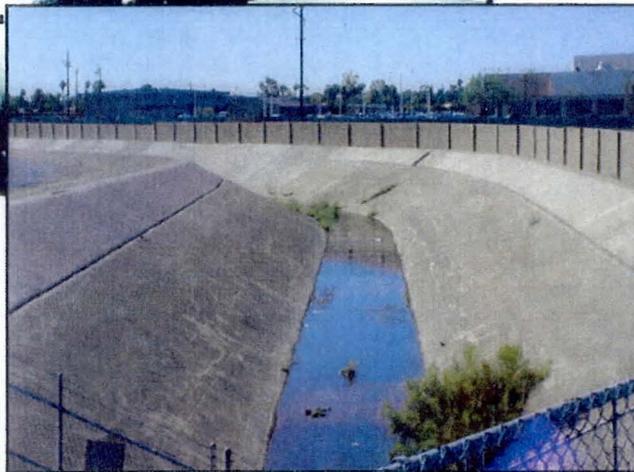


# Luke Air Force Base Outfall Candidate Assessment Report

## Final Summary Report

December 10, 2004  
Contract No. FCD2003C018 Task No. 3  
HDR Project No. 000000000014068

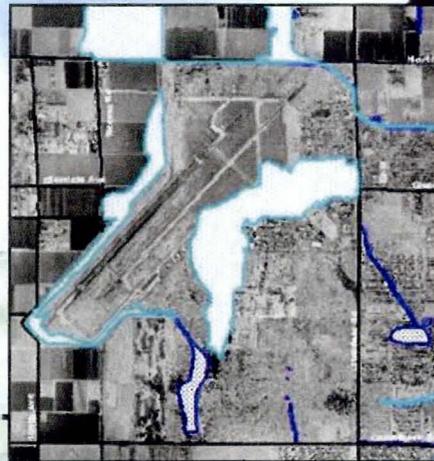


# HDR

# Luke Air Force Base Outfall Candidate Assessment Report

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# HDR

# Luke Air Force Base Outfall Candidate Assessment Report

## EXECUTIVE SUMMARY

Flooding in and around Luke Air Force Base is a continuing problem and a serious hazard. Luke AFB is threatened by development pressures and this problem adds to the jeopardy of Luke AFB remaining at its current location. A flood on September 20, 1992 closed the base for three days and is estimated to have caused more than \$3 million in flood damage. The relocation of Luke AFB would drastically change the social and economic future of the surrounding communities that benefit from jobs and business generated by the presence of the base.

HDR used the Loop 303 Corridor/White Tanks ADMP, associated models, and other data supplied by the FCDMC and Luke AFB to develop conceptual designs to alleviate the flooding in the study area which is shown in Figure 2 of the report. Two main concepts arose for ultimate disposal of the floodwaters: conveyance of flows southwest to Bullard Wash and conveyance north to the Dysart Drain. These two concepts were further developed to consider alternatives involving combinations of open channel and closed conduit conveyance structures and alignments through base and around the base's perimeter.

A total of four alternative conceptual alternatives were developed. From these four alternatives, through discussion with FCDMC, Luke AFB, and other stakeholders, a Final Recommended Alternative was developed.

The Final Recommended Alternative uses concepts from several of the alternatives and includes both open channel and closed conduit conveyance structures. Three main conveyance structures are used in the Final Recommended Alternative.

1) The Litchfield Road structure is a closed conduit with a north/south alignment. This pipe lies east of Litchfield Road and extends from just south of Glendale Road and outfalls north to the

Dysart Drain. It collects flows from the base and other offsite areas east of Litchfield Road, as well as flows that concentrate along Litchfield Road in the vicinity of the existing main gate.

2) The Super Sabre Street structure is a concrete lined open channel with an east/west alignment. This channel begins just west of Litchfield Road at an existing pump station outfall channel. The pump station collects water from the base area and lifts it to this outfall. The channel will convey the pump station outfall and flows from the south side of the base via a series of tie-ins along the southern perimeter of the base. The channel outfalls to the third main conveyance structure, Bullard Wash just west of Bullard Avenue.

3) Bullard Wash is proposed to become an improved open, earthen channel with a sinuous north/south alignment. Bullard Wash exists as a natural channel and will be graded and improved along much of its current flow path. The Final Alternative proposes starting the wash east of its current intersection with Super Sabre Street. The section of the wash within this study ends at a box culvert, proposed by another project, at the existing channel's approximate intersection with Camelback Road. It will convey the flows delivered by the Super Sabre channel and other flows drawn by the surrounding gradient along its flow path. The Final Alternative features an online detention basin at Camelback Road to attenuate flows south. This basin also has the potential to become a dual-use facility if it is designed to accommodate community recreation.

Other minor conveyance structures include two closed conduit storm drains, one along Kachina Road, and the other along Lalomai Road. These pipes will convey flows from Glendale Road and the on-base housing area north to the Dysart Drain. Another closed conduit is proposed to replace an inadequate, existing set of parallel pipes that convey storm water from an on-base detention basin at the north end of the base, east to the Dysart Drain.

The engineer's estimate of probable cost for the Final Alternative is \$9,243,959 including a 30% contingency item. See Table 3 on page 32 for a detailed listing of costs.

## RECOMMENDATIONS AND FUTURE STUDIES

HDR recommends the implementation of the Final Alternative flood control measures in the Candidate Assessment Report as a means to reduce the potential for future losses associated with flooding events. Exact sizes and locations of the various elements of the Final Alternative will need to be refined during design stages, particularly due to the lack of sufficient as-built utility information for underground facilities on the base. A detailed potholing program will be required to supplement the limited utility information. Where applicable, the opportunities for multi-use of facilities and aesthetic considerations should guide further refinement of the design, such as the use of the proposed online detention basin at Camelback Road as a public community recreation area, and a jogging track/loop trail at the Super Sabre Channel, for base use only.

It should also be noted that this project should be in place prior to construction of the underpass project, to avoid aggravating the flooding potential along Litchfield Road.

### *The recommendations and designs contained in this report assume the following:*

Ground subsidence activity, which has been recorded in the area, will not dramatically accelerate thereby altering the local gradient and flow paths, nor will it cause damage to the proposed structures beyond serviceable use.

The runoff flows and volumes predicted by the Loop 303 Corridor/White Tanks ADMP Update HEC-1 model are accurate enough to warrant their use in the design and placement of flood control structures.

All proposed flood control projects that may affect the hydrologic flows in the study area are known by HDR, and no other such projects will be implemented with out due consideration of the recommendations and designs contained in this report.

## TABLE OF CONTENTS

EXECUTIVE SUMMARY .....	i
RECOMMENDATIONS AND FUTURE STUDIES.....	iii
PART 1 PROJECT PURPOSE & NEED .....	1
1.1 Project Participation.....	3
1.2 Interagency Coordination.....	3
1.3 Project Overview & History .....	4
1.4 Project Location.....	4
1.5 Project Authorization.....	5
PART 2 EXISTING CONDITIONS.....	6
2.1 Data Collection .....	6
2.2 Hydrology.....	7
2.2.1 Watershed Description .....	8
2.2.2 Existing/Verified Hydrologic Model.....	8
2.2.3 Drainage Area Boundaries .....	9
2.2.4 Precipitation.....	10
2.2.5 Physical Parameters.....	10
2.2.6 Calibration .....	11
2.2.7 Hydrologic Analysis.....	11
2.2.8 Observed Storm Events.....	12
2.3 Hydraulics.....	13
2.3.1 Existing Conditions .....	13
2.3.2 Design Criteria .....	14
2.3.3 Culvert Analysis.....	16
2.3.4 Channel Analysis.....	17
2.4 Subsidence and Earth Fissures.....	17
PART 3 RECOMMENDATIONS FOR IMPROVEMENTS.....	19
3.1 Future Drainage Facilities.....	19
3.2 Alternatives Descriptions .....	20
3.2.1 Alternative 1: Exhibit 4.....	21
3.2.2 Alternative 2 .....	22
3.2.3 Alternative 3 .....	24
3.2.4 Alternative 4: Exhibit 9.....	25
3.3 Constraints .....	26
3.4 Rankings.....	28
3.5 Recommended Alternative .....	29
3.5.1 Draft Final Alternative Hydrology and Hydraulics .....	29
3.5.2 Costs .....	32
3.5.3 Channel Aesthetic Treatments.....	33
3.5.4 Water Quality Issues.....	34
3.5.5 Environmental Investigation .....	34
PART 4 REFERENCES .....	37

## **EXHIBITS**

- Exhibit 1 Luke Air force Base Outfall CAR Watershed Map
- Exhibit 2 Luke Air force Base Outfall CAR Existing Conditions
- Exhibit 3 Luke Air force Base Outfall CAR Proposed Improvements (by others)
- Exhibit 4 Luke Air force Base Outfall CAR Alternative 1 – No Action
- Exhibit 5 Luke Air force Base Outfall CAR Alternative 2A
- Exhibit 6 Luke Air force Base Outfall CAR Alternative 2B
- Exhibit 7 Luke Air force Base Outfall CAR Alternative 3A
- Exhibit 8 Luke Air force Base Outfall CAR Alternative 3B
- Exhibit 9 Luke Air force Base Outfall CAR Alternative 4
- Exhibit 10 Luke Air force Base Outfall CAR Final Alternative

## **APPENDIX A**

15% Plans – Recommended Alternative (11"x17" version)

## **APPENDIX B**

Land Use Information

## **APPENDIX C**

Project Documentation  
Meeting Minutes and Contact Logs  
Data Collection Summary  
Site Visits

## **APPENDIX D: Contained in Final Supplementary Report Hydrology**

Rational Method Excel Workbook Printout  
Existing Conditions HEC-1 Model Output (LABCAR.DAT)  
Diversion Scenario HEC-1 Model Output (LABCARD.DAT)  
Flow Routing Change HEC-1 Model Output (LABCARQ.DAT)

## **APPENDIX E: Contained in Final Supplementary Report Hydraulics**

Listing of Computer Software Used to Model Conveyance Structures  
Output of Hydraulic Models

## **TABLES**

Table 1 Peak Flow Rates from HEC-1 Modeling  
Table 2 Rational Method Calculated Runoff for Subbasins  
Table 3 Recommended Alternative Engineer's Estimate of Probable Cost

## **FIGURES**

Figure 1 Vicinity Map  
Figure 2 Study Area Map  
Figure 3 Watershed Subbasin Delineation from Loop 303/White Tanks ADMP  
Figure 4 Subdivision of Subbasins 223 and 226



# Luke Air Force Base Outfall Candidate Assessment Report

## PART 1 PROJECT PURPOSE & NEED

The Luke Air Force Base Outfall Candidate Assessment Report (CAR) was conducted for Bullard Wash and tributaries from Camelback Road northward, through the base to Litchfield Road, as partially modeled in the Loop 303/White Tanks Area Drainage Master Plan (ADMP), and as illustrated in the Vicinity Map found in Figure 1 and the Study Area Map in Figure 2.

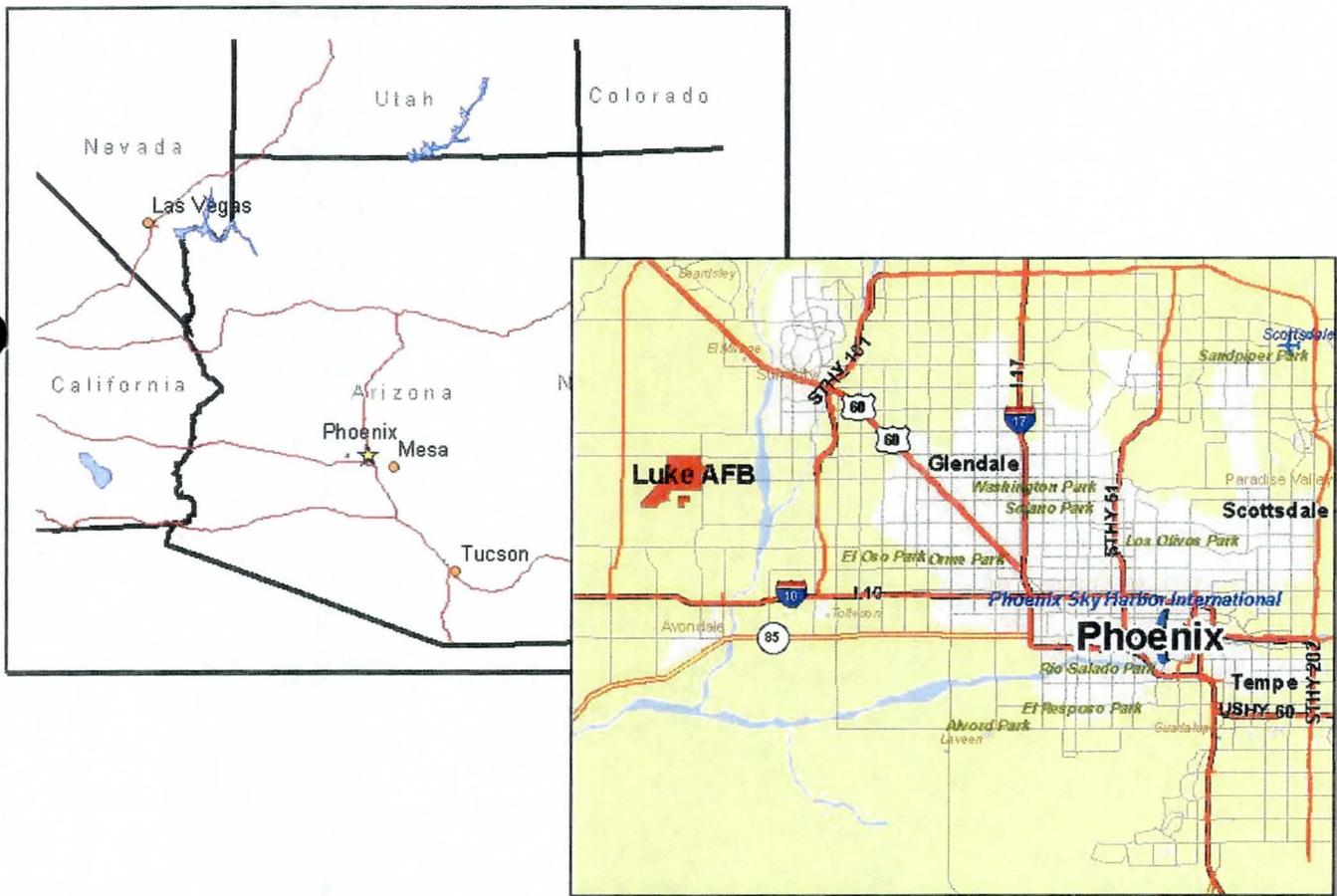


Figure 1: Vicinity Map

The Flood Control District of Maricopa County (District) initiated this CAR to establish the needs and necessity, identify fatal flaws, perform an alternatives analysis, and make recommendations for drainage improvements in response to:

## Luke AFB Outfall Candidate Assessment Report

- The Loop 303 Corridor/White Tanks ADMP, which identified a major channel located at the southern end of Luke Air Force Base, (Luke AFB). Analysis indicates this channel does not completely resolve the flooding hazard identified on Luke AFB, and
- Luke AFB has requested that the District perform additional studies to ensure the mitigation of the identified flooding hazards on Luke AFB in their March 19, 2004 letter (Appendix C).
- Continued progress in best management practices as acknowledged in the Community Rating System, a Federal Emergency Management Agency (FEMA) sponsored rating program under which residents of Maricopa County receive significantly reduced flood insurance rates.

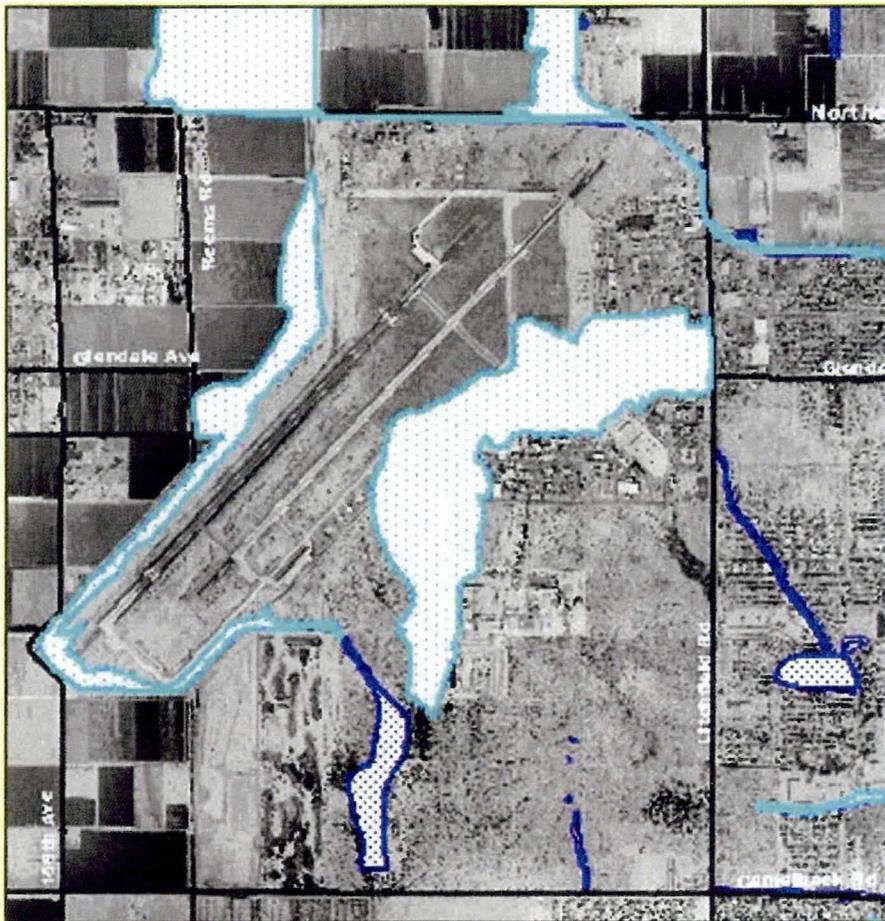


Figure 2: Study Area Map

## **Luke AFB Outfall Candidate Assessment Report**

Luke AFB accounts for a full time equivalent employment of nearly 19,000 and contributes nearly \$1.4 billion to annual economy activity. Increased efforts are underway to preserve Luke AFB, including legislative action, planning, zoning and infrastructure support by west valley communities, and general awareness promoted by advocacy groups.

This CAR presents the conceptual alternatives and plans for the preferred drainage facilities from Camelback Road to Luke AFB identified in the Loop 303 Corridor/White Tanks ADMP. The work efforts involved collection of the necessary documents and available data to establish the needs and necessity, identifying fatal flaws, perform an alternative analysis and then make recommendations to the District and U.S. Air Force, and to Luke AFB for the proposed drainage facilities. Included is documentation of existing flooding problems, current drainage and topographic features, existing floodplains (according to FEMA Federal Insurance Rate Maps (FIRM) documentation), and current plans for facilities by others.

### **1.1 Project Participation**

The development of the CAR was funded and managed by the District, and details the possible proposed improvements within the study area as proposed in the Loop 303/White Tanks ADMP. Potential funding sources for future projects include Luke AFB, U.S. Army Corps of Engineers, City of Glendale, City of Goodyear, and the Maricopa County Department of Transportation. Additionally, improvements could be constructed by individual developers as adjacent parcels improve, or by creating an improvement district.

### **1.2 Interagency Coordination**

Agencies contacted during the development of the CAR included the District, Luke Air Force Base, U.S. Army Corps of Engineers, Maricopa County Department of Transportation, City of Glendale, and the City of Goodyear. Representatives from SunCor Development Co. were also contacted.

## **Luke AFB Outfall Candidate Assessment Report**

### **1.3 Project Overview & History**

The District has collaborated with Luke AFB on numerous flood control projects and studies over the course of the past 45 years, including McMicken Dam, White Tanks ADMP, and the Dysart Drainage Project.

Large scale pumping of groundwater, mainly to irrigate crops in the surrounding area, has caused aquifer hydraulic heads measured in wells to decline more than 300 ft throughout much of the area. Differential land subsidence and resultant earth fissures have damaged buildings, roads, railroads, water wells, irrigation canals, and flood control structures on or near the base. In August 1992, a USGS Global Positioning System (GPS) satellite survey measured more than 17 feet of land subsidence northwest of the base.

The flood hazard on the base has been adversely affected by this land subsidence. The slope of the Dysart Drain had been reduced by differential land subsidence, and the carrying capacity of the drain and other storm drainage structures has been greatly reduced. On September 20, 1992, a high-intensity storm produced about 4 inches of rain immediately north of the base and resulted in extensive flooding on the base. Floodwater overtopped the Dysart Drain and spilled onto the runways, into the aircraft parking areas, and into the base housing area. The flooding closed the base for three days, inundated more than 100 homes, and generally disrupted base operations. Preliminary estimates of flood damage exceed \$3 million.

Part of the surface drainage from the south side of the base is captured by existing drainage facilities. These facilities are unreliable for collection of flows and are discounted in the hydrologic analysis, but are of great concern when dealing with any structural solution due to the inherent foundation instability they present.

### **1.4 Project Location**

The area of concern is the Bullard Wash and tributaries from Camelback Road northward to include Luke AFB. The easterly limits are confined to Litchfield Road. The legal location of the

## Luke AFB Outfall Candidate Assessment Report

project is Township 2 North, Range 1 West, Sections 3, 4, 5, 8, 9, 10, and 17. The Study Area Map is found in Figure 2.

### **1.5 Project Authorization**

The District is charged with floodplain management and flood control responsibilities under Arizona Revised Statutes, Chapter 21, Article 1, Title 48, Sections 3601 through 3628. This responsibility to the public includes efforts to prevent loss of life and reduce potential for property damage from flooding. The District endeavors to reduce the risks of flood loss; minimize the impacts of floods on human safety, health, and welfare; and restore and preserve the natural and beneficial values served by floodplains. This CAR was developed as part of the District's responsibility as stewards of the public trust, under its authority to reduce the potential for property damage from flooding and to enter into contracts.

This study was compiled under Contract Number FCD 2003C018 between the District and HDR. Task Order Number 3 issued May 10, 2004 provided "Notice-to-Proceed."

## **Luke AFB Outfall Candidate Assessment Report**

### **PART 2 EXISTING CONDITIONS**

#### **2.1 Data Collection**

##### **FCDMC**

- Loop 303 Corridor/White Tanks ADMP Update Letter of Map Revision (LOMR) Work Maps
- Loop 303 Corridor/White Tanks ADMP Plan & Profile Sheets
- Loop 303 Corridor/White Tanks ADMP Proposed Channel Quantities
- White Tanks HEC-1 Files
- Bullard Wash Channel Alternative HEC-RAS Files
- GIS Data (shape files) and 2003 Orthophotography
- Loop 303 Corridor/White Tanks ADMP Hydrology Assumptions at Luke AFB
- Parcel Data in Study Area in GIS Format
- Bullard Wash LOMR – HEC-RAS and DXF Files
- Loop 303 Corridor/White Tanks ADMP Preliminary Draft Level II Report
- 60% Dysart Drain HEC-2 Input and Output Files

##### **Luke AFB**

- Aerial Photos, 1-ft Contours and Stormwater Collection System Shape Files
- Noise Contour Maps
- Proposed Litchfield Road Underpass Alignments
- Utilities in Litchfield ROW Table
- Litchfield Road Profile Sheets
- Litchfield Road Traffic and Intersection Plan Sheets
- Storm Drain AutoCAD Drawings

##### **Glendale**

- ADWR Subsidence Data

## Luke AFB Outfall Candidate Assessment Report

### Environmental Engineering Consultants

- Bullard Wash Channel Improvement Plans

### FEMA

#### Federal Emergency Management Agency

- *Flood Insurance Rate Maps, Maricopa County, Arizona and Incorporated Areas, 04013C1615J, 04013C1595G* Effective July 19, 2001

### United States Geological Survey

- Waddell – 7.5 Minute Topographic Map – USGS
- El Mirage – 7.5 Minute Topographic map – USGS

## 2.2 Hydrology

Hydrologic analysis has been segmented into two parts. The first is presented in this section as existing conditions hydrology with the associated backup data sheets and HEC-1 output found in Appendix D. The second part is presented under the alternatives development portion of the study, where varying scenarios are examined in depth. Hydrology backup material associated with the alternatives is presented in Appendix D.

Two methods of hydrologic analysis were implemented, HEC-1 modeling and the Rational Method as prescribed by the FCDMC. The HEC-1 model was supplied by the FCDMC and featured detailed modeling of subbasins in the study area. However, once a level of planning was reached that required a breakdown of the hydrology within the subbasins, HDR utilized the Rational Method. Using the Rational Method HDR was able to model subbasin flows with a level of accuracy appropriate for a conceptual stage design in an efficient time frame and consistent with small watershed modeling criteria. Further, the Rational Method served as a useful crosscheck for the HEC-1 modeling.

To predict flows using the FCDMC Rational Method GIS analysis incorporating high-resolution aerial photography was used to determine the type and area of land within the subbasins. This

## Luke AFB Outfall Candidate Assessment Report

data was used to determine the tailored runoff coefficient for each of the subbasins. GIS analysis was also used to establish watercourse length and slope. Each of these parameters was entered into the FCDMC Rational Method equation to determine runoff for the 100-yr event for watersheds less than 180 acres.

### 2.2.1 Watershed Description

The watershed boundary is defined by the ridgeline in the White Tanks Mountains on the west, Camelback Road on the south, the Agua Fria River on the east, and the McMicken Dam / Deer Valley Road on the north. The watershed includes portions of the City of Glendale, City of Goodyear, as well as unincorporated Maricopa County. The upper watershed is steep rocky terrain with little vegetation. Lower portions of the watershed are relatively flat, typically agricultural lands. Those areas under development are required to provide retention for the 2 hour 100-year event, therefore future conditions are anticipated to include reduced peak discharges.

### 2.2.2 Existing/Verified Hydrologic Model

The existing hydrologic model used for this study was the Loop 303 Corridor/White Tank ADMP Update revised by URS on 01-14-04 (L303M1L.DAT). The model was constructed using the Hydrologic Engineering Center (HEC) -1 Flood Hydrograph Package, version 4.1, 1998. The methodology employed by this study comprised of:

- Verifying the existing HEC-1,
- Truncating the model to produce a more efficient run-time (existing conditions model LABCAR.DAT)
- Modifying the model to simulate flows produced by proposed alternatives (proposed conditions model for a Dysart Drain diversion LABCARD.DAT and for improved channel through the base LABCARQ.DAT)

URS had the following disclaimer regarding the existing conditions model:

## Luke AFB Outfall Candidate Assessment Report

*It should be noted that the draft existing condition hydrology model is currently a working model and not a final product. Minor adjustments may be made to this model until the completion of the ADMP Update if more detailed information becomes available in any given location throughout the project area.*

The naming convention of the Loop 303 Corridor/White Tank ADMP Updated model was maintained for this project. The model uses a simple alphanumeric system to identify subbasins of watersheds and preface letters to identify points of interest within the subbasin. The following example illustrates the naming convention used in the model.

- 221: a subbasin
- 221A: a subbasin; probably a division of subbasin 221 created later in the modeling process after the model number system was in place.
- CP221: the concentration point on subbasin 221 (a point where multiple flows converge).
- RCP221: routing of concentration point 221.
- 1D221: the first diversion of flow from subbasin 221.

For this study it was not necessary to create new subbasins or split existing ones in the HEC-1 model, therefore no additional naming protocol was used. The model was truncated at the storage route point 226 (SR 226). This point in the model represents the area close to the proposed reinforced concrete box culvert (RCBC) at Camelback Road, south of the airfield. Truncation of the model produced a more efficient run-time for the model. A top-down trimming of the model was not conducted, as the model contains many diversions (points where flows are diverted from one point and reintroduced at another). Diversions complicate the process of trimming the model to a reasonable size.

