Bethany Home / Grand Canal Flood Control Project

Pre-Design Study
Volume I

September 2000

DMJM
Daniel, Mann, Johnson, & Mendenhall

Pre-Design Study

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Bethany Home/Grand Canal Flood Control Project

Bethany Home Outfall Channel, Phase II

Project No. 98-46

Prepared for:
Flood Control District of Maricopa County
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Project No. 98-46

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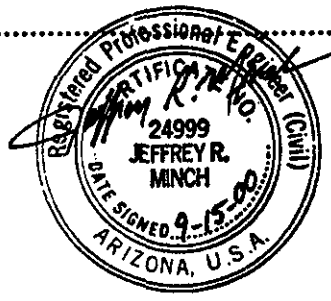

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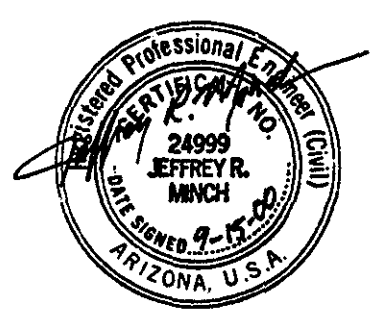

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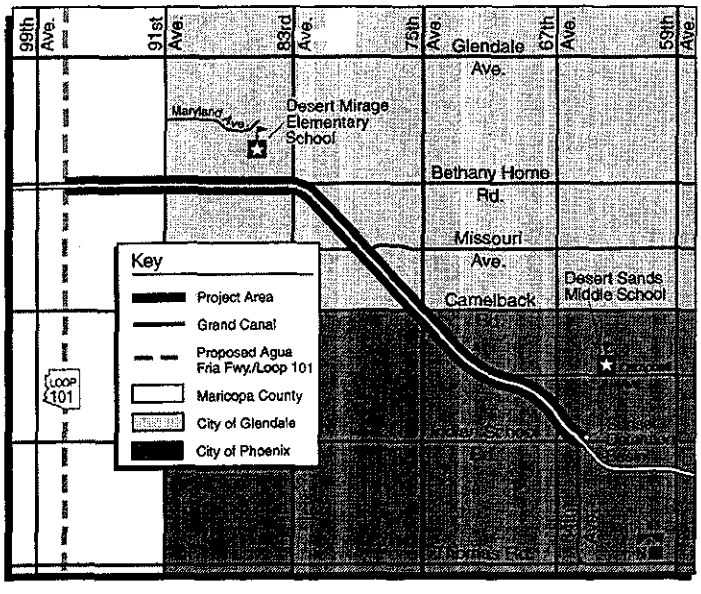
I. Executive Summary

A. Overview

The purpose of the Bethany Home / Grand Canal Flood Control Project (BH/GC FCP) project was to evaluate alternatives for mitigating flooding problems adjacent to the Grand Canal, Bethany Home Road and Camelback Road between the Sunset Detention Basin at 64th Avenue and Indian School Road to the Loop 101 Freeway. The Project Team was to develop a recommended solution, utilizing the input of the community. The selection of the recommended alternative was to be based on impact to the community, opportunities for multi-objective uses, land use, zoning, right-of-way and/or easements, maintenance and operations, safety, utilities, future drainage connections, hydraulic performance, constructability and cost. Upon funding commitments by the Flood Control District of Maricopa County (FCD), the City of Phoenix and the City of Glendale, the recommended alternative will be advanced to final design and the preparation of construction documents.

Executive Summary Figure – Project Area



B. Background

The FCD completed the Maryvale Area Drainage Study and Flood Mitigation Study (Maryvale ADMS) in November 1997. During the ADMS process, the District developed a concept to mitigate this regional flooding problem by constructing the Bethany Home Outfall Channel (BHOC). The BHOC project was conceived as an open U-shaped concrete lined channel from approximately 97th Avenue to 73rd Avenue with a linear detention basin from 73rd Avenue to 67th Avenue, both adjacent and north of the Grand Canal. The concept developed reflected an estimated construction cost of $12.9 million, with right-of-way and relocation costs of $8.3 million. These estimated costs did not include the Bethany Home Road or Camelback Road storm drain systems.

Daniel, Mann, Johnson, & Mendenhall (DMJM), under contract with the Arizona Department of Transportation (ADOT), developed the preliminary design for the Agua Fria Freeway from Northern Avenue to Interstate 10 (I-10). During the preliminary plan development, it was identified that the freeway would have to be protected from off-site overland stormwater flows. The original concept to protect the freeway was to intercept the 100-year off-site flows along the east edge of the freeway and route them south to the Grand Canal alignment. The proposed channel (Bethany Home Outfall Channel, Phase I) paralleled the Grand Canal from approximately the 97th Avenue alignment west, carrying stormwater to the New River.

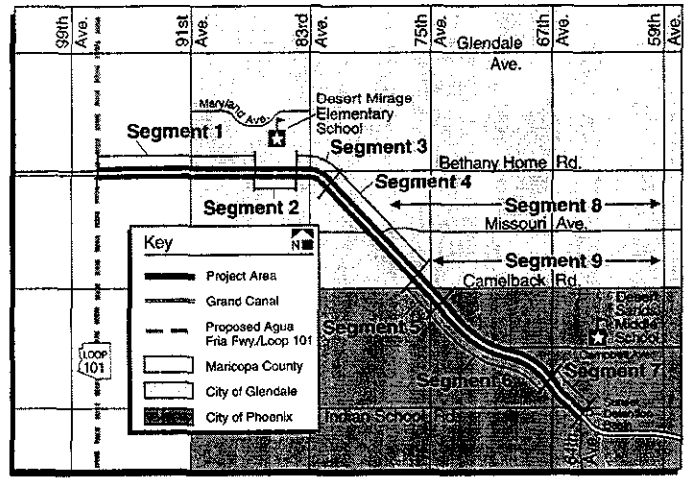
In 1999 the Engineering Consultant Team of DMJM was hired to investigate alternative methods of conveying floodwater along the Grand Canal based on jurisdictional boundaries. The Pre-Design study expanded on the original Maryvale ADMS solution and investigated various typical cross-sections for the Bethany Home Outfall Channel facility. Only slight modifications to the originally defined corridor were considered, namely between the 87th Avenue alignment and 83rd Avenue. Each alternative investigated was to be evaluated to define the BH/GC FCP and to determine a community friendly solution. The FCD directed the Project Team to pay particular attention on how the project would affect the adjacent neighborhoods.

C. Methodology

The study area delineated the region in which data collection would occur. The focus corridor highlighted the length of the project, from Sunset Detention Basin to the Loop 101 Freeway and a 1000-feet north and east of the Grand Canal. The focus corridor was broken into 9 segments. Similarities of local land uses, rights-of-way, easements, topography, tributaries, major circulation patterns, etc. determined the segments. Data collection was primarily applied to the focus corridor. Detailed surveys and aerial mapping assisted the Project Team in establishing a control line for the project. Information such as hydrology and channel alternatives were input into and developed within hydrologic, hydraulic and civil engineering software programs such as HEC-1, Flow Master and InRoads. Cost estimates, project communication and matrices for the evaluation procedures were performed using Microsoft Office.

These above mentioned computer software programs allowed the Project Team to keep a detailed record of all information gathered and generated.

Executive Summary Figure – Project Segment



D. Engineering Design Criteria

Design Criteria for this project were compiled from FCD standards, city criteria and federal guidelines:

- The 100-year peak discharge flows (Q) were determined by procedures outlined in the FCD the *Drainage Design Manual of Maricopa County.*
- Landscape guidelines were primarily adapted from the FCD Policy for the Aesthetic Treatment and Landscaping of Flood Control Projects, 1992.
- Safety guidelines were developed as an amalgamation of judgements made by the community, the FCD and the Project Team.
- Erosion design criteria focused on the minimization of erosion throughout the channel/conveyance system
- Maintenance guidelines were established using engineering judgement and Project Team evaluations.
- Alternative channel cross-sections resulted from discussions between the Project Team, the FCD, the City of Phoenix, the City of Glendale and the community.
- Roadway/traffic elements were based on meetings and discussions with the City of Phoenix, the City of Glendale and roadway classification design standards.
- Bridge/drainage structures were based on standard engineering practices, ADOT and AASHTO standards

E. Hydrologic Modeling Overview

DMJM updated the Maryvale ADMS hydrologic model for current land use in the contributing watershed and incorporated the Bethany Home Road storm drain and the Agua Fria Freeway as the base condition. DMJM then investigated 4 alternatives that provide varying levels of flood protection. The systems were to achieve

the following objectives based on city corporate boundaries due to the uncertainty associated with matching funding for the project:

- 100-year level of protection for Glendale and Phoenix,
- 100-year level of protection for only Glendale,
- 10-year level of protection for only Glendale, and
- 100-year level of protection for Glendale and Phoenix extended to the Sunset Detention Basin.

The last alternative was included to identify the feasibility of increasing the 10-year level of protection provided by the Sunset Detention Basin to a 100-year level of protection. The Sunset Detention Basin is located northeast of the Grand Canal and south of Indian School Road at the southeast end of the study corridor. DMJM also investigated potential 10-year storm drain systems in Camelback Road, and both Camelback Road and Missouri Avenue.

