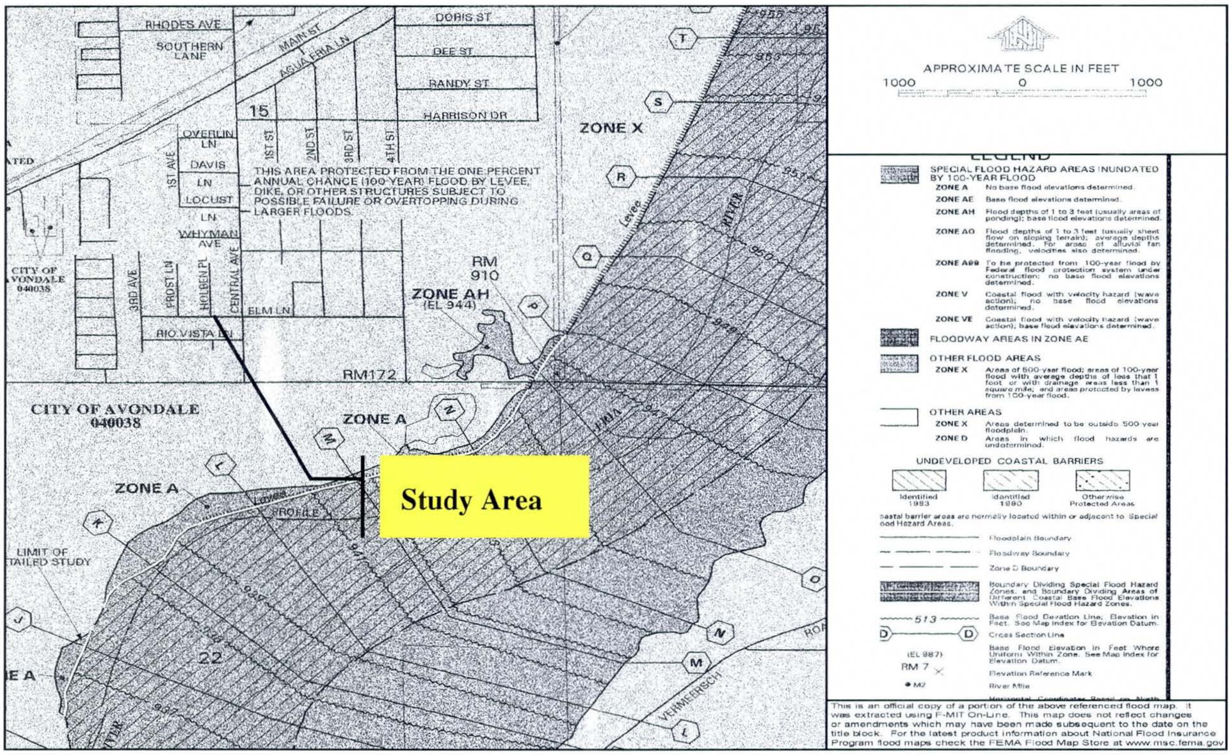


Figure 2: Floodplain Map

The Maricopa County, Arizona and Incorporated Areas Flood Insurance Rate Map (F.I.R.M.) panel number 04013C2090 G (Reference 9). The study area falls within Zone X. Zone X is defined by the Federal Emergency Management Agency (FEMA) as:

> Areas of 500-year flood; areas of 100-year flood with average depths of less than 1 foot or with drainage areas less than 1 square mile and areas protected by levees from 100-year flood.

reaching the elevation of the Central Avenue water surface and effectively becoming a backwater for the Central Avenue conveyance corridor. The elevation at the Central Avenue intersection is approximately 956 feet. The elevation at the Elm Lane sump is approximately 954.20 feet, resulting in ponding on the order of approximately ±2.0 feet.

In order to quantify the potential for stormwater runoff from Central Avenue to be directed to the Elm Lane study area weir analysis for the intersection was undertaken as part of this study. These calculations indicate that less than 20 cfs will be directed to Elm Lane from Central Avenue during the storm events evaluated. The results of this analysis are presented in Appendix G of this report.

6.0 COMMUNITY INVOLVEMENT

A community meeting was held on August 10, 2005 in order to facilitate communication with affected property owners and gather information on recent storm events and their effect on local property owners. The meeting was attended by Mr. David Fitzhugh, P.E., City of Avondale Assistant City Manager, Mr. Carnell Thurman, P.E., City of Avondale City Engineer, Mr. Greg Jones, Flood Control District of Maricopa County, Mr. Craig S. Bolze, P.E., Landmark Engineering, Inc., Members of the City of Avondale City Council, as well as local residents. The meeting was held at the Avondale Community Center located at 1007 S. 3rd Street, Avondale, Arizona.

In general, local residents reported ponding depths on the order of two (2) to three (3) feet in the vicinity of the intersection of Elm Lane and Holben Place. The most profoundly affected property was reported to be 103 W. Elm Lane, Avondale, Arizona. This resident reported ponding water within the home had destroyed the residence and made it uninhabitable. The resident had relocated with a relative within the Phoenix Metropolitan area.

7.0 FLOOD ZONE

Flood zone information for the study area and surrounding area is presented in Figure 2. The study area is situated in Zone X as protected by the Agua Fria River levee (Reference 9).

8.0 FLOODING REMEDIATION ALTERNATIVES

As part of this study LEI has prepared conceptual level alternatives focused on remediation of the localized flooding. Although presented separately in this report, these alternatives may be used in combination to form an integrated approach to stormwater management and remediation of existing flooding within the study area.

8.1 Regulation Of the Study Area As A Special Flood Hazard Area

The results of hydrologic analysis, public meetings, interviews with local residents, field reconnaissance, review of improvement plans for the study area, review of regional mapping, and hydraulic analysis of existing drainage facilities, identifies a continuing flood hazard for the study area and indicates a significant potential for continued flooding within the study area commensurate with the type of flooding experienced and reported in the past by local residents.

Subjective reports of ponding in the study area describe ponding depth of up to three feet at the Elm Lane sump. Assuming that stormwater runoff is inhibited from flowing to the south, the extreme outfall for the study area is Central Avenue to the east (Exhibit 2). The elevation of The Elm Lane and Central Avenue intersection is approximately 956 feet. The elevation at the Elm Lane sump is approximately ±954 feet, resulting in a maximum ponding depth on the order of approximately ±2.0 feet depending on the water surface elevation in Central Avenue.

In order to evaluate the effects of flooding due to ponding water in the study area, a water surface elevation was established based on the extreme stormwater outfall for the study area at Central Avenue as described in the previous paragraph. Using this information, a ponding depth water surface elevation of 956.5 feet was established. Based on this water surface elevation 33 residences within the study area will be impacted to various extents by ponding water. The extent of the defined ponding area and affected residences are shown on the *Study Area Detail Map* (Exhibit 3).

In addition to the ponding water affecting the lots along Elm Lane, the residences downstream along the north side of Rio Vista Lane are susceptible to flooding from flowing stormwater emanating from the ponding area on Elm Lane. The depth of flow and flowpath of this stormwater is largely dependent on the configuration of buildings, fences, on-lot grading, and other obstacles and is therefore difficult to predict. For the purpose of this study, those residences

Photograph 8: Photograph looking southwest at Lot 30, Ambrose Estates (Northwest corner of Holben Place and Elm Lane). Note sandbags on front porch to protect against flooding. Note mixed mobile home and slab-on-grade construction frequently found in this area.

on the north side of Rio Vista Lane that are directly downstream of the ponding area have been identified as susceptible to stormwater runoff from the area of ponding. This area is also shown on the *Study Area Detail Map* (Exhibit 3).

Based on the results presented in this report, this area may meet the criteria for regulation as a special flood hazard area by the City of Avondale and Federal Emergency Management Agency for existing and future development within the area.

8.2 Stormwater Runoff Outfall

Localized flooding in the study area is due to the inability of stormwater runoff to continue south to Rio Vista Lane. The creation of an extreme stormwater positive outfall to Rio Vista Lane as part of an integrated drainage solution would assist in eliminating ponding that is currently occurring and would serve to concentrate and convey stormwater to its existing outfall in the public right of way. The creation of a positive stormwater outfall would allow significant stormwater discharges to be safely conveyed between lots to Rio Vista Lane. The construction of a 20-foot wide shallow concrete spillway and outlet scupper along the lot-line from the sump to a scupper outlet in Rio Vista Lane would allow as much as approximately 60 cfs to be conveyed safely to the south to Rio Vista Lane. This alternative would require the purchase of a drainage easement and construction of the spillway and reconstruction of the screen walls and possibly some out-buildings (Photograph 7). Supporting hydraulic calculations are presented in Appendix F.

In implementing a positive outfall to Rio Vista Lane, care should be taken to examine the effect of this solution on downstream residents. The ponding occurring in the Elm Lane sump has been serving to detain and redirect stormwater runoff. The elimination of this ponding may cause increased downstream discharges and a commensurate increase in flooding potential for downstream residents.

8.3 Retention Basins – Outside the Study Area

Constructing retention basins for storage of stormwater runoff in the contributory area upstream of the study area would assist in attenuating peak stormwater discharges directed to the study area. Additionally, this area is likely the source of much of the sediment that is currently transported to the study area during storm events (Photographs 3 and 4). This sediment is directed to the Elm Lane storm drain, aggravating sediment deposition within the storm drain and associated discharge channel south of Lower Buckeye Road (Photograph 6).

No retention, detention, or other stormwater storage facilities were observed to exist within the contributory area directing stormwater to the study area. There is currently a substantial portion of vacant land within the northern portion of the contributory area that directs stormwater runoff to the study area. A retention basin designed to capture and contain the 100-year frequency; 2-hour duration storm event constructed at this location would significantly decrease the calculated peak stormwater runoff discharges directed to the study area.

Retention volume calculations were performed to determine the size and configuration of the retention basin required. The retention volume required to retain the 100-year frequency, 2-hour duration storm event for this area would be approximately 0.90 acre-feet. A preliminary design configuration for a retention basin sized to accommodate this calculated

Photograph 9: Photograph looking south showing vacant land in the upstream contributory area north of the study area. Proposed retention basin would be located upstream of residential development visible in the background.

volume has been prepared as part of this study. The results of these calculations are presented in Appendix E. The proposed retention basin location and conceptual configuration is shown on the *Study Area Detail Map* (Exhibit 3).

Hydrologic analysis conducted for the study area was modified to remove the vacant lot from peak discharge calculations (concentration point WB). A significant decrease in peak discharges at the Elm Lane sump was observed as a result of removing this area. The results of this hydrologic analysis are presented in Appendix B.

8.4 Retention/Detention Basins – Within the Study Area

Constructing retention or detention basins for storage of stormwater runoff within the study area would assist in concentrating stormwater runoff to a central location within an engineered drainage facility and directing it to a safe outfall location. A retention or detention basin situated near the Elm Lane sump would minimize collection and conveyance infrastructure necessary to convey stormwater runoff to the proposed facility. Additionally, a retention or detention facility would assist in attenuating peak stormwater discharges directed to the residences situated downstream that are currently receiving stormwater runoff from the upstream ponding area.

Suitable outfall locations for retention within the study area may include the existing storm drain system in Elm Lane or a new storm drain system constructed for the purpose of providing outfall for the new basins. A suitable extreme storm outfall for such a basin would be Rio Vista Lane, south of the study area.

The retention volume required to retain the 100-year frequency, 2-hour duration storm event for the Elm Lane subdivision area generally bounded by Elm Lane on the south, Central Avenue on the east, 3rd Avenue on the west, and the Whyman Avenue alignment on the north, is approximately 2.20 acre-feet. The results of these calculations are presented in Appendix E.

No retention, detention, or other stormwater storage facilities were observed to exist within the study area and there is currently no open space available for surface stormwater retention within the study area. The area required to retain the calculated volume of stormwater in a typical retention basin is approximately 42,000 square feet. Each lot along the south side of Elm Lane encompasses approximately 6,000 square feet. A typical surface retention basin would encompass approximately seven or eight lots.

Reduction in the retention volume provided while providing a similar level of protection to the downstream residences may be provided by integrating a smaller retention basin with a new storm drain system as outlined in the following section, Section 8.5. An integrated detention basin and storm drain system could be designed to provide suitable levels of protection while also reducing the size of both the required basin and storm drain line size.

Photograph 10: Photograph taken looking south at the residence located at 103 West Elm Lane. Note position of the finish floor with respect to the curb. Also, note site structures extending the width of the lot with no location for stormwater runoff to continue to the south. This lot is the location of a proposed retention basin.

As part of this study, two retention basins configurations have been evaluated; a retention basin encompassing the existing lot at 103 West Elm Lane and a retention basin encompassing both 103 West Elm lane and the lot immediately to the south having the physical address 104 West Rio Vista Lane. The parcel at 103 West Elm Lane is situated in the area of ponding as defined in this study and the parcel

Photograph 11: Photograph looking north at 104 West Rio Vista Lane. This parcel is the location of a proposed retention basin and is situated immediately downstream of 103 West Elm Lane.

situated at 104 West Rio Vista Lane is situated in the area susceptible to flooding via flowing water as delineated in this study.

The Elm Lane basin was included because this parcel has reported sustaining significant damage due to recent flooding and the owner has petitioned for buy-out as a flood-prone property by both the Flood Control District of Maricopa County and the City of Avondale. The second basin encompassing both the 103 West Elm Lane parcel and the 104 West Rio Vista Lane parcel was considered in order to provide an extreme storm outfall to Rio Vista Lane that does not exist for the 103 West Elm Lane Basin only.

For the purpose of this study, each of these basins were assumed to be three (3) feet deep, have typical 4:1 side slopes, and be connected to the existing storm drain in Elm Lane using an 18-inch diameter pipe and headwall. Stormwater runoff is to be directed to the basins via a depressed sidewalk or scupper and spillway in the Elm Lane sump.

The basin situated within the lot at 103 West Elm Lane has a calculated capacity of approximately 0.30 acre-feet of stormwater runoff storage. The combined basin encompassing both 103 West Elm Lane and 104 West Rio Vista Lane has a calculated combined stormwater runoff storage capacity of approximately 0.64 acre-feet. The results of these calculations are presented in Appendix E. Because the storage capacity of these basins is significantly less than the calculated 2.20 acre-feet required to retain the 100-year frequency, 2-hour duration storm event, neither of these basins is likely to provide significant attenuation of peak discharges for less frequent storm events. However, each of these basins would provide increased collection and conveyance capacity. Additionally, they would provide significant storage capacity and attenuation for downstream residences for more frequent storm events. Also, these basins would provide a convenient collection location and mechanism for sediment that is currently being transported to the study area from the upstream contributory area.

As mentioned previously, a basin constructed in the parcel situated at 103 West Elm Lane will not have access to Rio Vista Lane for an extreme storm outfall. The extreme storm outfall for this basin will be the existing residential lots to the south along Rio Vista Lane. Because the existing structures situated on 103 West Elm Lane likely serve to impound and redirect stormwater runoff in this area, removal of these structures may cause increased localized stormwater runoff discharges to the downstream residences. Therefore, the design of a retention basin at this location must consider and release excess stormwater runoff downstream in a manner that will not increase discharges to downstream residences.

8.5 Storm Drain

The existing Elm Lane storm drain lacks sufficient capacity to convey the multi-frequency storm events evaluated for this study. The capacity of the existing storm drain system is such that only very low-frequency storm events (less than the 10-year frequency event) can be conveyed to the outfall south of Lower Buckeye Road. As described in section 5.1 of this report, the existing storm drain line is 18-inches in diameter and capable of conveying peak discharges of only approximately seven (7) cfs. Hydraulic calculations conducted for this study indicate that the storm drain line size would need to be increased to 60-inches in order to have sufficient capacity to convey the 100-year frequency storm event. This line size could be reduced to 48-inches in diameter should upstream retention be added as described in section 8.3. Additional decreases in storm drain line size could be achieved if a positive surface outfall or additional retention could be provided as outlined in sections 8.2 and 8.4 respectively. Hydraulic calculations for storm drain line sizes are presented in Appendix D.

In addition to an increase in storm drain line size, additional catch basins would need to be added in order to capture the stormwater runoff for the design storm event. Additionally, local residents report that the existing catch basins are situated above the low point of the Elm Lane sump. Visual observations during site reconnaissance activities confirm that this is likely the case. The addition of retention basins provided along Elm Lane may act to provide the additional inlet capacity needed.

9.0 SUMMARY AND CONCLUSIONS

1. The study area is an existing mature, single-family residential neighborhood in the City of Avondale, Arizona.

2. The study area and surrounding area are situated in flood area Zone X as protected by the Agua Fria River levee.

3. The historic watershed directing stormwater runoff to the site extended from a ridge situated roughly along what is now the Litchfield Road alignment on the west to another low ridge along what is now roughly the 2nd Street alignment on the east. Stormwater runoff from this watershed has historically been concentrated and conveyed to the south in a low area watercourse that passed through the area immediately west of what is now the intersection of Holben Place and Elm Lane in the area of what is currently identified as the Elm Lane sump. Stormwater runoff then continued to the south, to the Agua Fria River.

4. The watershed has been altered significantly due to urbanization of this area. The most significant upstream feature is the Southern Pacific Railroad and MC 85 which form the northern boundary of the watershed. Local streets within the watershed serve to concentrate and convey stormwater runoff.

5. Within the watershed, Central Avenue serves as a significant conveyance corridor for stormwater runoff and redirects stormwater runoff away from the site in many instances. Local streets direct stormwater runoff to Central Avenue where it is directed south to Lower Buckeye Road and then overland to the Agua Fria River. However, low-frequency storm events likely exceed the conveyance capacity of Central Avenue. As a result, stormwater runoff that has been directed to Central Avenue may impact the study area during low-frequency storm events.

6. The contributory area directing stormwater runoff to the site extends to the north encompassing approximately 29.5 acres. Stormwater runoff from the upstream contributory area is directed to Frost Lane and Holben Place via sheet flow that is concentrated and conveyed in local streets to the low point at the intersection of Elm Lane and Holben Place.

7. Elm Lane was observed to slope downward from both Central Avenue to the west and 3rd Avenue to the east, to a sump condition near its intersection with Holben Place. This sump condition along with residences constructed immediately downstream on the south side of Elm Lane, facilitate ponding water during storm events causing flooding of residences within the study area.

8. Residents of the study area have experienced localized flooding due to a recent and very intense, storm event characteristic of late summer in the area. Local residents have reported ponding to depths of up to three (3) feet. One resident at 103 West Elm Lane, nearest and on the downstream side of the sump, reported sufficient flooding to leave the residence uninhabitable and has been relocated with relatives. Local residents have reported similar flooding of the area during storm events over the previous ten (10) to fifteen (15) years.

9. The results of this study indicate that ponding occurs because development on the south side of Elm Lane does not allow stormwater runoff to

continue south. Grading on lots, the construction of houses and ancillary buildings, and the construction of screen walls have all served to inhibit stormwater conveyance to the south and exacerbate ponding within the study area.

10. Stormwater runoff directed to Elm Lane is conveyed away from the study area via the Elm Lane storm drain system. The capacity of the storm drain situated in Elm Lane is insufficient to convey the calculated peak discharge from the multi-frequency storm events evaluated for this study. When the ponded stormwater runoff has reached a sufficient depth, it overflows to the south and flows through abutting lots that are situated along the north side of Rio Vista Lane, south of the study area. The stormwater runoff is then conveyed to the east in Rio Vista Lane to Central Avenue where it ponds and continues south to the vacant land south of Lower Buckeye Road and the Agua Fria River.