### 2.2.3 Drainage Area Boundaries

The original watershed delineation as supplied by URS remains unchanged for this report and is shown below in Figure 3. The Figure depicts the flow patterns and subbasin boundaries as defined near Luke AFB. Subbasins 223 and 226 are major contributors to runoff reaching the

## Luke AFB Outfall Candidate Assessment Report

Litchfield Road and Super Sabre Road. These subbasins were further subdivided and the Rational Method, as prescribed by the Flood Control District of Maricopa County (FCDMC), was used to analyze localized runoff from these areas for the 100-yr event. The break down of these subbasins allowed a more refined development of flood conveyance structures for instance the addition of stormwater drains along Kachina and Lalomai Roads to alleviate the flow burden arriving at Litchfield Road. This is further described depending on the alternative as presented in Part 3.

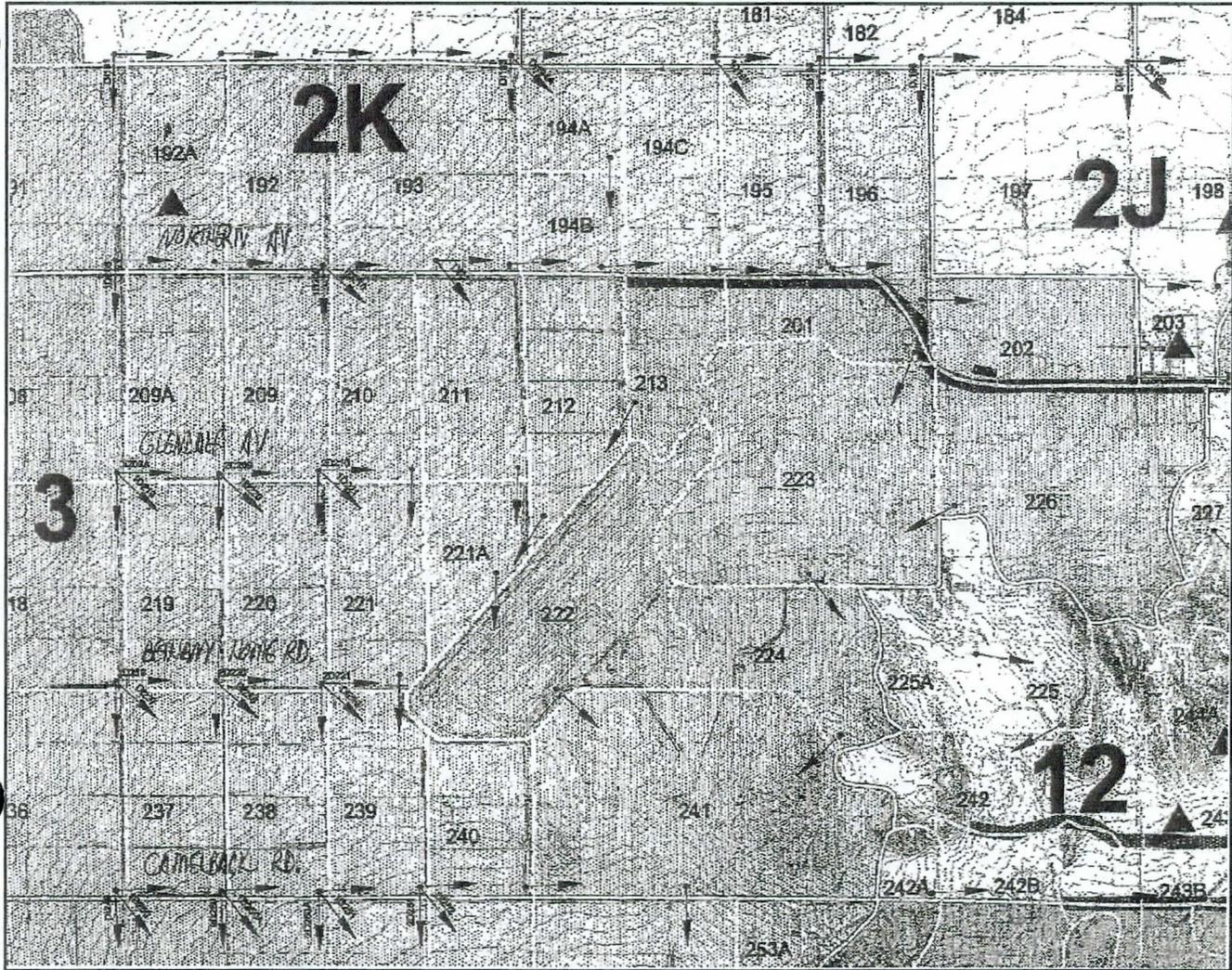
### 2.2.4 Precipitation

The existing hydrologic modeling included precipitation information. The precipitation pattern used in the HEC-1 model was the SCS Type II. This information was not modified for this study.

### 2.2.5 Physical Parameters

The watershed parameters have not changed significantly since the original model was developed. The only conceivable changes would be residential and/or commercial development, and these parameters are estimated to have not changed significantly enough since the model's creation to compromise the its accuracy.

## Luke AFB Outfall Candidate Assessment Report



**Figure 3: Watershed Subbasin Delineation from Loop 303/White Tanks ADMP**

### 2.2.6 Calibration

No quantitative calibration was attempted. Qualitative assessments included verification of watershed flow paths, subbasin boundaries, and watershed parameters.

### 2.2.7 Hydrologic Analysis

Major subbasin runoff was determined using the modified (as previously described) HEC-1 models derived from the FCDMC supplied file L303M1L.DAT. Table 1 summarizes the results of the model output.

## Luke AFB Outfall Candidate Assessment Report

**Table 1 – Peak Flow Rates From HEC-1 Modeling**

CP	Existing Flow (cfs)	North Diversion (To Dysart Drain) Alts. 2A & 3A ** (cfs)	South Diversion (To Bullard Wash) Alts. 2B & 3B ** (cfs)	Notes
201	379	379	379	Subbasin south of Dysart Drain at north end of airfield
CP 202	1480	1686	1480	Dysart Drain north of Luke AFB and downstream of Litchfield Road
CP 204	2295	2304	2295	Southeast of 203
CP 222	499	499	499	At east edge of airfield near Bethany Home Road
223	1534	460	2678	East of airfield, north of Maryland Road
CP 224	1856	894	2753	Close to new proposed base perimeter and Bullard Wash
226	1426	1426	1426	Subbasin southeast of proposed underpass and main entrance
R226	NA	NA	1516	Proposed Litchfield Road Channel
CP 241	2376	1718	3142	RCBC box on Camelback Road

\*\* North Diversion (To Dysart Drain) Alts. 2A & 3A and South Diversion (To Bullard Wash) Alts. 2B & 3B are described in Part 3

### 2.2.8 Observed Storm Events

On September 20, 1992, a high-intensity storm produced about 4 inches of rain immediately north of the base and resulted in extensive flooding on the base. The Dysart Drain, north of the base, was overtopped by floodwater which spilled onto the runways, into the aircraft parking areas, and into the base housing area. The flooding closed the base for three days, inundated more than 100 homes, and generally disrupted base operations. Estimates of flood damage exceeded \$3 million. Subsequent to this event Dysart Drain was studied for possible improvements in 1994 and improved in 1996.

## Luke AFB Outfall Candidate Assessment Report

### 2.3 Hydraulics

Hydraulic analysis has been segmented into two parts. The first is presented in this section as existing drainage facilities and model methodology with the associated backup data sheets and HEC-RAS output found in Appendix E. The second part is presented under the alternatives development portion of the study, where varying scenarios are examined in depth. Hydraulic backup material associated with the alternatives is presented in Appendix E.

#### 2.3.1 Existing Conditions

**Dysart Drain** - The Dysart Drain is an existing FCDMC drainage canal located along the northern boundary of Luke AFB that conveys storm water from the west into the Agua Fria River.

**Bullard Wash** - The study area includes Bullard Wash and its tributaries from Camelback Road northward to include Luke AFB. The easterly limits of the wash are limited to Litchfield Road. Throughout the study area, Bullard Wash is wide and shallow, with several small tributaries. Bullard Wash is currently undergoing improvements south of Camelback Road, and an eight barrel 10'x 4'x 134' box culvert is proposed for the wash crossing at Camelback Road.

**Pump/Lift Station** - A 2500 gpm on-site storm water pump station is located at the southeast corner of the base near the Litchfield Road and Super Sabre Street intersection. The pump station discharges storm water via 72" pipe to the south of Super Sabre Street. The storm water then flows east across Litchfield Road to a retention area located in an adjacent subdivision. The ponding that occurs across Litchfield during a storm event is a source of concern for the subdivision and motorists. This lift station is undersized for the watershed area it serves and the outfall which it discharges to.

**Storm Drains** - There is an existing storm water collection system in place throughout much of the Air Force Base. The design capacity of the system is unknown and is a mix of several designs and implementations. The collection system has been subjected to subsidence and thus

## Luke AFB Outfall Candidate Assessment Report

has lost capacity. The storm water collection system has several outlets. East of Litchfield Road, the storm water outlets north to the Dysart Drain and east along Glendale Road towards the Agua Fria River. West of Litchfield Road, the storm water system outlets north to the Dysart Drain, south to the pump station, or outlets directly to Bullard Wash or its tributaries. The capacity and pipe sizes of the existing stormwater system were determined to be insignificant in the analysis of the 100-year event. Flows from the subbasins studied would quickly overwhelm the typically small storm drain system (24" to 48" RCP), and in the hydrologic analysis the capacity of these systems had little effect on the hydrographs generated.

Part of the storm water collection system includes a set of existing pipes (4-30"RCP) that drain flows from subbasin 201 at the north east of the base into the Dysart Drain via an on-base detention basin.

**Retention Basins** - There are several retention basins that are located in the infield area near the base runways. These basins are surcharge basins and collect runoff during a 100-year storm event and discharge the storm water south into the existing storm water collection system. Areas such as Subbasin 201, off the north end of the runway have depressed features that must pond and surcharge before flowing towards an outfall thereby providing limit detention.

### 2.3.2 Design Criteria

The following design criteria apply to the channel design. The *FCDMC DRAINAGE DESIGN MANUAL for Maricopa County, Arizona, VOLUME II, HYDRAULICS, January 1996*, provide the following relevant design criteria.

#### Cross-Section:

##### *Side Slopes (maximum):*

Aggregate and unlined channels – 4:1 (H: V).

Concrete-lined channels – Vertical

## Luke AFB Outfall Candidate Assessment Report

### Alignment:

Horizontal and vertical channel alignments are independent of the roadway stationing for the concrete-lined channels.

### Transitions:

Vertical wall transitions are proposed for transitions into and out of box culverts between trapezoidal channel sections.

### Hydraulic Analysis:

#### *Manning's "n" value:*

Concrete-lined channel – 0.011 to 0.025

Earth or Sand bottom channel – 0.018 to 0.040

This analysis used Manning's "n" values of 0.013 for concrete-lined channels, 0.013 for box culverts, and 0.025 for the earthen channels.

#### *Froude Number:*

Upper limit – 2.0

#### *Energy Loss Coefficients:*

Gradual channel section transitions:

Expansion – 0.30

Contraction – 0.10

#### *Maximum Velocities:*

Concrete channel – 15 fps

Earth channel – 2.5 to 6.0 fps

#### *Minimum Velocities:*

Design velocities for all linings shall not fall below 2 fps.

### Freeboard:

Water surface elevation below natural ground: Minimum 1' for subcritical flows and 2' for supercritical flows.

## Luke AFB Outfall Candidate Assessment Report

### Maintenance Access:

One continuous 12' wide maintenance access road, at a minimum, is proposed for the drainage channel system. Ten-foot wide maintenance access ramps will be provided for concrete lined channels upstream and downstream of hydraulic structure transitions. The ramps will provide access to the channel invert.

### Channel Lining:

The drainage system comprises of several types of conveyance sections:

- Trapezoidal Concrete-lined Channel
- Trapezoidal Earthen Channel
- Box Culvert

### 2.3.3 Culvert Analysis

The culverts were sized using HEC-RAS version 3.1.1

HEC-RAS utilizes the Federal Highway Administrations 1985 standard equations for culvert hydraulics. Four cross sections are required at each culvert location to model the flow. One cross section must be located significantly downstream of the culvert, and one cross section must be located at the outlet. A cross section must be at the inlet and another significantly upstream, to not be affected by the culvert. Culvert data required includes length, size, number of barrels, Manning's roughness, and entrance and exit loss coefficients. Multiple pipes are modeled with the multiple opening approaches in HEC-RAS. In this approach, the program evaluates each opening as a separate entity and solves using an iterative process to generate flow through each barrel.

## Luke AFB Outfall Candidate Assessment Report

### 2.3.4 Channel Analysis

Normal depth channel calculations were performed using Manning's equation to estimate the cross section required for each reach associated with a given channel. New channel sections were computed at each location where a change in discharge occurred.

### 2.4 Subsidence and Earth Fissures

Subsidence and the resultant earth fissuring were a concern during the development of the alternatives. The City of Glendale provided two sets of information regarding subsidence. The first is a map depicting subsidence from 1957 to 1989. The second was current data readings since 1989 in a GIS format. Review of this data reveals several crucial points regarding the trend of subsidence, such as: 1) the area near Camelback Road and Litchfield Road has experienced very little subsidence, less than a foot over the last half of a century; and 2) the area near olive and Reems Road has experienced significant subsidence, over 15 feet in the same time period.

Any proposed drainage system near Luke Air Force Base will encounter subsidence that may impact its capacity. Dysart Drain is an example of a project that accounted for continued subsidence. A storm drain that flows southerly along Litchfield Road near the base will encounter reduced capacity, with the reverse being true should a system flow north. The present on-base drainage system must be pumped to an outfall near Litchfield Road and the Maryland Avenue alignment. This is due to subsidence that is expected to continue for the next 20 years, although at an expected reduced rate thanks to the efforts of the Arizona Department of Water Resources and Phoenix Active Management Area. These agencies have reduced groundwater pumping that thereby reduces subsidence.

Earth fissuring is typically a result of subsidence. Fissures present a unique risk in designing a flood control facility because of the foundation instability inherently present with them. An area where bedrock is near the surface forms a hard point where little subsidence will take place. Deeper deposits of alluvium, away from the hard point, experience subsidence when groundwater is withdrawn causing a differential settlement in the land surface. Differential settlement leads to tensile stress that pulls the ground apart forming an earth fissure. Earth

## Luke AFB Outfall Candidate Assessment Report

fissuring is dealt with by locating the fissure and implementing counter measures that prevent water from flowing into them, and avoid the fissure as much as is possible.

PART 3 RECOMMENDATIONS FOR IMPROVEMENTS

**3.1 Future Drainage Facilities**

Several future projects have been identified which will most likely alter the existing conditions within the watershed very significantly (see Proposed Improvements Exhibit 3). The first is the proposed depression of Litchfield Road under Thunderbird Road. This project will move the main base entrance north to Lightning Street. The grade separation at Litchfield and Thunderbird will allow traffic on Thunderbird east and west of Litchfield to move through the base at grade uninterrupted. Traffic north and south on Litchfield will not be subject to cross traffic at Thunderbird. No turning movements (i.e. access from Thunderbird to Litchfield or vice versa) will be allowed. The depressed portion of the grade-separated crossing will be located near the concentration point of drainage area 226, which is also the start of the mapped floodplain at Litchfield Road. Currently the flows from 226 collect just east of Litchfield Road and build up several feet before breaking over Litchfield Road. The grade separation project would have to account for this drainage, essentially evacuating the entire volume of the storm from the depressed area. It is likely that a storm water pump station with significant wet well storage will be required at the depressed area to handle the drainage, although the possibility of draining the depression by gravity to the Dysart Drain has not been ruled out.

A second proposed project that will impact current conditions is a future new road that connects the live munitions storage area directly to the ramp area where ordinance is loaded onto the planes. Currently, munitions are transported via a circuitous route through the base in order to avoid crossing the north end of Bullard Wash. The new road will cross Bullard Wash, requiring a concrete box culvert. The wash upstream and downstream of the box culvert will need to be incised to facilitate a narrower box culvert design.

The various alternatives investigated were all evaluated with regards to their impact on the proposed improvement projects.

### 3.2 Alternatives Descriptions

Four main alternatives have been developed for addressing the flood potential of the study area, including a “no action” alternative. These alternatives were fashioned from a larger pool of design features that included options or “sub-alternatives” that were created in the alternatives development phase. Through continued analysis, feasibility study and ongoing discussions with FCDMC, these options and potential features were shaped into the following four alternatives that were carried forward for qualitative evaluation.

The following describes the modifications that were performed to the truncated model described in Part 2 to simulate the four chosen conceptual alternatives.

Three models were found to be sufficient to describe the four alternatives:

- The first consisted of the truncated model that represented the existing conditions (Alternative 1), and southward drainage along Litchfield Road in combination with flows contributing to future depressed area of Litchfield Road underpass. From a hydrologic modeling stand point, at the level of detail in the existing models, flow through Luke AFB downstream of Litchfield Road concentrates at the same point regardless of the internal routing on the base.
- The second model consisted of the truncated model with modifications simulating diversion to the Dysart Drain of the combination of flows contributing to the depressed area of the future Litchfield Road underpass and subbasin 226. This model represents Alternatives 2A and 3A. The modifications for simulating the northward diversion flows from the depressed area on Litchfield Road to the Dysart Drain consisted of relocating the subbasin input code for subbasins 226 and 201 from their original place in the input code, and combining the hydrographs at the concentration point CP202 which represents the Dysart Drain north of Luke AFB and downstream of Litchfield Road in the model. These modifications were noted on the resulting input code.
- The third model simulated controlled capture and conveyance of flow from the depressed area on Litchfield Road, and construction of a channel either through the base or around the perimeter to the existing outfall to Bullard Wash. This consisted of eliminating the

## Luke AFB Outfall Candidate Assessment Report

storage routing code for subbasin 226 and modifying the 226 routing channel (R226) to depict the proposed channel along Litchfield Road. The storage routing code (SR226) in the original model depicted subbasin 226 as a large shallow reservoir that produced no flow until a specific water surface elevation was reached. The flow from subbasin 201 was also combined, with flow from subbasin 226 and routed into the proposed channel R226. The old channel routing for subbasin 201 was eliminated. These modifications model alternatives 2B and 3B.

### 3.2.1 Alternative 1: Exhibit 4

Alternative 1 is the "No Action" alternative. Under this condition, no stormwater or flood control improvement projects are to be constructed by Luke AFB, FCDMC, MCDOT or the City of Glendale which would directly impact the study area. The flood hazard potentials as identified on the effective FIRM panels will remain unchanged. The current floodplain is shown on the Existing Conditions Exhibit 2. The on-site stormwater pump station located at the southeast corner of the base will continue to discharge to the south and flow east across Litchfield Road. Flooding which currently occurs on the base along with the associated damage potential will continue.

This alternative does contain two serious flaws. First, construction of the proposed grade separation project at the current main gate location of Litchfield Road and Thunderbird Road (Thunderbird Road at grade with Litchfield Road depressed) will not be practical. The watershed area contributing to this intersection generates a 100-year flow rate of 1425 cfs. Storm flows build up on the east side of Litchfield Road to a depth of several feet before overtopping the road and continuing west. With Litchfield Road depressed, this entire volume would seek a path to the low point at the underpass. A pump station designed to handle this flow would be prohibitively large and expensive (typical ADOT pump stations at major freeway underpasses handle about 200 cfs). Second, an all-weather crossing of the upper limits of Bullard Wash with the "Munitions Road" project would be very difficult. This portion of Bullard Wash is wide and somewhat ill-defined. Flows from the north are uncontained. The crossing project would require at a minimum, channelization of the wash upstream of the

## Luke AFB Outfall Candidate Assessment Report

proposed road alignment, conveyance of the flows past the road, and likely channelization of the flows downstream to Camelback Road. While such a flood control project is buildable, it would add considerable cost to the “Munitions Road” project.

### 3.2.2 Alternative 2

Alternative 2 is the “Perimeter – Open Channel” alternative. In addition to solving the various regional flooding problems, this alternative also achieves an ongoing FCDMC objective of incorporating multi-use features into regional flood control facilities. This is accomplished at the southern end of the project by incorporating the potential for a detention basin along with a proposed City of Goodyear Park, and by using the channel along the south side of the base as a buffer against future development. Specifically, this alternative will;

- Drain the depressed area of the future Litchfield Road underpass (as well as associated portions of watershed areas 201 and 226) by pump station, which may either drain north to the Dysart Drain, or south to an open channel.
- An open channel will run south along the Litchfield Road alignment to the south boundary of the AFB, then turn west following the Super Sabre Street alignment to past Bullard Avenue.
- An open channel will be concrete lined for both the Litchfield Road and Super Sabre Street portions. Along Super Sabre Street, the channel will act to buffer the land uses to the south.
- An on-site pump station as well as several onsite drainage ditches will be intercepted into the open channel. Past a new Bullard Avenue concrete box culvert crossing, the channel will turn south by southwest and continue as an unlined channel.
- At the new “Munitions Road” crossing, a new concrete box culvert will be constructed.

## Luke AFB Outfall Candidate Assessment Report

- South of the 'Munitions Road' crossing, the unlined channel will become wider and intercept a major drainage way from the west.
- Before reaching the new box culvert at Camelback Road (by others), the widened unlined channel will become wider still and form an on-line detention basin just upstream of the Camelback Road box.

### Hydrology for Alternative 2A: Exhibit 5

A 2650' channel conveyance system was analyzed for Alternative 2A to capture on-site flows from the east along Litchfield Road and convey the discharge north to the Dysart Drain. The U.S. Army Corps of Engineers HEC-RAS 3.1.1 was used in the design. This channel is concrete-lined and was analyzed to have a capacity of 1426 cfs, which was obtained from the existing HEC-1 model for the Loop 303/White Tanks ADMP. The water surface elevation for the Dysart Drain at the channel tie-in was taken from the HEC-2 output file per NBS/Lowry Consultants study, dated May 30, 1994. A concrete-lined channel with 2:1 side slopes, a design water depth of 5', and a 15' bottom width would have sufficient capacity to meet discharge requirements.

A second channel would be placed south of and parallel to Super Sabre Street. This 4600' channel would begin west of Litchfield Road at the pump station outfall channel and would converge with Bullard Wash west of Bullard Avenue. The discharge for this channel increases from upstream to downstream. The beginning discharge is 263 cfs and the final discharge is 460 cfs. In order to meet the discharge requirements, an earthen-lined channel with 4:1 side slopes, a design water depth of 4', and a 10' wide bottom would be required. A 2-12'x5' box culvert was analyzed for the crossing at Bullard Avenue.

Bullard Wash channel improvements would begin west of the Super Sabre Street and Bullard Avenue intersection and would follow the existing flow path south to Camelback Road. The channel improvements at Bullard Wash consists of a 8750' earthen channel with 4:1 side slopes, a design water depth of 5 feet, and a 40' bottom width. A 2-12'x6' box culvert would be required for the crossing at Bullard Wash and the proposed Munitions Road.

## Luke AFB Outfall Candidate Assessment Report

### Hydrology Alternative 2B: Exhibit 6

A channel conveyance system was analyzed for Alternative 2B to capture on-site flows from the east along Litchfield Road and convey the flows south to Bullard Wash. This 8000' channel would begin southeast of the intersection at Litchfield Road and Thunderbird Road and would continue south past Super Sabre Street and would then turn west, crossing Litchfield Road and Bullard Avenue tying into the Bullard Wash improvements. This channel is concrete-lined along Litchfield Road and earthen along Super Sabre to the Bullard Wash Connection. The channel was analyzed with a beginning capacity of 1425 cfs. The capacity increases as it picks up the flow from the pump station and storm water collection system as it parallels Super Sabre. A concrete-lined channel with 2:1 side slopes, a design water depth of 5' and 20' bottom width meets capacity requirements along Litchfield Road. An earthen-lined channel with 4:1 side slopes, a design water depth of 6', and a 40' wide bottom would be required along Super Sabre. A 5-12'x5' box culvert is required at the Litchfield Road crossing and a 6-12'x4' box culvert is required at the Bullard Avenue crossing.

Bullard Wash channel improvements would begin west of the Super Sabre Street and Bullard Avenue intersection and would follow the existing flow path south to Camelback Road. An earthen channel with 6:1 side slopes, a design water depth of 6 feet, and a 40' bottom would be sufficient for the discharge requirements. A 6-12'x6' box culvert would be required for the crossing with Bullard Wash and the proposed Munitions Road.

### 3.2.3 Alternative 3

Alternative 3 is the "Perimeter – Closed Conduit" alternative. This alternative is similar to alternative 2, except that the Litchfield Road and Super Sabre Street concrete open channels are replaced with a large storm drain (either pipe or box culvert). To maximize the efficiency of the storm drains they have been sized for pressure flow, with the hydraulic grade line below pavement sub-grade.

## Luke AFB Outfall Candidate Assessment Report

### Hydrology for Alternative 3A: Exhibit 7

This alternative is identical to Alternative 2A, except that the Litchfield Road and Super Sabre Street open channels are replaced with box culvert. The Litchfield Road box culvert is 2650' in length and a 3-12'x6' box culvert was analyzed to meet the required discharge capacity of 1426 cfs. The Super Sabre Street box culvert is 4600' in length and a 2-12'x4' box culvert was analyzed to meet the required discharge capacity. The Bullard Wash improvements are identical to Alternative 2A.

### Hydrology for Alternative 3B: Exhibit 8

This alternative is identical to Alternative 2B, except that the Litchfield Road channel and Super Sabre Street channel is replaced with a box culvert. This box culvert is 8000' in length and is a 5-12'x5' box. The Bullard Wash improvements are identical to Alternative 2B.

### 3.2.4 Alternative 4: Exhibit 9

Alternative 4 is the "On-Site" alternative. This alternative is a combined storm drain, open-channel system which collects and conveys storm water from Litchfield Road to Super Sabre Street, through the base and generally along the centerline of the floodplain. The alternative consists of:

- Flows from the depressed area of the future Litchfield Road underpass (as well as associated portions of watershed areas 201 and 226) will be collected at a new pump station, which will drain north to the Dysart Drain.
- The 72" outfall pipe from the existing pump station at the southeast corner of the AFB will be directed west, outfalling to the Bullard Wash.
- A in-field drainage structure comprised of box culvert and open channel sections will capture flows generated from the in-field outfalling to the Bullard Wash.

## Luke AFB Outfall Candidate Assessment Report

### Hydrology for Alternative 4

This alternative is a combined storm drain, open-channel system which collects and conveys storm water generated from northern portions of subbasin 223 to Super Sabre Street. A 3200' 10'x4' box culvert located south of Thunderbird Road, aligned east-west, was analyzed to convey the storm water generated from northern portions of subbasin 223 west to the runway infield area. This box culvert was analyzed with a capacity of 150 cfs. A 1900' concrete-lined channel, aligned northwest-southeast, with 2:1 side slopes, a 10' wide bottom, and a 5' design water depth was analyzed to convey the runoff from through the infield area to another box culvert. A 2-10'x4' box culvert, aligned north-south, would then take the storm water 2000' south past Super Sabre Street and tie-in to Bullard Wash. This segment would have a design capacity of 460 cfs. The Bullard Wash improvements would be identical to Alternative 2A.

### **3.3 Constraints**

Several constraints were identified that were taken into consideration during the development and ranking of the alternatives. They include;

#### Right-of-way

While Litchfield Road has few utility conflicts, there is essentially no right-of-way available for placement of an open channel between the west curb line and the Luke AFB fence at the west property line. Likewise, there is little or no available right of way for an open channel between the east back of curb and the property fence north of Glendale. South of Glendale however, there is vacant land that could serve to accommodate an open channel. Along Litchfield Road, a large storm drain could be placed under the pavement or on base property just east of the east property line, running through open areas and parking lots.