Early in the project DMJM identified that connecting the Bethany Home Road storm drain to the BH/GC FCP exceeded the ADOT IGA discharge of 2,200 cfs at the Agua Fria Freeway. After reviewing 5 potential detention basin sites, the 91st Avenue basin site, located between 91st Avenue and the 87th Avenue alignment on the north side of the Grand Canal, was selected to mitigate the Bethany Home Road storm drain.

All 100-year systems assumed a detention facility between 73rd Avenue and 67th Avenue. This detention basin is referred to as the Maryvale Detention Basin (MDB). The Maryvale ADMS determined that it was not cost effective to provide a 100-year level of protection without the MDB.

F. Environmental Overview

The FCD contracted with Western Technologies, Inc. (WT) to perform a Phase I, Environmental Site Assessment for the BH/GC FCP. WT's project included the assessment of 100-foot corridors paralleling the north and south banks of the Grand Canal beginning at Indian School Road and ending at the Loop 101 Freeway. Based on WT's evaluation of the collected data, WT concluded that this assessment revealed no evidence of recognized environmental conditions in connection with the project. However, 5 sites were identified as potentially requiring further evaluation.

The City of Glendale determined that accepting irrigation return flows (i.e., field drains) into the BH/GC FCP does not violate their National Pollution Discharge Elimination System (NPDES), Phase I, Storm Water Discharge Permit. However, since construction activities for the project will disturb more than 5 acres, a Storm Water Pollution Prevention Plan (SWPPP) will be required. DMJM also determined that a 404 Permit was not required for the construction of this project.

G. Geotechnical Overview

ATL, Inc. (ATL) performed the preliminary geotechnical investigation for the Bethany Home/Grand Canal Flood Control Project. In general, ATL's scope of work was to perform 3 borings to depths of 20-feet below existing ground. The borings were located at the intersections of Bethany Home Road and 83rd Avenue, Camelback Road and 75th Avenue and Indian School Road on the north side of the Grand Canal. Soil samples were obtained from these borings and various tests were performed to determine the general soil profiles that might be encountered within the range of planned construction excavation depth for the proposed channel alignment. At the 2 southern boring locations, the soil pH and resistivity was considered corrosive for uncoated metal pipe. Consolidation of the soils was possible at the intersection of 75th Avenue and Camelback Road. In general, no swell potential was identified at the 3 boring locations.

ATL anticipates that dewatering of the excavation will be required when the excavation extends below the Grand Canal, or about 12-feet below grade. ATL recommended that the contractor be prepared to sheet and shore canal side excavations since dewatering activities can create local areas of subsidence if water was drained from coarse grained, granular soils. The contractor may have to be prepared to over-excavate wet soil

and replace it with a granular material that will allow water to flow without substantial movement. ATL also indicated that concrete lined channels may require more sophisticated soil drainage systems than the typical weephole and filter fabric against what was probably lean clay in the top 5 to 10-feet of the subgrade.

H. Alternative Plans

Alternative plans consisted of 3 elements: the cross-section, the horizontal alignment and the profile. The vertical alignments, or profiles, were created based on the feasible channel depth due to utility location, surface materials, erosion potential and existing longitudinal slope. This information combined with the peak flow rate and channel roughness coefficient was used to determine stormwater velocities. The velocity and depth of the channel and were determining factors in the development of the channel cross-sections. Numerous channel cross-sections were developed based on the design criteria. Each cross-section was applied to 1 or more segments. Various combinations of alignments and cross-sections were applied. By mixing and matching horizontal alignments and cross-sections the Project Team was able to evaluate 31 100-year flood and 26 10-year flood scenarios (The 10-year scenarios were developed for only Glendale). These studies were documented under separate cover as the initial alternative plans (Appendix H).

I. Evaluation of Alternatives

The alternative plans were evaluated against a series of weighted issues developed by the participating agencies and the public during the public involvement process. In addition, the Project Team developed a list of technical issues that were weighted and included in the evaluation process. The evaluation process applied a score to each of the issues that was multiplied against the weight, or importance. The Evaluation Team objectively evaluated each of the alternatives and developed a table of the segment, location, cross-section and alignment that scored the highest.

A cost estimate for each segment and alternative was generated to assist in the evaluation of technical issues (See Executive Summary Table – Draft Results from Matrix Evaluation). The lowest cost alternatives, for each segment, were added to determine the lowest construction cost possible and the highest construction costs were added to determine the maximum cost based on the design scenarios. Costs including; design, construction, utilities, traffic control, right-of-way acquisition and relocation, demolition and landscape were developed for the cost estimates. The cost estimates did not represent a final design construction amount, but provided a comparative project total cost.

Executive Summary Cost Evaluation Table

Segment	Location	Highest Estimate (in Millions)	Type of Conveyance Facility (Cross-Section)	Lowest Estimate (in Millions)	Type of Conveyance Facility (Cross-Section)
1	Loop 101 to 87th Ave. Alignment	$8.64	Grass-lined Trapezoidal Channel / Low Flow Pipe	$7.60	Grass-lined Trapezoidal Channel /Low Flow Channel
1A	91st Ave. Crossing	$1.27	Clear Span Bridge	$1.08	Box Culvert
2	87th Ave. to the Grand Canal	$10.78	Box Culvert South of Grand Canal	$4.53	Vertical Concrete Channel North of the Grand Canal
3	83rd Ave. Crossing	$1.00	Clear Span Bridge	$0.56	Box Culvert

Segment	Location	Highest Estimate (in Millions)	Type of Conveyance Facility (Cross-Section)	Lowest Estimate (in Millions)	Type of Conveyance Facility (Cross-Section)
4	Grand Canal to 75th Ave.	$13.70	Grass-lined Trapezoidal Channel / Low Flow Pipe	$7.68	Vertical Concrete Channel
5	75th Ave./ Camelback Rd. Crossing	$2.44	Box Culvert at the Flood Mitigation Study Alignment	$2.22	Box Culvert at Grand Canal
6A	Camelback Rd. to 73rd Ave.	$6.86	Grass-lined Trapezoidal Channel / Low Flow Pipe	$1.46	Vertical Concrete Channel
6B	73rd Ave. to 67th Ave.	$30.32	Box Culvert	$11.83	Grass-lined/ Low Flow Pipe
6C	67th Ave. Crossing	$0.45	Clear Span Bridge	$0.43	Box Culvert
7	67th Ave. to Indian School Rd.	$5.89	Grass-lined Trapezoidal Channel / Low Flow Pipe	$1.79	Box Culvert
7A	Indian School Rd. Crossing	$0.27	Clear Span Bridge	$0.21	Box Culvert
9	Camelback Storm Drain	$6.03	Storm Drain	$6.03	Storm Drain
Total		**$87.65**		**$45.42**	

J. Recommended Alternative Development

Once the matrix evaluation process was completed the Project Team presented the finding to the FCD, the City of Phoenix and the City of Glendale for review and comment. Generally, the matrix recommended alternatives were accepted as satisfactory solutions. However, two of the matrix evaluation selections, for Segments 2 and 6, required additional investigations after the matrix evaluation.

The City of Glendale believed that the matrix outcome for Segment 2 would not be well received by the property owners north of the Grand Canal. After meeting with these residents, the City of Glendale requested that the BH/GC FCP alignment be relocated to south of the Grand Canal within Segment 2. Subsequent meetings with the property owner to the south, resulted in the selection of a trapezoidal grass-lined channel with 6:1 (horizontal to vertical) side slopes south of the Grand Canal. The average depth of the channel would be 12' with a 40' bottom width. This alternative (S2A20) would require approximately 230' of right-of-way south of the Grand Canal and around the south side of the SRP Welborn Substation.

The City of Phoenix and the FCD were concerned about the matrix evaluation outcome for Segment 6. The highest-ranking cross-section, the box culvert detention facility, scored only five points higher than the natural grass-lined detention basin. The two cross-sections both displaced the same number of homeowners, but the box culvert scored higher in safety, aesthetics and multi-use opportunities. The significant difference between the two alternatives was in the cost. The box culvert was nearly three times more expensive to construct than the open grass-lined channel detention basin ($30 million vs. $12 million). The FCD and the City of Phoenix

did not believe that the benefits gained by placing the detention basin underground merited a $18.5 million construction increase. Therefore, the FCD and the City of Phoenix agreed that the recommended alternative for Segment 6 reflect and open grass-lined detention basin.

A large portion of the recommended alternative was planned as an above grade natural channel. The similarity between segment cross-sections will help simplify segment transitions and the landscape themes. The visual continuity of the project will help enhance the feeling of the open space and the trail linkages.

K. Recommended Alternative

The Recommended Alternative was generally well received at the 3rd and final Public Meeting for the Pre-Design Study (See Executive Summary Table – Recommended Alternative). Since no changes were made as a result of the public meeting, the Pre-Design Study engineering plans were completed and are presented under separate cover (Appendix H).

The BH/GC FCP is a necessary improvement to the West Valley drainage system and will improve the overall effectiveness of the existing drainage system by providing an outlet to the New River. The initial cost estimate for the 100-year design for the Recommended Alternative was determined to be approximately $54.6 million. The constructed project will remove the floodplain designation from 745 structures, therefore eliminating the need for flood insurance. A total of 75 structures (2 in Segment 2, 1 in Segment 4 and 72 in segment 6) were identified for acquisition to construct the Recommended Alternative. The FCD will assist each of the residents with the relocation process and pay fair market value for each of the properties identified for acquisition.