11. Finish floors for properties with slab-on-grade construction within the study area were observed to be low with respect to the surrounding topography, typical of development occurring in the 1970s. The low finish floor elevations increase the potential for these properties to experience flooding during storm events.

12. Assuming that stormwater runoff is inhibited from flowing to the south, the extreme outfall for the study area is Central Avenue to the east. The elevation of the Elm Lane and Central Avenue intersection is approximately 956 feet. In order to evaluate the effects of flooding due to ponding water in the study area, a water surface elevation was established based on the extreme stormwater outfall for the study area at Central Avenue and a ponding depth water surface elevation of 956.5 feet was established. Based on this water surface elevation, 33 residences within the study area will be impacted by ponding water.

13. In addition to the ponding water affecting the lots along Elm Lane, the residences downstream, along the north side of Rio Vista Lane, are susceptible to flooding from flowing water emanating from the ponding area on Elm Lane. The depth of flow and flowpath of this ponding water is largely dependent on the configuration of buildings, fences, on-lot grading, and other obstacles and is therefore difficult to predict. For the purpose of this study, those residences on the north side of Rio Vista Lane that are directly downstream of the ponding area have been identified as susceptible to stormwater runoff from the area of ponding. Nine (9) residences along the north side of Rio Vista Lane have been identified in this study as potentially being impacted due to flowing water.

14. Improvement of drainage facilities in the study area and upstream contributory area such as retention basins, storm drains, and open channels may serve to remediate flooding in the area. Of particular importance is the establishment of an extreme stormwater outfall to allow stormwater runoff to be conveyed to the south to prevent ponding in the area. However, care must be taken in the design of these facilities such that increased conveyance of stormwater from the study area does not cause increased potential for flooding downstream.

15. The results of hydrologic analysis, public meetings, interviews with local residents, field reconnaissance, review of improvement plans for the study area, review of regional mapping, and hydraulic analysis of existing drainage facilities, identifies a continuing flood hazard for the study area and indicates a significant potential for continued flooding within the study area commensurate with the type of flooding experienced in the past by local residents.

16. Based on the results presented in this report, this area may meet the criteria for regulation as a special flood hazard area by the City of Avondale and Federal Emergency Management Agency for existing and future development within the area.

ENGINEERING	SURVEYING	7310 NORTH 16TH STREET, SUITE 285 PHOENIX, AZ 85020 | LANDMARKENG.COM TEL: 602.861.2005 | FAX: 602.861.2175	LANDMARK ENGINEERING INC
LAND PLANNING	WATER RESOURCES		

10.0 INDIVIDUALS AND ORGANIZATIONS CONTACTED

Mr. Allen (Al) Robert Busbee
6 W. Rio Vista Lane
Avondale, Arizona
Mr. Busbee reported that the rain gage in his back yard recorded over 2-inches of rain for the storm event of August 2, 2005 through August 3, 2005. Mr. Busbee also reported that stormwater from the Elm Lane sump flows southerly through his lot

Mr. Carnell Thurman, P.E.
City Engineer
City of Avondale
11465 W. Civic Center Dr., #120
Avondale, AZ 85323
(623) 478-3270
cthurman@avondale.org
Mr. Thurman provided primary contact and coordination for the City of Avondale during this study.

Mr. Greg L. Jones
Project Manager
Flood Control District of Maricopa County
2801 W. Durango St.
Phoenix, Arizona 85009
(602) 506-5537
GLJ@mail.maricopa.gov
Mr. Jones provided primary contact with the Flood Control District of Maricopa County for this study.

11.0 REFERENCES CITED AND REVIEWED

1. City of Avondale Engineering Design Standards, City of Avondale, Dated June 1997.

2. Drainage Design Manual For Maricopa County, Arizona, Volume I, Hydrology, Flood Control District Of Maricopa County, January 1, 1995.

3. Drainage Design Manual For Maricopa County, Arizona, Volume II, Hydraulics, Flood Control District Of Maricopa County, January 28, 1996.

4. Tolleson, Quadrangle, Waddell, Arizona, 7.5 Minute Series (Topographical), United States Geological Survey, 1957, Photorevised 1982.

5. GIS Data for Sections 14, 15, 16, 21, and 22, T1N R1W, In Various Formats, Flood Control District of Maricopa County, Prepared August 12, 2005.

6. Ambrose Estates, Paving, Sewer, and Water Plans, Sheets 3 and 6 of 6, Ferguson, Morris & Associates, Inc., December 13, 1972.

7. Maricopa County Assessor GIS Online Data, Reviewed September 22, 2005.

8. White Tanks/Agua Fria Area Drainage Master Study and Revisions.

9. Flood Insurance Rate Map (F.I.R.M.) Maricopa County, Arizona and Incorporated areas, Panel Number 04013C2090 G, Federal Emergency Management Agency, July 19, 2001.

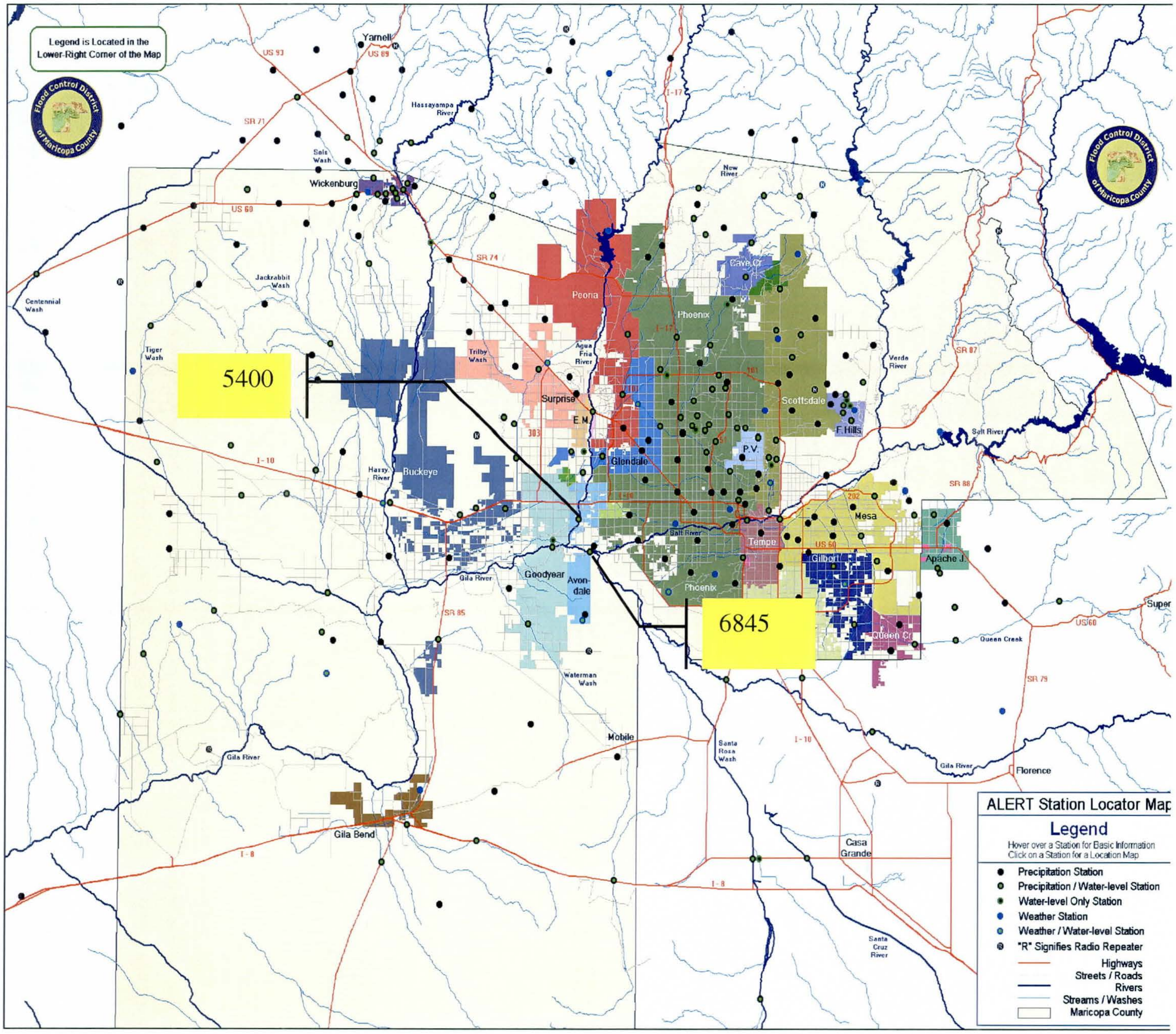
12.0 PROJECT TEAM

Mr. Carnell Thurman, City Engineer, City of Avondale.

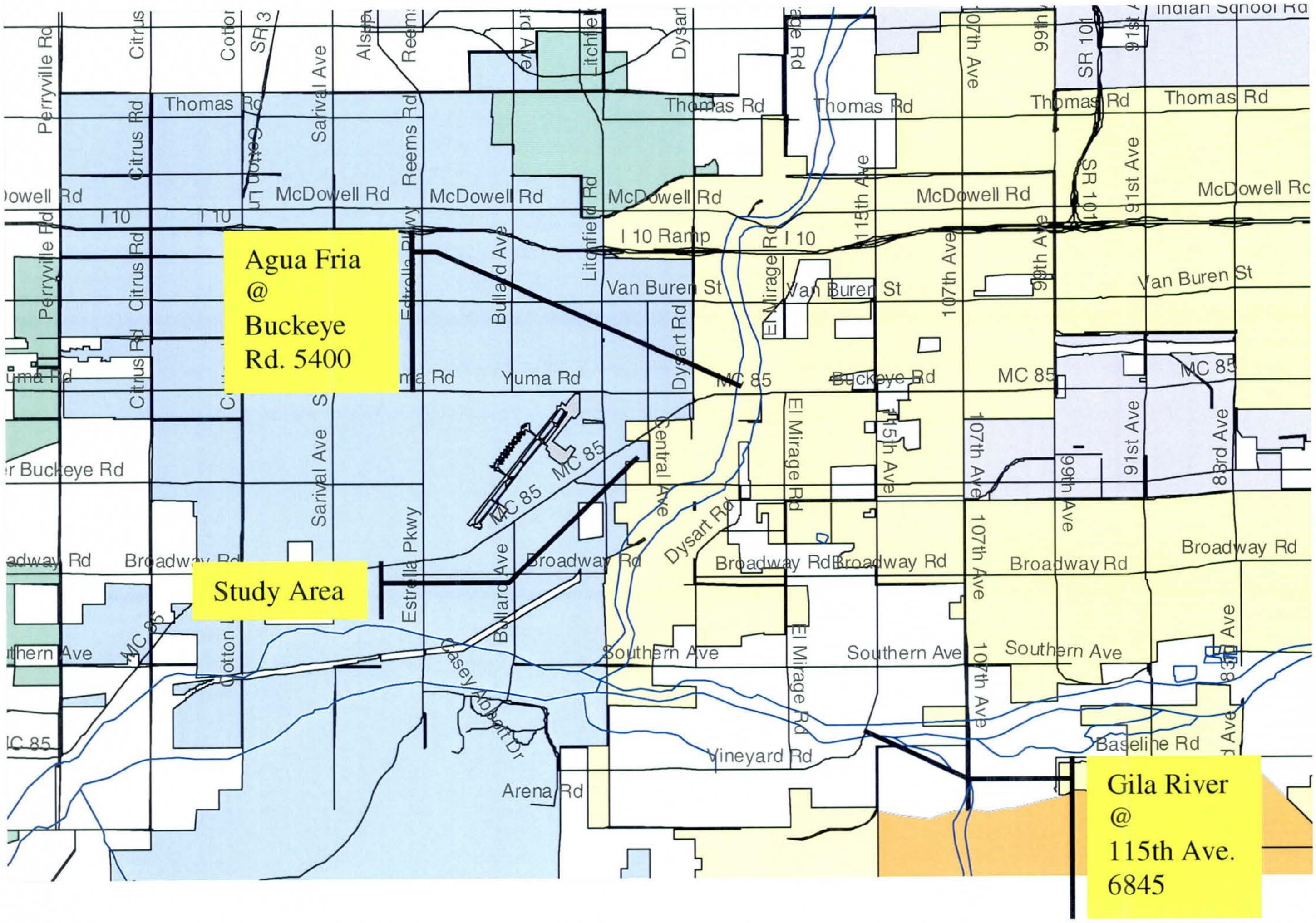
Mr. Craig S. Bolze, P.E., Project Manager, Landmark Engineering, Inc.

Mr. Rob Shelley, Senior Designer, Landmark Engineering, Inc.

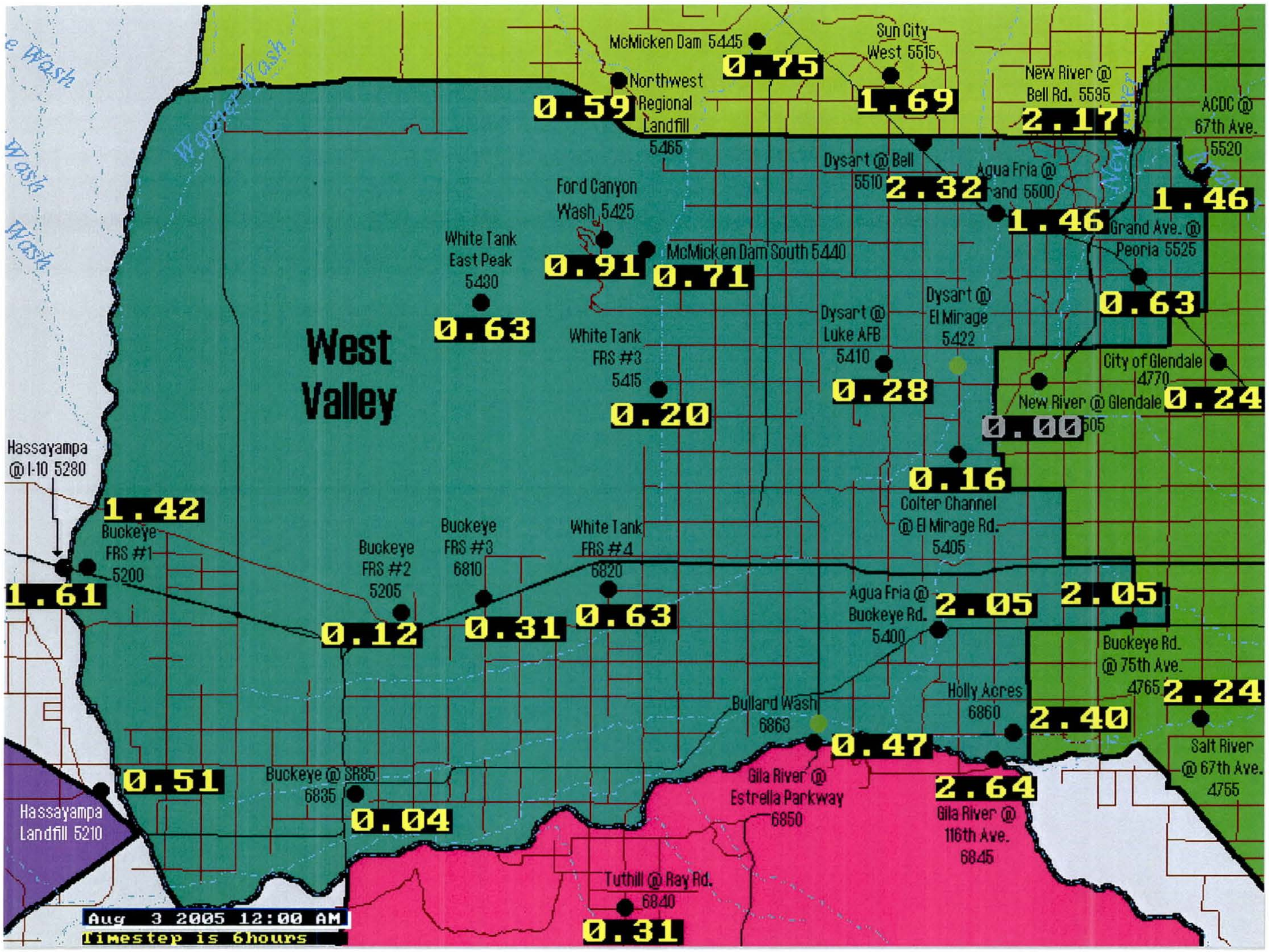
APPENDIX A
Rain Gage Records



Legend is Located in the Lower-Right Corner of the Map
Flood Control District of Maricopa County
5400
6845
Wickenburg
Peoria
Phoenix
Cave Cr.
Surprise
E.M.
Scottsdale
F. Hills
Glendale
P.V.
Buckeye
Goodyear
Avondale
Tempe
Mesa
Gilbert
Apache J.
Queen Cr.
Gila Bend
Mobile
Casa Grande
Florence
ALERT Station Locator Map
Legend
Hover over a Station for Basic Information
Click on a Station for a Location Map
Precipitation Station
Precipitation / Water-level Station
Water-level Only Station
Weather Station
Weather / Water-level Station
"R" Signifies Radio Repeater
Highways
Streets / Roads
Rivers
Streams / Washes
Maricopa County



Agua Fria
@
Buckeye
Rd. 5400
Study Area
Gila River
@
115th Ave.
6845
Indian School Rd
Thomas Rd
McDowell Rd
I 10
I 10 Ramp
Van Buren St
Yuma Rd
Buckeye Rd
MC 85
Broadway Rd
Southern Ave
Baseline Rd
Vineyard Rd
Arena Rd
Perryville Rd
Citrus Rd
Cotton Ln
Sarival Ave
Reems Rd
Estrella Pkwy
Bullard Ave
Litchfield Rd
Dysart Rd
Central Ave
El Mirage Rd
115th Ave
107th Ave
99th Ave
SR 101
91st Ave
83rd Ave



West Valley
McMicken Dam 5445
0.75
Sun City West 5515
1.69
Northwest Regional Landfill 5465
0.59
New River @ Bell Rd. 5595
2.17
ACDC @ 67th Ave. 5520
Dysart @ Bell 5510
2.32
Agua Fria @ Grand 5500
1.46
1.46
Ford Canyon Wash 5425
0.91
McMicken Dam South 5440
0.71
White Tank East Peak 5430
0.63
Grand Ave. @ Peoria 5525
0.63
White Tank FRS #3 5415
0.20
Dysart @ Luke AFB 5410
0.28
Dysart @ El Mirage 5422
City of Glendale 4770
0.24
New River @ Glendale
0.00
0.16
Colter Channel @ El Mirage Rd. 5405
Hassayampa @ I-10 5280
1.42
Buckeye FRS #1 5200
1.61
Buckeye FRS #2 5205
0.12
Buckeye FRS #3 6810
0.31
White Tank FRS #4 6820
0.63
Agua Fria @ Buckeye Rd. 5400
2.05
2.05
Buckeye Rd. @ 75th Ave. 4765
2.24
Holly Acres 6860
2.40
Salt River @ 67th Ave. 4755
Bullard Wash 6863
0.47
Gila River @ Estrella Parkway 6850
2.64
Gila River @ 116th Ave. 6845
0.51
Hassayampa Landfill 5210
Buckeye @ SR85 6835
0.04
Tuthill @ Ray Rd. 6840
0.31
Aug 3 2005 12:00 AM
Timestep is 6hours