Along the southern boundary of the base, a storm drain could be placed in or near the Super Sabre alignment, however there is no available right-of-way for an open channel. The base is planning to acquire 150 feet of right-of-way along the southern boundary to buffer future development. This area if available could serve to accommodate an open channel.

## Luke AFB Outfall Candidate Assessment Report

Within the base, streets are generally narrow and underground utilities follow these routes. The availability of excess right-of-way to accommodate either an open channel or a large diameter storm drain is limited.

### Adverse Grades

The natural topography of the study area, especially within the confines of the base, is generally flat. Therefore, the Luke AFB storm drain system and street network, as originally constructed, had minimal slopes. Because of the effects of differential subsidence over the years, many of these facilities now have completely level, if not adverse slopes. Within paved areas, i.e. streets, parking areas, maintenance and storage areas, etc., there are numerous depressions or “bird baths” where nuisance water will simply not drain. Within the base storm drain system, adverse grades have forced several previous storm drain outfalls to be abandoned and replaced with either reliever outfalls in the opposite direction, or in the case at the southeast corner of the base, a pump station to be installed which lifts the storm water to a higher elevation so that it can continue on it’s way by gravity. The wet well of the existing pump station is sufficiently deep, that it cannot be eliminated under any alternative.

### Dysart Drain

The Dysart Drain along the northern boundary of Luke AFB has excess capacity available to this project. This is due to the over design of the facility to accommodate future subsidence, the geometric configuration of the facility in relation to it’s ultimate outfall, the Agua Fria River, and the difference in the peak times of the drain compared to the contributing areas of basin 226. The hydraulic characteristics of the Dysart Drain were investigated and the constraints considered in developing the alternatives included; invert elevation, hydraulic grade line, energy grade line, top of lining elevation, geometric configuration, backwater effects, peak capacity, design capacity and physical constraints.

### Camelback Road Box Culvert

The existing Bullard Wash crossing at Camelback Road is scheduled to be replaced with an 8 cell, 10’x4’x134’ concrete box culvert. The location, capacity and invert grade of this structure

## Luke AFB Outfall Candidate Assessment Report

will establish the ultimate outfall conditions for the southern end of this project. These preliminary plans were obtained as part of the data collection process (see Appendix C).

### 3.4 Rankings

A qualitative assessment of the various alternatives was performed with the project stakeholders at Progress Meeting #2 (see meeting notes, Appendix C). Alternative 1, the “no action” alternative and Alternative 4, the “through the base” alternative were ranked as unacceptable. Alternative 1 was unacceptable because it did not meet the purpose and need of the project and because it contained the fatal flaws of being incompatible with future improvements identified by Luke AFB, specifically the moving of the main gate and reconfiguration of the intersect of Litchfield Road and Thunderbird Road, and the alignment of the new munitions road across Bullard Wash.

Alternative 4 was ranked as unacceptable, because although it met the purpose and need and was compatible with the future projects, it would require the extensive construction of storm drains, open channels and detention storage facilities within so many portions of the base. Additionally it would occupy so much right-of-way within the base that the disruption to base operations and activities would be prohibitively excessive.

Alternatives 2B and 3B were ranked as being higher in cost. Alternative 3B is the closed conduit alternative that drains south along Litchfield Road. Alternative 2B is the open channel alternative that drains south along Litchfield Road. Because the grade on Litchfield Road climbs to the south, both of these facilities would run against the grade, resulting in very large facilities needed to convey the full flow from drainage area 226.

Alternatives 2A and 3A were ranked as being lower in cost. Alternative 3A is the closed conduit alternative that drains north along Litchfield Road to the Dysart Drain. Alternative 2A is the open channel alternative that drains north along Litchfield Road to the Dysart Drain. Both the alternatives run with the grade to the north and are shorter in distance than the 2B and 3B alternatives.

### 3.5 Recommended Alternative

The recommended alternative was selected at Progress Meeting #2, which was attended by all the major stakeholders. It consists of the Super Sabre channel portion of Alternative 2A and the closed conduit to the Dysart Drain portion of Alternative 3A. A modification to the Super Sabre portion is concrete lining the channel, rather than the recommended earth-lined channel. While the concrete lined channel will increase the initial project cost, it will be easily maintained, will not be a security concern, and will require a smaller footprint and therefore less right-of-way impact. Because the channel will be located within the fenced boundary of the base, there is no real multi-use opportunity for the public; however the base has indicated the desire to construct a running track parallel to the channel. In addition the flow from subbasin 201 would be conveyed to the Dysart Drain by increasing the existing capacity of the outfall. This would be accomplished by replacing the existing pipes (4-30"RCP) that drain the local low-elevation point, an on-base detention basin, with an 8'x5' RCBC.

#### Draft Final Alternative: Exhibit 10

The Draft Final Alternative is a variation of the Super Sabre channel portion of Alternative 2A and the closed conduit to the Dysart Drain portion of Alternative 3A. A modification to the Alternative 2A Super Sabre portion is that the channel will be concrete lined instead of earth lined. The Bullard Wash improvements will be identical to Alternative 2A.

#### 3.5.1 Draft Final Alternative Hydrology and Hydraulics

Subbasin 226 was subdivided into smaller subbasins, and several new refined flow rates are a result of the subdivision, as previously discussed in the hydrology section. In order to decrease the total flow arriving at Litchfield Road, two stormwater pipes are proposed east of Litchfield Road, one at Lalomai Road and one at Kachina Road, each with a design flow of 416 cfs. These two pipes begin at Glendale Road and drain into the Dysart Drain. The pipe located parallel to Lalomai Road consists of two sections: a 1223' long 78" concrete pipe from Glendale Avenue to approximately Thunderbird Road and a 1327' long 84" concrete pipe from approximately

## Luke AFB Outfall Candidate Assessment Report

Thunderbird Road to the Dysart Drain. The proposed pipe located parallel to Kachina Road is a 2630' long 84" concrete pipe. The remainder of the flow from Subbasin 226 and the flow from portions of Subbasin 223 drain into a proposed stormwater system at Litchfield Road that empties into the Dysart Drain. This proposed system consists of three segments: 1) a 2-barrel 54" RCP 600' in length; 2) a 2-barrel 12'x 5' RCBC 1670' in length; and 3) a 2-barrel 12'x 6' RCBC 1100' in length.

Several storm drain laterals and catch basins will be added perpendicular to Kachina and Lalomai Roads. These drainage laterals will tie-in with the large pipes to be located along Kachina and Lalomai Roads. A drainage ditch would be located on the north side of Glendale Road and would provide drainage to the proposed storm drain along Lalomai Road. There would also be several laterals that would tie into the drainage system located along Litchfield Road. Several small laterals would connect to the drainage system from the west side of Litchfield Road. There would also be a long lateral located along Glendale Road that would drain into the Litchfield drainage system. Another drainage lateral system would be located along Thunderbird Road that would drain to the Litchfield drainage system.

The open channel system along Super Sabre Road is similar to the system described in Alternative 3A. The channel begins west of Litchfield Road and south of Super Sabre Road at the new box culvert. This box culvert provides drainage from the pump station outfall located north of the box. The upstream channel invert will match the box culvert invert. The channel will run east past Bullard Avenue and will tie-in with the Bullard Wash improvements. Lateral connections from the north will tie-into the Super Sabre channel throughout its length.

These connections will drain small drainage ditches located parallel to and north of Super Sabre Road. The channel required to handle the discharge was designed to be a 4600' long concrete lined channel with a 10' bottom, 2:1 side slopes, and a design water depth of 4'. A 10' access road would parallel the channel. There would also be several ramps located along the channel alignment to provide access to maintenance equipment. Additionally the flow from subbasin 201 would be conveyed to the Dysart Drain by increasing the existing capacity of the outfall from 4-30" RCP to an 8'x 5' RCBC.

## Luke AFB Outfall Candidate Assessment Report

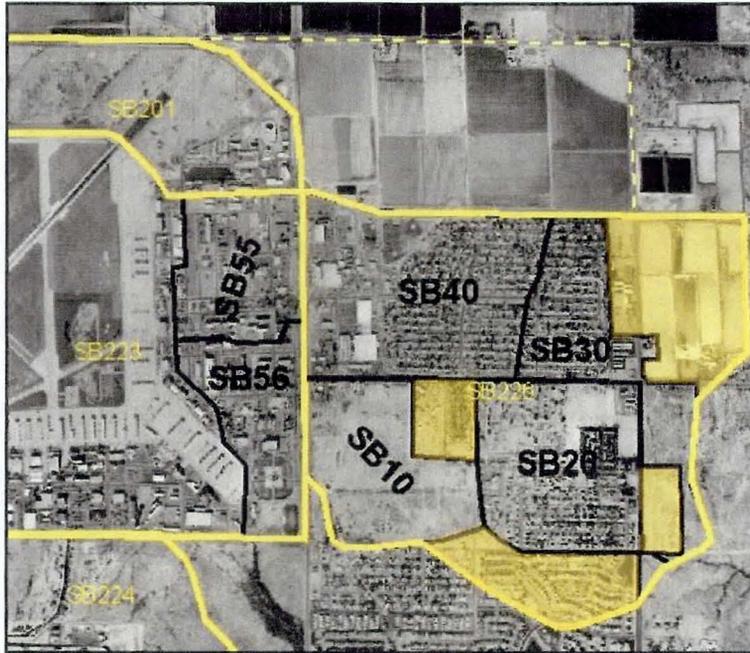


Figure 4 - Subdivision of Subbasins 223 and 226

<b>Table 2 - Rational Method Calculated Runoff for Subbasins</b>			
Subbasin	Area (acres)	Q100-yr (cfs)	Comments
10	115	221	A portion of subbasin 226 south and upstream of Glendale Ave. associated with Litchfield Road
20	161	559	A portion of subbasin 226 south and upstream of Glendale Ave.
30	111	272	A portion of subbasin 226 north and downstream of subbasin 20
40	200	587	A portion of subbasin 226 north and downstream of subbasin 10
55	100	364	A Portion of subbasin 223 on the Air Force Base proposed for diversion to Dysart Drain
56	97	263	A portion of subbasin 223 that will continue to the south and concentrate at the lift station

## Luke AFB Outfall Candidate Assessment Report

### 3.5.2 Costs

A quantitative cost estimate based on the Recommended Alternative, as depicted on the 15% plans (see Appendix A) was prepared. This estimate of course is very preliminary in nature, and therefore includes a contingency item of 30%.

**Table 3 - Recommended Alternative Engineer's Estimate of Probable Cost**

Items	Quantity (L.F.)	Cost	Total
<b>Closed Conduit System North to Dysart Drain</b>			
<ul style="list-style-type: none"> <li>• 54" circular concrete pipe along Litchfield Road north from approximately 400 ft south of Glendale to approximately 200 ft north of Glendale. Cost includes excavation &amp; backfill, concrete, steel, utility protection or relocation, removal and replacement of block fence, landscaping and parking areas &amp; traffic control. Right-of-way costs are not included.</li> </ul>	600	\$ 124	\$74,400
<ul style="list-style-type: none"> <li>• 78" circular concrete pipe along Lalomai Road from Glendale Avenue to approximately Thunderbird Road. Cost includes excavation &amp; backfill, concrete, steel, utility protection or relocation, landscaping and parking areas &amp; traffic control. Right-of-way costs are not included.</li> </ul>	1223	\$ 240	\$293,520
84" circular concrete pipe along Lalomai Road from approximately Thunderbird Road to the Dysart Drain. Cost includes excavation & backfill, concrete, steel, utility protection or relocation, landscaping and parking areas & traffic control. Right-of-way costs are not included.	1327	\$ 255	\$338,385
<ul style="list-style-type: none"> <li>• 84" circular concrete pipe along Kachina Road from Glendale Road north to the Dysart Drain. Cost includes excavation &amp; backfill, concrete, steel, utility protection or relocation, removal and replacement of block fence, landscaping and parking areas, &amp; traffic control. Right-of-way costs are not included.</li> </ul>	2630	\$ 255	\$670,650
<ul style="list-style-type: none"> <li>• 2 Barrel, 12'x5' RCBC along Litchfield Road north from approximately 200 feet north of Glendale to Thunderbird Road. Cost includes excavation &amp; backfill, concrete, steel, utility protection or relocation, removal and replacement of block fence, landscaping and parking areas, and traffic control. Right-of-way costs are not included.</li> </ul>	1670	\$ 938	\$1,566,460
<ul style="list-style-type: none"> <li>• 2 Barrel, 12'x6' RCBC along Litchfield Road north from Thunderbird Road to the Dysart Drain. Cost includes excavation &amp; backfill, concrete, steel, utility protection or relocation, removal and replacement of block fence, landscaping and parking areas, and traffic control. Right-of-way costs are not included.</li> </ul>	1100	\$1,100	\$1,210,000
<ul style="list-style-type: none"> <li>• 24" Drainage Laterals connecting to 100-year storm drain system. Cost includes excavation &amp; backfill, concrete, steel, utility protection or relocation, removal and replacement of block fence, landscaping and parking areas, and traffic control. Right-of-way costs are not included.</li> </ul>	4000	\$65	\$260,000

**Luke AFB Outfall Candidate Assessment Report**

<b>Table 3 - Recommended Alternative Engineer's Estimate of Probable Cost</b>			
Items	Quantity (L.F.)	Cost	Total
• Grader ditch along Glendale Avenue	2600	\$4	\$10,400
<b>Concrete Lined Drainage Channel Along Super Sabre</b>			
• Concrete lined channel with 10' bottom, 2:1 side slope. Cost includes channel excavation, concrete, steel, access ramps, and maintenance road.	4600	\$175	\$805,000
• Chain link security fence	4600	\$15	\$69,000
• Storm drain lateral tie-ins	400	\$140	\$56,000
• RCBC at Bullard Avenue	40	\$720	\$28,800
<b>Earthen Channel From Super Sabre South to Camelback</b>			
• Earth channel with 40' bottom, 4:1 side slopes. Cost includes channel excavation & grading, access ramps, maintenance road, and revegetation. Right-of-way costs are not included.	4600	\$40	\$184,000
• 2 Barrel, 12'x6' RCBC under proposed munitions road that crosses Bullard Wash. Cost includes excavation & backfill, concrete, steel, utility protection or relocation, removal and replacement of block fence, landscaping and parking areas, and traffic control. Right-of-way costs are not included.	60	\$1,100	\$66,000
<b>Closed Conduit System East From Subbasin 201</b>			
• 1 - 8' X 5' RCBC to replace small culverts that outfall into Dysart Drain.	586	\$500	\$293,000
		<b>Subtotal</b>	\$5,925,615
<b>Engineering, Surveying and Construction Management @ 20%</b>			\$1,185,123
		<b>Subtotal</b>	\$7,110,738
		<b>Contingency @ 30%</b>	\$2,133,221
		<b>TOTAL</b>	\$9,243,959

**3.5.3 Channel Aesthetic Treatments**

The only portion of the open channel system that will be located outside of the fenced boundary of Luke AFB, and therefore the only portion available for multi-use and aesthetic treatment opportunities, is the earthen portion from south of the munitions storage area, south to Camelback Road, a distance of approximately one mile. West of the channel is the Falcon Golf Course. The southern ½ mile is located within the City of Goodyear and the northern ½ mile is within Maricopa County. The area east of the channel is currently vacant.

## Luke AFB Outfall Candidate Assessment Report

The southern ½ mile in Goodyear has been identified by the town as a possible park location, and may serve as a trail node for a future multi-use path to the east. Depending on the programmed uses for this park, the earthen channel could be widened to form a basin or graded to some other configuration to augment aesthetic, visual, or functional opportunities in the future park.

### 3.5.4 Water Quality Issues

Both Maricopa County's and Luke AFB's stormwater discharge permits require that the initial runoff generated by a precipitation event, (i.e. "first flush" flows), be treated by a best management practice (BMP) before discharging into "Waters of the U.S.". In this project, two outfalls are affected: 1) The Dysart Drain, which connects directly to the Agua Fria River, serves as the outfall for the closed conduit storm drain part of the project; and 2) Bullard Wash is the outfall for the open channel portion of the project. BMPs appropriate for these types of systems will be required to be installed or observed as part of the constructed project.

The main constituents of concern are oils and other hydrocarbons that are washed off the pavements surfaces, along with floating debris. In the case of the closed conduit system, BMPs include the trapping of oils in the catch basins using oil absorbent inserts or similar systems, and preventing the introduction of large floatables into the system by using grated entrances at headwalls.

For the open channel system, first flush flows will enter the concrete channel section along Super Sabre before reaching the earthen section at Bullard Wash. BMPs may include installing a sediment trap at the downstream end of the concrete section, or at the downstream end of the earthen section, just prior to entering the Camelback Road box culvert.

### 3.5.5 Environmental Investigation

The environmental investigations and permitting for the final alternative shall consider and apply the appropriate level of environmental documentation to satisfy the requirements under the

## Luke AFB Outfall Candidate Assessment Report

National Environmental Policy Act of 1969, as amended. Specifically, the environmental resources anticipated to be investigated, and the permitting required based on the final alternative will include the following:

Clean Water Act (CLA) Section 404 Permit – A Section 404 permit from the U.S. Army Corps of Engineers (Corps) will be required for activities in the Dysart Drain and Bullard Wash. The activities may be covered under an individual permit or a nationwide permit. In either case coordination with the Corps will be required. Prior to obtaining the Section 404 permit, a jurisdictional delineation of waters of the U.S. may be necessary. The final design of the outfall structures, bridge, and culvert will determine whether an individual or nationwide Section 404 permit is appropriate.

Section 401 Water Quality Certification – Depending on the Section 404 permit type provided by the Corps, a Section 401 Water Quality certification will be required for the 404 permitting to be valid. If an individual Section 404 permit is required, an individual water quality certification will be required. If nationwide permits are applicable, conditional certification is currently in place, and can be used for water quality certification.

Arizona Pollutant Discharge Elimination System Permit – General permits for stormwater discharges will be required for the discharge of stormwater into Dysart Drain and Bullard Wash (Small Municipal Separate Storm Sewer Systems) and for the stormwater runoff that will be generated from construction activities.

Biological Resources – A review of the U.S. Fish & Wildlife Service's list of threatened, endangered, proposed, and candidate species for Maricopa County will need to be reviewed during final design to determine the potential for listed species to occur in the project area. In Addition, coordination with the Arizona Game & Fish Department is recommended to determine the existence of sensitive species in the area.

## Luke AFB Outfall Candidate Assessment Report

Cultural Resources – A Class I overview of the project area will be required to determine if the project area has been previously surveyed. If recent surveys have been completed, coordination with the State Historic Preservation Office may be all that is required. If surveys have not been completed, a Class III cultural resources survey will be necessary followed by consultation with the State Historic Preservation Office (SHPO).

Other environmental resources topics that will require investigation include impacts to 100-year floodplains in compliance with Executive Order 11988, invasive plant species based on Executive Order 13112, impacts on low income or minority populations based on Executive Order 12898, and a hazardous materials site assessment.

## Luke AFB Outfall Candidate Assessment Report

### PART 4 REFERENCES

Arizona Department of Water Resources, *Requirement for Floodplain and Floodway Delineation in Riverine Environments, State Standard Attachment 2-96*, July 1996.

Federal Emergency Management Agency, *Flood Insurance Study Maricopa County, Arizona and Incorporated Areas Volume 1 of 12*, September 30, 1995.

Flood Control District of Maricopa County, *District's Consultant Guidelines, Section 20*, August 1, 2000.

Flood Control District of Maricopa County, *Drainage Design Manual for Maricopa County, Volume I, Hydrology*, 1992.

Flood Control District of Maricopa County, *Drainage Design Manual for Maricopa County, Volume II, Hydraulics*, 1996.

U.S. Army Corps of Engineers, *HEC-1 Flood Hydrograph Package, Version 4.1*, Hydrologic Engineering Center, 1998.

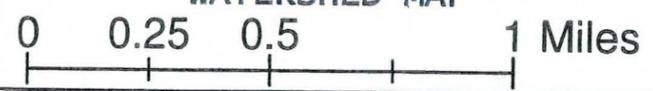
U.S. Army Corps of Engineers, *HEC-RAS River Analysis System, Version 3.1.1*, Hydrologic Engineering Center, 2003.

U.S. Geological Survey, *Estimated Manning's Roughness Coefficients for Stream Channels and Flood Plains in Maricopa County, Arizona*, April 1991

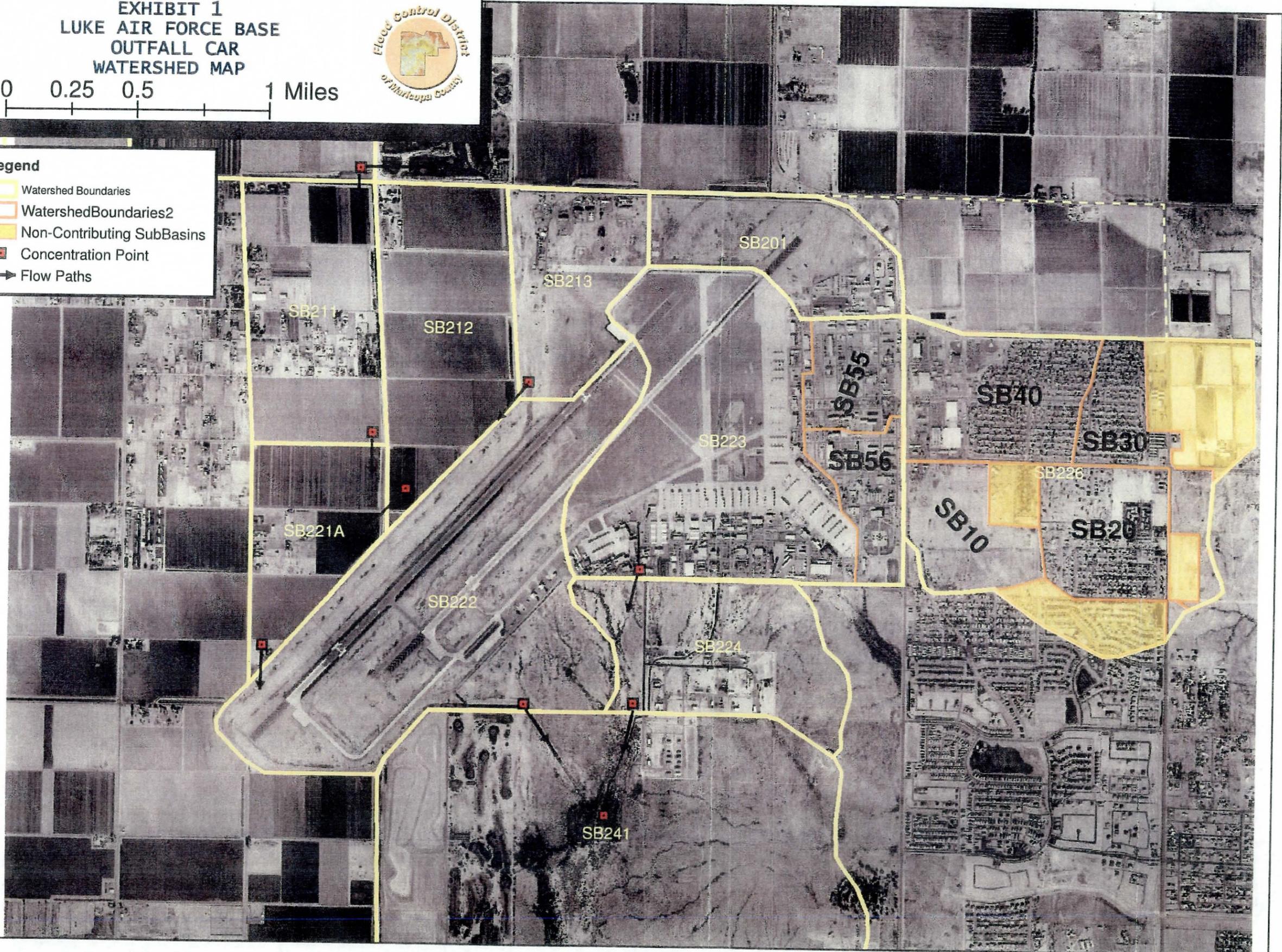
U. S. Geological Survey, El Mirage-7.5 Minute Topographic Map

U. S. Geological Survey, Waddell – 7.5 Minute Topographic Map

EXHIBIT 1  
LUKE AIR FORCE BASE  
OUTFALL CAR  
WATERSHED MAP



- Legend**
- Watershed Boundaries
  - WatershedBoundaries2
  - Non-Contributing SubBasins
  - Concentration Point
  - Flow Paths



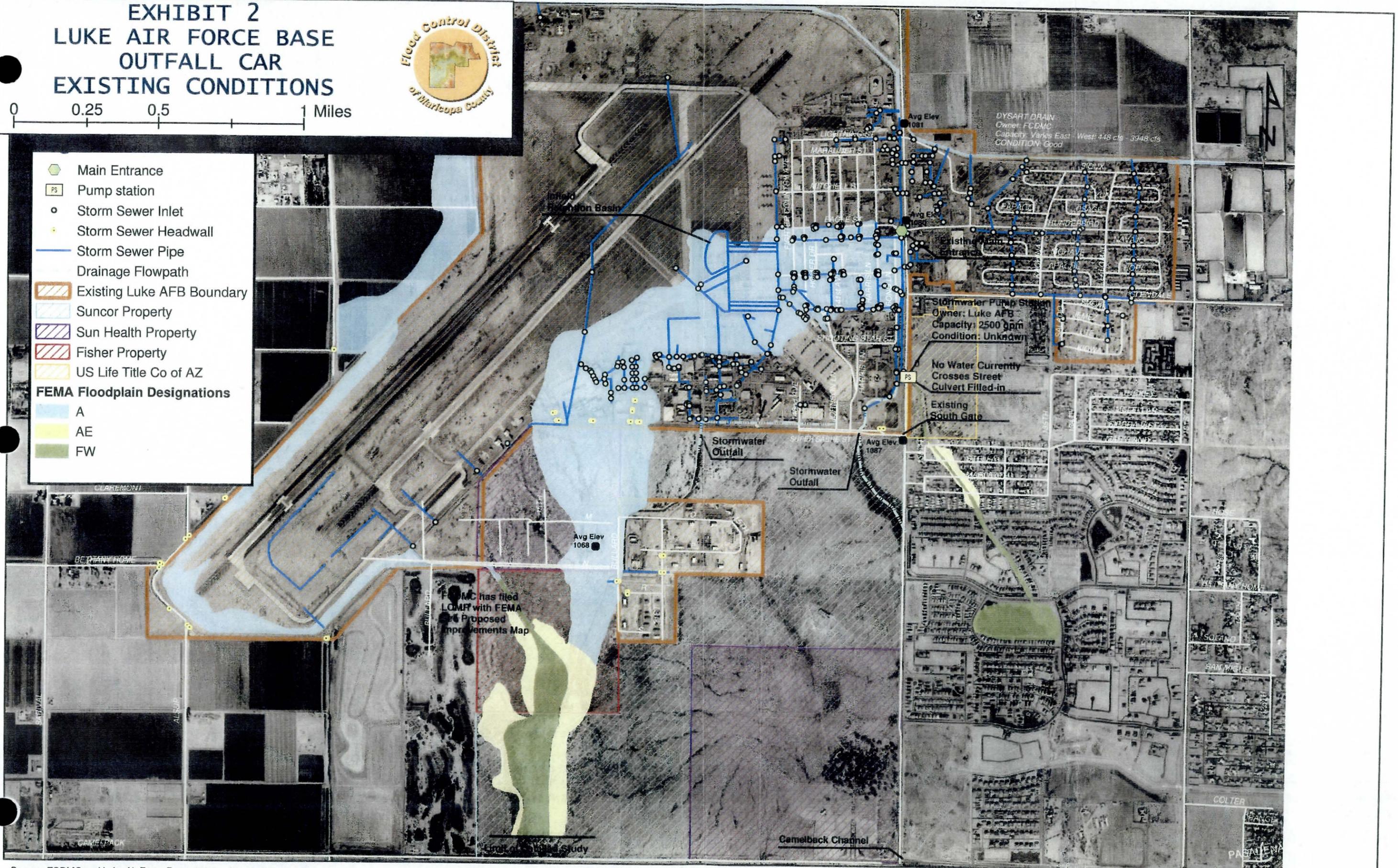
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# EXHIBIT 2 LUKE AIR FORCE BASE OUTFALL CAR EXISTING CONDITIONS