Executive Summary Table – Recommended Alternative

Segment	Location	Type of Conveyance Facility (Cross-Section)	Approximate. ROW Width Required	Estimate (in Millions)
1	Loop 101 to 87th Ave. Alignment	Grass-lined Trapezoidal Channel/Low Flow Channel	230 to 300-feet	$7.65
1A	91st Avenue Crossing	Clear Span Bridge	NA	$1.36
2	87th Ave. to the Grand Canal	Grass-lined Trapezoidal Channel South of Grand Canal	230-feet	$8.99
3	83rd Ave. Crossing	Clear Span Bridge	NA	$1.12
4	Grand Canal to 75th Ave.	Box Culvert	NA	$10.73
5	75th Ave./Camelback Rd. Crossing	Box Culvert	20-feet	$2.06
6A	Camelback Rd. to 73rd Ave.	Vertical Concrete Channel	25-feet	$1.28
6B	73rd Ave. to 67th Ave.	Grass-lined Trapezoidal Detention Basin	Varies	$12.74
6C	67th Ave. Crossing	Box Culvert	NA	$0.48
7	67th Ave. to Indian School Rd.	Box Culvert	20-feet	$1.78

Segment	Location	Type of Conveyance Facility (Cross-Section)	Approximate. ROW Width Required	Estimate (in Millions)
7A	Indian School Rd. Crossing	Box Culvert	NA	$0.39
9	Camelback Storm Drain	Pipe Culvert	NA	$6.08
Total				**$54.66**

L. Conclusion

Upon approval by the FCD and the cities of Phoenix and Glendale of the Pre-DesignStudy, DMJM will begin final design. Final design of the project will take approximately one year to complete. The final design process will include but is not limited to construction plan and specification development, utility coordination, final cost estimating, FEMA Conditional Letter of Map Revision (CLOMR) documentation, landscape planning and design and public involvement. The final design will accommodate 100-year floodwaters within the flood control facility from the Loop 101 to the Sunset Detention Basin.

The construction will be phased over several years, starting at the Loop 101 Freeway and progressing east. The Glendale portion of the project is funded. In March of 2001, the City of Phoenix will hold a bond election that will provide funding for the Phoenix share of the project cost. The public will be updated by means of meetings and/or newsletters throughout the development of the project.

II. Introduction

A. Project Purpose and Need

The Grand Canal is a large irrigation channel with banks that are raised several feet above adjacent ground in some locations. During large storm events, water ponds against the north and east bank of the Grand Canal and floods adjacent properties. This was not a problem when the area was farmland, but as the area developed it resulted in the flooding of homes and businesses and the potential for even greater flooding during large storm events. Several years ago the Federal Emergency Management Agency (FEMA) designated a floodplain containing 598 structures along the north side of the Grand Canal between Camelback Road and 67th Avenue. Property owners who mortgage or refinance a home/business in this floodplain are required to pay flood insurance at a cost of $250 to $500 per year. The FCD and the City of Phoenix are currently constructing the Sunset Detention Basin to help reduce flooding in the area of 64th Avenue and Indian School Road.

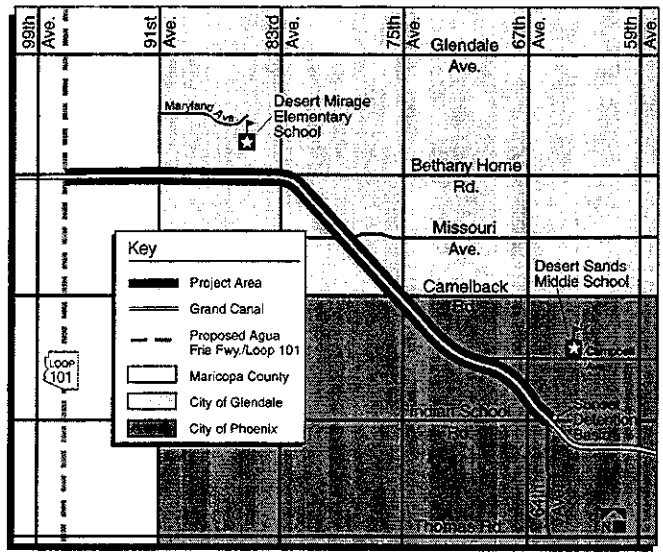
Several areas in Glendale, including several neighborhoods and downtown, experience street and local flooding from nearly every storm event. Glendale built retention basins to protect some of these areas and planned a storm drain along Bethany Home Road. This project will provide an outlet to the New River for the city's storm drains.

The FCD has studied these regional-flooding problems and suggested solutions. An efficient way to capture and move stormwater safely through and out of the area was the purpose of this study. Once a conveyance system is completed, local storm drains can be constructed to minimize local flooding.

B. Project Description

The BH/GC FCP project area extends along the Grand Canal between the Loop 101 Freeway and the Sunset Detention Basin, located at 64th Avenue and Indian School Road (See Figure 1). The Project Team broke the project area into 9 segments. The characteristics differ distinctly between the segments adjacent to the Grand Canal. Each segment was studied and analyzed for the flood control solution that best fits that segment's flood control, neighborhood, and community needs. In addition, storm drain construction was investigated along Bethany Home Road, Missouri Avenue and Camelback Road between the Grand Canal and 59th Avenue.

Figure 1 – Project Area



C. Background

In February 1997, the Flood Control District of Maricopa County (FCD) completed the Maryvale Area Drainage Master Study (ADMS). The purpose of the study was to identify and locate the flood prone areas within the study boundary. The study area was approximately 100 square miles in size and included portion of the cities of Peoria, Glendale, Avondale, Tolleson, Phoenix, and unincorporated Maricopa County. The study limits went from Interstate 10 (I-10) on the south to the Arizona Canal on the north, and from Interstate 17 (I-17) on the east to the Agua Fria and New Rivers on the west. One of the flood prone areas that was identified was along the north and east bank of the Grand Canal (See Figure 2).