Single - Sensor Report

Station Name: Agua Fria @ Buckeye

FCD of Maricopa County ALERT System

Date Time

08/10/2005-10:55:55

DeviceID 5400

StatType rain

DataType precip

Units in

08/03/05

1200	0.00
1130	0.00
1100	0.00
1030	0.00
1000	0.00
0930	0.00
0900	0.00
0830	0.00
0800	0.00
0730	0.00
0700	0.00
0630	0.00
0600	0.00
0530	0.00
0500	0.00
0430	0.00
0400	0.00
0330	0.00
0300	0.00
0230	0.00

0200	0.04
0130	0.00
0100	0.08
0030	0.24
08/02/05	
2400	0.00
2330	0.00
2300	0.04
2230	1.22
2200	0.79
2130	0.00
2100	0.00
2030	0.00
2000	0.00
1930	0.00
1900	0.00
1830	0.00
1800	0.00
1730	0.00
1700	0.00
1630	0.00
1600	0.00
1530	0.00
1500	0.00
1430	0.00
1400	0.00
1330	0.00
1300	0.00
1230	0.00

TOTALS: 2.40

Single - Sensor Report

Station Name: Gila R. @ 116th Ave

FCD of Maricopa County ALERT System

Date Time

08/10/2005-11:53:40

DeviceID 6845

StatType rain

DataType precip

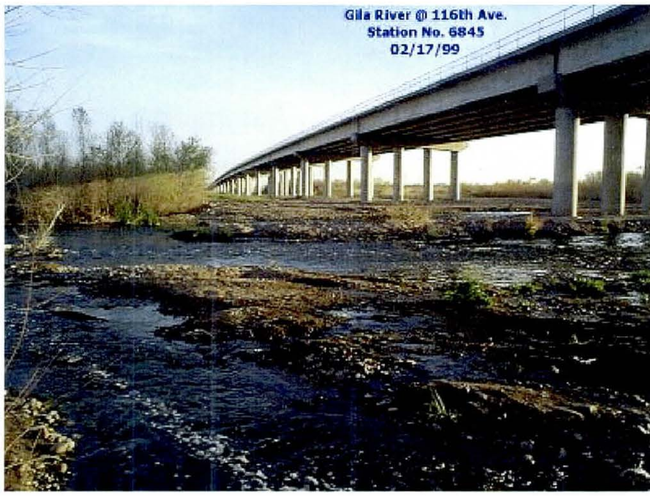
Units in

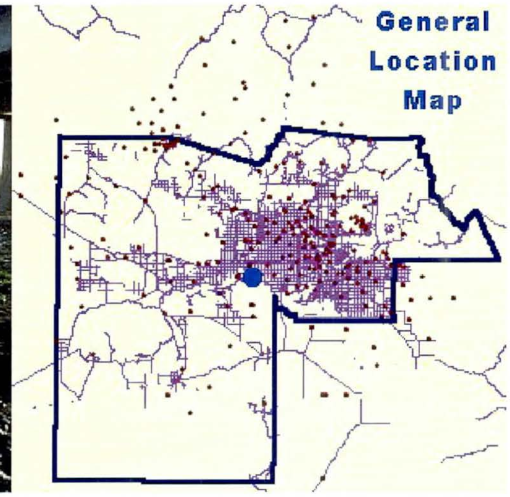
08/03/05

1200	0.00
1130	0.00
1100	0.00
1030	0.00
1000	0.00
0930	0.00
0900	0.00
0830	0.00
0800	0.00
0730	0.00
0700	0.00
0630	0.00
0600	0.00
0530	0.00
0500	0.00
0430	0.00
0400	0.00
0330	0.00
0300	0.00
0230	0.04

0200	0.00
0130	0.04
0100	0.04
0030	0.08
08/02/05	
2400	0.08
2330	0.00
2300	0.20
2230	2.05
2200	0.31
2130	0.00
2100	0.00
2030	0.00
2000	0.00
1930	0.00
1900	0.00
1830	0.00
1800	0.00
1730	0.00
1700	0.00
1630	0.00
1600	0.00
1530	0.00
1500	0.00
1430	0.00
1400	0.00
1330	0.00
1300	0.00
1230	0.00

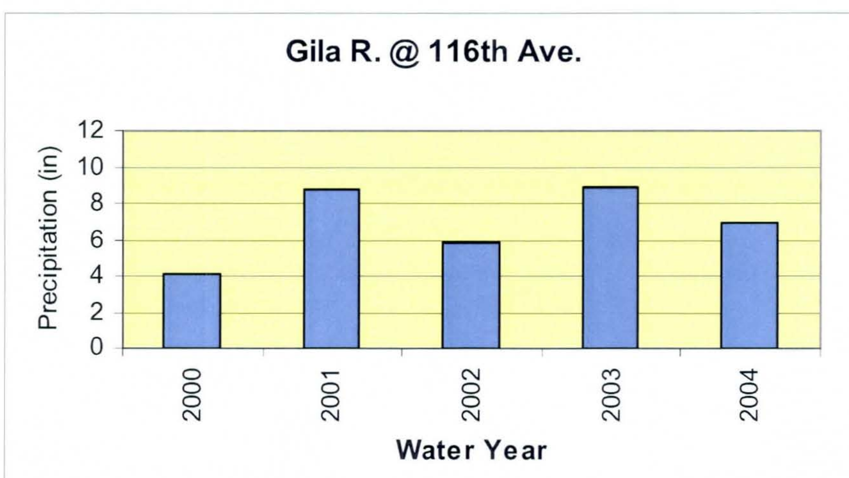
TOTALS: 2.83





Station Name: Gila River @ 116th Ave.

Station ID Number History:	**6845** since 12/16/1998
Station Type:	Rain / Stage
Data Begins:	12/16/1998
Years of Record:	5.79 (as of 10/01/04)
Data Repeater:	White Tank Peak
TRS:	T1N-R1W-Section 36
Latitude:	33° 23' 24"
Longitude:	112° 18' 28"
Elevation:	940 ft. msl
Location:	1/4 mile NNW of 115th Ave. and Baseline Road
Data Record:	
Partial Months (>10 days missing):	None
Missing Months:	None
Remarks:	Records Good



Data Statistics for Period of Record:

Number of storms greater than 1 inch in 24 hours:	9
Number of storms greater than 2 inches in 24 hours:	2
Number of storms greater than 3 inches in 24 hours:	0
Greatest 15 minute total:	1.50" on 09/07/02
Greatest 1 hour total:	2.36" on 07/14/04
Greatest 3 hour total:	2.40" on 07/14/04
Greatest 6 hour total:	2.40" on 07/14/04
Greatest 24 hour total:	2.40" on 07/14/04

Water Year Totals (Mean of Complete Water Years [5] = 6.91 inches):

Water Year	Total	Water Year	Total
2010		2000	4.09
2009		1999	M
2008		1998	
2007		1997	
2006		1996	
2005		1995	
2004	6.93	1994	
2003	8.90	1993	
2002	5.83	1992	
2001	8.78	1991	

M: One or more months contain partial or missing data

Daily Precipitation Totals And Annual Statistics Are On The Following Pages

Flood Control District of Maricopa County ALERT System

Daily Rainfall at Gila R. @ 116th Ave (gage # 6845) for Water Year 2004

DAY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1							.04					
2						.08	.98					
3							.04					
4						.16						
5						.16					.04	
6												
7												
8												
9												
10												
11			.16									
12		.63										
13		.04								.79	.20	
14										1.61		
15											.67	
16												
17												
18											.08	
19												.04
20												
21												
22				.16	.04							
23				.08	.79							
24			.04		.04							
25				.04								
26			-----							.04		
27			-----									
28			-----									
29												
30					-----							
31		-----			-----		-----		-----			-----
SUM	0.00	0.67	0.20	0.28	0.87	0.39	1.06	0.00	0.00	2.44	0.98	0.04
ACC	0.00	0.67	0.87	1.14	2.01	2.40	3.46	3.46	3.46	5.91	6.89	6.93
MAX	0.00	0.63	0.16	0.16	0.79	0.16	0.98	0.00	0.00	1.61	0.67	0.04
NO.	0	2	2	3	3	3	3	0	0	3	4	1

Maximum Daily Rainfall	1.61
Maximum Monthly Rainfall	2.44
Total Annual Rainfall	6.93
Number of Days with Rain	24

Notes:

Annual rainfall in millimeters: 176 — Total down-time: 3.45 days

Gage 6845 down from 12/25 21:04 (22) through 12/29 07:54 (22) for unknown reason; no rain fell.

Flood Control District of Maricopa County ALERT System

Daily Rainfall at Gila River @ 116th Ave (gage # 6845) for Water Year 2003

DAY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1											.08	
2												
3												
4												
5												
6												
7												
8				.47								
9				.04								.04
10												
11												
12					.24							
13					.98							
14					.51						1.89	
15							.12				.08	
16						.43						
17						.16						
18												
19												
20			.04	.04								
21				.04								
22												
23			.08								.08	
24										.04		.08
25					.51							
26	.12				.04						.94	
27					.24							
28					.04							
29		.43			-----					1.10		
30		.04			-----							
31		-----			-----		-----		-----			-----
SUM	0.12	0.47	0.12	0.59	2.56	0.59	0.12	0.00	0.00	1.14	3.07	0.12
ACC	0.12	0.59	0.71	1.30	3.86	4.45	4.57	4.57	4.57	5.71	8.78	8.90
MAX	0.12	0.43	0.08	0.47	0.98	0.43	0.12	0.00	0.00	1.10	1.89	0.08
NO.	1	2	2	4	7	2	1	0	0	2	5	2

Maximum Daily Rainfall	1.89
Maximum Monthly Rainfall	3.07
Total Annual Rainfall	8.90
Number of Days with Rain	28

Notes:

Total annual rainfall in millimeters: 226

Total down-time: 0.00 days

Flood Control District of Maricopa County ALERT System

Daily Rainfall at Gila River @ 116th Ave (gage # 6845) for Water Year 2002

DAY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1												
2												
3												
4			.43									
5		.47										
6	.47											.83
7	-----											1.81
8	-----											.04
9												
10												
11			.47									
12												
13												
14										1.10		
15			.04							.04		
16												
17												
18												
19												
20												
21												
22												
23												
24												
25												
26												
27												
28												.08
29					-----							
30				.04	-----							
31		-----			-----		-----		-----			-----
SUM	0.47	0.47	0.94	0.04	0.00	0.00	0.00	0.00	0.00	1.14	0.00	2.76
ACC	0.47	0.94	1.89	1.93	1.93	1.93	1.93	1.93	1.93	3.07	3.07	5.83
MAX	0.47	0.47	0.47	0.04	0.00	0.00	0.00	0.00	0.00	1.10	0.00	1.81
NO.	1	1	3	1	0	0	0	0	0	2	0	4

Maximum Daily Rainfall	1.81
Maximum Monthly Rainfall	2.76
Total Annual Rainfall	5.83
Number of Days with Rain	12

Notes:

Total annual rainfall in millimeters: 148

Total down-time: 2.67 days

Gage 6845 down from 10/06 15:00 (8) through 10/09 07:08 (12) due to programming error; assigned 4 mm to 10/06.

Flood Control District of Maricopa County ALERT System

Daily Rainfall at Gila River @ 116th Ave (gage # 6845) for Water Year 2001

DAY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1												
2												
3												
4	.24											
5							.08					
6		.08					.04					
7						.59						
8				.12								
9	.08			.04								
10	.71											
11												
12				.63								
13					.12						.04	.28
14					.43							
15					.04							
16				.20								
17										.51	.31	
18								----				
19								----				
20								----				
21	.63						.12	----				
22	.71											
23	.28											
24	.20											
25					.08							
26												
27	.91			.55	.12							
28	.04				.12							
29					----							
30	.31				----					.16		
31	.04	----			----		----		----			----
SUM	4.13	0.08	0.00	1.54	0.91	0.59	0.24	0.00	0.00	0.67	0.35	0.28
ACC	4.13	4.21	4.21	5.75	6.65	7.24	7.48	7.48	7.48	8.15	8.50	8.78
MAX	0.91	0.08	0.00	0.63	0.43	0.59	0.12	0.00	0.00	0.51	0.31	0.28
NO.	11	1	0	5	6	1	3	0	0	2	2	1

Maximum Daily Rainfall	0.91
Maximum Monthly Rainfall	4.13
Total Annual Rainfall	8.78
Number of Days with Rain	32

Notes:

Annual rainfall in millimeters: 223

Total down-time: 4.50 days

Gage 6845 down from 5/17 20:44 (190) through 5/22 08:44 (190) due to transmitter failure; no rain fell.

Flood Control District of Maricopa County ALERT System

Daily Rainfall at Gila R. @ 116th Ave (gage # 6845) for Water Year 2000

DAY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1												
2												
3												
4												
5						.87						
6						1.26						
7						.28					.47	
8										.16		
9												
10												
11												
12												
13												
14												
15												
16												
17											.04	
18									.04			
19												
20												
21					.31							
22									.08			
23												
24												
25												
26												
27											.04	
28									.24			
29									.08			
30					----					.12		
31		----			----	.08	----		----	.04		----
SUM	0.00	0.00	0.00	0.00	0.31	2.48	0.00	0.00	0.43	0.31	0.55	0.00
ACC	0.00	0.00	0.00	0.00	0.31	2.80	2.80	2.80	3.23	3.54	4.09	4.09
MAX	0.00	0.00	0.00	0.00	0.31	1.26	0.00	0.00	0.24	0.16	0.47	0.00
NO.	0	0	0	0	1	4	0	0	4	3	3	0

Maximum Daily Rainfall	1.26
Maximum Monthly Rainfall	2.48
Total Annual Rainfall	4.09
Number of Days with Rain	15

Notes:

Annual rainfall in millimeters: 104

Total down-time: 0 days

Flood Control District of Maricopa County ALERT System

Daily Rainfall at Gila R. @ 116th Ave (gage # 6845) for Water Year 1999

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	----	----	----				.20					
2	----	----	----				.87		.04			
3	----	----	----									
4	----	----	----		.28		.08					
5	----	----	----								.12	
6	----	----	----									
7	----	----	----			.04				.51		
8	----	----	----									
9	----	----	----									
10	----	----	----								.08	
11	----	----	----									
12	----	----	----									
13	----	----	----				.04					
14	----	----	----							.63		.08
15	----	----	----							.20		.16
16	----	----				.04						.04
17	----	----										
18	----	----										
19	----	----										.39
20	----	----										
21	----	----										
22	----	----										
23	----	----										.08
24	----	----										
25	----	----		.04								
26	----	----										
27	----	----									.39	
28	----	----								.28	.04	
29	----	----			----					.04		
30	----	----			----						.04	
31	----	----			----		----		----			----
SUM	----	----	0.00	0.04	0.28	0.08	1.18	0.00	0.04	1.65	0.67	0.75
ACC	----	----	0.00	0.04	0.31	0.39	1.57	1.57	1.61	3.27	3.94	4.69
MAX	----	----	0.00	0.04	0.28	0.04	0.87	0.00	0.04	0.63	0.39	0.39
NO.	----	----	0	1	1	2	4	0	1	5	5	5

Maximum Daily Rainfall 0.87

Maximum Monthly Rainfall 1.65

Partial Annual Rainfall 4.69

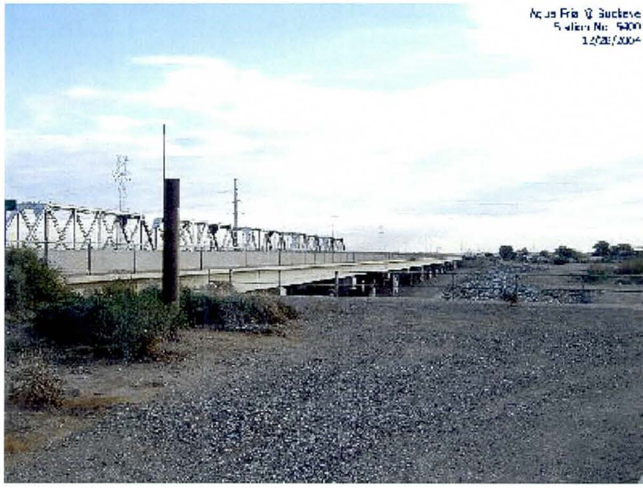
Number of Days with Rain 24

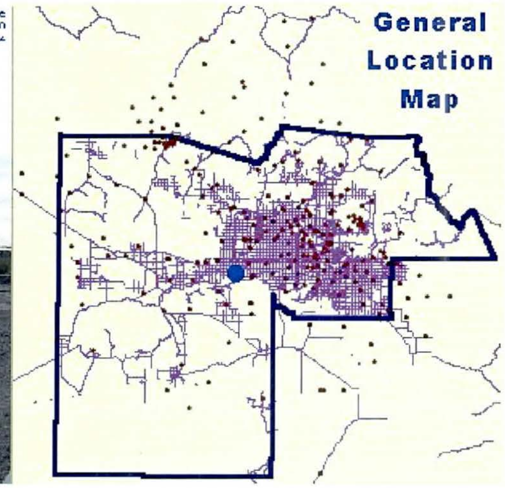
Notes:

Partial annual rainfall in millimeters: 119

Total down-time: 0.00 days

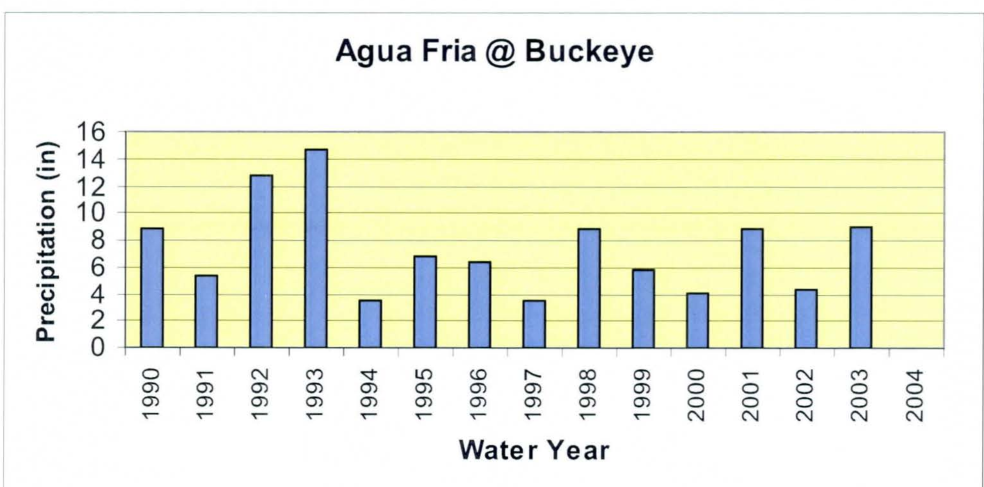
Station installed 12/16/1998.





Station Name: Agua Fria River @ Buckeye Rd.