0 0.25 0.5 1 Miles

- Main Entrance
  - Pump station
  - Storm Sewer Inlet
  - Storm Sewer Headwall
  - Storm Sewer Pipe
  - Drainage Flowpath
  - Existing Luke AFB Boundary
  - Suncor Property
  - Sun Health Property
  - Fisher Property
  - US Life Title Co of AZ
- FEMA Floodplain Designations**
- A
  - AE
  - FW



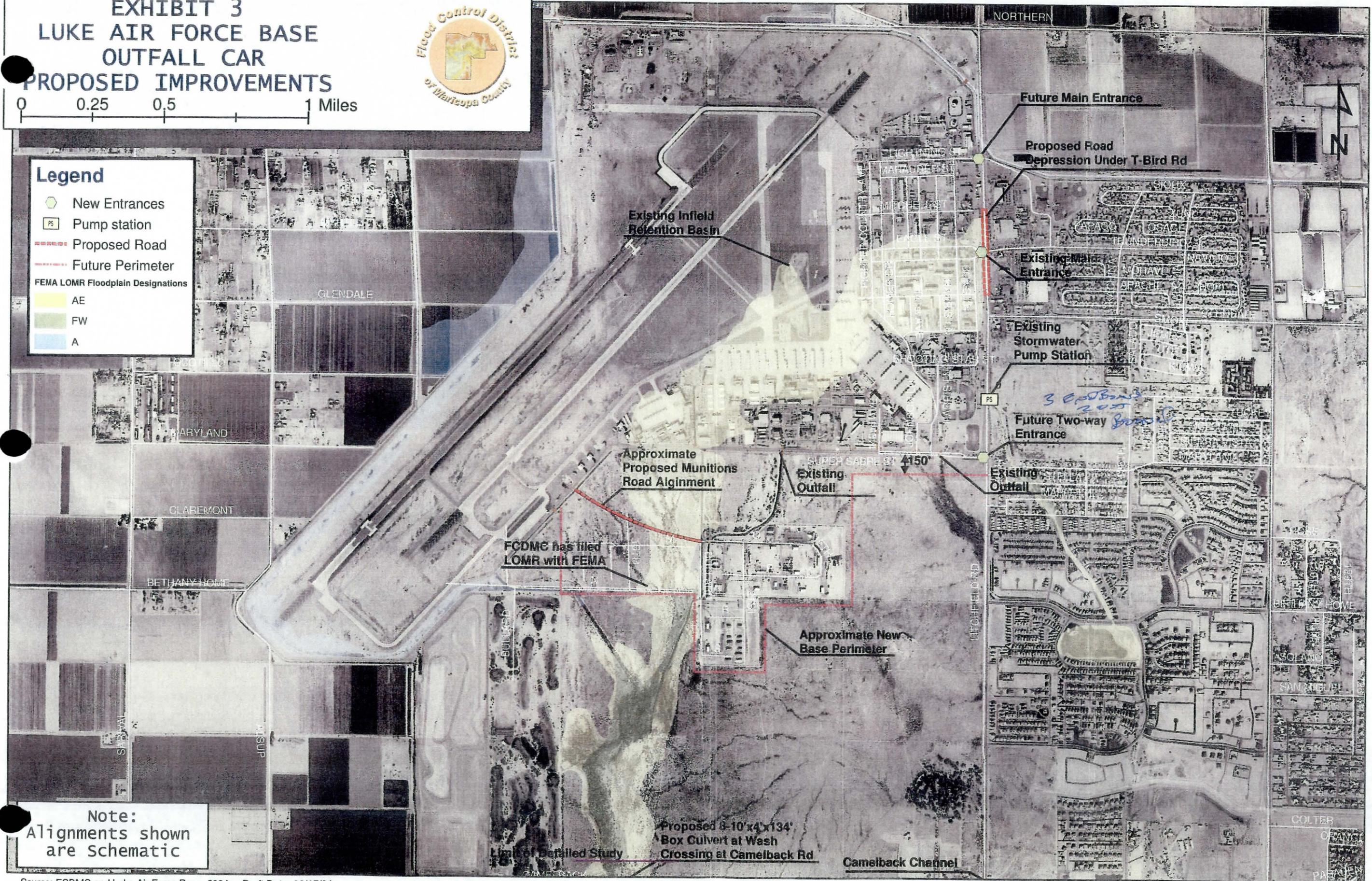
# EXHIBIT 3 LUKE AIR FORCE BASE OUTFALL CAR PROPOSED IMPROVEMENTS



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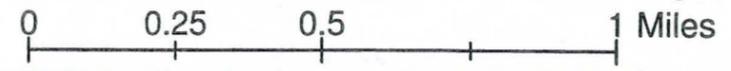
## Legend

- New Entrances
  - Pump station
  - Proposed Road
  - Future Perimeter
- FEMA LOMR Floodplain Designations
- AE
  - FW
  - A



Note:  
Alignments shown  
are Schematic

# EXHIBIT 4 LUKE AIR FORCE BASE OUTFALL CAR ALTERNATIVE 1- NO ACTION



**Legend**

- Concentration Point
- ◊ New Entrances
- PS Pump station
- Proposed Road
- Future Perimeter
- Drainage Flowpath

**FEMA LOMR Floodplain Designations**

- AE
- FW
- A



Note:  
Alignments shown  
are Schematic

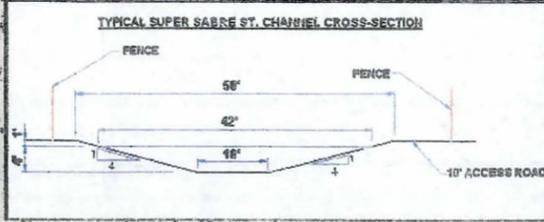
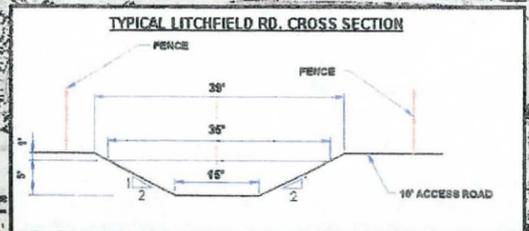
# EXHIBIT 5 LUKE AIR FORCE BASE OUTFALL CAR ALTERNATIVE 2A



0 0.25 0.5 1 Miles

- Legend**
- Concentration Point
  - ◊ New Entrances
  - PS Pump station
  - Proposed Road
  - Future Perimeter
  - Pump Station Conector
  - Alternative 2a Alignment

Existing Infield Retention Basin



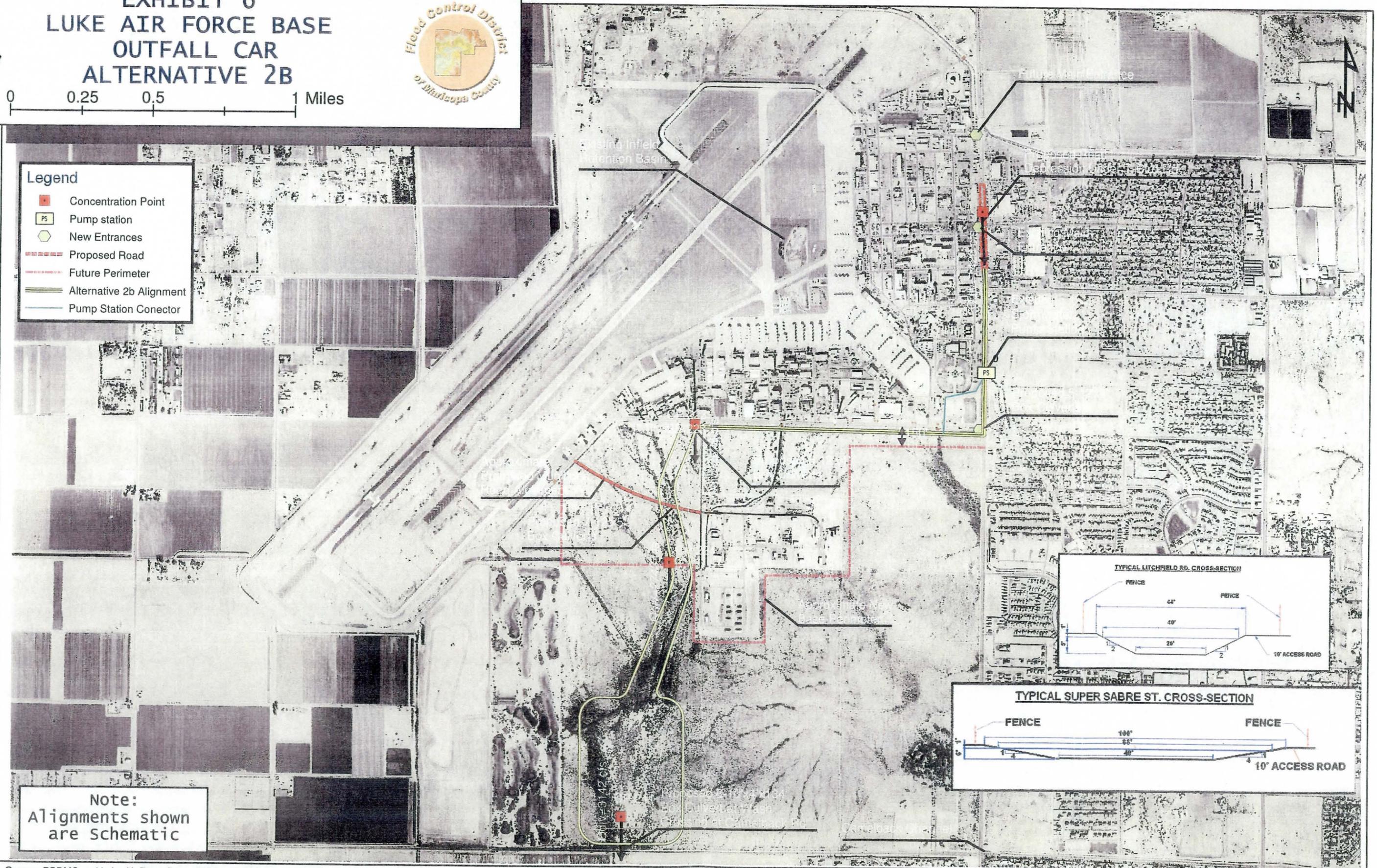
**Note:**  
Alignments shown  
are Schematic

# EXHIBIT 6 LUKE AIR FORCE BASE OUTFALL CAR ALTERNATIVE 2B



0 0.25 0.5 1 Miles

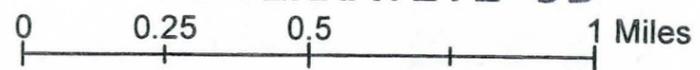
- Legend**
- Concentration Point
  - PS Pump station
  - ◊ New Entrances
  - Proposed Road
  - Future Perimeter
  - Alternative 2b Alignment
  - Pump Station Conector



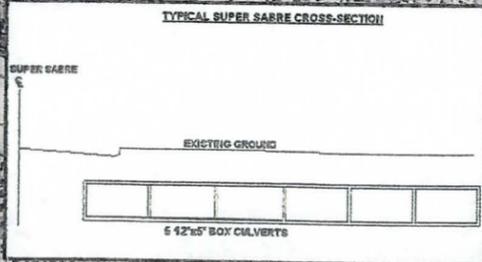
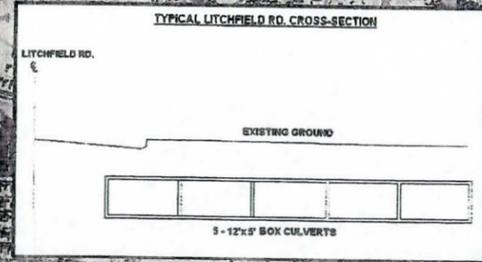
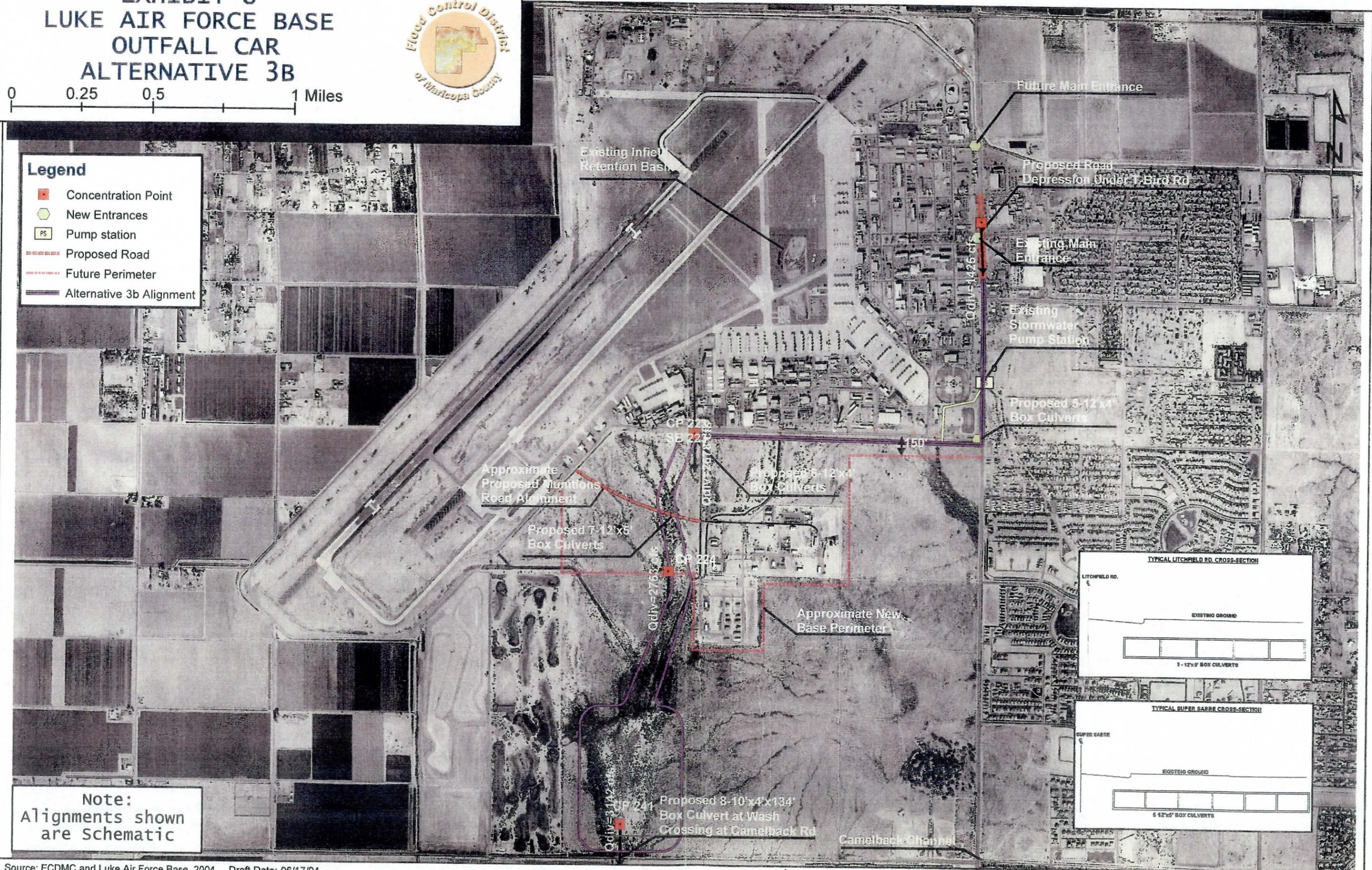
Note:  
Alignments shown  
are Schematic



# EXHIBIT 8 LUKE AIR FORCE BASE OUTFALL CAR ALTERNATIVE 3B



- Legend**
- Concentration Point
  - New Entrances
  - PS Pump station
  - Proposed Road
  - Future Perimeter
  - Alternative 3b Alignment



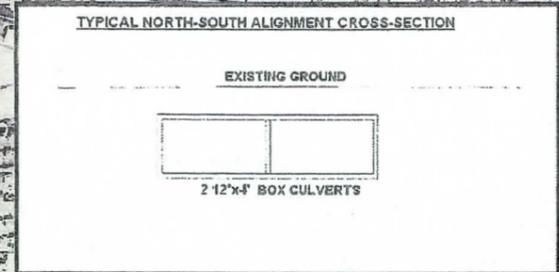
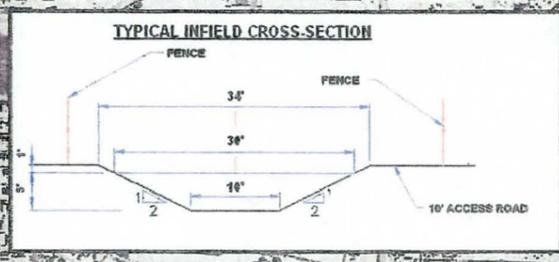
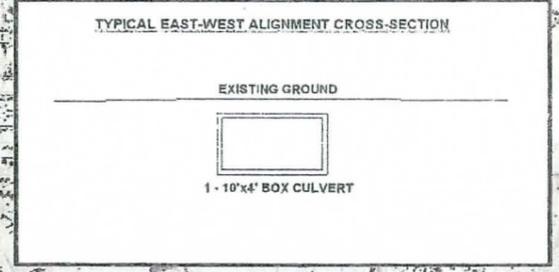
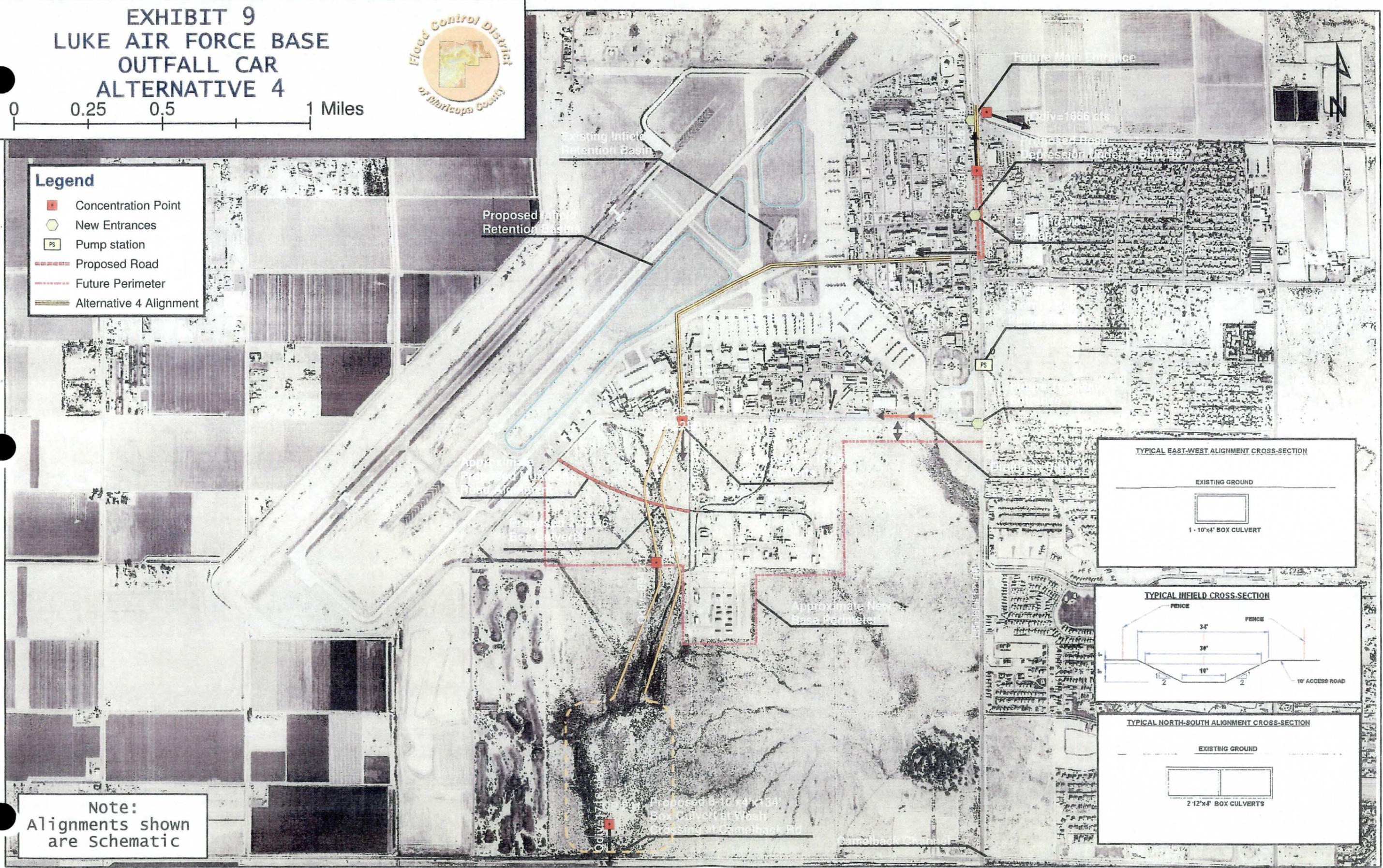
**Note:**  
Alignments shown  
are Schematic

# EXHIBIT 9 LUKE AIR FORCE BASE OUTFALL CAR ALTERNATIVE 4



0 0.25 0.5 1 Miles

- Legend**
- Concentration Point
  - ◊ New Entrances
  - PS Pump station
  - Proposed Road
  - Future Perimeter
  - Alternative 4 Alignment



**Note:**  
Alignments shown  
are Schematic

# EXHIBIT 10 LUKE AIR FORCE BASE OUTFALL CAR DRAFT FINAL ALTERNATIVE

0 0.25 0.5 1 Miles

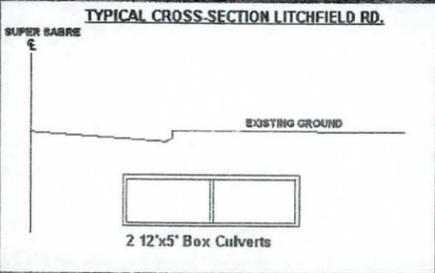
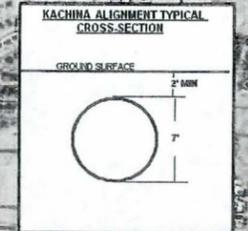
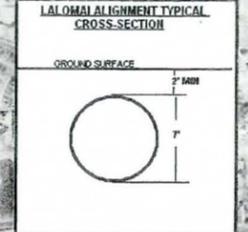
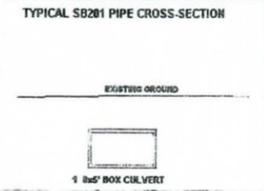
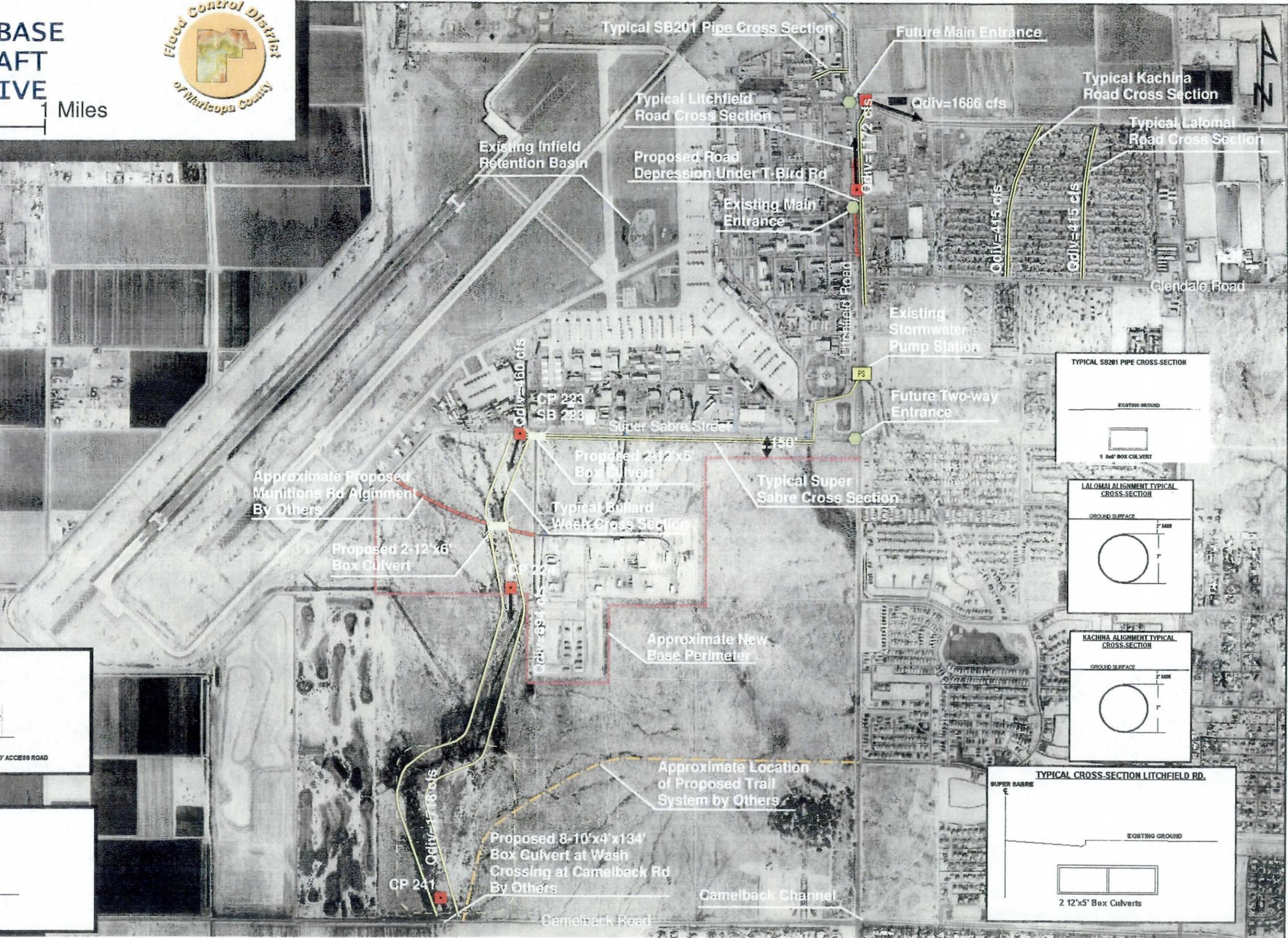
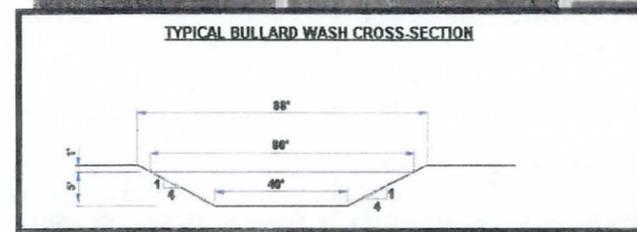
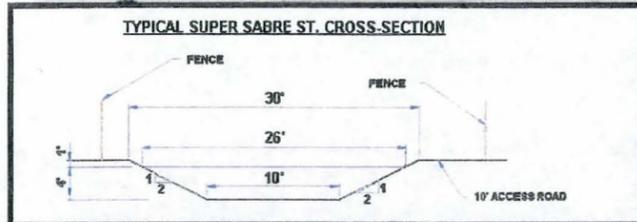