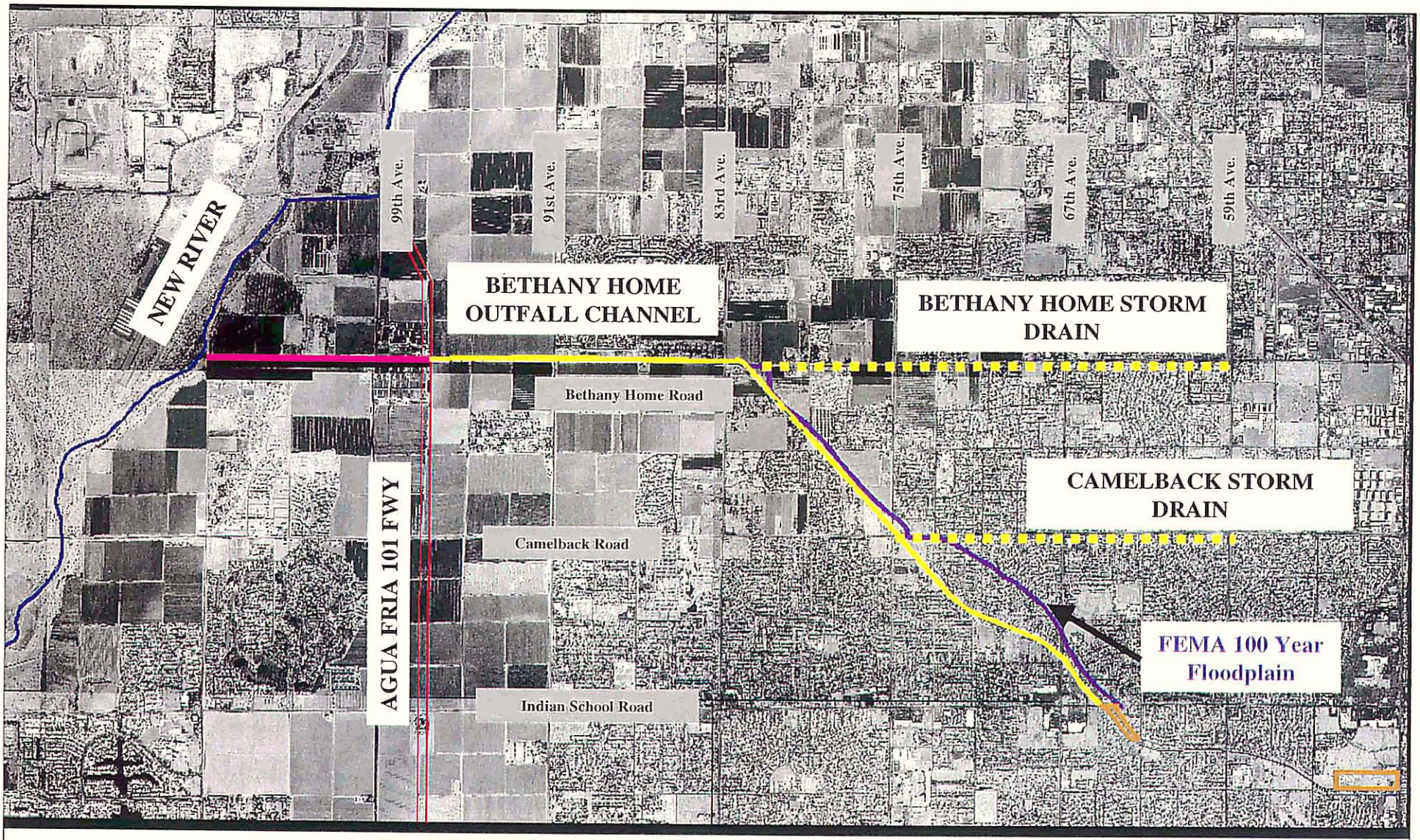
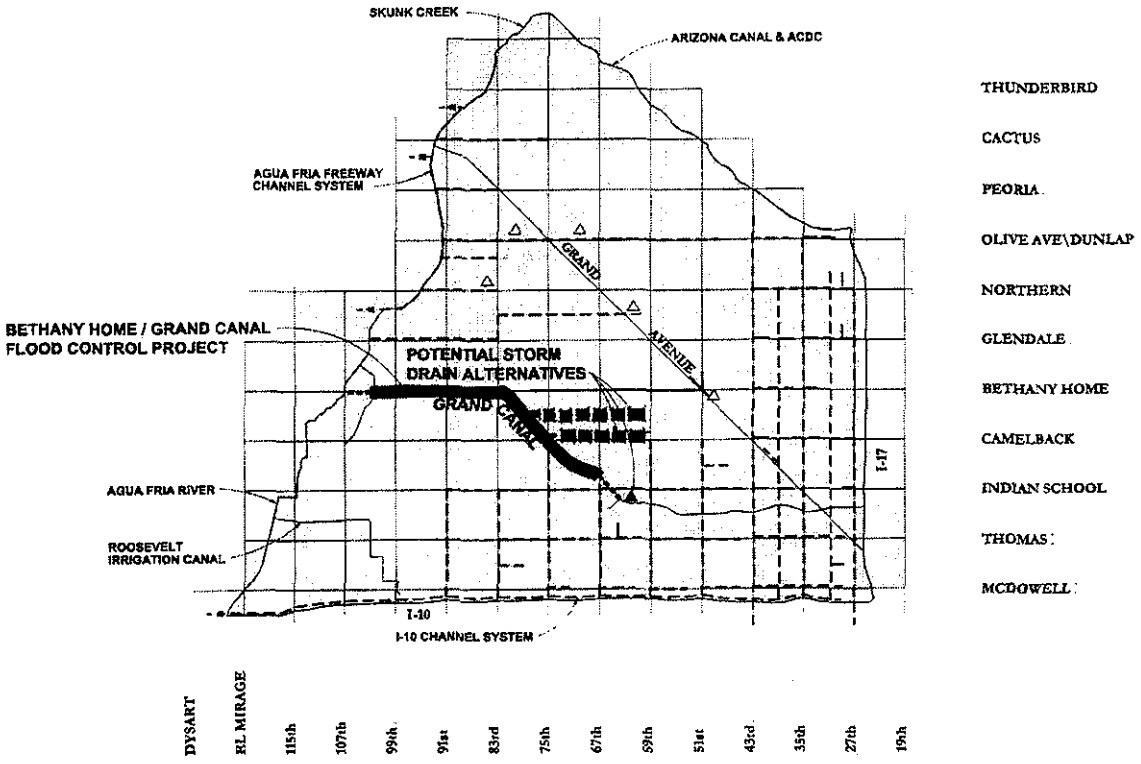


Figure 2 - 100-Year Flood Plain

A second study, the Maryvale Area Floodplain Mitigation Study, was completed in November 1997 for the District. The purpose of this study was to identify and evaluate feasible mitigation options for each of the flood prone areas identified in the initial study. After identifying and evaluating the mitigation options, the most viable options were recommended for further evaluation. A drainage feature along the north and east side of the Grand Canal was identified as the option to be evaluated further for mitigating flooding adjacent to the Grand Canal. This drainage feature, which outlets into the New River at the Bethany Home Road alignment, was referred to as the Bethany Home Outfall Channel (See Figure 3).

Figure 3 – Regional Drainage



DMJM, under contract with the Arizona Department of Transportation (ADOT), developed the preliminary design for the Agua Fria Freeway (Loop 101) from Northern Avenue to I-10. During the preliminary plan development, it was identified that the freeway would have to be protected from off-site overland flows. The original concept to protect the freeway was to intercept and route the 100-year off-site flows south to the Grand Canal alignment. The Bethany Home Outfall Channel (BHOC) Phase I was proposed to parallel the Grand Canal from approximately the 97th Avenue alignment west to the New River.

An Intergovernmental Agreement (IGA) was developed between ADOT and the FCD in 1998. This document defines that the State will design and construct the BHOC from the Loop 101 Freeway to the New River. The document further stated that the BHOC would be constructed at a capacity that will serve the freeway drainage as well as potential floodwaters from the surrounding region. The FCD funded the additional costs incurred by the State for right-of-way, design, construction, engineering and additional structures associated with enlarging the BHOC, to convey the FCD's desired 2200 cubic feet per second (cfs) flows.

In June of 1999, the FCD initiated the Bethany Home/Grand Canal Flood Control Project (BH/GC FCP) in co-operation with the cities of Glendale and Phoenix to define and design the recommended solution based on public input. Daniel, Mann, Johnson & Mendenhall (DMJM) were retained by the FCD to perform the

BH/GC FCP. DMJM in coordination with Logan Simpson Design, Inc., Collins-Pina, and ATL, Inc. assisted the FCD and the cities in the public involvement program, preparation of the Pre-Design Study, and development of construction documents for the recommended alternative.

The BH/GC FCP developed alternatives and a recommended solution to minimize flooding adjacent to and north of the Grand Canal. The project limits were located between the Loop 101 Freeway, currently under construction at approximately 97th Avenue at the Bethany Home Road alignment, to the Sunset Detention Basin at Indian School Road and 64th Avenue. In addition, storm drain construction was studied along Bethany Home Road, Missouri Avenue, Camelback Road and between the Grand Canal and 59th Avenue. The project also reduced the potential for flooding in downtown Glendale by providing an outlet for the city's storm drain systems.

In April of 1999, the FCD initiated a Memorandum of Understandings (MOU) between the FCD, the City of Phoenix and the City of Glendale to summarize the intent and cost sharing aspects of the project (See Appendix A). Upon completion of the Pre-Design Study, the FCD, the City of Phoenix and the City of Glendale will develop an IGA that defines all responsibilities and commitments regarding the cost responsibilities, final design, construction and maintenance of the project. A bond issue, to be voted on in the spring of 2001, will fund the City of Phoenix portion of the project. The City of Glendale already has bonding capacity available for their portion.

III. Methodology

A. Pre-Design Study Methodology

The multi-discipline Project Team, working in an interactive format, identified potential conflicts, impediments and issues at the onset of the project. Addressing these issues up-front allowed the Project Team to concentrate their efforts on problem solving and the feasibility of previous flood control concepts. The multi-discipline approach addressed flood control, local drainage, land use, utilities, right-of-way, structures, traffic, landscape, recreation and the public participation process. This cohesive approach allowed the team members to prevent missed opportunities, subsequent redesign and construction dilemmas. The key, to the design development, public participation and the outcome of this report, was the accuracy and thoroughness of the data collection.

B. Data Collection

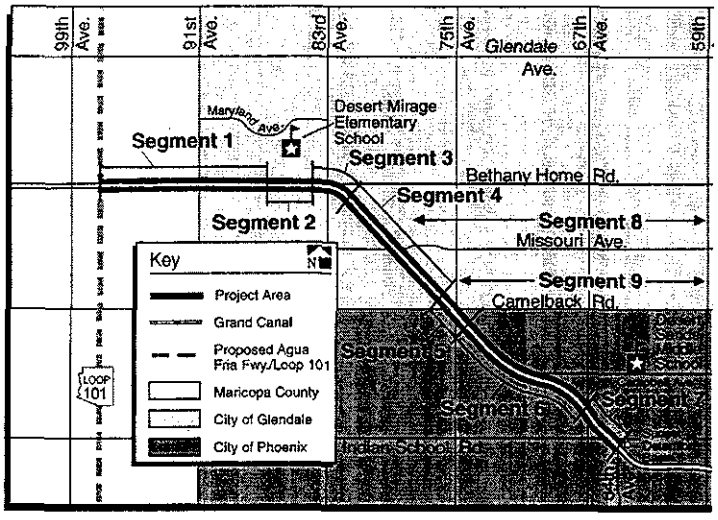
The research process allowed the Project Team to become familiar with the existing conditions and demographics within the study area. The data collection materials helped highlight the key points within the community and aided the public in understanding the facts regarding the existing flooding and how it related to their neighborhoods, from the past to the present. The majority of the data collection effort took place during the first 4 to 6 weeks of the project. It was comprehensive in nature. Information was obtained through site surveys, record searches, interviews, phone calls, written correspondence and other various forms of research. A database was developed to document all the information collected for the project (See Appendix B).