Station ID Number History:	**5400** since 06/12/92 **2800** from 10/06/88 - 06/12/92
Station Type:	Rain / Stage
Data Begins:	10/06/1988
Years of Record:	15.99 (as of 10/01/04)
Data Repeater:	Direct
TRS:	T1N-R1W-Section 14
Latitude:	33° 26' 05.9" (33.4350)
Longitude:	112° 19' 55.7" (112.3321)
Elevation:	970 ft. msl
Location:	Buckeye Rd. bridge over Agua Fria River
Data Record:	
Partial Months (>10 days missing):	None
Missing Months:	None
Remarks:	Records Fair



Data Statistics for Period of Record:

Number of storms greater than 1 inch in 24 hours:	20	
Number of storms greater than 2 inches in 24 hours:	2	
Number of storms greater than 3 inches in 24 hours:	0	
		Approx. T_r
Greatest 15 minute total:	0.71" on 07/14/02	10 years
Greatest 1 hour total:	1.54" on 08/14/03	25 years
Greatest 3 hour total:	1.77" on 08/14/03	30 years
Greatest 6 hour total:	1.81" on 08/14/03	20 years
Greatest 24 hour total:	2.20" on 02/13/03	10 years

Water Year Totals: (Mean of Complete Water Years [14] = 7.34 inches)

Water Year	Total	Water Year	Total	Water Year	Total
2010		2000	4.06	1990	8.90
2009		1999	5.75	1989	M
2008		1998	8.86	1988	
2007		1997	3.50	1987	
2006		1996	6.34	1986	
2005		1995	6.77	1985	
2004	M	1994	3.43	1984	
2003	8.98	1993	14.72	1983	
2002	4.33	1992	12.83	1982	
2001	8.94	1991	5.39	1981	

M: One or more months contain partial or missing data

NOAA Atlas 14 Precipitation Frequency Estimates, Daily Precipitation Totals, And Annual Statistics Are On The Following Pages

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

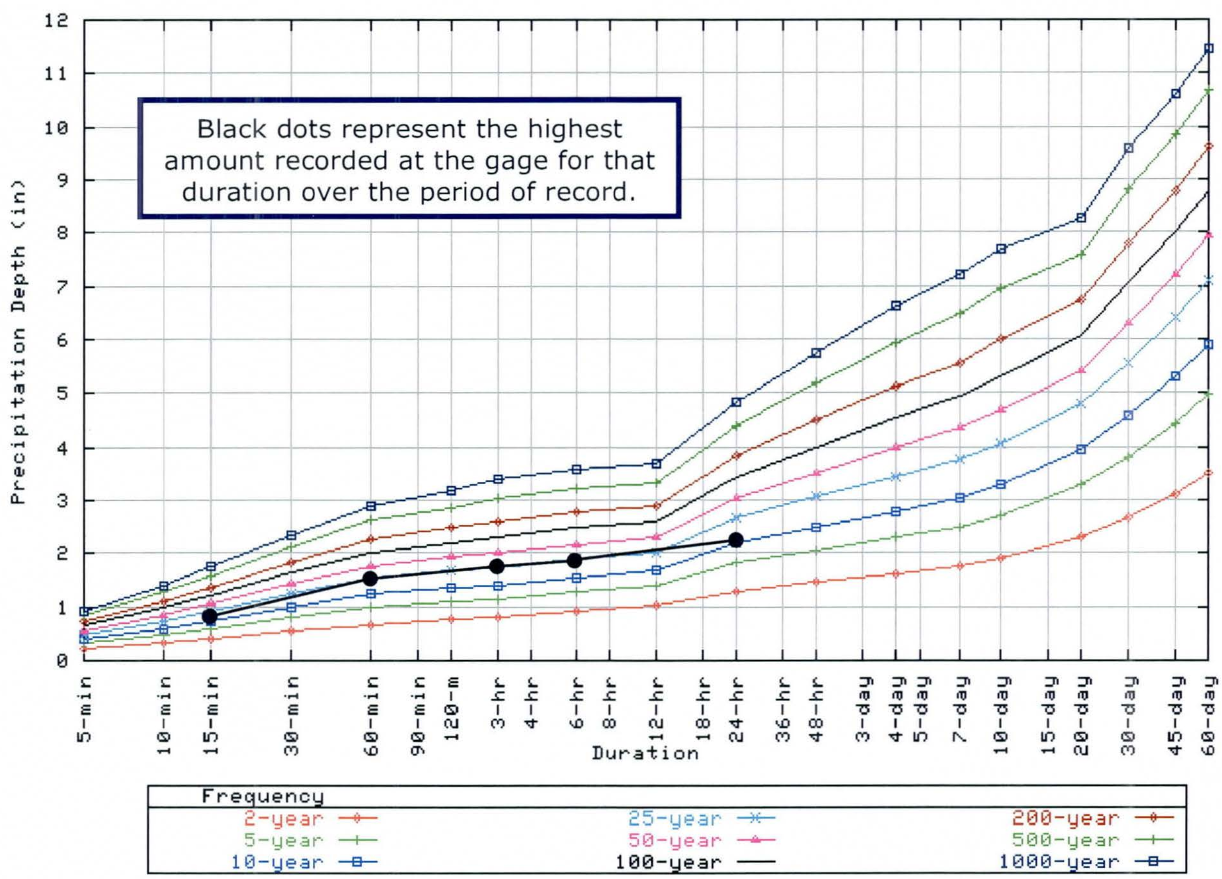
Arizona 33.435°N 112.3325°W 997 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 3
G.M. Bonnin, D. Todd, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2003
Extracted: Tue Mar 2 2004

Precipitation Frequency Estimates (inches)

return period	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
2	0.21	0.33	0.41	0.55	0.68	0.76	0.79	0.92	1.01	1.30	1.45	1.61	1.76	1.91	2.30	2.68	3.12	3.49
5	0.32	0.49	0.60	0.81	1.00	1.10	1.14	1.29	1.40	1.82	2.06	2.29	2.50	2.72	3.28	3.81	4.44	4.96
10	0.39	0.60	0.74	1.00	1.23	1.34	1.39	1.54	1.67	2.18	2.49	2.78	3.04	3.29	3.93	4.57	5.31	5.91
25	0.49	0.74	0.92	1.24	1.54	1.67	1.72	1.90	2.03	2.66	3.07	3.45	3.76	4.07	4.78	5.56	6.40	7.09
50	0.56	0.86	1.06	1.43	1.77	1.93	2.00	2.17	2.31	3.04	3.52	3.97	4.34	4.69	5.42	6.30	7.20	7.95
100	0.64	0.98	1.21	1.63	2.02	2.19	2.29	2.47	2.60	3.43	4.00	4.53	4.93	5.32	6.06	7.05	8.00	8.79
200	0.72	1.10	1.36	1.84	2.27	2.47	2.60	2.78	2.91	3.83	4.49	5.12	5.57	5.99	6.72	7.81	8.79	9.62
500	0.84	1.27	1.58	2.12	2.63	2.86	3.05	3.23	3.34	4.39	5.19	5.95	6.47	6.93	7.59	8.82	9.82	10.68
1000	0.92	1.41	1.74	2.35	2.91	3.17	3.42	3.59	3.69	4.83	5.74	6.62	7.19	7.69	8.26	9.60	10.61	11.47

Annual Maxima based Point Precipitation Frequency Estimates Version: 3
33.435 N 112.3325 W 997 ft



Flood Control District of Maricopa County ALERT System
Daily Rainfall at Agua Fria @ Buckeye (gage # 5400) for Water Year 2004

DAY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	-----	-----	-----	-----	-----	-----	-----					
2	-----	-----	-----	-----	-----	-----	-----			-----		
3	-----	-----	-----	-----	-----	-----	-----			-----		
4	-----	-----	-----	-----	-----	-----	-----			-----		.98
5	-----	-----	-----	-----	-----	-----	-----					
6	-----	-----	-----	-----	-----	-----	-----					
7	-----	-----	-----	-----	-----	-----	-----					
8	-----	-----	-----	-----	-----	-----	-----					
9	-----	-----	-----	-----	-----	-----	-----					
10	-----	-----	-----	-----	-----	-----	-----					
11	-----	-----	-----	-----	-----	-----	-----					
12	-----	-----	-----	-----	-----	-----	-----					
13	-----	-----	-----	-----	-----	-----	-----				.35	
14	-----	-----	-----	-----	-----	-----	-----			.55		
15	-----	-----	-----	-----	-----	-----	-----					
16	-----	-----	-----	-----	-----	-----	-----					
17	-----	-----	-----	-----	-----	-----	-----					
18	-----	-----	-----	-----	-----	-----	-----					
19	-----	-----	-----	-----	-----	-----	-----					
20	-----	-----	-----	-----	-----	-----	-----					
21	-----	-----	-----	-----	-----	-----	-----					
22	-----	-----	-----	-----	-----	-----	-----					
23	-----	-----	-----	-----	-----	-----	-----					
24	-----	-----	-----	-----	-----	-----	-----					
25	-----	-----	-----	-----	-----	-----	-----			.04		
26	-----	-----	-----	-----	-----	-----	-----			.04		
27	-----	-----	-----	-----	-----	-----	-----					
28	-----	-----	-----	-----	-----	-----	-----					
29	-----	-----	-----	-----	-----	-----						
30	-----	-----	-----	-----	-----	-----						
31	-----	-----	-----	-----	-----	-----	-----		-----			-----
SUM	-----	-----	-----	-----	-----	-----	0.00	0.00	0.00	0.63	0.35	0.98
ACC	-----	-----	-----	-----	-----	-----	0.00	0.00	0.00	0.63	0.98	1.97
MAX	-----	-----	-----	-----	-----	-----	0.00	0.00	0.00	0.55	0.35	0.98
NO.	-----	-----	-----	-----	-----	-----	0	0	0	3	1	1

Maximum Daily Rainfall	0.98
Maximum Monthly Rainfall	0.98
Partial Annual Rainfall	1.97
Number of Days with Rain	5

Notes:

Partial annual rainfall in millimeters: 50
Total down-time: 214.76 days
Station back in service on 04/29/2004.
Gage 5400 down from 7/01 20:01 (0) through 7/05 08:20 (0) for unknown reason; no rain fell.

Flood Control District of Maricopa County ALERT System

Daily Rainfall at Agua Fria @ Buckeye (gage # 5400) for Water Year 2003

DAY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1											.08	
2												
3												
4												
5												
6												
7												
8				.47								
9												
10												
11												
12					.24							
13					2.01							
14					.35						1.77	
15							.12				.04	
16						.79						
17	.08					.20						-----
18												-----
19											.20	-----
20												-----
21												-----
22												-----
23			.08									-----
24										.12		-----
25					.63							-----
26	.08				.43					-----		-----
27					.12					-----		-----
28					.04					-----		-----
29		.43			-----					.71		-----
30					-----							-----
31		-----			-----		-----		-----			-----
SUM	0.16	0.43	0.08	0.47	3.82	0.98	0.12	0.00	0.00	0.83	2.09	0.00
ACC	0.16	0.59	0.67	1.14	4.96	5.94	6.06	6.06	6.06	6.89	8.98	8.98
MAX	0.08	0.43	0.08	0.47	2.01	0.79	0.12	0.00	0.00	0.71	1.77	0.00
NO.	2	1	1	1	7	2	1	0	0	2	4	0

Maximum Daily Rainfall	2.01
Maximum Monthly Rainfall	3.82
Total Annual Rainfall	8.98
Number of Days with Rain	21

Notes:

Total annual rainfall in millimeters: 228

Total down-time: 3.89 days

Gage 5400 down from 7/25 08:50 (157) through 7/29 06:16 (157) due to battery failure; no rain fell.

Gage 5400 out-of-service from 09/15 06:19 through the end of the water-year due to bridge construction; assume no rain fell in those 15 days.

Flood Control District of Maricopa County ALERT System

Daily Rainfall at Agua Fria @ Buckeye (gage # 5400) for Water Year 2002

DAY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1												
2												
3												
4			.39									
5		.43										
6	.31											.71
7												.55
8												.08
9												
10												
11			.31									
12												
13												
14										1.22		
15										.04		
16												
17												
18												
19												
20												
21												
22												
23										.24		
24												
25												
26												
27												
28												
29					-----							
30				.04	-----							
31		-----			-----		-----		-----			-----
SUM	0.31	0.43	0.71	0.04	0.00	0.00	0.00	0.00	0.00	1.50	0.00	1.34
ACC	0.31	0.75	1.46	1.50	1.50	1.50	1.50	1.50	1.50	2.99	2.99	4.33
MAX	0.31	0.43	0.39	0.04	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.71
NO.	1	1	2	1	0	0	0	0	0	3	0	3

Maximum Daily Rainfall	1.22
Maximum Monthly Rainfall	1.50
Total Annual Rainfall	4.33
Number of Days with Rain	11

Notes:

Total annual rainfall in millimeters: 110

Total down-time: 0.00 days

Flood Control District of Maricopa County ALERT System

Daily Rainfall at Agua Fria R. @ Buckeye Rd. (gage # 5400) for Water Year 2001

DAY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1												
2												
3												
4	.31											
5							.04					
6		.04					.04					
7						.55						
8				.12								
9				.08							.08	
10	.43										.04	
11												
12				.59								
13					.12							
14					.28							
15				.04								
16				.20								
17										.08	.12	
18	.04											
19								.04				
20												
21	.63						.31					
22	1.02											
23	.20											
24	.12											
25					.04						----	
26					.08						----	
27	1.54			.55	.16							
28	.08				.39							
29					----							
30	.39				----					.20		
31		----			----		----		----			----
SUM	4.76	0.04	0.00	1.57	1.06	0.55	0.39	0.04	0.00	0.28	0.24	0.00
ACC	4.76	4.80	4.80	6.38	7.44	7.99	8.39	8.43	8.43	8.70	8.94	8.94
MAX	1.54	0.04	0.00	0.59	0.39	0.55	0.31	0.04	0.00	0.20	0.12	0.00
NO.	10	1	0	6	6	1	3	1	0	2	3	0

Maximum Daily Rainfall	1.54
Maximum Monthly Rainfall	4.76
Total Annual Rainfall	8.94
Number of Days with Rain	33

Notes:

Annual rainfall in millimeters: 227

Total down-time: 3.57 days

Gage 5400 down from 8/24 00:26 (227) through 8/27 14:12 (227) due to transmitter failure; no rain fell.

Flood Control District of Maricopa County ALERT System

Daily Rainfall at Agua Fria @ Buckeye (gage # 5400) for Water Year 2000

DAY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1												
2												
3												
4												
5						.75						
6						1.34						
7						.24					.28	
8										----		
9										----		
10										----		
11										----		
12												
13												
14												
15												
16												
17												
18									.35			
19												
20												
21					.12							
22									.04		.04	
23												
24												
25												
26												
27												----
28									.39			----
29											.04	
30					----					.39		
31		----			----	.08	----		----			----
SUM	0.00	0.00	0.00	0.00	0.12	2.40	0.00	0.00	0.79	0.39	0.35	0.00
ACC	0.00	0.00	0.00	0.00	0.12	2.52	2.52	2.52	3.31	3.70	4.06	4.06
MAX	0.00	0.00	0.00	0.00	0.12	1.34	0.00	0.00	0.39	0.39	0.28	0.00
NO.	0	0	0	0	1	4	0	0	3	1	3	0

Maximum Daily Rainfall	1.34
Maximum Monthly Rainfall	2.40
Total Annual Rainfall	4.06
Number of Days with Rain	12

Notes:

Annual rainfall in millimeters: 103 Total down-time: 7.02 days

Gage 5400 down from 7/07 21:48 (84) through 7/12 09:49 (84) due to antenna failure; no rain fell.

Gage 5400 down from 9/26 12:02 (103) through 9/29 00:24 (103) for unknown reason; no rain fell.

Flood Control District of Maricopa County ALERT System

Daily Rainfall at Agua Fria @ Buckeye (gage # 5400) for Water Year 1999

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1							.24					
2							.67		.16			
3			.04				.04					
4					.39		.08					
5					.24							
6			.24		.04							
7										.39		
8												
9		.04										
10											.08	
11												
12												.04
13							.08					
14										.08		
15			.08							.31		.12
16						.04						
17												
18												
19												.24
20												
21	.08											
22											.04	
23							----			.04		.04
24							----					
25	.16			.04			----					
26	.04						----					
27				.04					----	.04	.55	
28		.12							----	.75		
29		.04			----				----	.04		
30	.08				----						.04	
31		----			----		----		----			----
SUM	0.35	0.20	0.35	0.08	0.67	0.04	1.10	0.00	0.16	1.65	0.71	0.43
ACC	0.35	0.55	0.91	0.98	1.65	1.69	2.80	2.80	2.95	4.61	5.31	5.75
MAX	0.16	0.12	0.24	0.04	0.39	0.04	0.67	0.00	0.16	0.75	0.55	0.24
NO.	4	3	3	2	3	1	5	0	1	7	4	4

Maximum Daily Rainfall	0.75
Maximum Monthly Rainfall	1.65
Total Annual Rainfall	5.75
Number of Days with Rain	37

Notes:

Annual rainfall in millimeters: 146 Total down-time: 9.45 days

Gage down from 4/22 01:26 (71) through 4/27 12:15 (71) due to antenna failure; no rain fell.

Gage down from 6/26 09:55 (75) through 6/30 09:55 (75) due to transmitter failure; no rain fell.

Flood Control District of Maricopa County ALERT System

Daily Rainfall at Agua Fria @ Buckeye (gage # 5400) for Water Year 1998

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1							.12					
2												
3				.04								
4					.91							.16
5										.16		
6			.08								.04	.08
7			.16		.04					.39	.12	
8					.75							
9					.31			----				.24
10				.16				----				
11		.04					.04					.91
12							.04					
13												
14					.08	.31						
15					.71	.04						
16												
17					.83					.24	.04	
18					.08							
19										.08		
20					.12							
21			.08									
22			.12									
23										.04		
24					.20							
25												
26						.31						
27												
28						.35						
29					----	.47						
30					----							
31		----			----		----		----			----
SUM	0.00	0.04	0.43	0.20	4.02	1.50	0.20	0.00	0.00	0.91	0.20	1.38
ACC	0.00	0.04	0.47	0.67	4.69	6.18	6.38	6.38	6.38	7.28	7.48	8.86
MAX	0.00	0.04	0.16	0.16	0.91	0.47	0.12	0.00	0.00	0.39	0.12	0.91
NO.	0	1	4	2	10	5	3	0	0	5	3	4

Maximum Daily Rainfall	0.91
Maximum Monthly Rainfall	4.02
Total Annual Rainfall	8.86
Number of Days with Rain	37

Notes:

Annual rainfall in millimeters: 225

Total down-time: 2.9 days

Gage down from 5/08 21:31 (162) through 5/11 19:36 (162) due to programming error; no rain fell.