**Legend**

- Concentration Point
- PS Pump Station
- Proposed Road
- Future Perimeter
- Pump Station Outfall
- Proposed Trail

Note:  
Lateral Storm Drain  
Connectors Not  
Shown on Exhibit

Note:  
Alignments shown  
are Schematic



## **APPENDIX A**

### **15% Plans – Final Alternative (11"x17" version)**

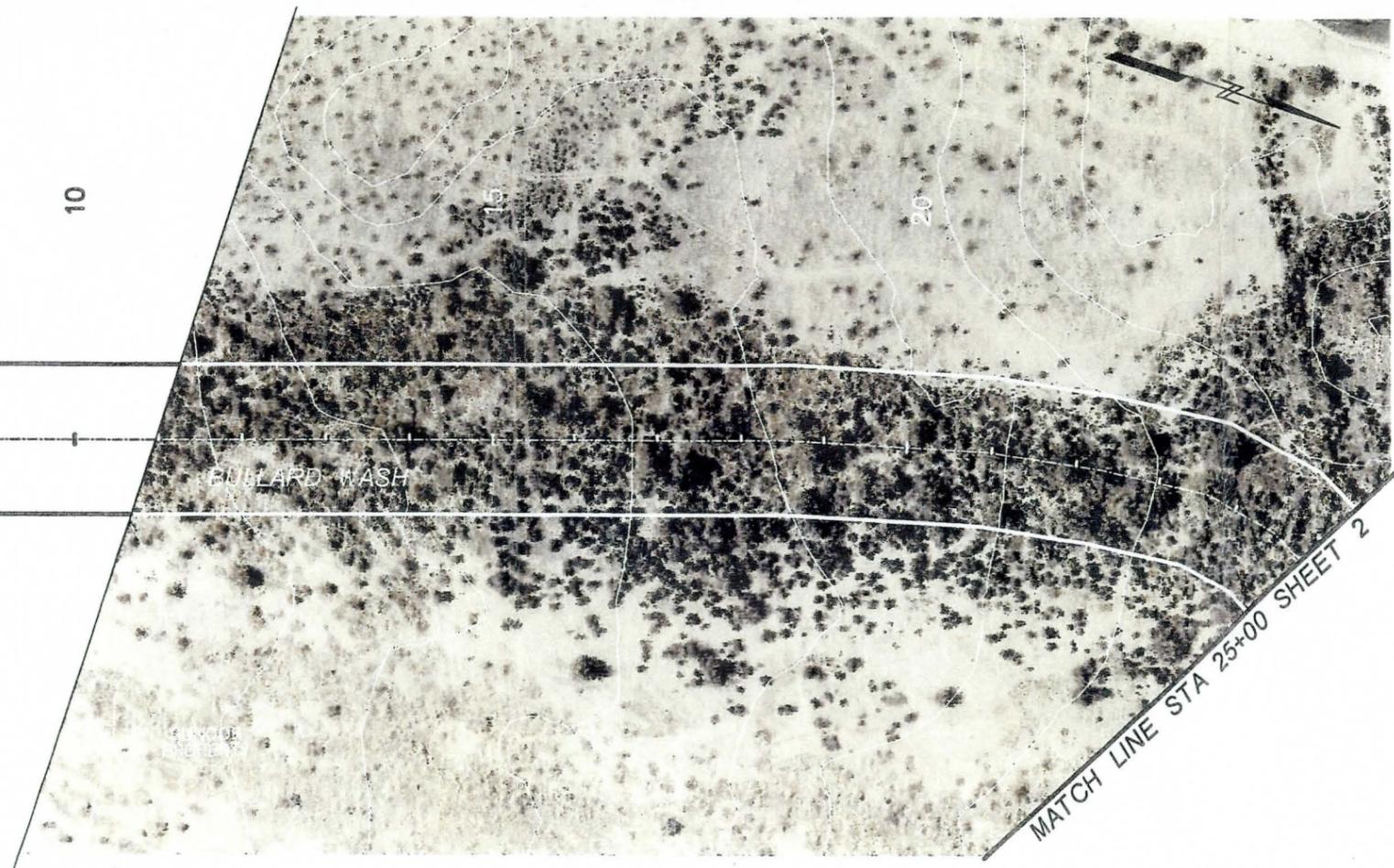
- Bullard Wash Plan and Profile
- Super Sabre Plan and Profile
- Litchfield Road Plan and Profile
- Kachina Road Plan and Profile
- Lalomai Street Plan and Profile
- Subbasin 201 Outfall to Dysart Plan and Profile
- Details and Typical Sections

CAMELBACK RD

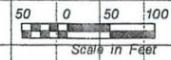
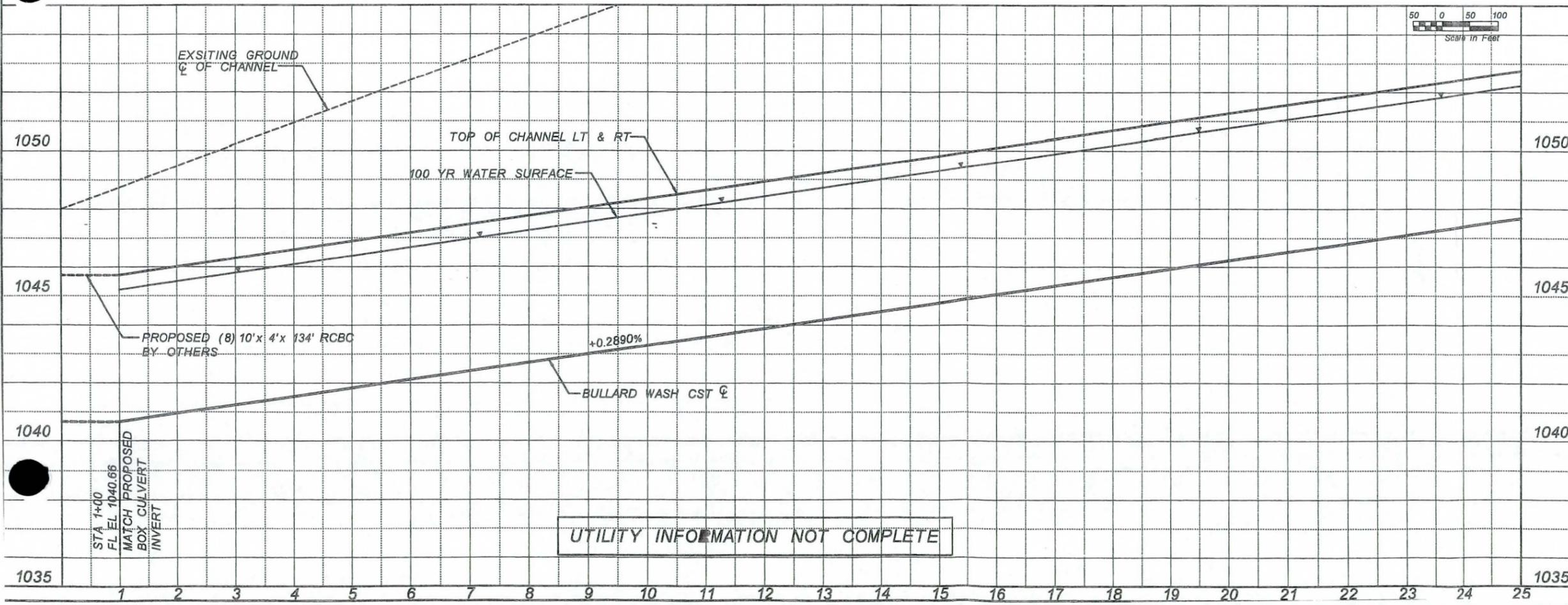
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MATCH LINE STA 25+00 SHEET 2



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- UTILITY POLE
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NOTE:  
ALL UTILITIES-  
LOCATION APPROXIMATE  
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**FLOOD CONTROL DISTRICT  
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ENGINEERING DIVISION**

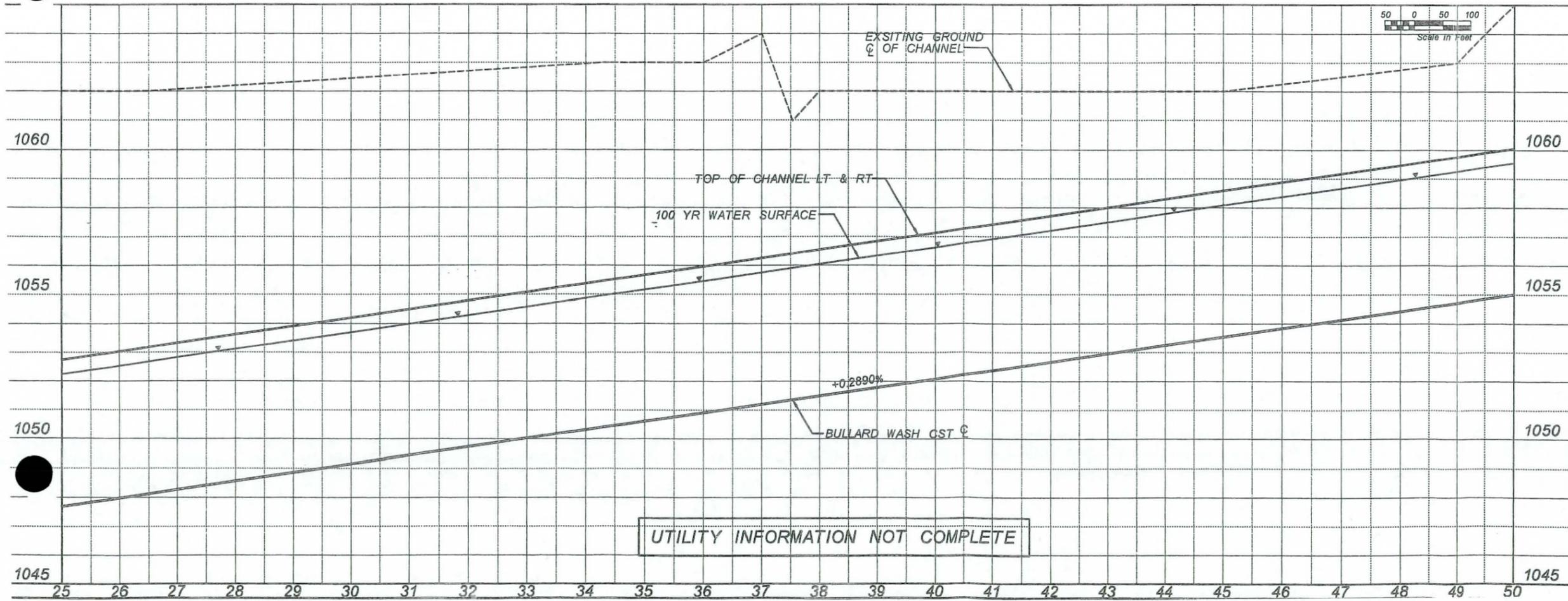
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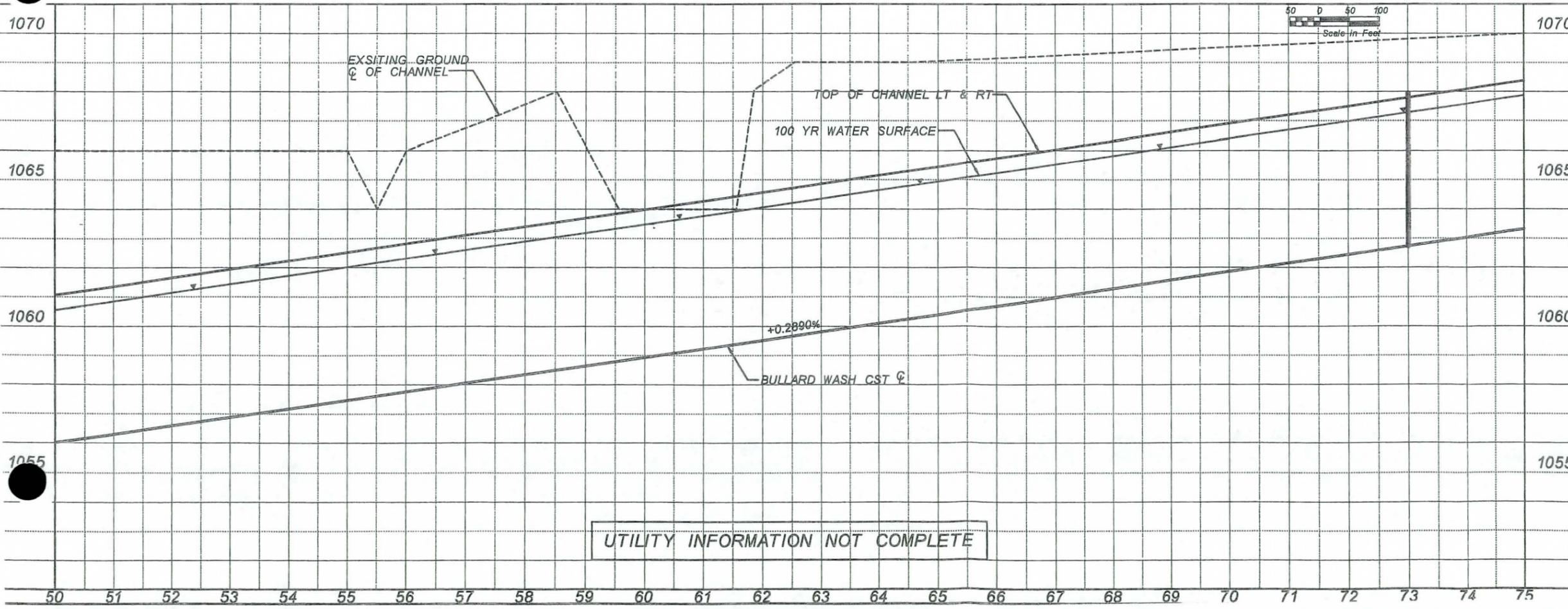
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**FLOOD CONTROL DISTRICT  
OF MARICOPA COUNTY  
ENGINEERING DIVISION**

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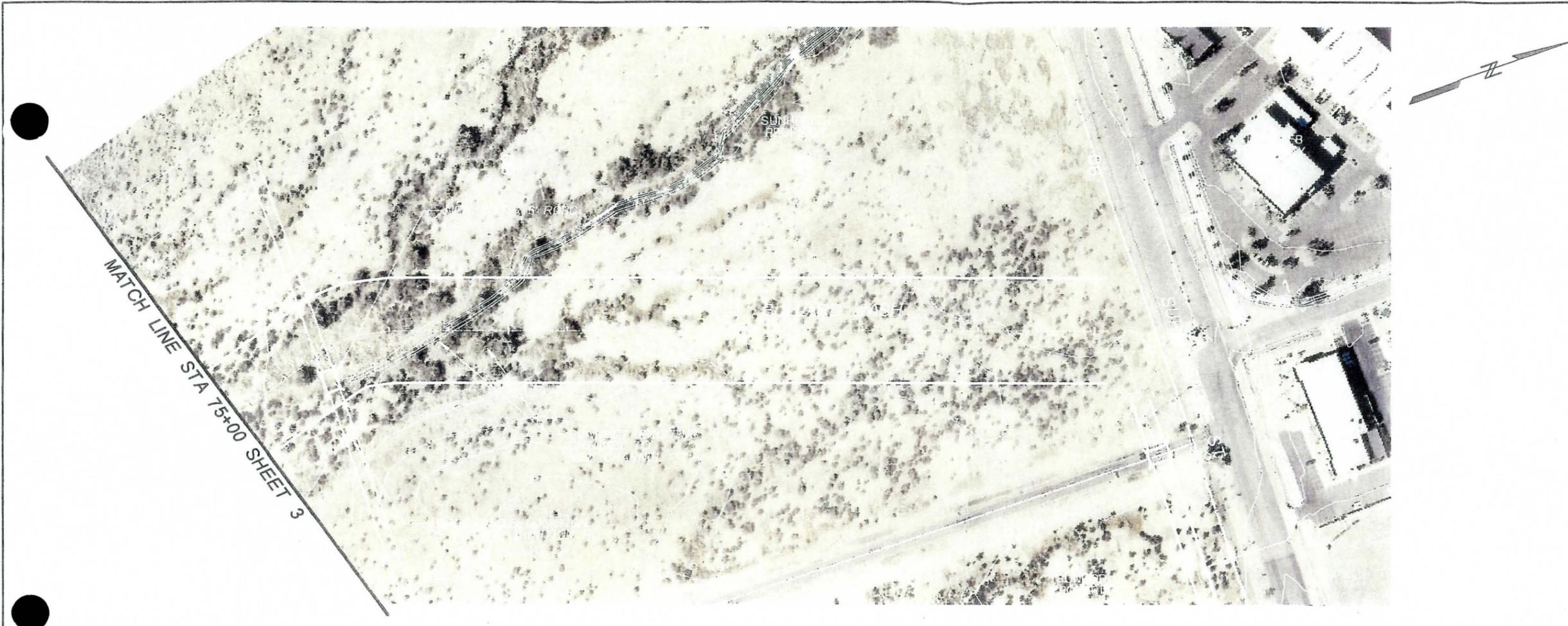
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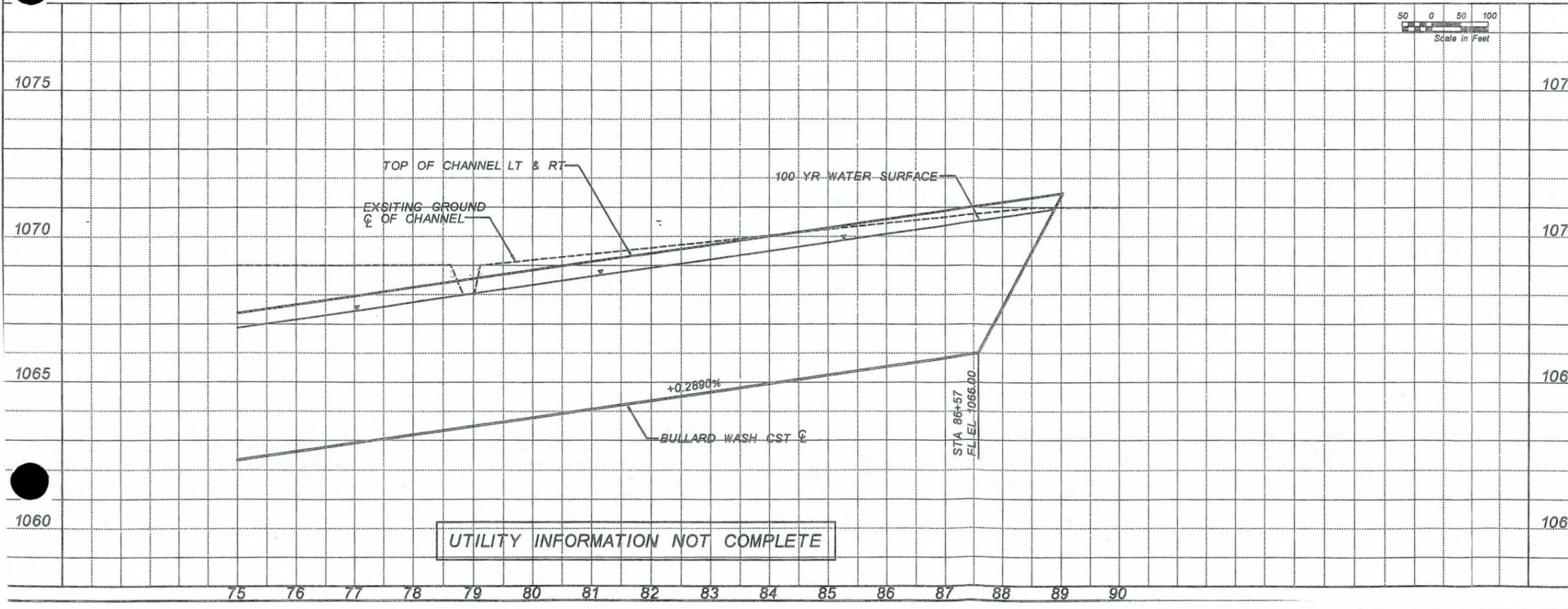
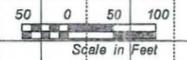
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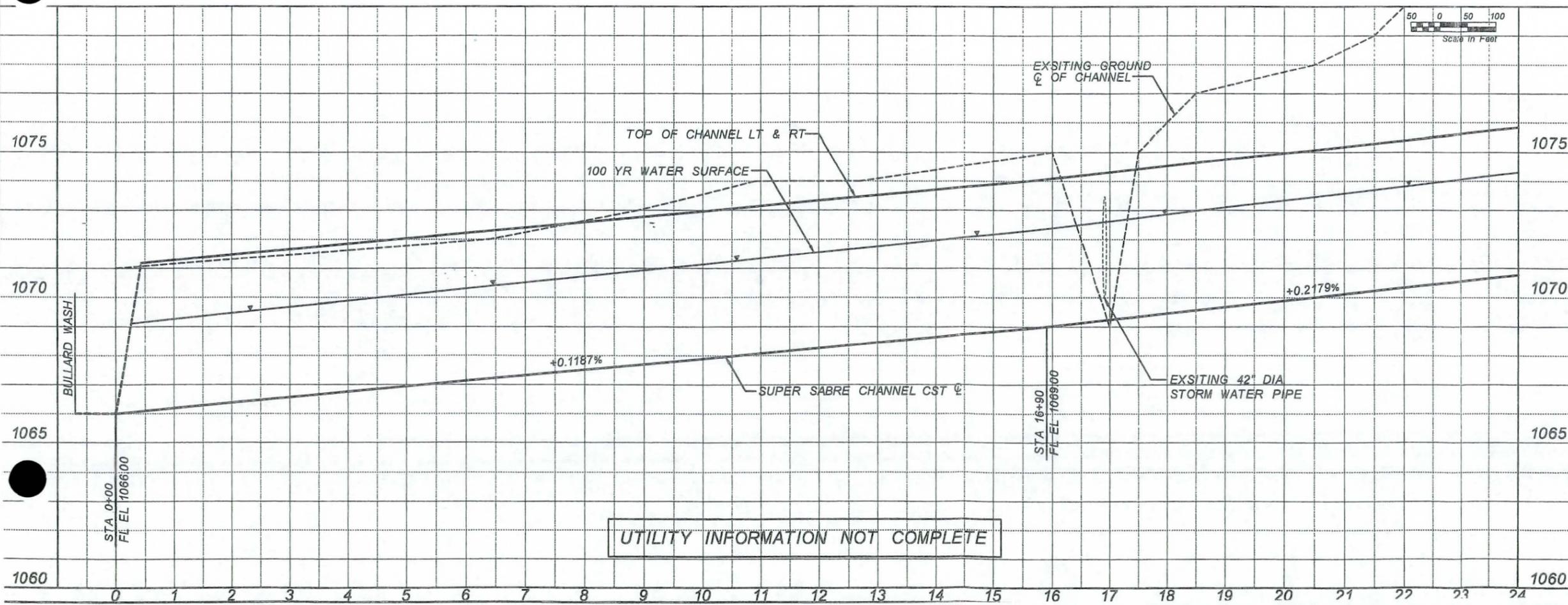
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ENGINEERING DIVISION**

LUKE AIR FORCE BASE OUTFALL  
CANDIDATE ASSESSMENT REPORT  
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UTILITY INFORMATION NOT COMPLETE

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NOTE:  
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**FLOOD CONTROL DISTRICT  
OF MARICOPA COUNTY  
ENGINEERING DIVISION**

LUKE AIR FORCE BASE OUTFALL  
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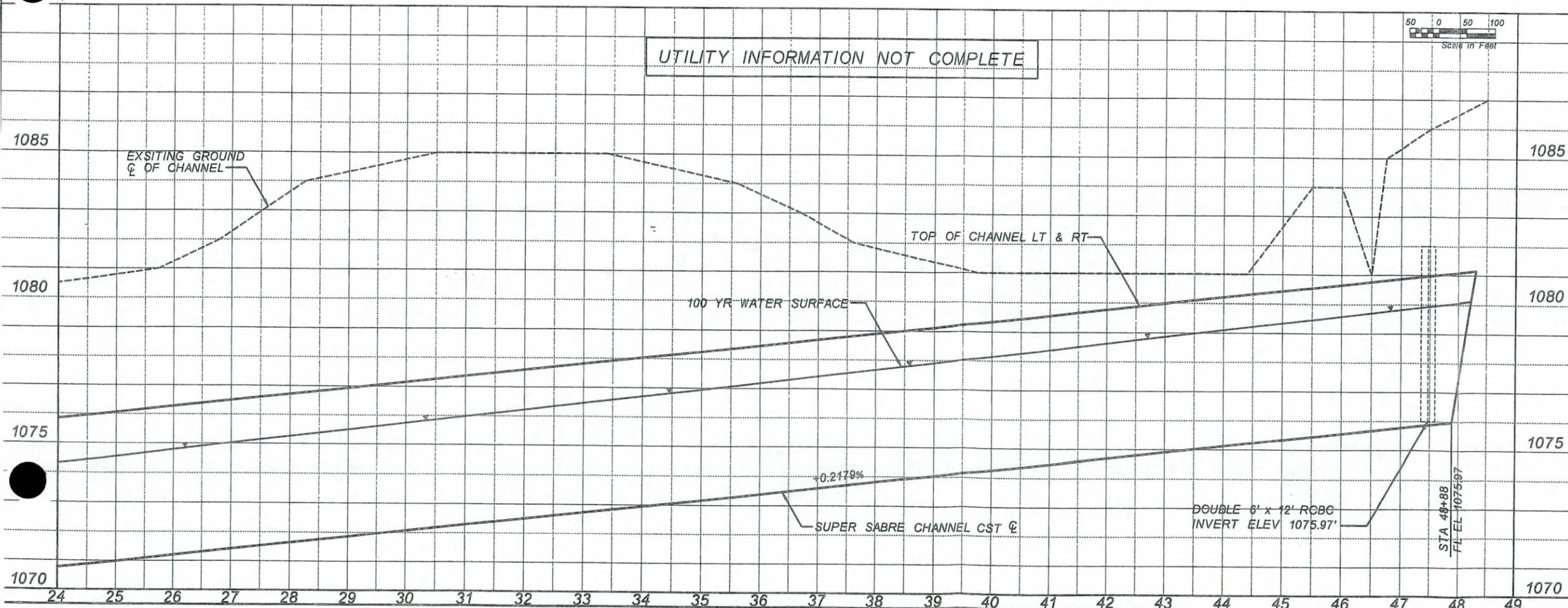
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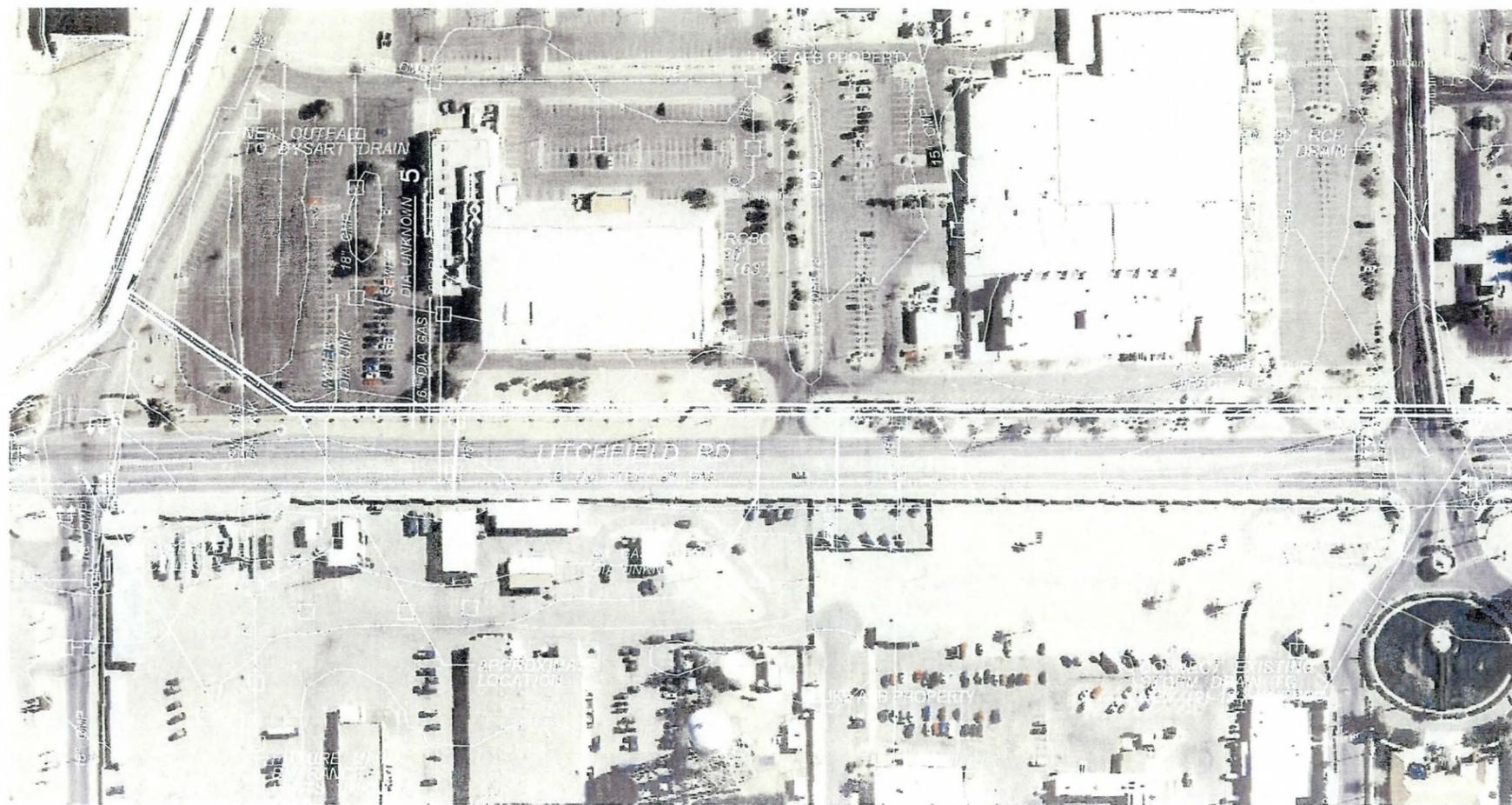
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**FLOOD CONTROL DISTRICT  
OF MARICOPA COUNTY  
ENGINEERING DIVISION**