C. Segments

The first step in the data collection process was to understand the project corridor and parameters. To better focus the Project Team's effort, and the necessary data needed, the corridor was divided into 9 segments (See Figure 4). Areas of similar characteristics defined the segments, as did physical features that create obvious subsets (See Table 1). These segments provided the Project Team the ability to study different needs within each segment, collect specific data and conduct field surveys.

During the course of the project some of these segments were further subdivided depending upon adjacent land use and roadway crossings. Segment 1A was defined as the 91st Avenue road crossing of the proposed facility. Segment 6 was subdivided into three sub-segments.

Figure 4 – Project Segments



Segment 6A was that portion of Segment 6 from Camelback Road to 73rd Avenue. This subdivision permitted more careful consideration of the adjacent radio tower facility. Segment 6B was defined at the linear detention basin from 73rd Avenue to 67th Avenue. The 67th Avenue road crossing was independently defined as Segment 6C. Segment 7 was subdivided into the conveyance system from 67th Avenue to Indian School Road and Segment 7A was defined as the Indian School Road crossing.

Table 1 – Project Segments

Segment	Location	Opportunity	Constraints	Comments
1	97th Ave. to 87th Ave.	Recreational; aesthetic; landscaping; equestrian access to the Sun Circle Trail; existing BMX track; retention for adjacent properties; integrate open space into adjacent development.	BHOC Phase I; SRP tailwater; SRP laterals; SRP well site; sanitary sewer; equestrian access; transformer relocation; unlined Grand Canal; telephone; existing retention; tiered basins; storm drain outfalls; local street inflow; traffic control.	Incorporate existing retention facility; create community amenity; existing ROW varies from 66 feet. to 94-feet.
2	87 Ave. to 83rd Ave.	Potential Grand Canal realignment alternatives; provide equestrian access to Agua Fria; buffer channel from homes.	Equestrian properties; SRP tailwater; SRP substation; power lines; property takes; underground telephone; fence relocation; tree compensation; political representation.	Significant ROW costs; potential closed conduit alternative; cut and cover alternative; ROW varies from 94-feet. to 98-feet.
3	83rd Ave. & Bethany Home Rd.	Negotiate retention for agricultural property to the north; realign Bethany Home Rd.; enlarge existing linear retention facility; incorporate recreation; landscape; and aesthetics.	Agricultural property; commercial property; 6-foot elevation difference; retaining walls required; T-intersection; SRP tailwater; SRP irrigation; SRP irrigation facilities south of the Grand Canal; SRP well site; maintenance ramps; new waterline project.	Potential basin site; roadway improvements from COG; canal ROW varies; Bethany Home Rd. 66-foot. ROW.
4	Bethany Home Rd. to Camelback Rd.	Incorporate facility into new development; off-line detention; reduce size of down stream facilities.	Power transmission poles; SRP well site; existing retention; original farm headquarter; possible environmental clearance; existing sewer within existing grassed areas; tot lot; linear retention; multi-purpose trail; HOA; pedestrian safety; drainage siphons under Grand Canal.	Safely incorporate facility into new development; COG owns existing retention basins and trails; canal ROW is 80-feet.

Segment	Location	Opportunity	Constraints	Comments
5	75th Ave. & Camelback Rd.	Off-line basin-site; recreational; connection between communities.	SRP substation; SRP well site; existing duplexes; existing radio towers; existing floodplain; existing sanitary sewers in Camelback and 75th Avenue; environmental impacts; new planned development; outfall for new storm drain on Camelback Rd.	Proposed linear detention in channel; potential to reduce crossing size with structural design.
6	Camelback to 67th Ave.	Recreation; aesthetic; landscaping; existing 16-foot. and 20-foot alleys	Public perception; existing structure total takes; existing sanitary sewer system; pedestrian bridge for school access; drainage siphons under Grand Canal; 8-foot. grade difference between SRP maintenance road and land to the north.	Consider alternative configurations to minimize takes; potential to utilize downstream vacant properties to detain flows; canal ROW averages 80-feet; 16-foot drainage parcel.
7	67th Ave. to Indian School Rd.	Increase flood protection provided by Sunset Basin	Limited ROW; alley garbage collection & utility access; church parking lot; 16-foot. alley available; SRP and COP coordination.	Provide outfall for Sunset Basin that would possibly provide 100-year protection; must minimize disruption to utilities in alley.
8	Missouri Ave. Storm Drain	Mitigate local flooding	Varying ROW; houses fronting onto the road; interruption of 2 school circulation patterns.	Mitigate the size of the Camelback Road Storm Drain.
9	Camelback Rd. Storm Drain	Mitigate local flooding	Twin sanitary sewer lines at outfall to facility; collection system; traffic control during construction.	Need to mitigate downstream flooding.

D. Mapping and Surveying

Initial alternatives used existing topographic mapping and photography, flown in March 1994 for the Maryvale ADMS. The field survey and aerial mapping performed on this project are consistent with FEMA requirements and standard procedures. The field survey procedures utilized conventional survey methods for establishing control of the horizontal plane and vertical differential leveling. The survey data provided information pertinent to the development of the study area and final design. Aerial mapping utilized the survey control data to verify the location and elevations of existing points on the ground plane. The survey included approximately 300-feet on either side of the Grand Canal, Camelback Road from 75th Avenue to 59th

Avenue and Missouri Avenue from the Grand Canal to 59th Avenue. The results of the field surveys will be used to produce mapping for the final design.

The Results-of-Survey are included with the alternative plans (Appendix H, under separate cover). The datum used for the survey is the National Geodetic Vertical Datum of 1929. A conversion factor is provided for the North American Vertical Datum of 1988. The survey could not define a consistent relationship between the project vertical datum and the City of Glendale vertical datum.

E. Hydrology

DMJM followed the hydrologic modeling and calculations procedures outlined in the Drainage Design Manual for Maricopa County, Volume I, Hydrology, Revised January 1995. The FCD's DDMS computer program was used to develop the hydrologic models (HEC-1). Specific hydrologic modeling techniques used included:

- Rainfall Excess – Green and Ampt methodology was used for the estimation of all rainfall losses.
- Unit Hydrograph – The Clark method was used to generate excess storm water runoff.
- Time of Concentration – The Papadakis method was used in conjunction with the Clark unit hydrograph.
- Channel Routing – Normal depth methods.
- Reservoir Routing – Modified Puls reservoir routing method.

F. Hydraulics

DMJM utilized procedures outlined in the Drainage Design Manual for Maricopa County, Volume II, Hydraulics, January 1996, for all hydraulic calculations. Manning's roughness coefficient or "n" value was determined for the different types of conveyance systems using standard FCD values. All channel sections were designed for subcritical flow conditions with a Froude number of less than 0.85. Supercritical flow conditions will be considered during final design for closed conduit systems. The hydraulic analyses for channel and roadway crossing alternatives used the FlowMaster and HY-8 computer programs to determine the required dimensions for the various channel, roadway crossing and box culvert sections. The Haestad Methods StormCAD program was used to calculate the hydraulic grade line and size the proposed storm drains. Minor loss coefficients for hydraulic structures were based on the FCD design manual, calculated independently, and entered manually into the StormCAD program.

G. Cross-Section Development

The development of alternative channel cross-sections were the result of discussions and conversations between the Project Team, the FCD, the City Phoenix, the City of Glendale and the community participants. Initially there were 15 channel cross-sections developed. The field was narrowed to 6 for the alternative evaluation process. The 6 channel cross-sections evaluated were: a box culvert; a vertical walled concrete lined; a concrete trapezoidal; a grass-lined channel with a low flow concrete trickle channel, a grass-lined channel with a low flow conduit and 2 box culverts, 1 for the Grand Canal and 1 for the BH/GC FCP channel.

H. Evaluation of Alternative Plans

During the public involvement process the citizens of Glendale and Phoenix each developed a top 10 issues list. The lists were similar, but not identical. The Project Team added 7 technical issues to the evaluation matrix. The technical issues were the same for both cities and represented issues that the Project Team found to be critical to the success of the project.

The evaluation process required that scoring criteria be developed for each issue so that Alternative Plans could be judged for compliance with the public's desires. Each of the issues was broken into 5 scoring

categories with 5 being the highest score and 1 being the lowest. In some cases only a score of 5 and 1 were used because the answer was clearly a yes or a no. The score given to each alternative issue was then multiplied against the weight, or importance, and the total score for each alternative was calculated. The technical issues were given appropriate weights in relation to the public issues and project priorities. The public's issues were both ranked and weighted based on the questionnaire responses. The Project Team used this evaluation process and scoring to define the matrix recommended alternative.

I. Evaluation of Roadway Crossings

Various circulation patterns, access routes for fire, police, bus, street classifications, traffic data and interviews with city traffic departments were compiled during the data collection phase to establish the need and requirement for roadway crossings. The road crossings evaluated for this project included 91st Avenue (Segment 1), 83rd Avenue (Segment 3), 75th Avenue and Camelback Road (Segment 5), 67th Avenue (Segment 6) and Indian School Road (Segment 7). Culvert systems that were evaluated for each segment included reinforced concrete boxes (RCBC), bridges, and reinforced concrete pipes for the 100-year storm events in both Phoenix and Glendale. Glendale also requested that 10-year solutions be developed from Camelback Road to the west.