Flood Control District of Maricopa County ALERT System

Daily Rainfall at Agua Fria @ Buckeye (gage # 5400) for Water Year 1997

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1												.20
2												
3							.16				.04	
4							.04					
5												.16
6												.04
7												
8											.79	
9											.04	
10												
11												.67
12												.08
13				.39								
14	.12			.04								
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
25												
26				.12								
27					.51							
28					.12							
29												
30												
31												
SUM	0.12	0.00	0.00	0.55	0.63	0.00	0.20	0.00	0.00	0.00	0.87	1.14
ACC	0.12	0.12	0.12	0.67	1.30	1.30	1.50	1.50	1.50	1.50	2.36	3.50
MAX	0.12	0.00	0.00	0.39	0.51	0.00	0.16	0.00	0.00	0.00	0.79	0.67
NO.	1	0	0	3	2	0	2	0	0	0	3	5

Maximum Daily Rainfall	0.79
Maximum Monthly Rainfall	1.14
Total Annual Rainfall	3.50
Number of Days with Rain	16

Notes:

Annual rainfall in millimeters: 89

Total down-time: 3.0 days

Gage down from 4/4/97 7:02 (38) through 4/7/97 7:05 (38) due to transmitter failure; no rain fell.

Flood Control District of Maricopa County ALERT System

Daily Rainfall at Agua Fria @ Buckeye (gage # 5400) for Water Year 1996

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1					.98							
2												
3												
4												.43
5		.47										.04
6										.08		.08
7												
8												
9										.08		
10										.12		.04
11												.87
12												
13						.28						
14						.79				.12	.35	
15										.28		
16												
17												
18												
19												
20												
21												
22				.08								
23												
24												
25					.51					.08		
26												
27										.08		
28												
29											.43	
30												
31				.16								
SUM	0.00	0.47	0.00	0.24	1.50	1.06	0.00	0.00	0.00	0.83	0.79	1.46
ACC	0.00	0.47	0.47	0.71	2.20	3.27	3.27	3.27	3.27	4.09	4.88	6.34
MAX	0.00	0.47	0.00	0.16	0.98	0.79	0.00	0.00	0.00	0.28	0.43	0.87
NO.	0	1	0	2	2	2	0	0	0	7	2	5

Maximum Daily Rainfall	0.98
Maximum Monthly Rainfall	1.50
Total Annual Rainfall	6.34
Number of Days with Rain	21

Notes:

Annual Rainfall in mm: 161

Gage down from 8/04 23:54 (104) through 8/08 11:54 (104) for unknown reason; no rain fell.

Gage down from 9/19 07:01 (161) through 9/24 19:01 (161) for unknown reason, no rain fell.

Gage down from 9/28 07:01 (161) through 10/01 07:01 (0) due to for unknown reason, assume no rain fell.

Flood Control District of Maricopa County ALERT System

Daily Rainfall at Agua Fria @ Buckeye Rd (gage # 5400) for Water Year 1995

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1												
2												
3												
4			0.04	0.47								
5			0.39	0.20								
6			0.12			0.24						0.12
7												0.20
8												
9												
10												
11				0.04		0.43						
12		0.31		0.08	0.04	0.39						
13					0.12							
14												
15	0.24				0.12						0.04	
16							0.04					
17												
18							0.24					
19							0.16				0.04	
20											0.24	
21											0.08	
22					0.04							
23			1.06									
24												
25			0.63	0.31								
26			0.20	0.04								
27												0.08
28												
29			0.04									
30												
31												
SUM	0.24	0.31	2.48	1.14	0.31	1.06	0.43	0.00	0.00	0.00	0.39	0.39
ACC	0.24	0.55	3.03	4.17	4.49	5.55	5.98	5.98	5.98	5.98	6.38	6.77
MAX	0.24	0.31	1.06	0.47	0.12	0.43	0.24	0.00	0.00	0.00	0.24	0.20
NO.	1	1	7	6	4	3	3	0	0	0	4	3

Maximum Daily Rainfall	1.06
Maximum Monthly Rainfall	2.48
Total Annual Rainfall	6.77
Number of Days with Rain	32

Notes:

Annual rainfall in mm: 172

Flood Control District of Maricopa County ALERT System

Daily Rainfall at Santa Cruz @ SR 84 (gage # 785) for Water Year 1994

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1												
2												0.08
3												
4												0.04
5												
6												
7												
8											0.04	
9												0.20
10												
11												
12											0.59	
13												
14												
15												
16											0.20	
17										0.08		
18										0.16		
19											0.04	
20						0.28						
21												0.12
22												
23												
24								0.51				
25						0.55		0.04				0.12
26						0.04	0.12					
27												
28										0.24		
29												
30												
31												
SUM	----	----	----	----	----	0.87	0.12	0.55	0.00	0.47	0.87	0.55
ACC	----	----	----	----	----	0.87	0.98	1.54	1.54	2.01	2.87	3.43
MAX	----	----	----	----	----	0.55	0.12	0.51	0.00	0.24	0.59	0.20
NO.	----	----	----	----	----	3	1	2	0	3	4	5

Maximum Daily Rainfall	0.59
Maximum Monthly Rainfall	0.87
Partial Annual Rainfall	3.43
Number of Days with Rain	18

Notes:

Partial annual rainfall in mm: 87
Gage installed 3/16/94.
Gage down from 9/3 10:15 (75) through 9/7 22:15 (76) due to repeater problem; assigned rainfall to 9/4.
Gage down from 7/28 18:43 (48) through 8/02 22:13 (51) due to repeater problem; assigned rainfall to 7/28.
Gage down from 8/14 10:16 (67) through 8/17 22:16 (72) due to repeater problem; assigned rainfall to 8/16.

Flood Control District of Maricopa County ALERT System

Daily Rainfall at Agua Fria @ Buckeye (gage # 5400) for Water Year 1993

DAY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1												
2												
3			.12	.08								
4			1.02									
5											.28	
6				.47							.75	
7				.55							.08	
8			1.26	.35	.79							
9					.16							
10				1.38								
11				.39								
12				.16								.12
13				.08								
14				.20	.28							
15				.04	.04							
16				.39								
17				.35								
18			.08	.59								
19					.08							
20												
21												
22												
23												
24												
25											.04	
26						.12						
27			.24		.04	.12					.04	
28			.91		.55	.47					.67	
29			.08		-----	.12					1.26	
30					-----							
31		-----			-----		-----		-----			-----
SUM	0.00	0.00	3.70	5.04	1.93	0.83	0.00	0.00	0.00	0.00	3.11	0.12
ACC	0.00	0.00	3.70	8.74	10.67	11.50	11.50	11.50	11.50	11.50	14.61	14.72
MAX	0.00	0.00	1.26	1.38	0.79	0.47	0.00	0.00	0.00	0.00	1.26	0.12
NO.	0	0	7	13	7	4	0	0	0	0	7	1

Maximum Daily Rainfall	1.38
Maximum Monthly Rainfall	5.04
Total Annual Rainfall	14.72
Number of Days with Rain	39

Flood Control District of Maricopa County ALERT System

Daily Rainfall at Agua Fria @ Buckeye (gage # 5400) for Water Year 1992

DAY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1							.31					
2						.24	.16					
3				.20		.31						
4				.08				.08				
5				.08				.16				
6				.43	.04						.39	
7					1.26	.12				.20		
8					.12	.28						
9						.35						
10		.04	.43		.24					.12		
11				.24	.04					.79	.28	
12				.08								
13					.24							
14		.12										
15					.08							
16												
17												
18			.43									
19			1.02									
20			.04	.08				.24				
21						.24		.28				
22											.75	
23								.04			.35	
24										.83		
25												
26												
27	.04					.39						
28						.04						
29		.12								.04		
30		.12	.16		-----	.08				.08		
31		-----			-----		-----		-----			-----
SUM	0.04	0.39	2.09	1.18	2.01	2.05	0.47	0.79	0.00	2.05	1.77	0.00
ACC	0.04	0.43	2.52	3.70	5.71	7.76	8.23	9.02	9.02	11.06	12.83	12.83
MAX	0.04	0.12	1.02	0.43	1.26	0.39	0.31	0.28	0.00	0.83	0.75	0.00
NO.	1	4	5	7	7	9	2	5	0	6	4	0

Maximum Daily Rainfall 1.26

Maximum Monthly Rainfall 2.09

Total Annual Rainfall 12.83

Number of Days with Rain 50

Flood Control District of Maricopa County ALERT System

Daily Rainfall at Agua Fria @ Buckeye (gage # 5400) for Water Year 1991

DAY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	.55					.12						
2		.16										
3												.20
4				.55								
5												
6												
7												
8												
9												
10				.04								
11											.51	
12												
13												
14												
15						.43						
16												
17					.08							
18					.04							
19						.16						
20						.31						
21			.04									
22												.35
23												
24												
25											.04	
26		.12				.28					.08	
27					.04	.63						
28			.04		.47	.04						
29			.08		-----							
30					-----							
31		-----			-----		-----		-----			-----
SUM	0.55	0.28	0.16	0.59	0.63	1.97	0.00	0.00	0.00	0.00	0.63	0.55
ACC	0.55	0.83	0.98	1.57	2.20	4.17	4.17	4.17	4.21	4.21	4.84	5.39
MAX	0.55	0.16	0.08	0.55	0.47	0.63	0.00	0.00	0.00	0.00	0.51	0.35
NO.	1	2	3	2	4	7	0	0	0	0	3	2

Maximum Daily Rainfall	0.63
Maximum Monthly Rainfall	1.97
Total Annual Rainfall	5.39
Number of Days with Rain	24

Flood Control District of Maricopa County ALERT System

Daily Rainfall at Agua Fria @ Buckeye (gage # 5400) for Water Year 1990

DAY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1					.20							
2				.16								
3	.04										.04	1.06
4	.12											.04
5												.24
6												
7										.08		
8												
9												
10						.04			.31	.94		
11						.12					.08	
12											.08	
13												
14										.12	.47	.75
15				.04						.79		.12
16												
17				.35								
18												
19	.08				.12							
20												.20
21	.67	.04										.35
22												
23												
24							.04			.79		
25												
26												
27												
28			.04					.08				
29			.04		-----	.28						
30					-----							
31		-----			-----		-----		-----			-----
SUM	0.91	0.04	0.08	0.55	0.31	0.43	0.04	0.08	0.31	2.72	0.67	2.76
ACC	0.91	0.94	1.02	1.57	1.89	2.32	2.36	2.44	2.76	5.47	6.14	8.90
MAX	0.67	0.04	0.04	0.35	0.20	0.28	0.04	0.08	0.31	0.94	0.47	1.06
NO.	4	1	2	3	2	3	1	1	1	5	4	7

Maximum Daily Rainfall	1.06
Maximum Monthly Rainfall	2.76
Total Annual Rainfall	8.90
Number of Days with Rain	34

Flood Control District of Maricopa County ALERT System

Daily Rainfall at Agua Fria @ Buckeye (gage # 5400) for Water Year 1989

DAY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	-----											
2	-----											
3	-----											.04
4	-----			.63								
5	-----											
6												
7												
8												
9												
10												
11												
12												
13												
14	1.22	.20										
15								.08				
16											.31	
17											.08	
18												
19												
20												
21										.08		
22												
23												
24												
25		.75		.04								
26		.04				.55						
27												
28												
29					-----							
30					-----							
31		-----			-----		-----		-----			-----
SUM	1.22	0.98	0.00	0.67	0.00	0.55	0.00	0.08	0.00	0.08	0.39	0.04
ACC	1.22	2.20	2.20	2.87	2.87	3.43	3.43	3.50	3.50	3.58	3.98	4.02
MAX	1.22	0.75	0.00	0.63	0.00	0.55	0.00	0.08	0.00	0.08	0.31	0.04
NO.	1	3	0	2	0	1	0	1	0	1	2	1

Maximum Daily Rainfall	1.22
Maximum Monthly Rainfall	1.22
Partial Annual Rainfall	4.02
Number of Days with Rain	12

Station installed on 10/06/1988.

APPENDIX B
Hydrologic Analysis: Rational Method Calculations

HYDROLOGIC CALCULATION SUMMARY SHEET
RATIONAL METHOD
Landmark Engineering, Inc.

Project Name: Elm Lane   Prepared by: CSB   Date: 09/25/05
Project No.: 05220   Revised by: CSB   Date:

Complete calculations for each concentration point are presented in the attached hydrologic calculation sheets.

	C			I			A	Q		
	Runoff Coefficient			Intensity			Area	Peak Discharge		
Concentration	Frequency			Frequency				Frequency		
Point	10-year	50-year	100-year	10-year	50-year	100-year		10-year	50-year	100-year
ID				[in/hr]			[acres]	[cfs]		
WA	0.48	0.53	0.56	3.9	5.8	6.7	29.42	55.07	90.44	110.38
WB	0.58	0.64	0.69	4.2	6.2	7	14.44	35.18	57.3	69.75
WC	0.65	0.72	0.75	3.3	5.15	5.95	57.89	124.17	214.66	258.33

HYDROLOGIC DESIGN DATA SHEET
RATIONAL METHOD
Landmark Engineering, Inc.

Concentration Point ID: WA

Project Name: Elm Lane Drainage — Prepared by: CSB — Date: 09/26/05
Project No.: 05220 — Checked by: — Date:

Location Data

State: Arizona — County: Maricopa — City: Avondale

Design Data

Design Frequency:	100	[yrs]	Flow Path Length (L)=	2225.00	[ft]
Check Frequency:	50	[yrs]	Elevation $_{Max}$:	972.00	[ft]
Check Frequency:	10	[yrs]	Elevation $_{Min}$:	955.00	[ft]
Drainage Area (A)=	29.42	[acres]	Elevation $_{Difference}$:	17.00	[ft]
			Flow Path Slope$_{Average}$ (S)=	0.00764	[ft/ft]

Watershed Characteristics

Hydrologic Soil Group:
Vegetation Cover: <25 [%]
Classification Type: A (Reference, Table 3.1, Page 3-3)

Rational Method Computations

Time of Concentration, (Tc)$^{(2)}$:
Tc = 11.4*L0.5*Kb0.52*S-0.31*i-0.38

L	[mi]	Kb=m Log A + b
S	[ft/mi]	m= -0.00625
i	[in/hr]	b= 0.04
		A = Area [acres]

Frequency [yr]	m	b	K_b	T_c [min]	i [in/hr]
10	-0.00625	0.04	0.030821	14.0	3.9
50	-0.00625	0.04	0.030821	12.0	5.8
100	-0.00625	0.04	0.030821	11.0	6.7

Peak Discharge (Q):
Q = C*i*A [cfs]

A [acres]
i [in/hr]
C Runoff Coefficient

$C_{50}^{(2)}$ = 0.48
$C_{50}^{(2)}$ = 0.53
$C_{100}^{(2)}$ = 0.56

Q_{10} = 55.07 **[cfs]**
Q_{50} = 90.44 **[cfs]**
Q_{100} = 110.38 **[cfs]**

Reference: Drainage Design Manual for Maricopa County, Arizona, Volume I, Hydrology, January 1, 1996

HYDROLOGIC DESIGN DATA SHEET
RATIONAL METHOD
Landmark Engineering, Inc.

Concentration Point ID: WB

Project Name: Elm Lane Drainage — Prepared by: CSB — Date: 09/26/05
Project No.: 05220 — Checked by: — Date:

Location Data

State: Arizona — County: Maricopa — City: Avondale

Design Data

Design Frequency:	100	[yrs]	Flow Path Length (L)=	1275.00	[ft]
Check Frequency:	50	[yrs]	Elevation $_{Max}$:	961.00	[ft]
Check Frequency:	10	[yrs]	Elevation $_{Min}$:	955.00	[ft]
Drainage Area (A)=	14.44	[acres]	Elevation $_{Difference}$:	6.00	[ft]
			Flow Path Slope$_{Average}$ (S)=	0.00471	[ft/ft]

Watershed Characteristics

Hydrologic Soil Group:
Vegetation Cover: <25 [%]
Classification Type: A (Reference, Table 3.1, Page 3-3)

Rational Method Computations

Time of Concentration, (Tc)[(2)]:
Tc = 11.4*L0.5*Kb0.52*S-0.31*i-0.38

L	[mi]	Kb=m Log A + b	
S	[ft/mi]	m=	-0.00625
i	[in/hr]	b=	0.04
		A =	Area [acres]

Frequency [yr]	m	b	K_b	T_c [min]	i [in/hr]
10	-0.00625	0.04	0.032753	12.0	4.2
50	-0.00625	0.04	0.032753	10.0	6.2
100	-0.00625	0.04	0.032753	10.0	7

Peak Discharge (Q):
Q = C*i*A [cfs]

A [acres]
i [in/hr]
C Runoff Coefficient

$C_{50}^{(2)}$ = 0.58
$C_{50}^{(2)}$ = 0.64
$C_{100}^{(2)}$ = 0.69

Q_{10} = 35.18 **[cfs]**
Q_{50} = 57.30 **[cfs]**
Q_{100} = 69.75 **[cfs]**

Reference: Drainage Design Manual for Maricopa County, Arizona, Volume I, Hydrology, January 1, 1996

HYDROLOGIC DESIGN DATA SHEET
RATIONAL METHOD
Landmark Engineering, Inc.