LUKE AIR FORCE BASE OUTFALL  
CANDIDATE ASSESSMENT REPORT  
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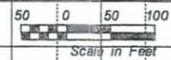
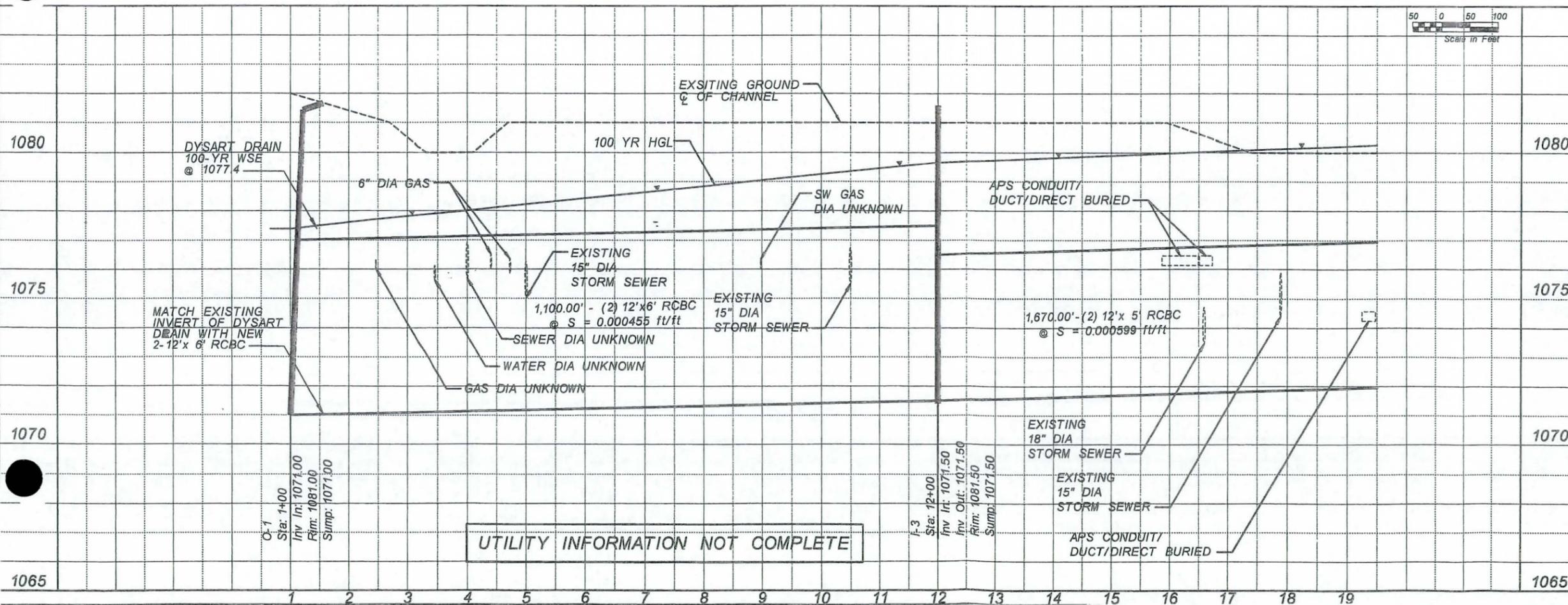


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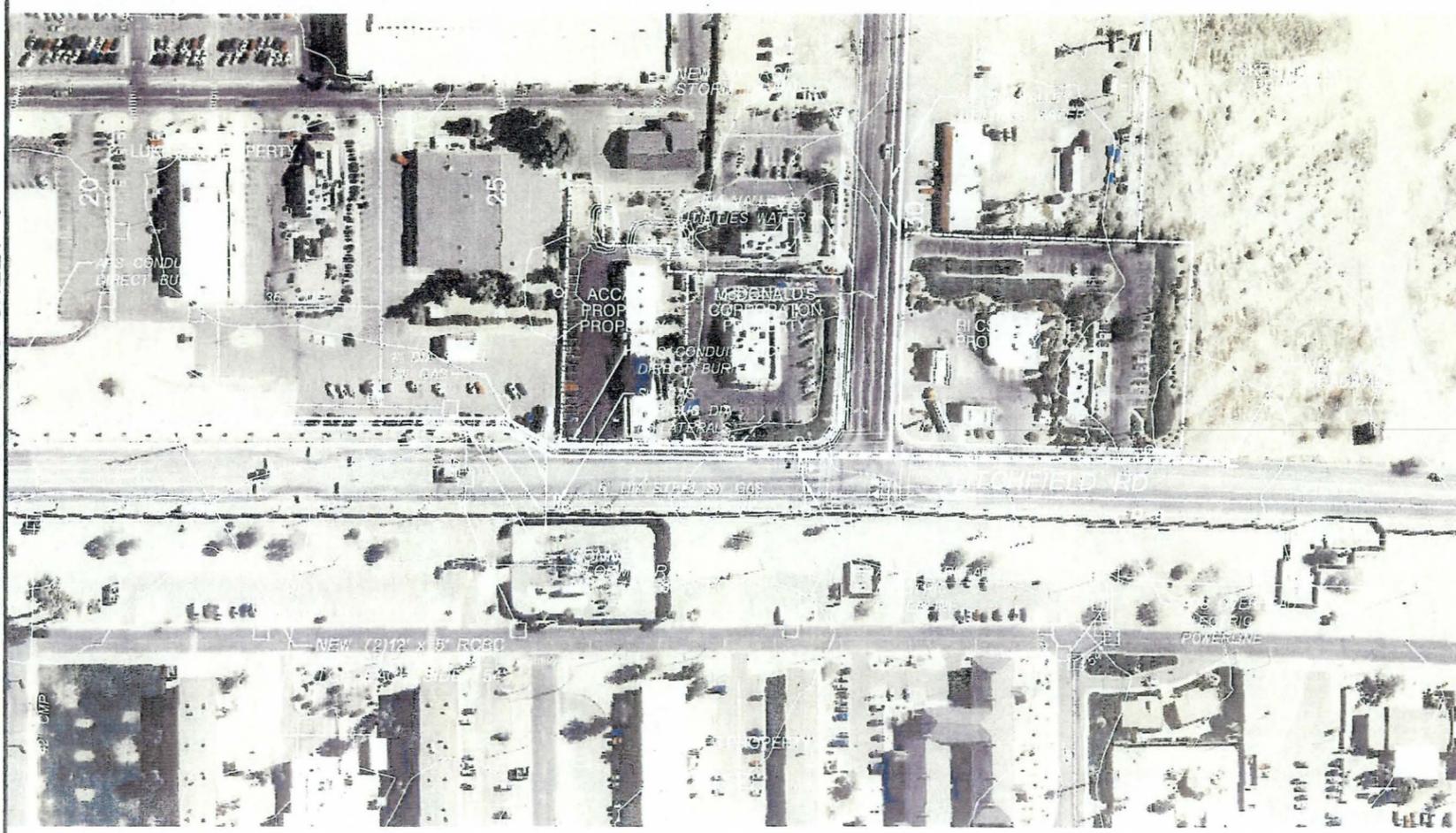
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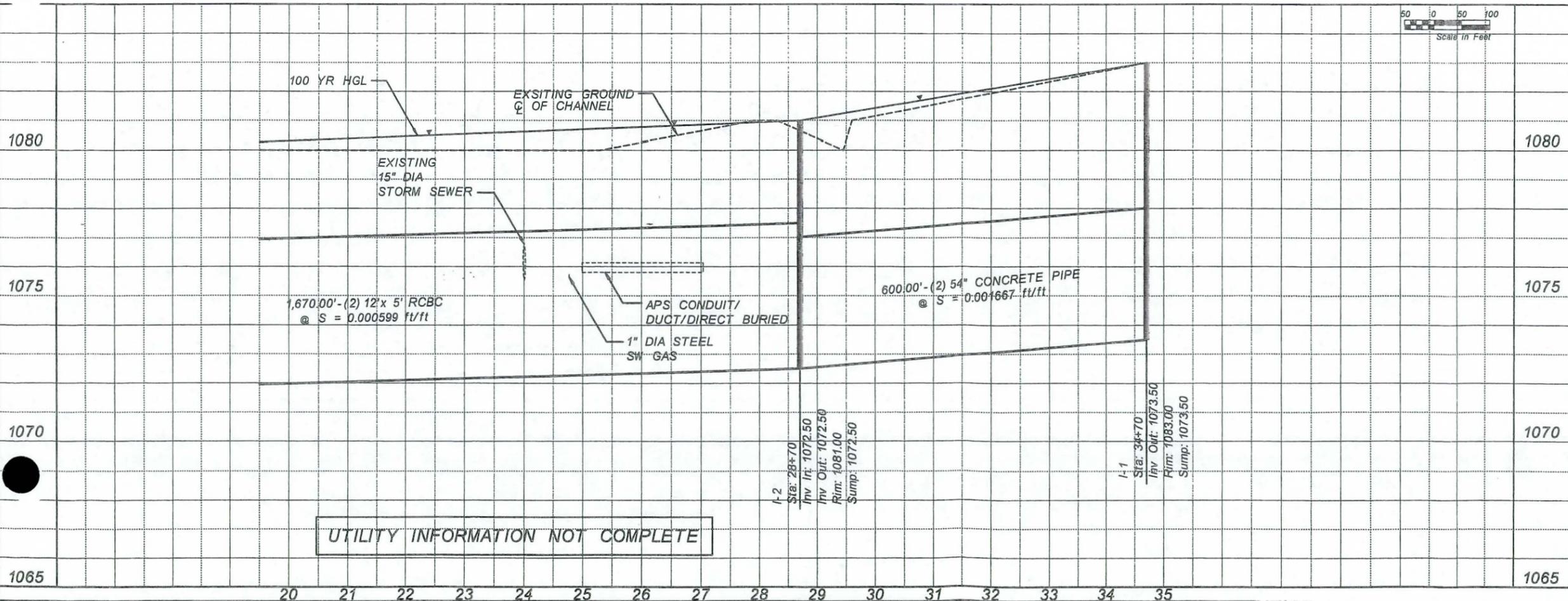
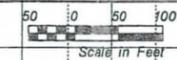
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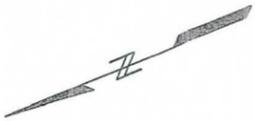
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NOTE:  
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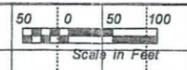
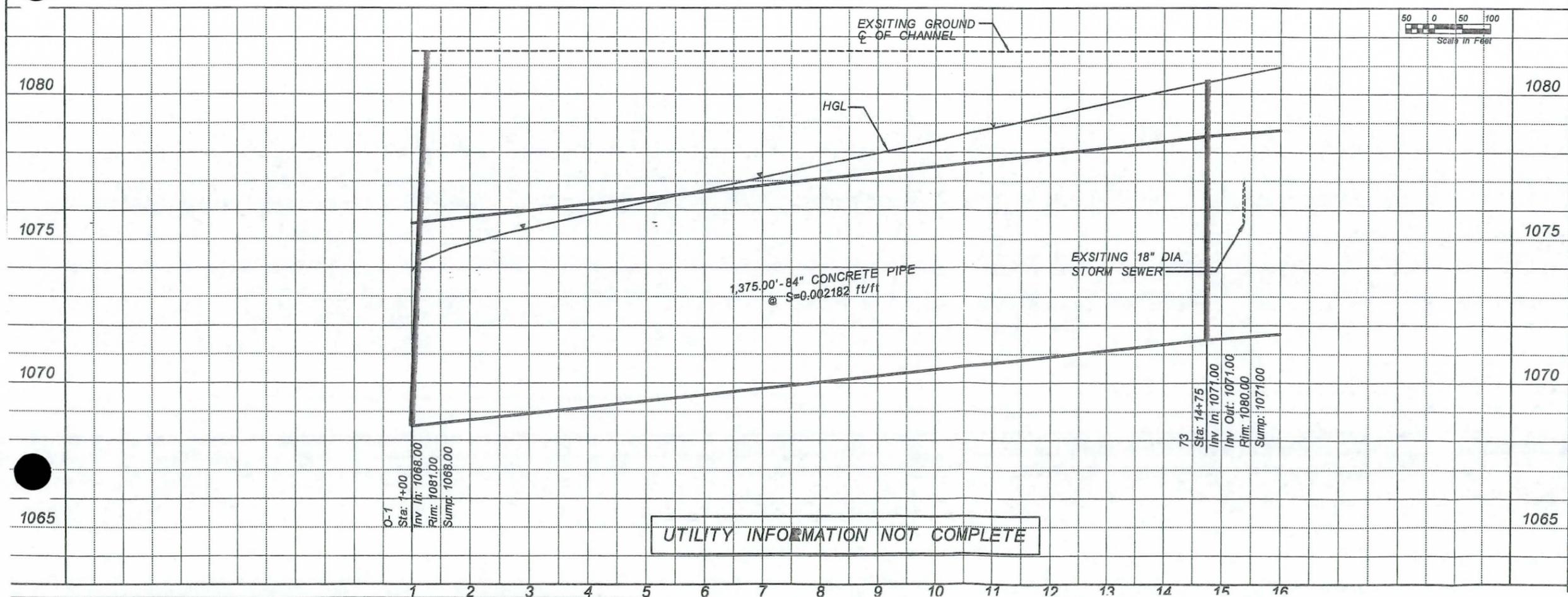
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LUKE AIR FORCE BASE OUTFALL CANDIDATE ASSESSMENT REPORT  
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- LEGEND**
- APS POLE
  - UTILITY POLE
  - TRAFFIC SIGNAL POLE

NOTE:  
ALL UTILITIES-  
LOCATION APPROXIMATE  
ELEVATION UNKNOWN

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**FLOOD CONTROL DISTRICT OF MARICOPA COUNTY ENGINEERING DIVISION**

**LUKE AIR FORCE BASE OUTFALL CANDIDATE ASSESSMENT REPORT**  
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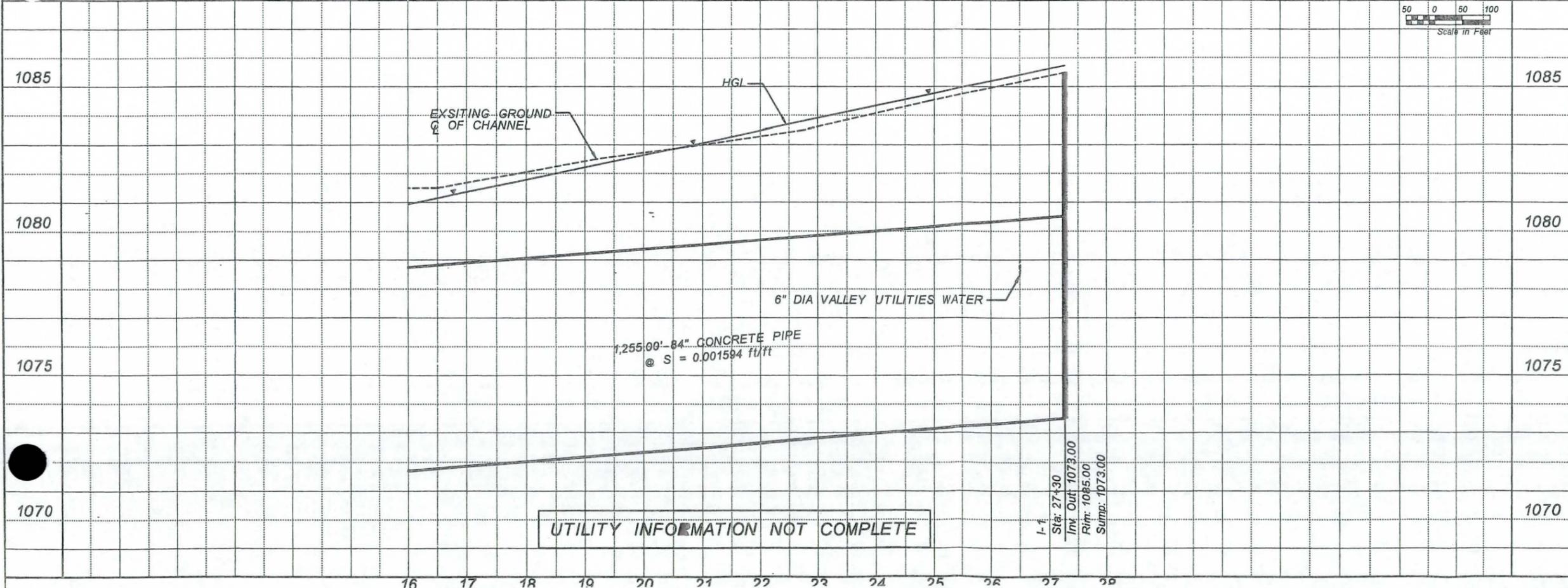
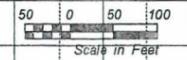
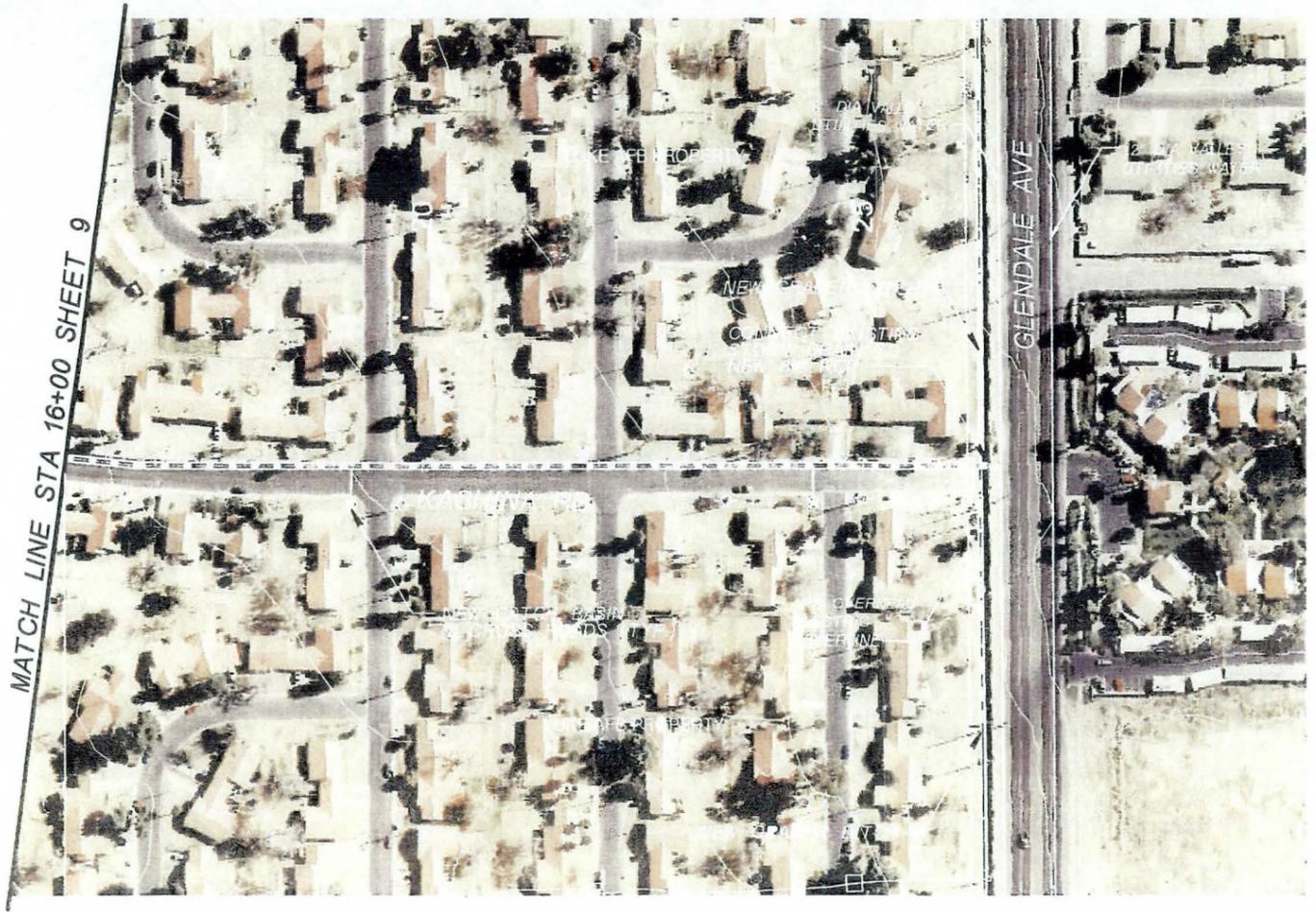
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  - UTILITY POLE
  - TRAFFIC SIGNAL POLE

NOTE:  
ALL UTILITIES-  
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ELEVATION UNKNOWN

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**FLOOD CONTROL DISTRICT  
OF MARICOPA COUNTY  
ENGINEERING DIVISION**

LUKE AIR FORCE BASE OUTFALL  
CANDIDATE ASSESSMENT REPORT  
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15% PRELIMINARY NOT FOR CONSTRUCTION	BY		DATE
	DESIGNED	RH	AUG-04
DRAWN	MC	AUG-04	
CHECKED		AUG-04	

UTILITY INFORMATION NOT COMPLETE

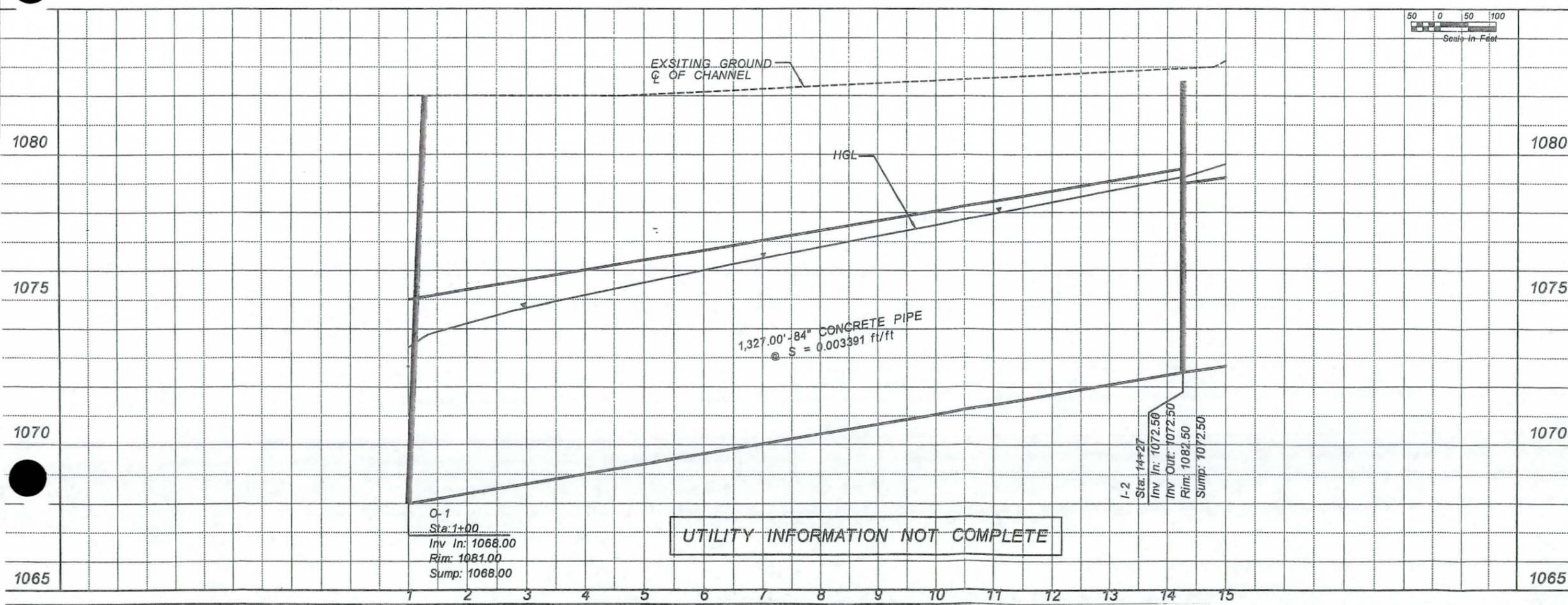
I-1  
Sta: 27+30  
Inlet: 1073.00  
Rim: 1085.00  
Sump: 1073.00