Segment 5 alignments, at Camelback Road and 75th Avenue, included a culvert system parallel to the existing Grand Canal and a second alignment around the existing Salt River Project (SRP) Grasmoen substation located at the northeast corner of the intersection. The road crossing alignments for the remainder of the crossings were established by assuming the most extreme transition between adjacent segment alternatives. In many cases, this condition resulted in a skewed bridge or box culvert crossing. All skewed crossings with the exception of Indian School Road (Segment 7) were skewed at 5-degree increments for consistency with ADOT structure standards. The RCBC crossings were proposed for the full right-of-way width to allow for meandering of sidewalks. The bridge crossings were proposed for the road section width only.

Pavement replacement limits were established by using a typical trench width for both RCBC's and bridges. The trench width was established by taking the width of the proposed structure, adding an additional 3-feet and projecting a 1.5:1 slope from the invert to existing ground. Culvert system transitions of 2:1 and 4:1 (horizontal to vertical) were used for the inlet and outlet structure transitions, respectively. A maximum 150-foot transition was used for outlet structures.

J. Maintenance of Traffic During Construction

The evaluation or ranking of alternatives must include construction impacts to the local street system. Due to current circulation patterns, alternative routes available, access for fire, police and emergency vehicles to the local communities, it was imperative that major arterial streets impacted by the project remain open during construction.

The ability to maintain traffic on the arterial streets during construction was evaluated based on the ability to maintain at least 1 lane in each direction of travel during construction. Those alternatives that can provide more than the minimum number of lanes during construction ranked higher.

Alternatives were also evaluated in terms of temporary road closures required during construction. Alternative alignments or construction techniques that minimize or eliminate road closures were considered during final design.

Construction impacts to adjacent signalized intersections were also assessed for each alternative. Each alternative was evaluated to determine if the construction would require traffic control that would restrict movements at adjacent signalized intersections. Alternatives with alignments that do not impact the adjacent signalized intersections will be ranked higher than alternatives that effect intersection operations.

K. Utilities

The utilities investigation task on this project included the collection and compilation of all utility plans, profiles and other information from the various private; commercial, local government entities and agencies to identify the potential impact of channel and storm drain alternatives on existing utilities. To determine which utilities were in the project area, contact was made with local utility companies:

- Salt River Project Irrigation
- Salt River Project Power (69kV and 12kV)
- Cox Communications
- Southwest Gas Engineering Department
- US West Communications
- American Telephone and Telegraph Company
- Arizona Public Service, Inc.
- City of Phoenix Water & Wastewater Department
- City of Glendale Engineering Department
- Flood Control District of Maricopa County

Upon compilation of all the utility information, DMJM developed a CADD as-built base file. This base file was referenced to every alternative investigated to identify potential conflicts. Potholing of existing utilities to verify horizontal and vertical locations was performed to assist the Project Team in the identification of potential conflicts or assist in establishing the profile constraints for alternatives studied.

L. Cost Estimates

Unit costs for channel construction; utility relocation, landscaping, right-of-way acquisition and easements, relocation of structures, operation and maintenance, engineering and construction administration were obtained and/or developed for each alternative. The costs were based on several different sources:

- Flood Control District of Maricopa County Bid Tabulations on recent similar construction contracts
- ADOT Construction Costs (1999)
- Project Team, COP and COG experience on similar projects
- Involved utility companies
- Operation and Maintenance records for the FCD
- Appraisal, land acquisition, relocation and severance data from the FCD along the Focus Corridor
- Real estate sales data by location land use and parcel number from public records provided by the FCD.

Quantities were developed for each alternative and segment using the output from MicroStation, In-Roads, the Alternative plans and engineering judgement applied to the unit cost data. Costs for landscaping and aesthetic features were based on the Project Teams interpretation of FCD policy. Additional features that each city may propose along the multi-purpose corridor have not been included in the project cost estimates since they have yet to be defined. Some of these additional features might include security lighting, trash receptacles, street furniture and water fountains.

M. Socio-Economics

The socio-economic condition of a city, neighborhood or block face may be determined by analyzing a number of different factors such as real estate statistics, crime statistics, zoning violations and complaints, census tract information, visual analysis and property appraisal. For the purpose of this report the Project Team conducted a general conditions windshield survey (See Appendix C). A general condition windshield survey is a broad based visual analysis method used to classify neighborhood blocks. Professionals such as: planners, engineers, real estate brokers and architects drive, walk and study maps of an area, analyzing the segments or blocks based on a set list of criteria. The segments within the Bethany Home / Grand Canal Flood Control Project were broken into block faces and studied by design professionals based on the following criteria:

- Quality of the buildings and lots
- Stability and maintenance of the area
- Land use compatibility or incompatibilities
- Loss of housing stock and it's impact on sales and revenue within the community
- Cohesive or continuity of the neighborhood
- Loss of employment opportunity (taking of commercial property).

After each block face was studied based on the above criteria, a ranking system was applied to determine the overall quality of each neighborhood block face. A block face was judged based on which category best fit its description. The higher the grade (1 being the highest), the more importance is placed on preserving the neighborhood and minimizing impacts. The following was the ranking system that was used:

1. *Stable / Preserve*
   - The buildings have been developed or upgrade to current building standards.
   - The infrastructure and character of the area is stable and of good quality.
   - There are no incompatible land uses.
   - The taking of housing would impact the quality of the neighborhood
   - There is no loss of employment

2. *Preserve / Upgrade*
   - The majority of the buildings were developed or upgraded to current building standards.
   - The area requires some public and private upgrades to remain stable.
   - There are a few incompatible land uses or deviations in zoning compliance.
   - The taking of housing would minimally impact the quality of the neighborhood
   - There is no loss of employment

3. *Rehab / Transition*
   - Private property was not constructed to current standards
   - The area requires major maintenance and infrastructure improvements

- There is a mix of incompatible land uses
- The taking of buildings would eliminate some existing blight
- There is a potential for loss of employment

4. *Transition/ Redevelopment*
   - The private buildings do not meet current code and are beyond rehabilitation
   - Redevelopment of the area or transition to alternate uses is required
   - New development may require a change in zoning
   - The taking of buildings would be positive
   - There is a loss of employment

5. *Vacant / New*
   - The land is primarily vacant
   - General site clean-up is required
   - New development may require a change in zoning and the General Plan
   - There are no buildings in use
   - There is no employment at risk

N. Maintenance and Operations

Upon completion of the construction, maintenance activities will be the responsibility of the cities. During the course of the project, the Project Team met with the representatives of the city's engineering, parks and recreations staff to identify the Cities maintenance policies and established a customized set of design and maintenance criteria for the BH/GC FCP. Alternatives considered and selected for evaluation took these maintenance and operations issues into consideration.

The choice of cross section utilized and the choice of materials used can have a significant effect on operations and maintenance. A concrete lined channel would attract graffiti, while a wide grass-lined swale avoids graffiti, but requires on-going maintenance. The ease of maintenance, for a project such as the Bethany Home / Grand Canal Flood Control Project, is critical for future operations. Maintenance, access points, and circulation patterns were reviewed and commented on by the Project Team. By creating simple maintenance traffic flow and regularly spaced access points, maintenance divisions could use existing equipment and man power in an effective and efficient manner.

O. Rights-of-Ways and Easements

The acquisition of new rights-of-way and/or easements can be a major cost item associated with a project. The land acquisition costs were collected and carefully evaluated to determine the impact on the alternative plans and eventually the recommended alternative. As each alternative was developed, the rights-of-way requirements were minimized as much as possible. The parcels were identified using tax assessor's data, filed plats, legal descriptions, survey data, and City quarter section maps. In addition, SRP irrigation right-of-way plans were collected for the Grand Canal. The property boundaries and roadway right-of-way were calculated based on survey control and placed in a CADD database. Average values for various types of property and improvements were developed based on recent sales data that compared a ratio of assessed value to full market value of each property. An additional cost for moving and relocation expenses and severance was also included based on FCD standards and supplied data.

P. Development of Alternative Plans

The Alternative Plans were developed through an interactive effort involving the West Valley community, the City of Glendale, the City of Phoenix, the FCD and the Project Team. Through the public involvement process, valuable input was accumulated regarding pertinent issues and goals. Internally, the FCD and Project Team studied numerous horizontal alternative and channel cross-sections. Selected cross-sections and alignments were reviewed and commented on by the public, the FCD, the City of Phoenix and the City of Glendale. For each of the nine segments, 15 cross-sections were originally considered, with the feasible ones developed in more detail. Ultimately, 57 total conveyance alternatives were selected between the 9 segments for initial plan development. The initial design was created at 1-inch equals 100-feet on the ADMS base mapping.

Alternative channel cross-sections were then applied to each of the 9 segments within each alternative. The alignments, cross-sections and existing corridor information was input into "InRoads", a civil design software program. The program combined each of the contributing factors creating test channels for each of the segments. The final output of the InRoads program was limits of construction, design profiles, cross-sections, earthwork and quantities.

The InRoads references files were shared with MicroStation for further graphic enhancement and input of additional information such as the requirements for additional rights-of-way, easements, maintenance roads, trails, roadways and alley modifications. Once complete, the alternative plans were studied by the FCD, the City of Phoenix, the City of Glendale and the Project Team using the matrix evaluation process.