Concentration Point ID: WC

Project Name: Elm Lane Drainage
Project No.: 05220

Prepared by: CSB
Checked by:

Date: 09/26/05
Date:

Location Data

State: Arizona County: Maricopa City: Avondale

Design Data

Design Frequency:	100	[yrs]	Flow Path Length (L)=	3255.00	[ft]
Check Frequency:	50	[yrs]	Elevation $_{Max}$:	973.00	[ft]
Check Frequency:	10	[yrs]	Elevation $_{Min}$:	956.00	[ft]
Drainage Area (A)=	57.89	[acres]	Elevation $_{Difference}$:	17.00	[ft]
			Flow Path Slope$_{Average}$ (S)=	0.00522	[ft/ft]

Watershed Characteristics

Hydrologic Soil Group:
Vegetation Cover: <25 [%]
Classification Type: A (Reference, Table 3.1, Page 3-3)

Rational Method Computations

Time of Concentration, (Tc)$^{(2)}$:
Tc = 11.4*L0.5*Kb0.52*S-0.31*i-0.38

L	[mi]	Kb=m Log A + b	
S	[ft/mi]	m=	-0.00625
i	[in/hr]	b=	0.04
		A =	Area [acres]

Frequency [yr]	m	b	K_b	T_c [min]	i [in/hr]
10	-0.00625	0.04	0.028984	19.0	3.3
50	-0.00625	0.04	0.028984	16.0	5.15
100	-0.00625	0.04	0.028984	15.0	5.95

Peak Discharge (Q):
Q = C*i*A [cfs]

A [acres]
i [in/hr]
C Runoff Coefficient

$C_{50}^{(2)}$ = 0.65
$C_{50}^{(2)}$ = 0.72
$C_{100}^{(2)}$ = 0.75

Q_{10} = 124.17 **[cfs]**
Q_{50} = 214.66 **[cfs]**
Q_{100} = 258.33 **[cfs]**

Reference: Drainage Design Manual for Maricopa County, Arizona, Volume I, Hydrology, January 1, 1996

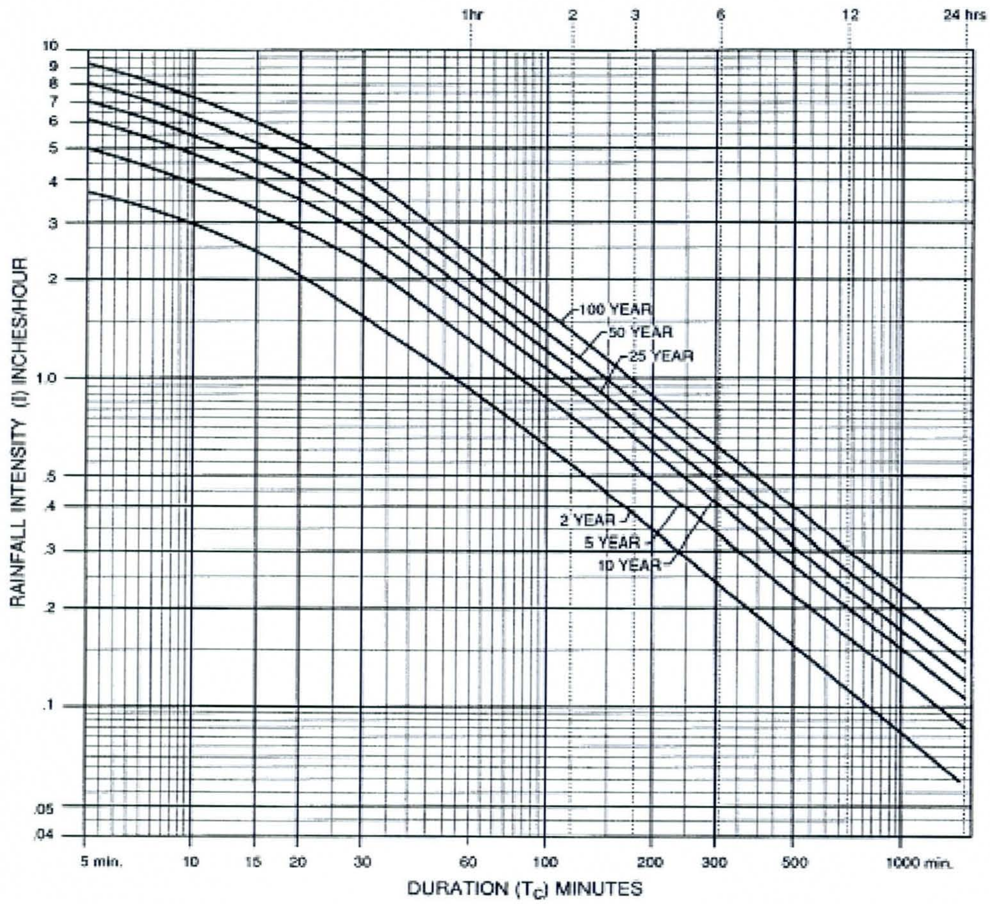


FIGURE 2.2-13

Rainfall Intensity (I) Values for Use in Rational Method

Source: Hydrologic Design Manual for Maricopa County

Maricopa County IDF Values

Time Minutes	Intensity 10 year	Intensity 50 year	Intensity 100 year
5	6.00	8.00	9.00
6	5.50	7.50	8.50
7	5.20	7.00	8.00
8	4.95	6.75	7.50
9	4.70	6.45	7.25
10	4.50	6.20	7.00
11	4.35	6.00	6.70
12	4.20	5.80	6.50
13	4.00	5.55	6.30
14	3.90	5.45	6.00
15	3.75	5.30	5.95
16	3.65	5.15	5.75
17	3.50	5.00	5.50
18	3.45	4.80	5.45
19	3.30	4.70	5.25
20	3.20	4.50	5.10
21	3.15	4.40	4.95
22	3.00	4.30	4.80
23	2.95	4.10	4.70
24	2.85	4.00	4.55
25	2.80	3.95	4.45
26	2.75	3.85	4.40
27	2.65	3.80	4.25
28	2.60	3.70	4.20
29	2.55	3.55	4.10
30	2.50	3.50	4.00
40	2.12	2.9	3.36
50	1.84	2.52	2.87
55	1.75	2.40	2.70
60	1.67	2.25	2.55
65	1.58	2.10	2.40
70	1.49	1.97	2.25
75	1.42	1.90	2.13
80	1.33	1.83	1.98
85	1.25	1.75	1.92
90	1.18	1.68	1.86
95	1.12	1.62	1.80
100	1.06	1.56	1.74

From: Drainage Design Manual for Maricopa County, Arizona, Vollume I, Hydrology, January 1,

^

HYDRAULIC CALCULATION SHEET
Weighted "C" Calculations

Project Name: Elm Lane
Project No.: 05220

Prepared by: CSB
Revised by:

Date: 09/25/05
Date:

Purpose: Calculate the weighted "C" value for the contributory area for use in developing peak discharge calculations.

Calculations: Weighted $C_W = (C_{Roads} * A_{Roads} + C_{VacLand} * A_{VacLand} + C_{Res} \cdot A_{Res}) / A_{Total}$

Results:

Entire Contributory Area	Areas sq ft	acres	C Values 10-yr	50-yr	100-yr
Roads	103207.49	2.37	0.8	0.9	0.95
Vacant Land	482495.08	11.08	0.3	0.35	0.35
Single Family Residential/Commercial	695689.97	15.97	0.55	0.6	0.65
Total Area	**1,281,393**	**29.42**	**0.48**	**0.53**	**0.56**

W/O Vacant Land (Retention)	sq ft	acres	C Values 10-yr	50-yr	100-yr
Roads	103207.49	2.37	0.8	0.9	0.95
Vacant Land	0	0.00	0.3	0.35	0.35
Single Family Residential/Commercial	695689.97	15.97	0.55	0.6	0.65
Total Area	**798,897**	**18.34**	**0.58**	**0.64**	**0.69**

Table 3.2
RUNOFF COEFFICIENTS FOR MARICOPA COUNTY

Land Use Code	Land Use Category	Runoff Coefficients by Storm Frequency[1, 2]							
		2-10 Year		25 Year		50 Year		100 Year	
		min	max	min	max	min	max	min	max
VLDR	Very Low Density Residential[3]	0.33	0.42	0.36	0.46	0.40	0.50	0.41	0.53
LDR	Low Density Residential[3]	0.42	0.48	0.46	0.53	0.50	0.58	0.53	0.60
MDR	Medium Density Residential[3]	0.48	0.65	0.53	0.72	0.58	0.78	0.60	0.82
MFR	Multiple Family Residential[3]	0.65	0.75	0.72	0.83	0.78	0.90	0.82	0.94
I1	Industrial 1[3]	0.60	0.70	0.66	0.77	0.72	0.84	0.75	0.88
I2	Industrial 2[3]	0.70	0.80	0.77	0.88	0.84	0.95	0.88	0.95
C1	Commercial 1[3]	0.55	0.65	0.61	0.72	0.66	0.78	0.69	0.81
C2	Commercial 2[3]	0.75	0.85	0.83	0.94	0.90	0.95	0.94	0.95
P	Pavement and Rooftops	0.75	0.85	0.83	0.94	0.90	0.95	0.94	0.95
GR	Gravel Roadways & Shoulders	0.60	0.70	0.66	0.77	0.72	0.84	0.75	0.88
AG	Agricultural	0.10	0.20	0.11	0.22	0.12	0.24	0.13	0.25
LPC	Lawns/Parks/Cemeteries	0.10	0.25	0.11	0.28	0.12	0.30	0.13	0.31
DL1	Desert Landscaping 1	0.55	0.85	0.61	0.94	0.66	0.95	0.69	0.95
DL2	Desert Landscaping 2	0.30	0.40	0.33	0.44	0.36	0.48	0.38	0.50
NDR	Undeveloped Desert Rangeland	0.30	0.40	0.33	0.44	0.36	0.48	0.38	0.50
NHS	Hillslopes, Sonoran Desert	0.40	0.55	0.44	0.61	0.48	0.66	0.50	0.69
NMT	Mountain Terrain	0.60	0.80	0.66	0.88	0.72	0.95	0.75	0.95

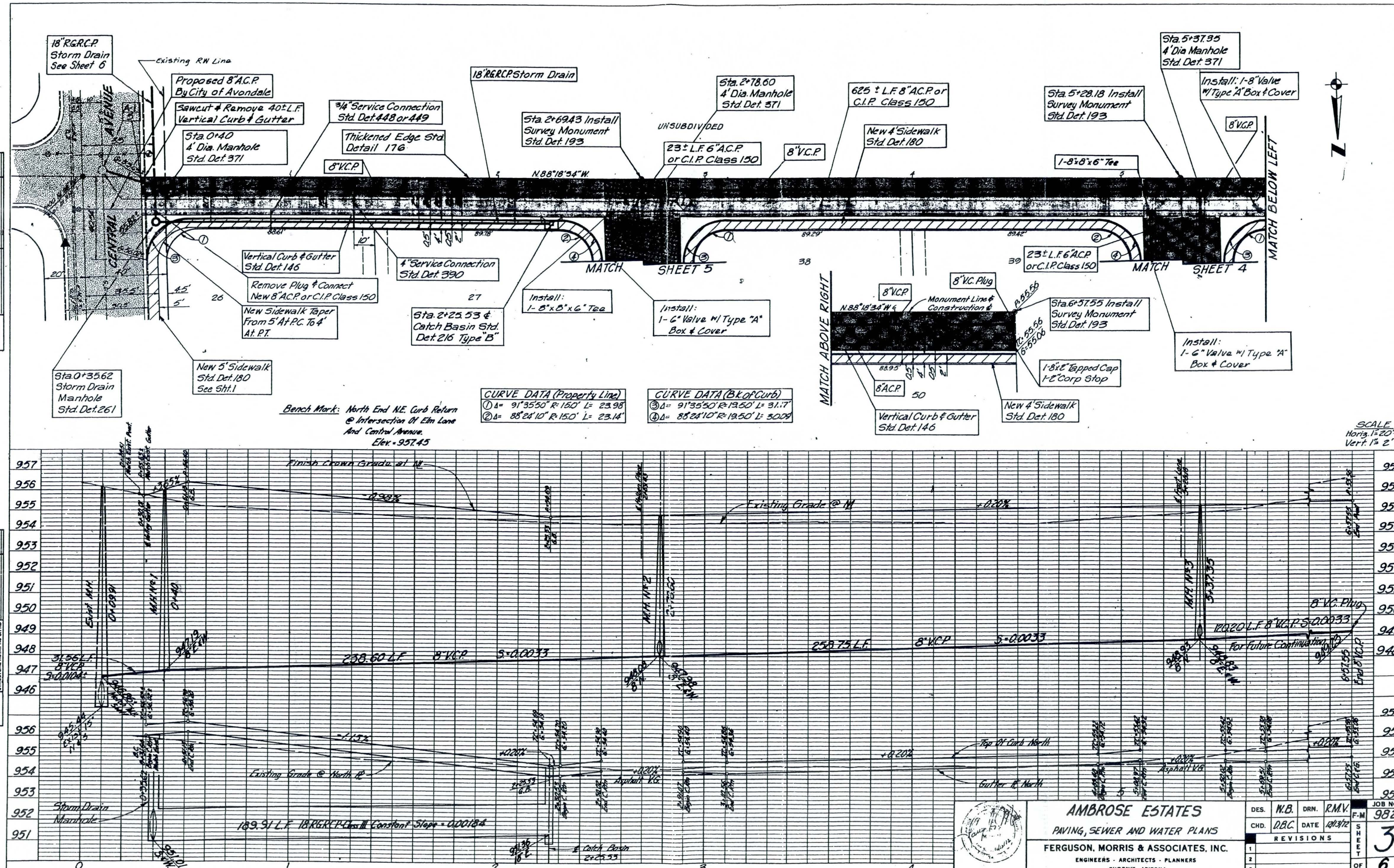
Notes:

1. Runoff coefficients for 25-, 50- and 100-Year storm frequencies were derived using adjustment factors of 1.10, 1.20 and 1.25, respectively, applied to the 2-10 Year values with an upper limit of 0.95.

2. The ranges of runoff coefficients shown for urban land uses were derived from lot coverage standards specified in the zoning ordinances for Maricopa County.

3. Runoff coefficients for urban land uses are for lot coverage only and do not include the adjacent street and right-of-way, or alleys.

APPENDIX C
Elm Lane Improvement Plans



AMBROSE ESTATES

PAVING, SEWER AND WATER PLANS

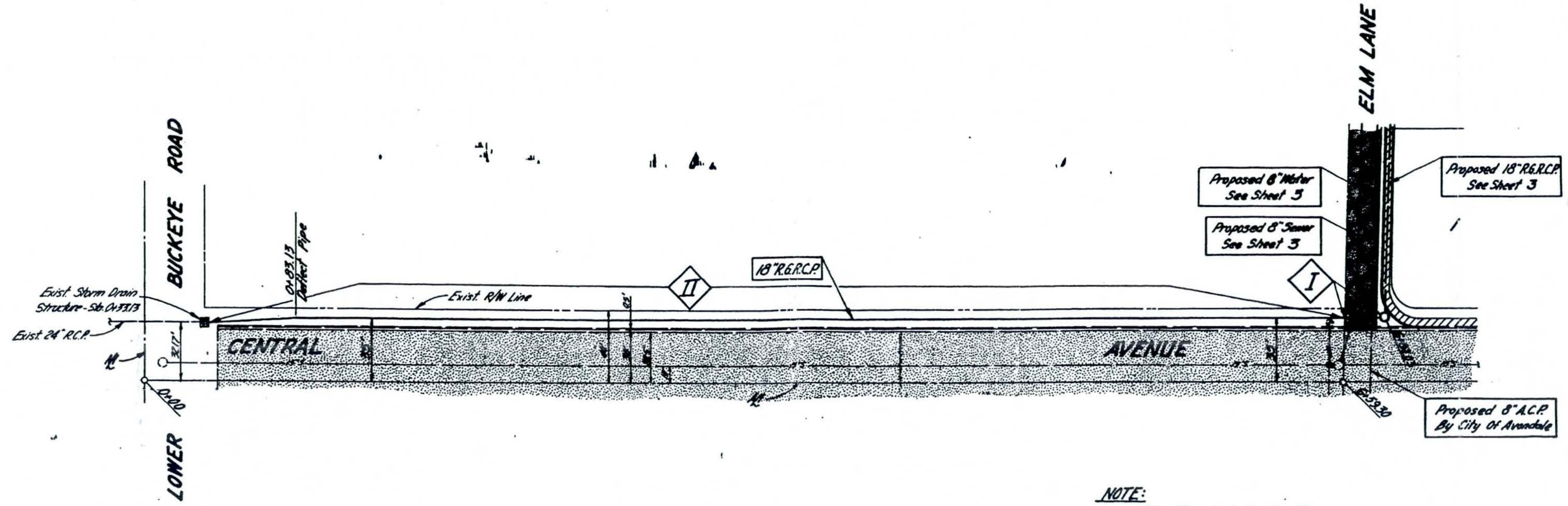
FERGUSON, MORRIS & ASSOCIATES, INC.
ENGINEERS - ARCHITECTS - PLANNERS
PHOENIX ARIZONA

DES.	W.B.	DRN.	R.M.V.
CHD.	D.B.C.	DATE	12/13/72

REVISIONS 1 / 2 / 3

JOB NO. F-M 982

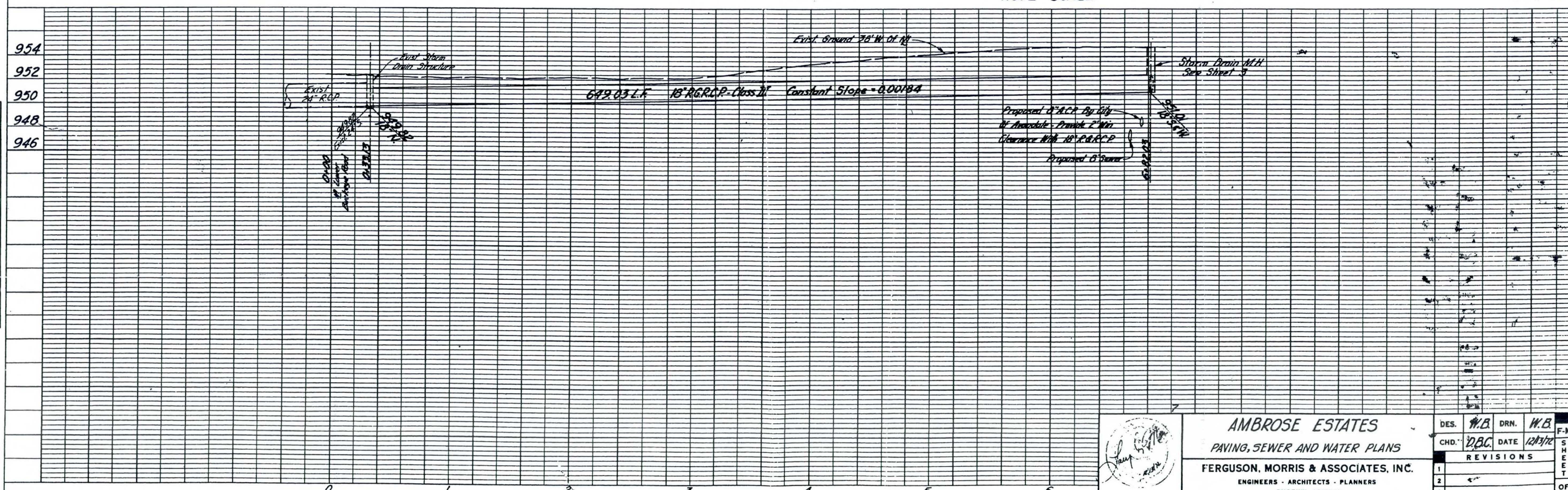
SHEET 3 OF 6



NOTE:
This Plan And Profile Shows 18" R.G.R.C.P. Only On Central Avenue. For Continuation On Elm Lane See Sheet 3.

Scale
1" = 40' Horiz.
1" = 4' Vert.

NOTE SCALE



AMBROSE ESTATES	DES. W.B.	DRN. W.B.	JOB NO. F-M 98
PAVING, SEWER AND WATER PLANS	CHD. D.B.C.	DATE 12/13/72	SHEET 6
FERGUSON, MORRIS & ASSOCIATES, INC. ENGINEERS - ARCHITECTS - PLANNERS PHOENIX ARIZONA	REVISIONS 1 2 3		OF 6

PLAN — NOTE BOOK NO. — SURVEYED — PLOTTED — ALIGNMENT CHECKED — RT. OF WAY CHECKED — BY — DATE

PROFILE — NOTE BOOK NO. — SURVEYED — PLOTTED — GRADES CHECKED — B.M.'s NOTED — STRUCTURE NOTAT'NS CH'KD — BY — DATE

BRUNING 44-512

PLATE 1 SINGLE PLAN - PROFILE CHARLES BRUNING CO.

APPENDIX D
Hydraulic Calculations: Hydraulic Grade Line Calculations for Elm Lane Storm Drain

HYDRAULIC CALCULATION SHEET
HYDRAULIC GRADE LINE CALCULATIONS

Project Name: Elm Lane Drainage Study | Prepared by: CSB | Date: 09/24/05
Project No.: 05220 | Revised by: CSB | Date: 11/15/2005

Purpose: Evaluate the hydraulic grade line (hgl) in storm drain line for the 100-year frequency storm event.

Methodology: $hgl_{inlet} = hgl_{outlet} + h_{L\text{-}Pipe} + h_{L\text{-}Structures + hL\text{-}Inlet}$

Assumptions:
1. The water surface at the pipe outlet is at the pipe soffit
2. Use headloss calculated for a straight-thru manhole to analyze entrance headloss (k_b=0.5)

Criteria: The hgl is to be a minimum of 0.50 feet below theinlet headwall or pavement (at junction) elevation. corresponding to the 10-year fequency storm event.