MATCH LINE STA 15+00 SHEET 12

REMOVE

CONSTRUCT



- LEGEND
- APS POLE
  - UTILITY POLE
  - TRAFFIC SIGNAL POLE

NOTE:  
ALL UTILITIES-  
LOCATION APPROXIMATE  
ELEVATION UNKNOWN

NO.	REVISION	BY	DATE
3			
2			
1			

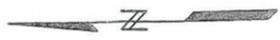


**FLOOD CONTROL DISTRICT  
OF MARICOPA COUNTY  
ENGINEERING DIVISION**

LUKE AIR FORCE BASE OUTFALL  
CANDIDATE ASSESSMENT REPORT  
14068  
CON0002212

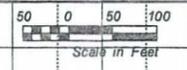
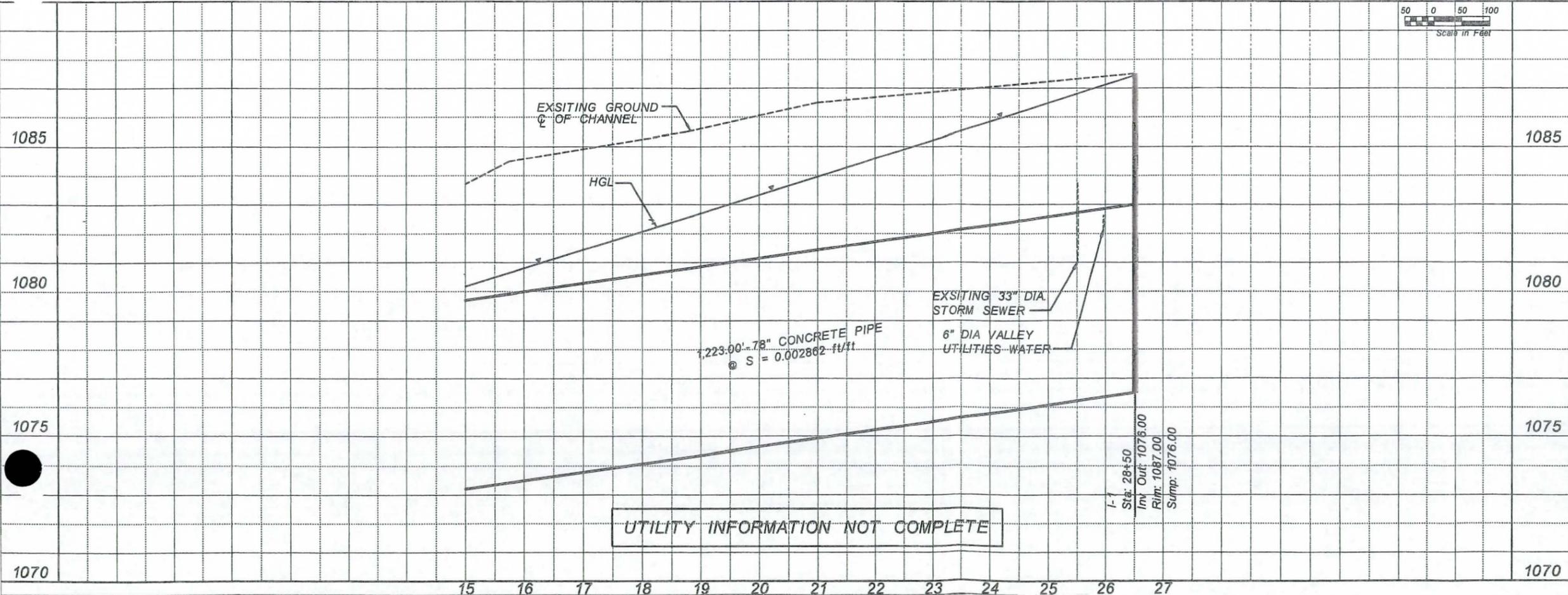
15% PRELIMINARY NOT FOR CONSTRUCTION	BY		DATE
	DESIGNED	RH	AUG-04
	DRAWN	MC	AUG-04
CHECKED		AUG-04	

MATCH LINE STA 15+00 SHEET 11



REMOVE

CONSTRUCT



- LEGEND**
- APS POLE
  - UTILITY POLE
  - TRAFFIC SIGNAL POLE

NOTE:  
ALL UTILITIES-  
LOCATION APPROXIMATE  
ELEVATION UNKNOWN

3			
2			
1			
NO.	REVISION	BY	DATE



**FLOOD CONTROL DISTRICT  
OF MARICOPA COUNTY  
ENGINEERING DIVISION**

LUKE AIR FORCE BASE OUTFALL  
CANDIDATE ASSESSMENT REPORT  
14068  
CON0002212

15% PRELIMINARY NOT FOR CONSTRUCTION	DESIGNED	RH	BY	DATE
	DRAWN	MC		AUG-04
	CHECKED			AUG-04

UTILITY INFORMATION NOT COMPLETE

I-1  
Sta: 28+50  
Inv. Out: 1076.00  
Rim: 1087.00  
Sump: 1076.00

1,223.00'-78" CONCRETE PIPE  
@ S = 0.002862 ft/ft

EXISTING 33" DIA.  
STORM SEWER  
6" DIA VALLEY  
UTILITIES WATER

EXISTING GROUND  
C.O. OF CHANNEL

HGL

1085

1085

1080

1080

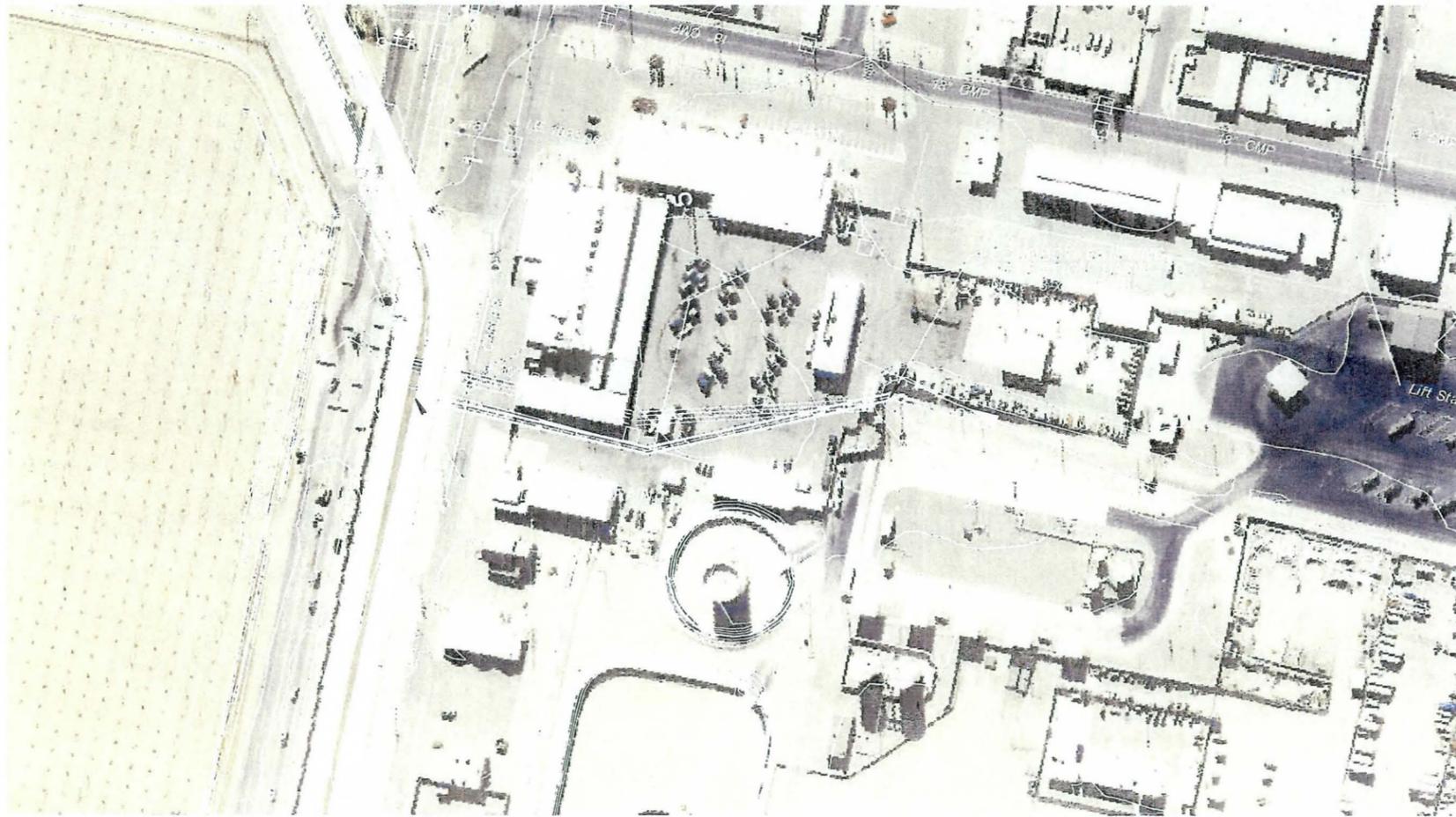
1075

1075

1070

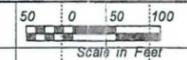
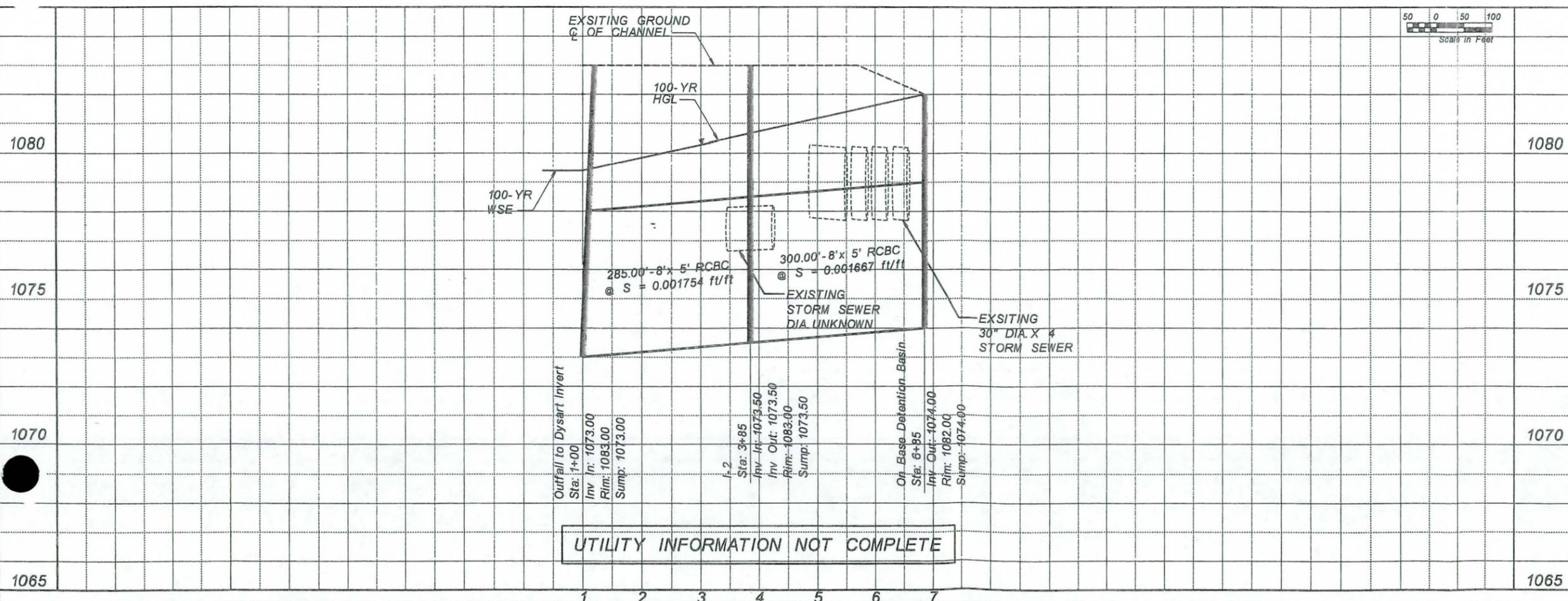
1070

15 16 17 18 19 20 21 22 23 24 25 26 27



REMOVE

CONSTRUCT



- LEGEND
- APS POLE
  - UTILITY POLE
  - TRAFFIC SIGNAL POLE

NOTE:  
ALL UTILITIES-  
LOCATION APPROXIMATE  
ELEVATION UNKNOWN

3			
2			
1			
NO.	REVISION	BY	DATE

**FLOOD CONTROL DISTRICT  
OF MARICOPA COUNTY  
ENGINEERING DIVISION**

LUKE AIR FORCE BASE OUTFALL  
CANDIDATE ASSESSMENT REPORT  
14068  
CON0002212

15% PRELIMINARY NOT FOR CONSTRUCTION	DESIGNED	RH	DATE
	DRAWN	MC	AUG-04
	CHECKED		AUG-04

DRAWING NO. 13 PLAN AND PROFILE SB201 SHEET OF

UTILITY INFORMATION NOT COMPLETE

## **APPENDIX B**

### **Land Use Information**

- Land Ownership and Jurisdiction
- Existing Land Use
- Zoning
- Future Land Use
- Conclusion
- References

## Land Use Information

Luke Air Force Base (AFB), originally established in 1941, is the home of the 56th Fighter Wing (FW), an Air Education and Training Command unit, and is the world's largest fighter training facility. Luke AFB is located in western Maricopa County and employs more than 8,000 people (DOC, 2003).

The study area for the project extends beyond the Luke AFB property, encompassing approximately 7,040 acres; from Northern Avenue on the north to Camelback Road on the south, one-quarter mile west of Alsup Avenue to the west and Dysart Road to the east.

### **Land Ownership and Jurisdiction**

Land ownership in the vicinity of the Luke AFB is private outside of the base property. The base itself is owned by the United States of America.

Most of the study area land is unincorporated Maricopa County, the base itself is part of the incorporated area of Glendale, and Glendale strip annexation surrounds the base. The unincorporated area surrounding the base is within the Glendale planning area. South of the base the study area includes portions of the City of Goodyear, and to the east of Bullard Avenue, the City of Litchfield Park.

### **Existing Land Use**

Within the study area, the base is the largest land use occupying approximately 1,977 acres (28 percent). After the base, vacant land is the next largest "land use" with 25 percent, followed by agriculture which occupies 22 percent. Residential land uses represent 19 percent of the study area. Residential lands use encompasses a range of densities, from large-lot residential to multi-family. The remaining land uses are categorized in Table B-1. Exhibit B-1 shows the existing land use for the study area.

**EXHIBIT B-1  
LUKE AIR FORCE BASE  
OUTFALL CAR DRAFT  
EXISTING LAND USE**

0 0.25 0.5 1 Miles



**Legend**

- Low Density Res (SF)
- Medium Lot Res (SF)
- Small Lot Res (SF)
- Multi-Family Res
- Commercial
- Warehouse/Distribution Ctr
- Tourist/Visitor Accomodations
- Public Facilities
- Airports
- Parks/Open Space
- Agriculture
- Vacant



Source: FCDMC, HDR and Luke AFB, 2004 Draft Date: 8/16/04

**Table B-1, Existing Land Use**

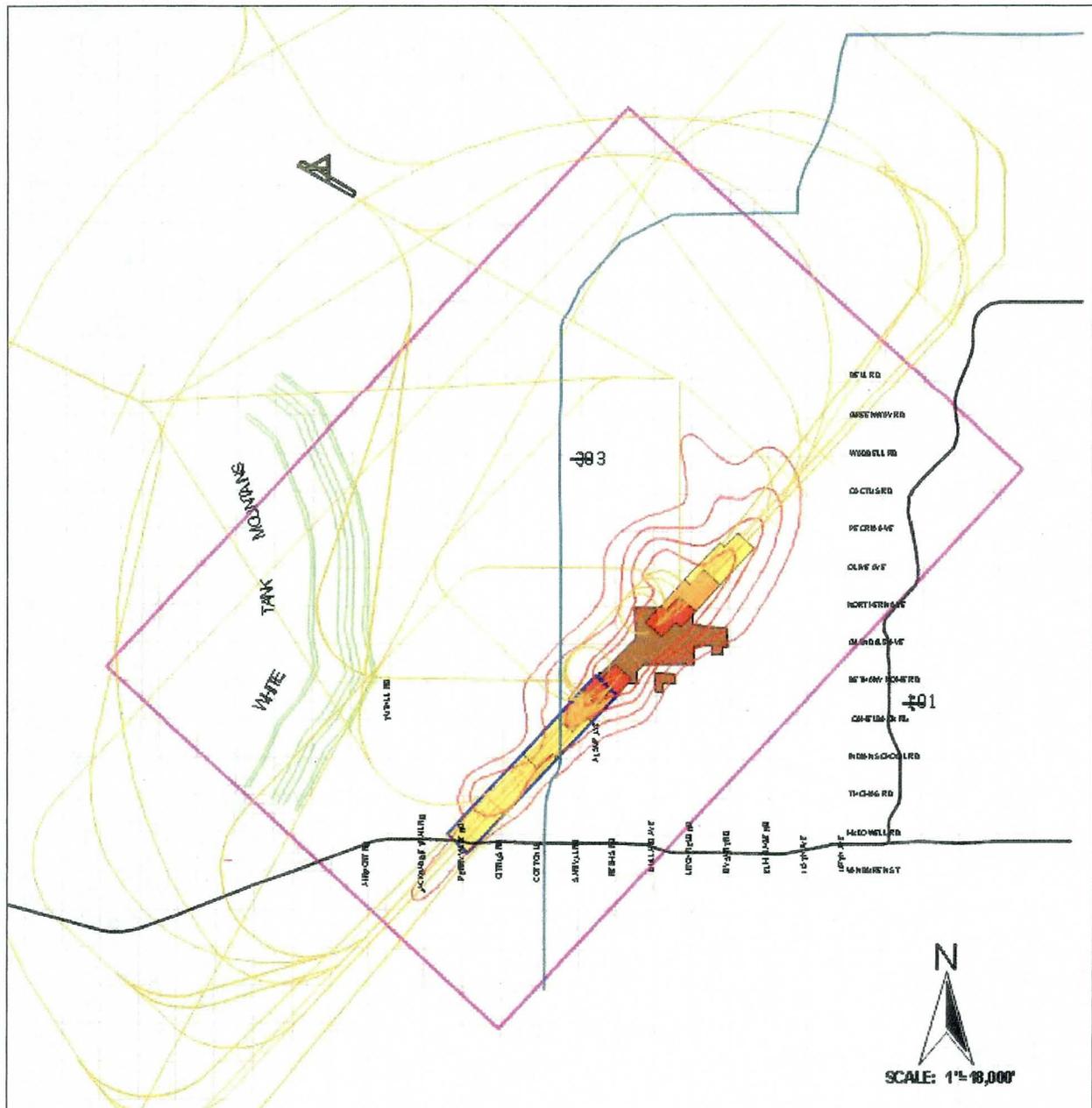
<b>Land Use</b>	<b>Acres</b>	<b>Percent</b>
Airport	1,976.9	28%
Vacant	1,767.4	25%
Agriculture	1,581.2	22%
Residential	1,309.2	19%
Open Space	232.9	3%
Commercial	78.9	1%
Public/Quasi-Public	69.62	1%
Industrial	20.3	0%
<hr/>		
<i>Total</i>	7,036.3	100.0%

Source: Maricopa Association of Governments (2000), HDR.

Development of incompatible land uses in the vicinity of Luke Air Force Base constrains the bases ability to perform current and future missions. In 2001 the Arizona Legislature enacted legislation to ensure that development near a military airport is consistent with the airport's operations (see Arizona Revised Statutes § 28-8481 and 8482.). The law, Airport Zoning and Regulation, outlines the planning and zoning requirements for municipalities in the vicinity of Luke Air Force Base. Political subdivisions must adopt plans and enforce zoning regulations to "assure development compatible with the high noise and accident potential generated by military airport operations." A.R.S. § 28-8481(A). Exhibit B-2 shows the Luke AFB "Airport Vicinity Map" identifying noise contours and territory in the vicinity of the base.

### **Zoning**

The majority of land in the study area is under the jurisdiction of Maricopa County and the existing zoning is Rural-43, defined as "Rural Zoning-1 Acre per Dwelling Unit." The purpose of Rural-43 zoning district is "to conserve and protect farms and other open land uses; to foster orderly growth in rural and agricultural areas; and, to prevent urban and agricultural land use conflicts." Principal uses permitted in this zoning district include both farm and non-farm residential uses, farms, and recreational and institutional uses. The land extending off both ends of the base runways are zoned AD-1 and AD-2, Airport Districts, created to protect people and infrastructure from the Luke Air Force Base operations. These areas are regulated by the 1978



**Legend**

- LUKE AFB BOUNDARY
- MAJOR FLIGHT TRACKS
- TERRITORY IN THE VICINITY OF A MILITARY AIRPORT
- HIGH NOISE OR ACCIDENT POTENTIAL ZONE
- NOISE CONTOURS
- CLEAR ZONE
- ACCIDENT POTENTIAL ZONE 1
- ACCIDENT POTENTIAL ZONE 2

\* LINE WIDTHS ARE GRAPHIC REPRESENTATIONS ONLY

**AIRPORT VICINITY MAP  
FOR LUKE AIR FORCE BASE**

THIS MAP FULFILLS THE STATUTORY REQUIREMENT ENACTED UNDER ARIZONA REVISED STATUTE 28-9482 AND 9483

AS OF 20020628

Military Zoning Ordinance, and the allowable uses are very restrictive with most requiring a Special Use Permit.

East of Litchfield Road, County zoning includes industrial and commercial zoning, as well as single family residential zoning and higher density multi-family.

### **Future Land Use**

Future land use in the study area is largely influenced by the Luke AFB operations. Adjacent to the Luke AFB, Glendale has designated all of the land in the vicinity of the base<sup>1</sup> as the *Luke Compatible Land Use Area (LUCU)* category (Glendale, 2002). Residential and other noise sensitive land uses, particularly those which include large gatherings of people, are discouraged in the LUCU. This land use category encourages the retention of agricultural uses and future industrial development. Following these uses, residential development is the next largest future land use. All of the future land uses are categorized in the Table B-3.

**Table B-3, Future Land Use**

<b>Land Use</b>	<b>Acres</b>	<b>Percent</b>
Luke Compatible Land Use Area	3,073.3	43.7%
Airport	2,158.4	30.7%
Residential     Single Family	1,296.9	18.4%
Multi-Family	80.9	1.1%
Commercial	93.4	1.3%
Industrial	281.0	4.0%
Office	4.3	0.1%
Open Space	20.9	0.3%
Other Employment	27.3	0.4%
<i>Total</i>	7,036.3	100.0%

<sup>1</sup> The Luke Compatible Land Use Area category designation is adjacent to Luke Air Force Base and is delineated by the 1988 JLUS 65 ldn noise contour created by military flight operations (Glendale, 2002).

## **Conclusion**

In 1941, at the time of Luke AFB's establishment, the base was far outside the urbanized area of Phoenix, surrounded by desert and agriculture. Today, the urbanized area of the Phoenix Metropolitan area has extended to Luke and beyond.

Land use in the vicinity of the base is still largely vacant or agriculture. Residential development to the east of Luke is characterized by small lots, while west of the base residential development is on large lots. The majority of existing undeveloped or agricultural land is zoned for low-density residential development. Future land use plans for the undeveloped area largely falls into Glendale's *Luke Compatible Land Use Area* land use category, which limits development to uses compatible with the continued operation of the base.

## **References**

Arizona Department of Commerce. 2003. *Arizona Military Regional Compatibility Project: Western Maricopa County / Luke Air Force Base Regional Compatibility Plan*. Arizona Department of Commerce Community Planning Department: Phoenix, AZ.

Glendale. 2002. *Glendale 2025: The Next Step, General Plan*. Glendale Planning Department: Glendale, AZ.

Litchfield Park. 2004. *Litchfield Park Zoning Map*. City of Litchfield Park: Litchfield Park, AZ.

Maricopa Association of Governments. 2000. *Existing Land Use*. Maricopa Association of Governments: Phoenix, AZ.

Maricopa County. 2003. *Zoning Ordinance*. Maricopa County Planning and Development Department: Phoenix, AZ.

## APPENDIX C

- Project Documentation
- Meeting Minutes and Contact Logs
- Site Visits
- Historic Photographs Depicting Luke AFB Flooding

# LUKE AFB OUTFALL - CANDIDATE ASSESSMENT REPORT

## KICKOFF MEETING

Thursday, May 19, 2004, 9:00 a.m.

City of Goodyear  
190 N. Litchfield Road

### AGENDA

#### I. WELCOME & INTRODUCTIONS -

#### II. REVIEW SCOPE OF WORK -

This project is for a Candidate Assessment Report (CAR) to develop the conceptual alternatives and plans for the preferred drainage facilities from Camelback Road to Luke AFB identified in the Loop 303 Corridor/White Tanks ADMP. The CAR will involve collection of the necessary documents and available data to establish the needs and necessity, identify fatal flaws, perform an alternative analysis and then make recommendations to the Flood Control District of Maricopa County (DISTRICT) and Luke Air Force Base (Luke AFB) for the proposed drainage facilities this project.

The Loop 303 Corridor/White Tanks ADMP identified a major channel to the southern end of Luke AFB. After performing internal analysis, this channel does not completely resolve the flooding hazarded identified on Luke AFB. Additionally, Luke AFB has requested that the DISTRICT perform additional studies to ensure the mitigation of the identified flooding hazards on Luke AFB under their March 19, 2004 letter.

#### III. REVIEW SCHEDULE -

A. Preliminary Schedule is Attached

#### IV. DOCUMENTS REQUIRED -

- A. Documents to be provided by the District -
- Digital Aerial Maps & Topography
  - Loop 303 Corridor/White Tanks ADMP Update
    - Future completely developed land use condition w/ project hydrology model
    - Hydraulic models
    - Conceptual designs for the project
  - Existing FEMA Studies and Models
  - October 2001 Flooding Report
  - Land Ownership Information for the Project Area
  - Electronic Assessors Form
- B. Luke AFB to provide -
- Proposed Plans and Planning Information with the Project Area
    - Litchfield Road Underpass
    - Munitions Area Road across Bullard Wash
    - Others?

#### V. SITE VISIT -

A. Immediately Following the Kickoff Meeting

Luke AFB Outfall Project Kickoff  
 May 20, 2004  
 Sign In Sheet

Person	Organization	Phone	Email
Linda Potter	HDR	602-522-4349	Linda.Potter@HDRINC.COM
DAVID BURAS	HDR	602-522-4334	DAVID.BURAS@HDRINC.COM
Mike Duncan	FCDMC	602-506-4732	mwd@mail.maricopa.gov
DAVE DEGERNESS	FCDMC	602-506-4730	DJD@mail.maricopa.gov
William Hays	FCD	506-5472	WH@ "
Cindy Doerter	FCDMC	—	—
BRIAN BARNES	GOODYEAR	623-693-7201	bbarnes@goodyearaz.gov
David Ramirez	Goodyear	623-882-7954	dramirez@goodyearaz.gov
Tom Hill	Sou Cor	802-390-2375	tomhill@primusnet.com
Richard Mousel	Luke AFB	623-856-3635	Richard.Mousel@luke.af.mil
Richard Zumbel	Luke AFB	623-856-6136	richard.zumbel@luke.af.mil
ZANE HOIT	Luke AFB	623-856-7634	zane.hoit@luke.af.mil
Gregory Jones	FCD	602-506-5537	GLJ@mail.maricopa.gov
Greg Rudzenko	Grendale	623-930-7923	grudzenko@grendale.com
Michael Jones	Maricopa County	602-506-8632	michaeljones@mail.maricopa.gov
JAMES L. NEWMAN	MARICOPA COUNTY	602-506-8325	JAMES.NEWMAN@mail.maricopa.gov
JOE DERUNGS	USACE	602 640 2021	JOE.V.DERUNGS@USACE.ARMY.MIL

**Luke AFB – Alternative Formulation – 28 May 2004 Meeting**

Depression at New Entrance

- Gravity
- Force Main

Water Cross at Litchfield

- Pick-up in storm drain
- Pick-up in channel

Water at Southern boundary

- Pick-up pump station outfall
- Collector Channel (150' easement)
- Storm Drain (150' easement)

Collector channel west of Bullard

Road Crossings at Bullard Ave and New Munitions Rd

Tie into new box at Camelback

Cut-off Channel in Litchfield to North

Route through Base

- Channel (at edge of ramp parking)
- Storm drain
- Cut corner

Verify 150' Easement

LUKE AFB OUTFALL CAR  
PROGRESS MTG. No 1

JUNE 17, 2004

<u>NAME</u>	<u>ORG</u>	<u>PHONE #</u>
DAVID BURTS	HDR	602-522-4334
Cathy Overton	FCMC	602-506-4695
MIKE DUNCAN	FCMC	602-506-4732
DAVE DEGERNESS	FCD	602-506-4730
Tim Montgomery	HDR	602-522-7700
Gregory Z Jones	FCD	506-5537

Subject: Progress Meeting No.1	
Client: Flood Control District of Maricopa County	
Project: Luke AFB Outfall Candidate Assessment Report	Project No: HDR 00000000014068 FCD 2003C018 Task 3
Meeting Date: June 17, 2004	Meeting Location: FCDMC
Notes by: David Buras	

## MEETING PURPOSE

To present and discuss progress to date, specifically the 4 preliminary alternatives, as well as several options within those alternatives. The hydrology for the alternatives and options was presented. There was a discussion about the pros and cons of each alternative and option. A recommended alternative was not be selected at this stage however. The objective was to get concurrence on which alternatives and options are most realistic and then move those 4 along for further study, i.e. sizing and costing of the facilities.