Q. Matrix Evaluation

The matrix evaluation process was a method in which to evaluate a design based on numerically scored issues. The Project Team developed a spreadsheet that organized the top 10 public issues for each city as well as 7 technical issue. The issues were weighted to assist in emphasizing the importance (1 the lowest and 5 the highest) of each issue. The top 10 public issues, for each city, were weighted by the importance given to the issue from the public. The Evaluation Team consisted of 2 project engineers, 2 project planners, 1 to 2 City representatives and 1 to 2 FCD representatives. The Matrix Evaluation Team evaluated each alternative based on each issue and assigned a base score. The base score was then multiplied by the weight to determine the issue score. The issue scores were summed to determine the alternative score. The highest alternative score for each segment was submitted to the FCD, the City of Phoenix and the City of Glendale for review.

R. Recommended Alternative

The recommended alternative selection was based on the matrix evaluation process outcome, a review of the matrix, and on supplemental information as needed. The FCD and the cities were given the power to override the matrix and select a different alternative based on further review of the information gathered after the matrix preparation. If the FCD or the City decided to override the matrix selection the matrix spreadsheet and was not altered in anyway. Changes due to overrides by the FCD or the City were made at an administrative level and are documented in the report (See Section X, Recommended Alternatives).

S. Coordination and Public Information

A comprehensive public information and coordination program was developed for the Bethany Home/Grand Canal Flood Control Project (BH/GC FCP). Documentation of the program is included in Appendix D. The goals of the public involvement plan was to: coordinate team members; minimize time, and maximize results; identify community groups that would like to participate in the design development process; hold a series of public forums to gather community input and gain project support. The public process was invaluable in the formulation of the alternative plans, identification, ranking, weighting and evaluation of the alternatives and in the selection of the recommended plan.

1. *Public Meetings*

The involvement of the public in the design process was extremely important. Three sets of 2 public meetings were held throughout the study to seek input, share information, gain acceptance and support. Graphic illustration of concepts and ideas was a very important tool used at the public meetings. These same graphics were also scanned and placed on the FCD Website (www.fcd.maricopa.gov) as well as used in this report. Any information or comments gathered at the public meetings were included in this report and placed on the FCD Website (See Appendix D).

a) Public Meeting #1

The first in the series of public meetings occurred on consecutive nights in August. The meetings were held at Desert Sands Middle School (in Phoenix) on August 25, 1999 and Desert Mirage Elementary School (in Glendale) on August 26, 1999. The Agenda Included:

- Introductions
- Project Purpose
- Opportunities and Constraints
- Community Input and Prioritization of Issues

The second half of the meeting was held in an open house format. The open house format allowed for the discussion of the questionnaire and the review of the 9 segments.

The handouts, presentation outline, questionnaire, questionnaire responses, questionnaire tabulation sheets, flooding photographs provided by a local citizen, and the comments recorded from the community and the meeting sign-in-sheets were documented.

b) Public Meeting #2

Public Meeting No. 2 was held on October 20 and 21, 1999 to gather public input and receive comments on the Preliminary Alternatives that were shown at the meeting. Over 84 people attended the meetings. A short presentation preceded the open house format. The presentation consisted of:

- Historical Overview
- Results of the Initial Public Issues and Prioritization Process
- Explanation of the Open House Format and Graphic Displays
- Graphic displays of the cross-sections and horizontal alternatives that would be studied in the Alternative Plans

An informal question and answer open house followed the presentation. Those attendees that did not get to fill out a questionnaire and participate in the community issues prioritization at t public meeting #1 were given the opportunity to do so. Based on the questionnaires received the project's top 10 community issues were identified.

c) Public Meeting #3

The 3rd and final series of public involvement meetings for the BH/GC FCP Pre-design Study were held to present the recommended alternative prior to final design. The public meetings were held on consecutive nights, July 18, 2000 at the Christ Presbyterian Church (located in Phoenix) and July 19, 2000 at the Glendale City Hall (located in Downtown Glendale). Approximately 65 people participated on the first night and 16 on the second. Presentation boards depicting the recommended alternative were displayed around the room and numerous Project Team members including; the FCD, the City of Phoenix, the City of Glendale, SRP and DMJM, were available to answer questions.

2. *Publications*

The FCD of Maricopa County uses a number of different methods of contacting the public and keeping them informed regarding on-going and up-coming projects. The FCD added a BH/GC FCP web page to their web site (www.fcd.maricopa.gov). The web page, accessed through the project and structures heading, displays the latest public information regarding the project.

A BH/GC FCP newsletter was developed to keep the community informed of the status and up-coming events. The newsletter was distributed to over 10,000 residences throughout the study area 2 weeks prior to each public meeting. Newsletters were hand delivered to residents within one-quarter mile of the Grand Canal. In addition the newsletters were published on the web site under the project heading.

IV. Design Criteria

A. General

The design criteria for the study were established by the FCD in the Scope of Work. This section of the report documents the criteria the community and the Project Team developed as the study progressed.

The locations of the larger utility lines and facilities, such as SRP well sites and City of Glendale 48-inch interceptor sanitary sewer, represent major design considerations affecting the comparison of the various alternative alignments. In addition, the City of Glendale's concern regarding any pumping or siphon solutions originally impacted the depth at which the BH/GC FCP channel could be placed and therefore affected the width and efficiency of the channel and roadway crossing alternatives. Among the more critical utilities whose relocation will present a challenge, are large gravity sewers. At 5 locations the alignment crosses sanitary sewers between 15 and 48 inches in diameter. DMJM investigated several alternatives for lowering the sewers to avoid the conflict including siphons, installing a multiple-barrel crossing of smaller diameter, pumping or alternative routing. The evaluations of these utility relocation alternatives are included in Appendix E.

B. Hydrology

The design criteria established for the hydrologic analyses were to investigate 4 alternative systems that provide varying levels of flood protection. The systems were to achieve the following objectives based on city corporate boundaries due to the uncertainty associated with matching funding for the project:

- 100-year level of protection for Glendale and Phoenix,
- 100-year level of protection for only Glendale,
- 10-year level of protection for only Glendale, and
- 100-year level of protection for Glendale and Phoenix extended to the Sunset Detention Basin.

The last alternative was included to identify the feasibility of increasing the 10-year level of protection provided by the Sunset Detention Basin to a 100-year level of protection. The Sunset Detention Basin (SDB) is located northeast of the Grand Canal and south of Indian School Road at the southeast end of the study corridor.

Both 100-year systems assume a detention facility between 73rd Avenue and 67th Avenue. This detention basin is referred to as the Maryvale Detention Basin (MDB). The Maryvale ADMS determined that it was not cost effective to provide a 100-year level of protection without the MDB. In addition, all 100-year systems have to comply with the ADOT IGA discharge of 2,200 cfs into the BHOC, Phase I at the Agua Fria Freeway.

C. Hydraulics

The channel and storm drain longitudinal slope was established by the Project Team to meet velocity criteria, fit into existing conditions and account for the connection of future facilities. Normal depth calculations were performed to determine channel depth, width and flow velocity for all open channel sections. One foot of freeboard was assumed for all open channel alternatives. These dimensions, including freeboard, were applied to the tested cross-sections during the development of the initial alternative plans.

The approximate hydraulic grade line for the 100-year design storm for the BH/GC FCP channel was used as the tailwater condition for the storm drain analysis. An additional 0.5-feet of head was added for exit losses. Laterals at the junction structures were assumed to come in normal to the main trunk line. This was a conservative approach since it generates larger minor losses. All of the storm drain trunk lines were sized to keep the hydraulic grade line 1-foot below existing ground.

The 50-year water-surface elevation in the New River was used as the design starting tailwater condition for the BH/GC FCP. This return interval was based on watershed size for the mainstream versus the tributary and empirical recommendations developed by the U.S. Army Corps of Engineers.

D. Safety

The design criteria used for safety were obtained from public involvement meetings with the community, FCD personnel and professional judgement. Below is the criteria used:

- Unfenced channels must not exceed a design flood velocity of 6-feet per second.
- If the channel is fenced (denied access to the public) or a closed conduit is proposed there are no flow velocity restrictions.
- Bridge and culvert crossings of the channel must be constructed with handrails/fencing and traffic barriers.
- Curvilinear or sharp angled alignments should be minimized in order to maximize the safety view corridor for public protection.
- Channel alignments should utilize existing roadway lighting to the maximum extent possible for nighttime protection.
- The bottom of the channel should be visible from the surrounding banks.
- Unfenced channel side slopes should not exceed 4:1 slope.
- The channel shall be kept clean and free of weeds and debris.

Based on current safety criteria for multi-use open channels, the project may require the development of a flood warning system. The necessity and design details for this system will be developed during the final design process.

E. Erosion

Based on the FCD "Drainage Design Manual, Volume II, Hydraulics" the Project Team kept the unlined channel velocities under 5-feet per second. The clayey nature of the natural soils and the proposed grass lining will keep the unlined channels stable and non-erosive. Typically, the channel profiles do not exceed 0.1%. These relatively flat slopes will also limit channel erosion. Some locations will require erosion protection. These locations are typically found at significant change in channel profiles and at outlets of the road crossing structures.