References: 1. Drainage Design Manual for Maricopa County, Arizona, Voilume II, Hydraulics, January 1, 1996

Calculations:

Head Loss In Pipe:

$h_L = L * n^2 * Q^2 / 2.21 * A^2 * R^{4/3}$

$R = A/P$

$A = 0.25*PI*D^2$

$P = PI*D$

Head Loss Across Manhole/Inlet:

$h_L = k * V^2 / 2 * g$ [ft]

$V = Q/A$ [ft/s]

$k_{MH\text{-}Thru} = 0.05$ (Reference 1, Page 4-17)

$k_{MH\text{-}Bend} =$ (Reference 1, Figure 4.7, Page 4-19)

$k_{Inlet} = 0.5$

I.D.	Pipe								Manhole/Inlet			El_{hgl}	$El_{Control}$	Depth
	D	L	n	Q	A	P	R	hL	k	V	hL			hgl
	[in]	[ft]		[cfs]	[ft2]	[ft]	[ft]	[ft]		[ft/s]	[ft]	[ft]	[ft]	[ft]
EXISTING ELM LANE STORM DRAIN														
Outlet												951.82	--	
MH	24	649.00	0.013	7.5	3.1416	6.2832	0.5	0.71	0.2	2.39	0.02	952.55	956.00	3.45
Inlet	18	190.00	0.013	7.5	1.7671	4.7124	0.375	0.97	0.5	4.24	0.14	953.66	954.19	0.53
UPGRADED ELM LANE STORM DRAIN														
Outlet												952.32	--	
MH	60	649.00	0.013	110.38	19.635	15.708	1.25	1.16	0.2	5.62	0.1	953.58	956.00	2.42
Inlet	60	190.00	0.013	110.38	19.635	15.708	1.25	0.34	0.5	5.62	0.25	954.17	954.19	0.02
UPGRADED ELM LANE STORM DRAIN WITH UPSTREAM RETENTION BASIN														
Outlet												951.82	--	
MH	48	649.00	0.013	69.75	12.5664	12.5664	1	1.53	0.2	5.55	0.1	953.45	956.00	2.55
Inlet	48	190.00	0.013	69.75	12.5664	12.5664	1	0.45	0.5	5.55	0.24	954.14	954.19	0.05

APPENDIX E
Retention Calculations

HYDRAULIC CALCULATION SHEET
Retention Calculations
Landmark Engineering, Inc.

Project Name: Elm Lane   Prepared by: CSB   Date: 11/03/05
Project No.: 05220   Revised by: csb   Date: 11/15/2005

Purpose: Evaluate the required and provided retention volumes in order to assess conformance to project criteria.

Methodology: Calculate the volume of stormwater required to be retained using City of Avondale criteria. Calculate the volume of stormwater retained using stage-storage relationship for retention basin geometry.

Criteria: Retain the calculated stormwater run-off for the 100-year frequency, 2-hour duration storm event.

References: 1. Drainage Design Manual for Maricopa County, Arizona. Volume I - Hydrology

Calculations: Volume Required = C * (P/12)* A [ac-ft]   (Reference 1)
Volume Provided = $(A_1 + A_2)/2 * d/43560$ [acre-ft]

$$\text{Weighted } C_W = (C_{Pavement} * A_{Pavement} + C_{Res} * A_{Res} + C_{LS} \cdot A_{LS})/A_{Total}$$

Results:

Calculate Retention Volume Required:

Surface	C
Asphalt Pavement/Concrete/Roof	0.95
Medium Density Residential	0.65
Landscaping/Vacant Land	0.35

Volume Required = C * (P/12)* A [ac-ft]
P = 2.8 [in]

Area ID	Areas [Sq ft] Landsc./Vac.	Asph. Pvmt./ Conc./Roof	Med. Dens. Residential	Total	C Values C_w	V [acre-ft]
WB	482495	--	--	482,495	0.35	0.90
Elm Subdivision			632895	632,895	0.65	2.20
--						
--						
--						
Totals	**482,495**	**0**	**632,895**	**1,115,390**		**3.10**

Calculate Retention Volume Provided:

CALCULATE RETENTION VOLUME PROVIDED IN BASINS				
Retention Basin ID	**El [ft]**	**Area [ft²]**	**Volume Provided [ft³]**	**[acre-ft]**
WB	962	16016.00		
	959	10400.00	39624	0.91
		SUBTOTAL	**39624.00**	**0.91**
Elm Basin	955	6016.00		
	952	2800.00	13224	0.3
		SUBTOTAL	**13224.00**	**0.30**
Rio Vista/ Elm Basin	954	12032.00		
	951	6560.00	27888	0.64
		SUBTOTAL	**27888.00**	**0.64**
		Totals	**80736.00**	**1.85**

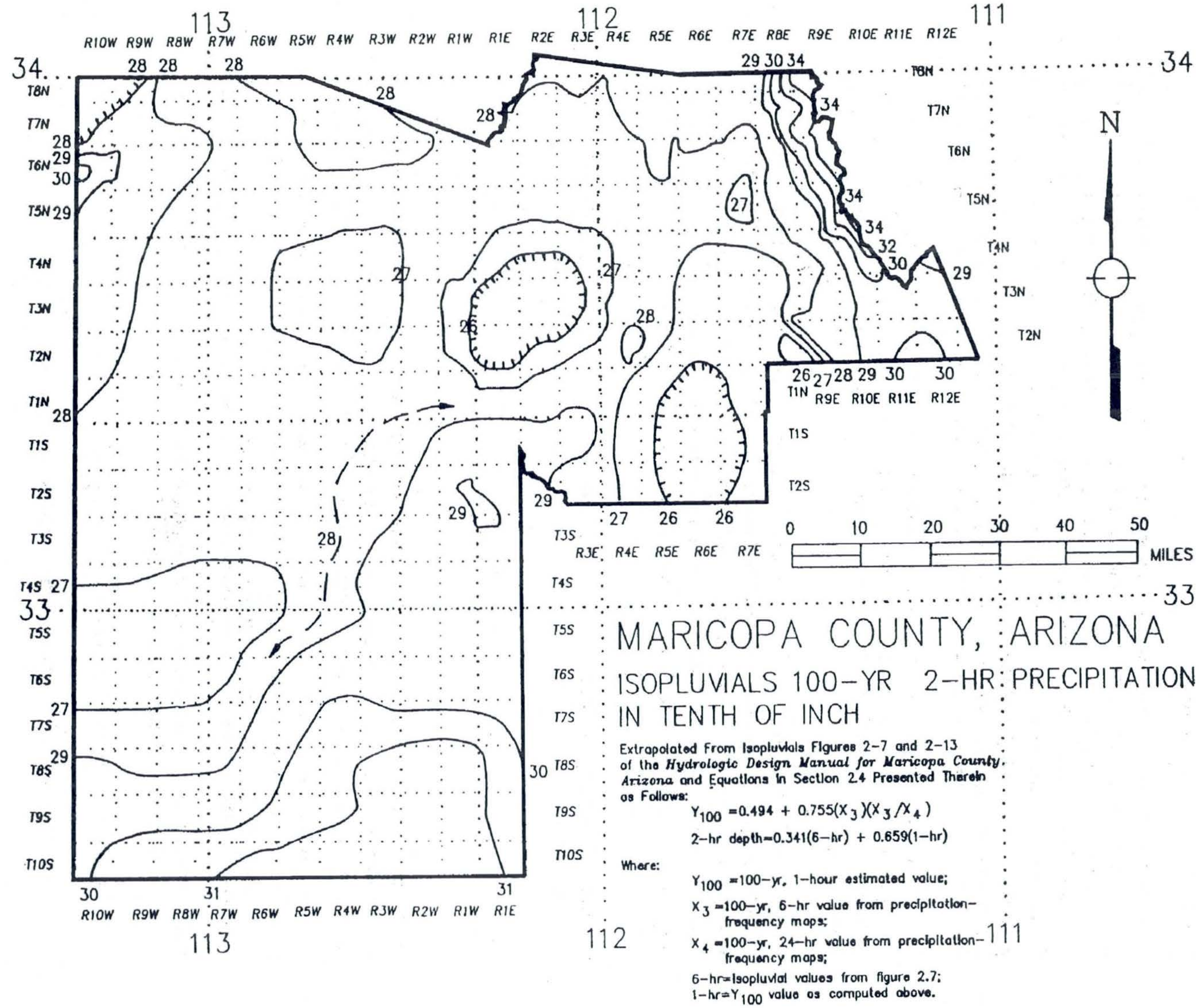


Figure 8.1
Isopluvial 100-Year, 2-Hour Precipitation

APPENDIX F
Hydraulic Calculations:
Normal Depth Channel Calculations

Worksheet
Worksheet for Rectangular Channel

Project Description	
Worksheet	Rectangular Chann(
Flow Element	Rectangular Chann(
Method	Manning's Formula
Solve For	Discharge

Input Data		
Mannings Coeffic	0.013	
Slope	005000	ft/ft
Depth	0.50	ft
Bottom Width	12.00	ft

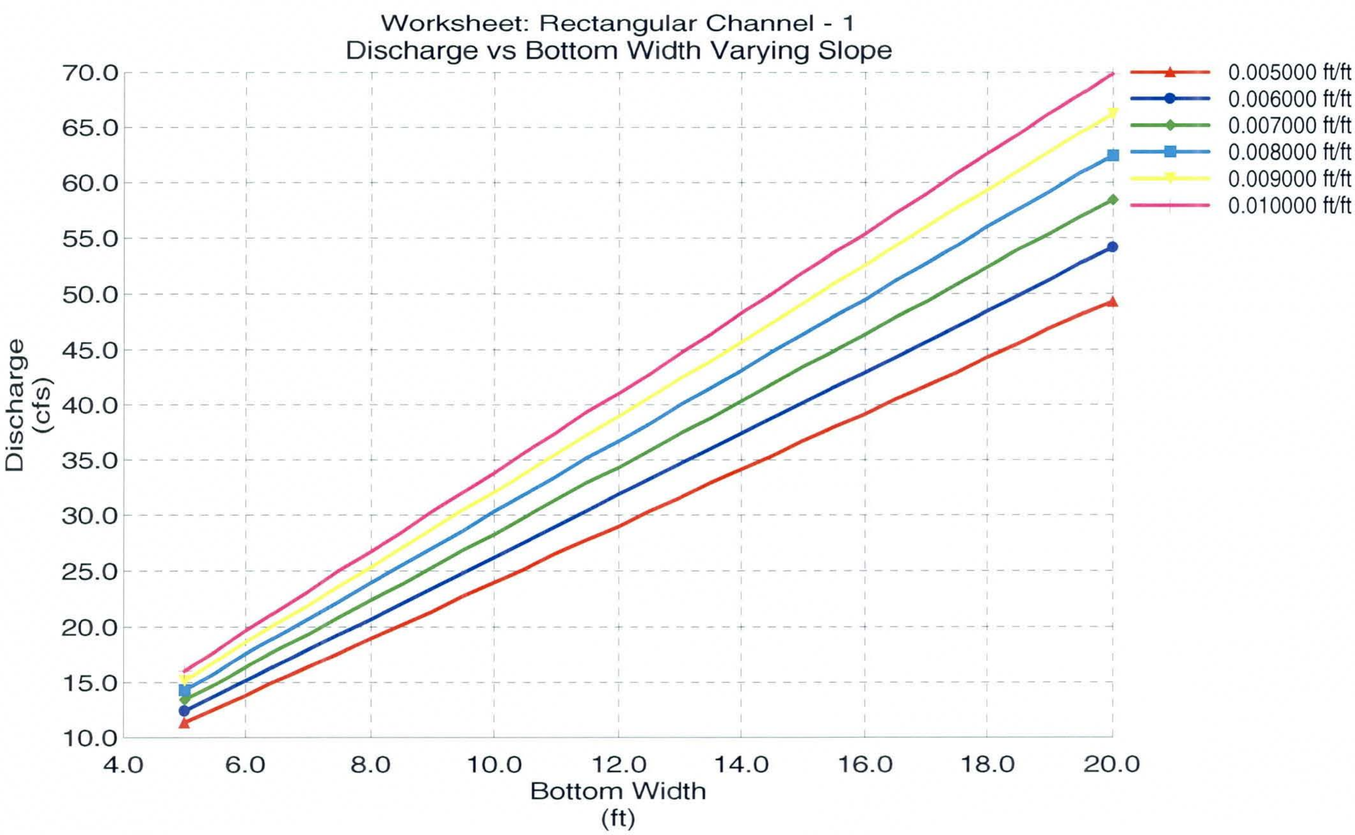
Results		
Discharge	28.96	cfs
Flow Area	6.0	ft²
Wetted Perime	13.00	ft
Top Width	12.00	ft
Critical Depth	0.57	ft
Critical Slope	0.003358	ft/ft
Velocity	4.83	ft/s
Velocity Head	0.36	ft
Specific Energ	0.86	ft
Froude Numbe	1.20	
Flow Type	Supercritical	

Curve
Plotted Curves for Rectangular Channel

Project Description	
Worksheet	Rectangular Chann‹
Flow Element	Rectangular Chann‹
Method	Manning's Formula
Solve For	Discharge

Input Data	
Mannings Coeffic	).013
Depth	0.50 ft

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	5.00	20.00	0.50
Slope (ft/ft)	0.005000	0.010000	0.001000



APPENDIX G
Hydraulic Calculations:
Weir Flow Calculations

Worksheet
Worksheet for Broad Crested Weir

Project Description	
Worksheet	Elm Lane
Type	Broad Crested \
Solve For	Discharge

Input Data		
Headwater Elev:	)56.12	ft
Crest Elevation	)55.75	ft
Tailwater Elevati	0.00	ft
Crest Surface Ty	Paved	
Crest Breadth	5.00	ft
Crest Length	20.00	ft

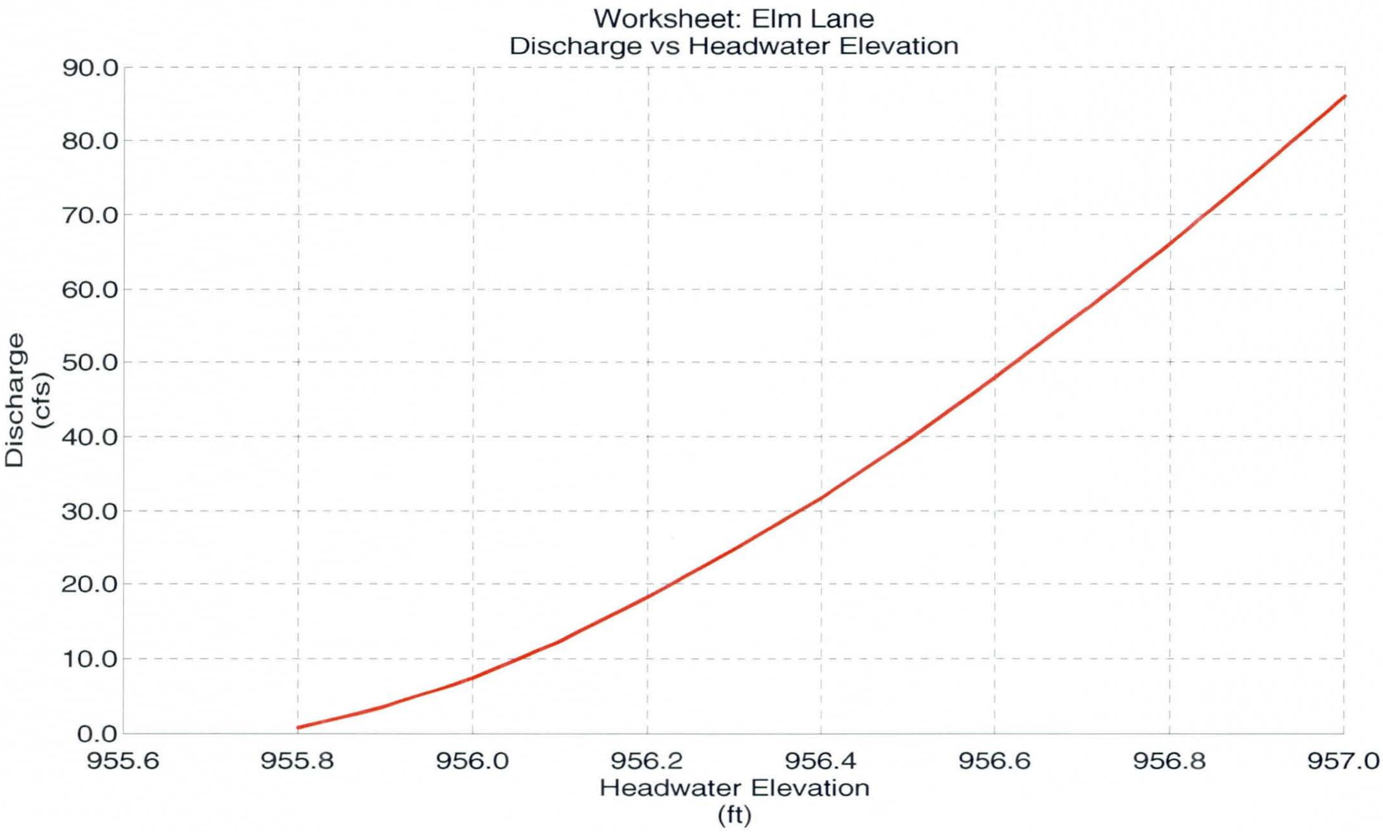
Results		
Discharge	13.46	cfs
Headwater Height Above	0.37	ft
Tailwater Height Above C	955.75	ft
Discharge Coefficient	2.99	US
Submergence Factor	1.00	
Adjusted Discharge Coeff	2.99	US
Flow Area	7.4	ft^2
Velocity	1.82	ft/s
Wetted Perimeter	20.74	ft
Top Width	20.00	ft

Curve
Plotted Curves for Broad Crested Weir

Project Description	
Worksheet	Elm Lane
Type	Broad Crested \
Solve For	Discharge

Input Data		
Crest Elevation	›55.75	ft
Tailwater Elevati	0.00	ft
Crest Surface Ty	Paved	
Crest Breadth	5.00	ft
Crest Length	20.00	ft

Attribute	Minimum	Maximum	Increment
Headwater Elevation	955.00	957.00	0.10



Worksheet
Worksheet for Irregular Channel

Project Description	
Worksheet	Central Ave Secl
Flow Element	Irregular Channe
Method	Manning's Formu
Solve For	Discharge

Input Data		
Slope	009000	ft/ft
Water Surface Elev:	956.50	ft

Options	
Current Roughness Metho	oved Lotter's Method
Open Channel Weighting I	oved Lotter's Method
Closed Channel Weighting	Horton's Method

Results		
Mannings Coeffic	0.012	
Elevation Range	5.23 to 956.00	
Discharge	632.96	cfs
Flow Area	58.8	ft²
Wetted Perimeter	71.53	ft
Top Width	70.00	ft
Actual Depth	1.27	ft
Critical Elevation	957.02	ft
Critical Slope	0.001823	ft/ft
Velocity	10.76	ft/s
Velocity Head	1.80	ft
Specific Energy	958.30	ft
Froude Number	2.07	
Flow Type	Supercritical	

Calculation Messages:
Water elevation exceeds lowest end station by 0.89 ft.