## ATTENDEES

See attached.

## MEETING AGENDA

See attached.

## DISCUSSION ITEMS

- Existing Conditions
  - FCDMC to provide additional floodplain information regarding the LOMR. Revise note to say something like "see Proposed Improvements Exhibit for LOMR floodplain"
  - Show LOMR floodplain on Proposed Improvement Exhibit.
- Proposed Improvements
  - Obtain design information on Dysart Drain from Don Rerrick.
  - Utility research to be added. Talk to Dan Sherwood and Greg Rodzenko at Glendale, Elliot Silverstein (371-1100) at URS, Zane Hoit at Luke AFB.
- Watershed Map
  - Add subbasins 202 and other subbasins that contribute to 193.
  - Difference between 1426 cfs and 450 cfs in subbasin 226 is the storage routing that occurs within 226, east of Litchfield Road.
  - 92'-93' flooding on the AFB with substantial dollar damage was the reason for Dysart Drain to be improved. Capacity had been restricted because of earlier subsidence.
- Alternative 1 – fatal flaw is the flooding that will occur at the future depressed area of Litchfield Road.

- Alternative 2 – drainage channel along south boundary could be unlined or lined. Unlined if 6:1 slope on base side, 2:1 on outside. Alignments shown are approximate. Grant Anderson (Goodyear) has agreed that a multi-use detention basin/park north of Camelback Road could work well for the Town.
- Noise contours around the base should be shown in the CAR.
- Qualitative costs to be discussed at next progress meeting.
- Alternative 4 – Infield graded areas to be evaluated.

## **DISTRIBUTED ITEMS**

- Spreadsheet summary of hydrology analysis
- Draft – Existing Conditions 11"x17" Exhibit
- Draft – Proposed Improvements 11"x17" Exhibit
- Plan/Profile of Proposed Litchfield Road Underpass (11"x17")
- Draft – Watershed Map 11"x17" Exhibit
- Draft – Alternative 1 "No Action" 11"x17" Exhibit
- Draft – Alternative 2A 11"x17" Exhibit
- Draft – Alternative 2B 11"x17" Exhibit
- Draft – Alternative 3A 11"x17" Exhibit
- Draft – Alternative 3B 11"x17" Exhibit
- Draft – Alternative 4 11"x17" Exhibit

## **SCHEDULED MEETINGS**

Next meeting will be Progress Meeting No.2. This meeting has not yet been scheduled, but is anticipated to be around July 8<sup>th</sup>, per the initial project schedule.

*These minutes reflect the understanding of HDR Engineering, Inc or it's representative. If revisions or additions are needed, contact either the distributor or David Buras.*

# LUKE AFB OUTFALL - CANDIDATE ASSESSMENT REPORT

## PROGRESS MEETING NO.2

Friday, July 9, 2004, 9:00 a.m.

City of Goodyear

### AGENDA

#### I. WELCOME AND INTRODUCTIONS

II. **PURPOSE** - The purpose of today's meeting is to select the preferred alternative from the several alternatives and options presented. The hydrology and pros and cons of each alternative will be presented and discussed. A recommendation by the consultant on a preferred alternative will be given. The objective is to get group concurrence on the preferred alternative that will be used in the candidate assessment report for 15% design.

#### III. PRESENTATION OF ALTERNATIVES

##### ALTERNATIVE 1 - "NO ACTION"

##### ALTERNATIVE 2A - PERIMETER-OPEN CHANNEL (NORTH)

- Drainage area east of Litchfield Road channeled north to Dysart Drain
- Earth channel along south edge of AFB
- Graded flowpath south of AFB to Camelback Road

##### ALTERNATIVE 2B - PERIMETER-OPEN CHANNEL (SOUTH)

- Drainage area east of Litchfield Road channeled south to Super Sabre
- Earth channel along south edge of AFB
- Graded flowpath south of AFB to Camelback Road
- Detention Basin north of Camelback Road

##### ALTERNATIVE 3A - PERIMETER-CLOSED CONDUIT (NORTH)

- Drainage area east of Litchfield Road piped north to Dysart Drain
- Storm Drain along south edge of AFB
- Graded flowpath south of AFB to Camelback Road

##### ALTERNATIVE 3B - PERIMETER-CLOSED CONDUIT (SOUTH)

- Drainage area east of Litchfield Road piped south to Super Sabre
- Storm Drain along south edge of AFB
- Graded flowpath south of AFB to Camelback Road
- Detention Basin north of Camelback Road

##### ALTERNATIVE 4 - ON-SITE

- Drainage area east of Litchfield Road channeled north to Dysart Drain
- On-site storm drain, drainage channel, on-line detention basins
- Graded flowpath south of AFB to Camelback Road

#### IV. DISCUSSION AND SELECTION OF PREFERRED ALTERNATIVE

## LUKE AFB OUTFALL QUALITATIVE ALTERNATIVE ASSESSMENT

	POTENTIAL FLOOD DAMAGE	COMPATABLE WITH FUTURE PROJECTS	INCONVENIENCE TO LUKE AFB OPERATIONS	RIGHT OF WAY	STORM DRAIN COSTS	DRAINAGE CHANNEL COSTS	DETENTION BASIN COSTS	QUALITATIVE COSTS
Alternative 1	-	-	0	0	0	0	0	UNACCEPTABLE
Alternative 2A	+	+	0	-2	0	-2	0	LESS COST
Alternative 2B	+	+	0	-2	0	-2	-1	MORE COST
Alternative 3A	+	+	0	-1	-2	0	0	LESS COST
Alternative 3B	+	+	0	-1	-2	0	-1	MORE COST
Alternative 4	+	+	-2	-1	-2	-1	-1	MODERATE COST UNACCEPTABLE

+ Positive (i.e. Potential Flood Damage Reduced)

0 Zero (i.e. Little or No Cost Impact)

- Negative (i.e. Potential Flood Damage Unchanged)

-1 Moderate Cost Impact

-2 Great Cost Impact

- V. CONSULTANT RECOMMENDATION - CLOSED CONDUIT TO DYSART DRAIN OPTION (3A) WITH OPEN CHANNEL ALONG SOUTH EDGE OF AFB OPTION (2A)



Subject: Progress Meeting No.2	
Client: Flood Control District of Maricopa County	
Project: Luke AFB Outfall Candidate Assessment Report	Project No: HDR 00000000014068 FCD 2003C018 Task 3
Meeting Date: July 9, 2004	Meeting Location: FCDMC
Notes by: Chris Payne	

## MEETING PURPOSE

To present and discuss progress to date, specifically the four alternatives, as well as options within those alternatives. The hydrology and hydraulics for the alternatives and each option was presented. The consultant's preferred alternative was presented. There was a discussion about the pros and cons of each alternative, and a preferred alternative was selected by the Project Team.

## ATTENDEES

See attached.

## MEETING AGENDA

See attached.

## DISCUSSION ITEMS

- Each of the following alternatives was presented and discussed: alternatives 1, 2A, 2B, 3A, 3B, and 4.
- Alternative 1 – No action alternative.
- Alternative 2A – Perimeter-Open Channel Alternative. An open channel would drain the depressed area as well as portions of watershed 201 and 226 to Dysart Drain along Litchfield Road. An open channel would also be located parallel to Super Sabre St. and would drain west to the Bullard Wash.
- Alternative 2B – Perimeter-Open Channel Alternative. An open channel would drain the depressed area and portions of watershed 201 and 226 south along Litchfield Road to Super Sabre Street. An open channel would then drain the water west along Super Sabre to the Bullard Wash.
- Alternative 3A – Perimeter-Closed Conduit Alternative. The option is identical to Alternative 2A, except the open channel is replaced with box culverts.
- Alternative 3B – Perimeter-Closed Conduit Alternative. The option is identical to Alternative 2B, except the open channel is replaced with box culverts.
- Alternative 4 – On-Site Alternative. This option is storm drain, open-channel system which collects and conveys storm water from Litchfield Road west to the infield area and south past Super Sabre Street to Bullard Wash. Several detention basins would be placed within the infield area and would drain into the system.

- Alternatives 2B and 3B would require a detention basin located north of the Camelback crossing to regulate flow through the proposed box culvert. For Alternatives 2A, 3A, and 4, a retention basin could be placed for multi-use purposes only.
- A qualitative cost analyses for each alternative was presented and discussed.
- The consultant's preferred alternative was presented and discussed. This alternative consists of a hybrid of alternatives 2A and 3A. A closed conduit would run north along Litchfield Road to the Dysart Drain, and an open channel would begin west of Litchfield Road parallel to Super Sabre Street and would drain to the Bullard Wash.
- It was noted that an earthen channel along the southern edge of the base along Super Sabre may raise security concerns or maintenance problems. The ease of maintenance and less right-of-way needs for a concrete channel along Super Sabre should be evaluated along with an earthen channel with more right-of-way. Security, cost, and maintenance should be included in the evaluation.
- Luke expressed an idea to make the channel along Super Sabre a multi-use facility with a possible running path next to the channel. FCD noted that all such multi-use improvements paid by the District would have to be open to the public, not just for base personnel. Idea to be evaluated and discussed further.
- The hydrology and hydraulics of the Dysart Drain and the surrounding area was discussed. The proposed depression at Thunderbird would be owned and operated by the City of Glendale. The need of a pump station or gravity drain for the depression as well as raising the depression several feet was discussed. Any direct discharge to the Dysart Drain would first have to go through an oil/water separator.
- Base area subsidence was discussed. Greg Rodzenko from Glendale has current information on subsidence for the area and will provide HDR with copies of the information. Subsidence should be taken into account in any design.
- FCD noted that improvements along Bullard wash may be needed all the way to Camelback. Currently, ponding occurs north of Camelback and this must be taken into account in any design.
- A discussion of the affect the hybrid alternative would have on the floodplain took place.
- All parties agreed that the hybrid alternative is preferred and will be developed further.

## DISTRIBUTED ITEMS

- Draft – Alternative 1 “No Action” 11”x17” Exhibit
- Draft – Alternative 2A 11”x17” Exhibit
- Draft – Alternative 2B 11”x17” Exhibit
- Draft – Alternative 3A 11”x17” Exhibit
- Draft – Alternative 3B 11”x17” Exhibit
- Draft – Alternative 4 11”x17” Exhibit
- Draft – 1 copy of Luke AFB Outfall CAR Working Draft to FCDMC only

## SCHEDULED MEETINGS

There will be a site visit on Wednesday July 14<sup>th</sup>, 2004 at 8 am for all interested parties. The next meeting will be Progress Meeting No.3. This meeting has not yet been scheduled, but is anticipated to be around August 2<sup>nd</sup>, per the initial project schedule.

*These minutes reflect the understanding of HDR Engineering, Inc or it's representative. If revisions or additions are needed, contact either the distributor or David Buras.*

# LUKE AFB OUTFALL - CANDIDATE ASSESSMENT REPORT

## PROGRESS MEETING NO.3

Monday, August 2, 2004, 3:30 p.m.

City of Goodyear

### AGENDA

#### I. WELCOME AND INTRODUCTIONS

**II. PURPOSE** - The purpose of today's meeting is to present the final draft alternative. The final draft alternative is a refined version of the preferred alternative that was selected at Progress Meeting #2. Essentially, the preferred alternative was field verified, and refinements were prepared based on refined hydrology and actual field conditions. Once presented, the final draft alternative will be detailed in the candidate assessment report, including design drawings prepared to a 15% level of completion.

#### III. PRESENTATION OF THE FINAL DRAFT ALTERNATIVE

- ALTERNATIVE DESCRIPTION
- ALTERNATIVE EXHIBIT
- WATERSHED MAP
- COST ESTIMATE

#### IV. SCHEDULE



Subject: Progress Meeting No.3	
Client: Flood Control District of Maricopa County	
Project: Luke AFB Outfall Candidate Assessment Report	Project No: HDR 000000000014068 FCD 2003C018 Task 3
Meeting Date: August 2, 2004	Meeting Location: FCDMC
Notes by: Dave Buras	

## MEETING PURPOSE

The purpose of the meeting was to present the final draft alternative. The final draft alternative is a refined version of the preferred alternative that was selected at Progress Meeting #2. Essentially, the preferred alternative was field verified, and refinements were prepared based on refined hydrology and actual field conditions. Once presented, the final draft alternative will be detailed in the candidate assessment report, including design drawings prepared to a 15% level of completion.

## ATTENDEES

See attached.

## MEETING AGENDA

See attached.

## DISCUSSION ITEMS

- Aesthetic and multi-use opportunities for the project are limited to the earthen channel south of the munitions area.
- Improvements will be included to assure that Drainage Area 201 (north of Lightning Street) will positively drain to Dysart Drain, not to the onsite storm drain system.
- The cost estimate should be revised to include;
  - 1) Provisions for water quality treatment of "first flush" flows from areas with large amounts of pavement in their contributing areas.
  - 2) The concrete box culvert crossing of the proposed future munitions road. This may or may not end up being a project cost, depending on the IGA to be reached between the District and Luke AFB.
  - 3) Provisions for upgrades to the existing onsite storm water pump station, to evacuate the onsite storm drain system quicker, because the outfall capacity of the Super Sabre channel will be much greater than that of the ditch that outfalls across Litchfield Road.

## DISTRIBUTED ITEMS

- Final Draft Alternative 11"x17" Exhibit (Preliminary)

## SCHEDULED MEETINGS

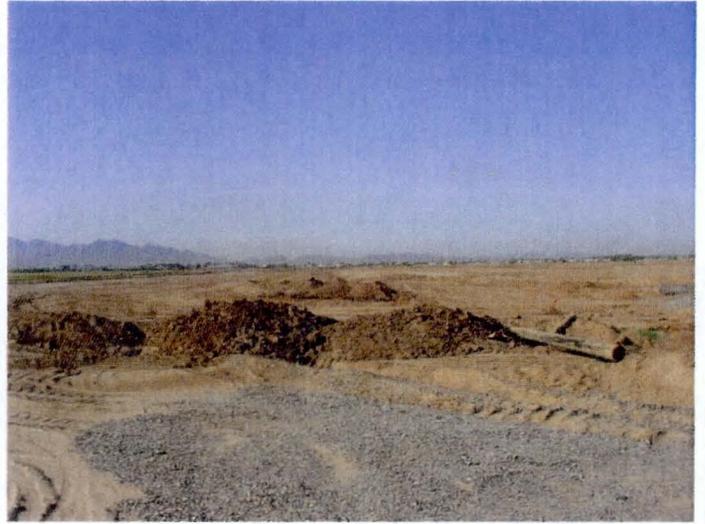
This Progress Meeting No. 3 was the last team meeting. The draft Candidate Assessment Report (and 15% plans) will be submitted to the District for review on August 17<sup>th</sup>, with comments to be received by August 24<sup>th</sup>. Final submittal will be August 31<sup>st</sup>.

*These minutes reflect the understanding of HDR Engineering, Inc or it's representative. If revisions or additions are needed, contact either the distributor or David Buras.*

Luke AFB Site Visit Photographs 6/25/04



1) Camelback Rd. at proposed RCBC facing southwest



2) Camelback Rd. at proposed RCBC facing south



3) Camelback Rd. at proposed RCBC facing north



4) Camelback Rd. at proposed RCBC facing north; elevation marked on side of road

Luke AFB Site Visit Photographs 6/25/04



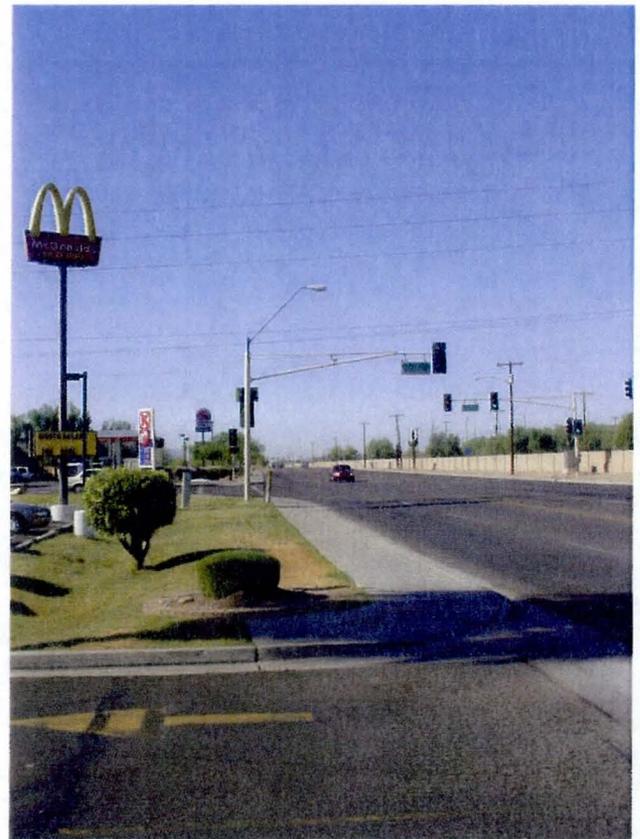
5) Litchfield Rd facing northwest; wash outlet onto Litchfield Rd south of Luke AFB



6) Litchfield Rd facing east; housing subdivision on the opposite side of the road from wash outlet (picture 5) where water overflows road

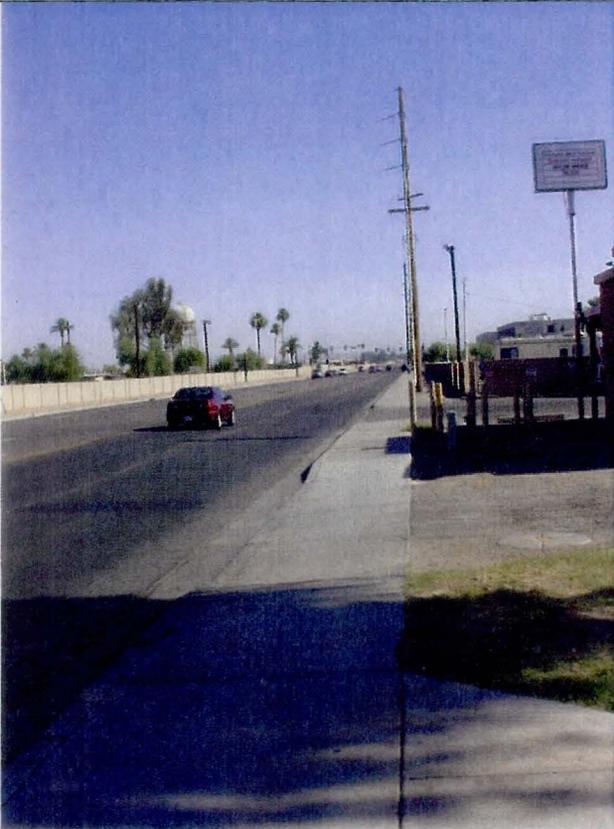


7) Litchfield Rd facing south drainage on the opposite side of the road from picture 5



8) Litchfield Rd. facing south; intersection of Glendale Rd.

Luke AFB Site Visit Photographs 6/25/04



9) Litchfield Rd. facing north; intersection seen in distance is Thunderbird Rd.



10) Litchfield Rd. facing north; intersection is Thunderbird Rd.

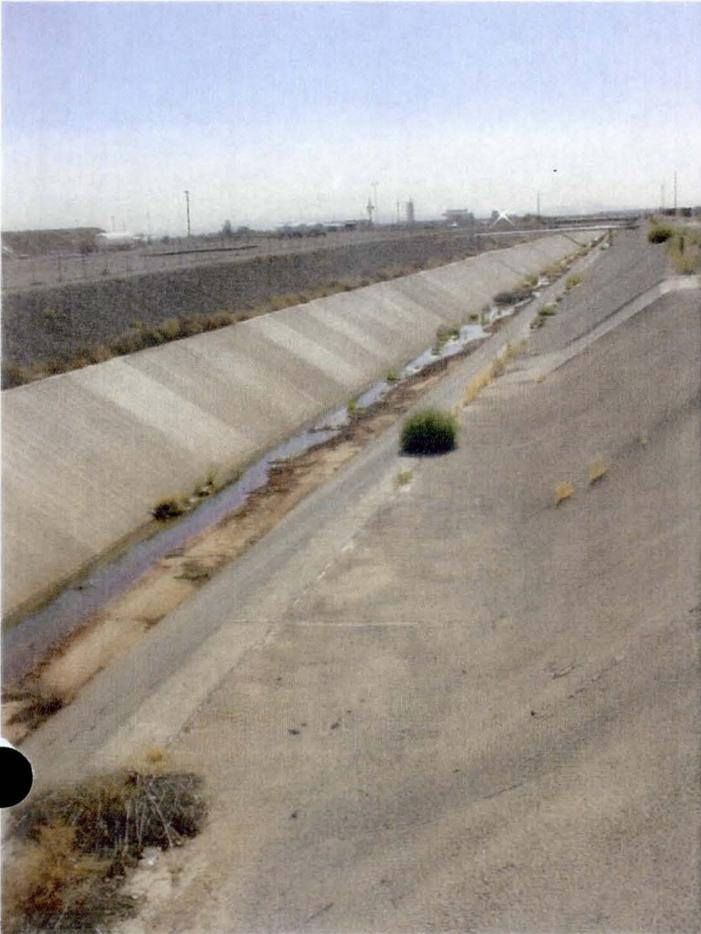


11) Litchfield Rd. near Lightning Rd. intersection facing south; Dysart drain passing under Litchfield Rd.



12) Litchfield Rd. near Lightning Rd. intersection facing east; Dysart drain passing under Litchfield Rd.

Luke AFB Site Visit Photographs 6/25/04



13) Dysart Rd. facing east; Dysart drain passing under Dysart Rd. (salt facility on left of channel)



14) Dysart Rd. facing west; Dysart drain passing under Dysart Rd.

Historic Photographs depicting LAFB Flooding



Slide 236 - LAFB 1992-1993 (no other info)



Photo 1-5 - Litchfield Road and Northern, Luke Field, 1951

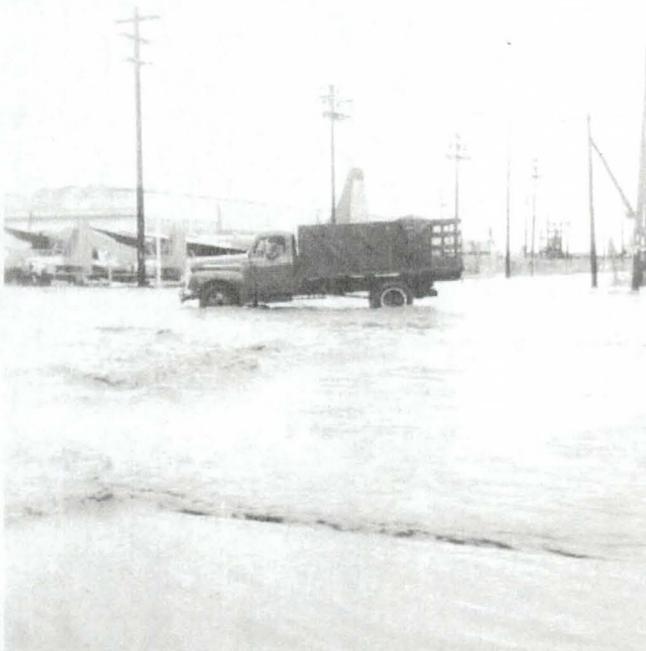


Photo 1-6 - Luke Field near flight line, 8/1951

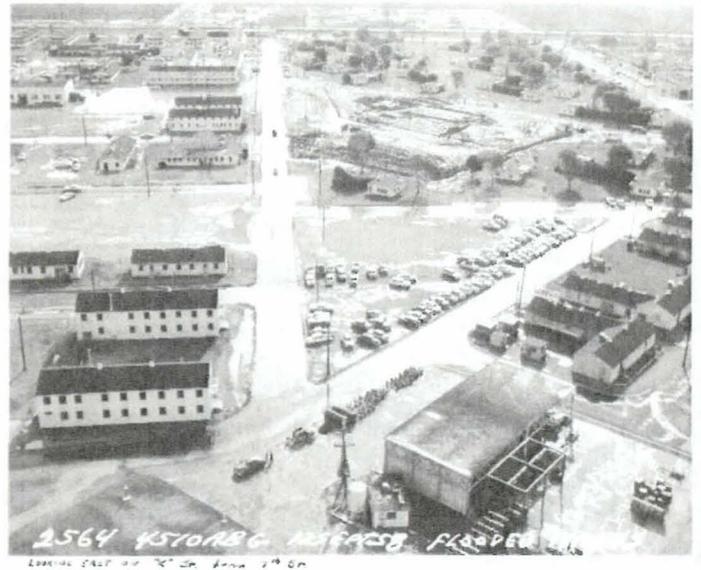


Photo 2-11 - Luke AFB - 8/1951

Historic Photographs depicting LAFB Flooding

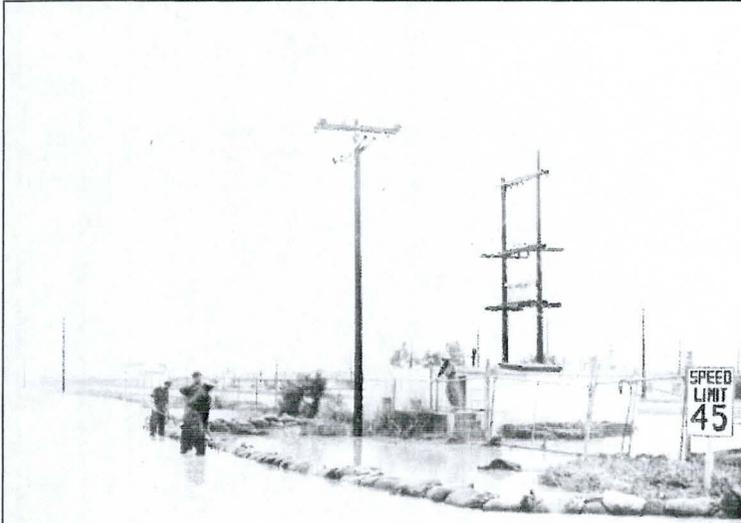


Photo 2-18 - Luke AFB - Sand bagging to keep flood water out of pumping plant - 1951



Photo 7 - Luke AFB, looking east on K Street from 7th Street (Dale Creek Channel Flooding), 1958