Roughness Segments

Start Station	End Station	Mannings Coefficient
0+50	1+20	0.012

Natural Channel Points

Station (ft)	Elevation (ft)
0+50	955.61
0+60	955.23
0+75	956.00
0+80	955.90
1+00	955.50
1+20	955.90

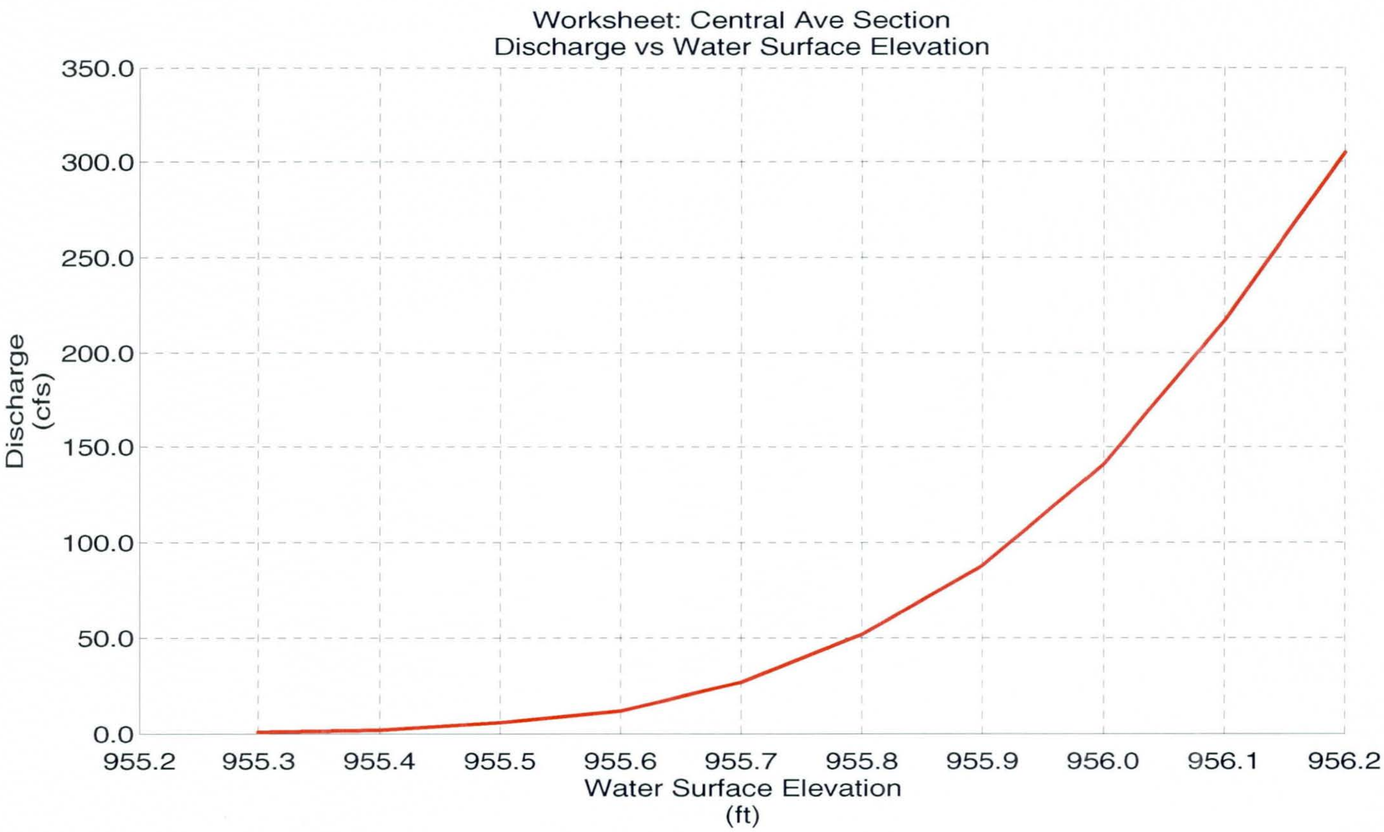
Curve
Plotted Curves for Irregular Channel

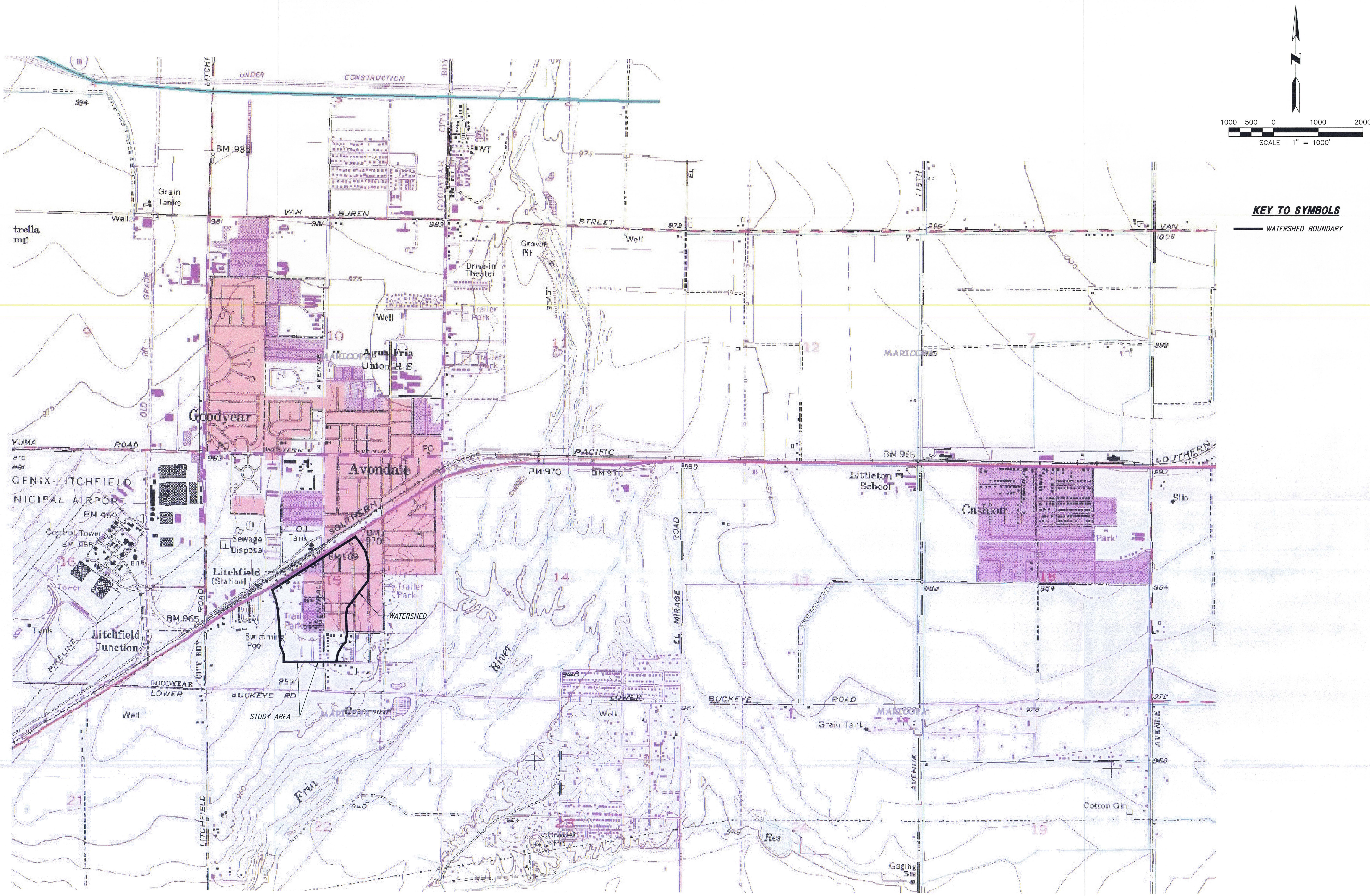
Project Description	
Worksheet	Central Ave Secl
Flow Element	Irregular Channe
Method	Manning's Formu
Solve For	Discharge

Input Data		
Slope	009000	ft/ft

Options	
Current Roughness Metho	oved Lotter's Method
Open Channel Weighting I	oved Lotter's Method
Closed Channel Weighting	Horton's Method

Attribute	Minimum	Maximum	Increment
Water Surface Elevati	955.00	956.20	0.10





REVISIONS		
NO.	DESCRIPTION/DATE	BY

LANDMARK ENGINEERING INC

7310 North 16th Street
Suite 285
Phoenix, Arizona 85020
602.861.2005

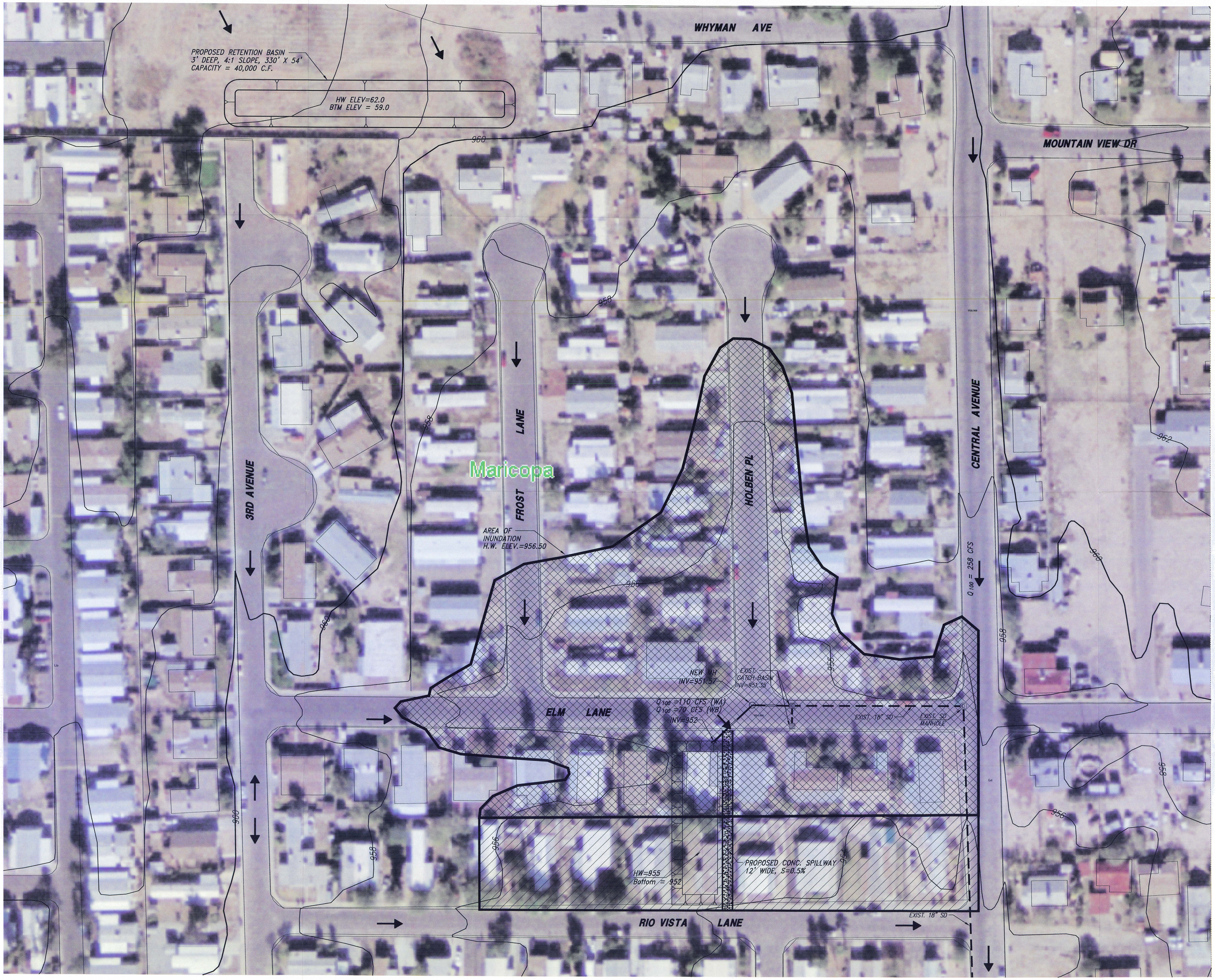
EXHIBIT 1 - USGS TOPOGRAPHIC MAP

ELM LANE DRAINAGE STUDY - AVONDALE, AZ

LOCATED IN THE SOUTHWEST QUARTER OF SECTION 15
TOWNSHIP 1 NORTH, RANGE 1 WEST
MARICOPA COUNTY, ARIZONA

JOB NO.	05220
DESIGNED	RMS
DRAWN	RMS
ACAD FILE	5220usgs
CHECKED	C. BOLZE
DATE	11-17-05

1 OF 1 SHEETS



50 25 0 50 100

SCALE 1" = 50'

KEY TO SYMBOLS

- DRAINAGE FLOW DIRECTION
- Q_{100} 100-YEAR CALCULATED PEAK DISCHARGE
- POTENTIAL FLOODING DUE TO PONDING WATER
- POTENTIAL FLOODING DUE TO FLOWING WATER
- 958 EXISTING CONTOUR
- RETENTION BASIN
- CONCRETE SPILLWAY

REVISIONS		
NO.	DESCRIPTION/DATE	BY

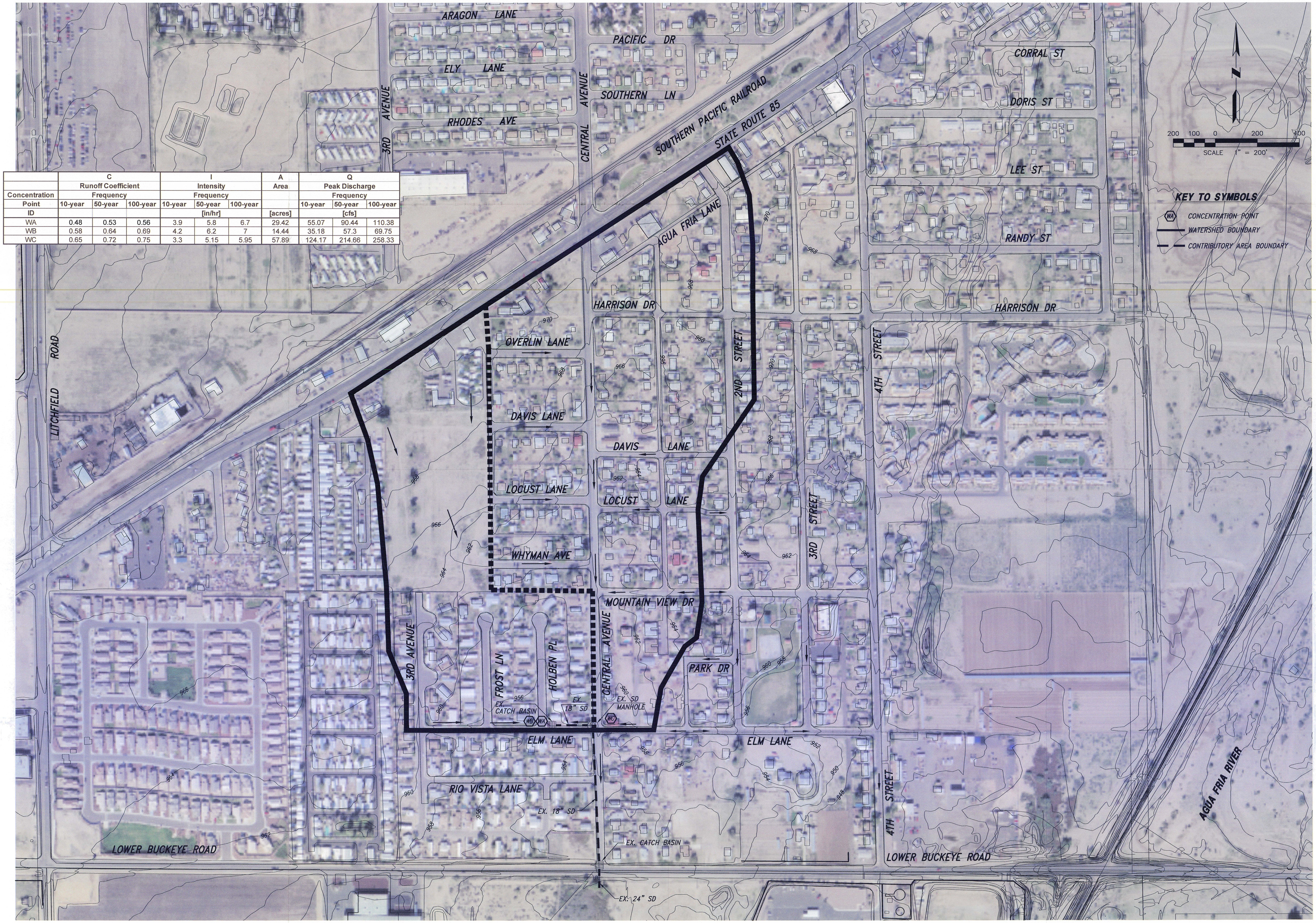
LANDMARK ENGINEERING INC
7310 North 16th Street Suite 285
Phoenix, Arizona 85020
602.861.2005

EXHIBIT 3 - STUDY AREA DETAIL MAP
ELM LANE DRAINAGE STUDY - AVONDALE, AZ

LOCATED IN THE SOUTHWEST QUARTER OF SECTION 15
TOWNSHIP 1 NORTH, RANGE 1 WEST
MARICOPA COUNTY, ARIZONA

JOB NO.	05220
DESIGNED	RMS
DRAWN	RMS
ACAD FILE	5220drxb
CHECKED	C. BOLZE
DATE	11-17-05

1 OF 1 SHEETS



	C			I			A	Q		
	Runoff Coefficient			Intensity			Area	Peak Discharge		
Concentration	Frequency			Frequency				Frequency		
Point	10-year	50-year	100-year	10-year	50-year	100-year		10-year	50-year	100-year
ID				[in/hr]			[acres]	[cfs]		
WA	0.48	0.53	0.56	3.9	5.8	6.7	29.42	55.07	90.44	110.38
WB	0.58	0.64	0.69	4.2	6.2	7	14.44	35.18	57.3	69.75
WC	0.65	0.72	0.75	3.3	5.15	5.95	57.89	124.17	214.66	258.33

REVISIONS		
NO.	DESCRIPTION/DATE	BY

LANDMARK ENGINEERING INC
7310 North 16th Street
Suite 285
Phoenix, Arizona 85020
602.861.2005

EXHIBIT 2 - STUDY AREA & WATERSHED BOUNDARY MAP
ELM LANE DRAINAGE STUDY - AVONDALE, AZ

LOCATED IN THE SOUTHWEST QUARTER OF SECTION 15
TOWNSHIP 1 NORTH, RANGE 1 WEST
MARICOPA COUNTY, ARIZONA

JOB NO.	05220
DESIGNED	RMS
DRAWN	RMS
ACAD FILE	5220wshd
CHECKED	C. BOLZE
DATE	11-17-05

1 OF 1 SHEETS