F. Maintenance

The design will utilize the Landscape and Aesthetic Policy to provide landscaping and aesthetic improvements to the project. The Cities will be responsible for the funding, completion and maintenance of all recreational, aesthetic and landscaping features that are not authorized by the FCD. The criterion was determined through interviews with FCD personnel, FCD documents, staff and engineering judgement. Below is a summary of the information gathered from these conversations, previous experience and the criteria used in the design of the project:

- The bottom width of the channel shall be a minimum of 8-feet wide
- The height of structures must be a minimum of 5-feet clear
- Box culverts will have access provided at either end of each structure or at roadway crossings
- The project must have at least 1 parallel maintenance roadway with periodic access points

- Maintenance roads must be a minimum of sixteen feet wide unless the channel bottom is used
- Intermittent access to the project low points must be provided
- If handrails are used along a bench wall or walkway, maintenance access must be provided from the opposite side
- Materials selected for the project must be durable and provide for minimal maintenance
- Construction materials selected should discourage vandalism through rough textures and varying surface materials
- Ramp access or access to the project bottom can not exceed a longitudinal grade of 10%

G. Channel Cross-Sections

The general design criteria for all of the cross-sections is listed below:

- If the existing SRP maintenance road is impacted or altered in any way it must be replace with an improved 30-foot maintenance road
- All cross-sections will provide a 16-foot maintenance road adjacent to the channel
- Any vertical channel or channel with side slopes 2:1 or steeper must be fenced
- There is a minimum channel bottom width of 8-feet for all of the cross-sections
- 1-foot of freeboard is standard

H. Roadways

Roadway design was based on the City of Glendale, the City of Phoenix, and the Maricopa Association of Governments (MAG), traffic counts and roadway classifications and design standards. The AASHTO Policy on Geometric of Highway and Streets should be followed for roadway design, unless it was in conflict with an applicable City standard.

- New roadways shall follow the City of Phoenix and the City of Glendale design standards.
- Provisions shall be made for emergency vehicle access.
- Maintain current traffic volumes by maintaining current street hierarchy.
- Maintain current traffic patterns during construction.

I. Bridges/Drainage Structures

The bridge/drainage structure design criteria was based on ADOT, FCD, MAG, city design standards and professional judgement. The following structural design criteria was applied to this project:

- AASHTO Standard Specifications for Highway Bridges 15th Edition (Adopted by the American Association of State Highway Transportation Officials).
- Footing and foundations shall be designed for maximum depth of scour.
- Design for HS20-44 loading.

J. Traffic Elements

The traffic element criteria was based on the City of Phoenix and the City of Glendale design standards, the MAG design standards, the manual on uniform traffic control devices, public workshops and professional judgement. The following traffic design criteria was applied to this project:

- Retain alley access for trash collection, utility service and maintenance where practicable
- Maintain existing traffic patterns when possible
- Use loop roadways if eliminating through access
- Maintain access to adjacent business and residents during construction
- Adjust construction sequence/activities so as to impact traffic on only arterial at any given time during the construction
- All open trenches must be plated during none work periods
- Restrict construction during peak traffic hours
- Traffic is to be maintained on all streets at all times during construction (a minimum of 1 lane in each direction only very short term temporary closure of streets will be permitted)
- Direction of travel must be maintained during construction
- Maintain signalized intersections during construction
- If through access is maintained, but narrowed, convert the road to 1 lane in each direction.

K. Utility Relocation

To minimize utility relocation costs associated with the project, the Project Team applied the following design criteria:

- Avoid the relocation of major utilities
- Avoid conflicts with minor utilities
- It is recommended that wet utilities crossing the BHOC be sleeved in order to maintain access to the infrastructure
- The use of siphons should be minimized
- The use of multiple-barrel crossings of smaller diameter pipe, pumping or alternative routing is encouraged
- Avoid significant impact to SRP Well Sites and high voltage power lines.
- It is preferable to relocate existing SRP well sites within 600-feet
- When in conflict with SRP return irrigation lines (tailwater), use of overchutes (pipe bridges) shall be used as the last choice, after all other alternative solutions have been exhausted
- Utilities such as telephone, electrical and sewers will be buried within the project corridor
- Large SRP electrical service boxes will be relocated adjacent to the project
- Water lines shall be vertically realigned to pass under BHOC
- Avoid relocating the existing SRP 69kV Transmission line paralleling the Grand Canal corridor
- Minimize impacts to the Grasmoen and Welborn Substations
- The potential for combining sewers should be studied
- The undergrounding of OHE is preferred

- Utilities must remain in service to serve the community during construction
- Minimize impacts to several US West high-importance underground telephone facilities in this area.
- In areas of conflict keep the relocated utility a minimum of 1-foot from any element of the project.

The FCD and the cities expressed an interest in undergrounding 69kV power lines. DMJM discussed the cost associated with undergrounding these facilities with representatives from SRP. SRP's recent experiences on these types of projects indicate that undergrounding this size of transmission facility costs $700,000 to $900,000 per mile.

L. Aesthetics

The criteria guiding aesthetics was derived from the FCD's Policy for the Aesthetic Treatment and Landscaping of Flood Control Projects and the suggestions of the community. The following criteria were used in the evaluation of the alternatives:

- Aesthetic features developed at the expense of cost-share partners, or other participating parties, will not increase the FCD's liability regarding personal safety and/or property.
- Aesthetic multi-purpose uses of FCD projects will be encouraged to the extent that other uses do not interfere with FCD operations or maintenance.
- Aesthetic features, not relating directly to flood control, which are included in the design and construction of the project at a cost-share partner's request shall be the financial and operation/maintenance responsibility of the cost-share partner. The FCD shall not be responsible for the repair of such features in the event of damage caused by flooding, unless specifically included in the cost-sharing program.
- Aesthetic features will be constructed concurrent with construction, unless a delay is warranted.

M. Landscape/Recreation

Design criteria for landscaping and construction materials were based on the FCD Policy for the Aesthetic Treatment and Landscaping of Flood Control Projects. Generally the design criteria and policy address topics such as aesthetics, water usage, multi-jurisdictional coordination and existing landscape. Additional requirements were derived from discussions with the community, FCD personnel and the Project Team's judgement.

- Maintenance roads shall be used as multi-purpose trails
- The trail should be constructed of a natural material that will provide for dust control
- The trail should connect to other existing and proposed trails in the area
- Landscape materials should be low water use and low in maintenance
- Solid walls shall be designed to minimize hiding places
- Fences or walls shall be designed to minimize graffiti.
- Plants should be used when appropriate to provide erosion control and protect the visual qualities of the area
- Shrubs and plant materials that could be used for concealment should not be located adjacent to trails or walkways
- Existing recreation facilities impacted by the proposed project must be replaced or relocated in kind
- The existing SRP Grand Canal maintenance road will be maintained for equestrian and other trail uses

V. Hydrologic Modeling Overview

A. General

All of the design methodology and criteria was documented in meeting minutes and memorandums as the project evolved. Details of the hydrologic modeling performed on this project are provided in Appendix F. In order to improve the speed, at which the hydrologic model (HEC-1) executes, the model was separated into an upper model (Bgc00u.dat) and a middle model (Bgc00mid.dat). The dividing line between these 2 models was Glendale Avenue. The middle model was later used as the base model for hydrologic alternatives. The southernmost portion of the watershed, south of the Grand Canal, was removed from the hydrologic model and not updated per the project scope of work.

B. Land Use Update

At the beginning of the project, the FCD provided DMJM with the hydrologic models (HEC-1) and supporting documentation developed for the Maryvale ADMS and the Maryvale Floodplain Mitigation Study (FMS). DMJM reviewed these models and confirmed that flow diversions for the existing City of Phoenix storm drains were included. DMJM then updated the HEC-1 model to account for new development in the watershed since the original study was performed in 1996. The land use parameters were updated based on overlaying the original study land use boundaries on updated aerial photography of the watershed. Each of the new developments identified through the aerial overlay process was field verified and revisions were incorporated as appropriate. Revised land use and retention volumes were then tabulated in the spreadsheets developed for the original hydrology study. The calculation methodology for new development retention assumed the facilities would be 80% efficient based on current FCD recommendations.

C. Base Model Development

At the project's onset, several routing modifications to the HEC-1 models were necessitated by the project's scope of work. The base hydrologic model provided by the FCD was for a 100-year, 24-hour design storm event and included a recalculation or "rerun" that combined various hydrographs for the BH/GC FCP alignment. Initially, the routing modifications involved revisions to include the Bethany Home Road storm drain system. The 10-year hydrologic model provided by FCD, to represent the Bethany Home Road storm drain, directed all flows to the west using street and intersection diversions. These diversions were incorporated into the updated 100-year model to properly represent the Bethany Home Road storm drain during the 100-year event. All flows up to and including the 10-year discharges were diverted west while the remaining portions of the 100-year runoff was diverted with the same ratings as the original 100-year model.

To better reflect current and proposed conditions, revisions were made to incorporate the Agua Fria Freeway construction. For this task, the HEC-1 model developed by Wood/Patel Associates (WPA) for ADOT (100AFBH) was incorporated into base hydrologic models.

D. Hydrologic Alternatives

A base model with updated land use information was created, to incorporated the Bethany Home Road storm drain and Agua Fria Freeway. DMJM started generated various models for the alternatives evaluation process, including; models with a storm drain in Camelback Road, and storm drain systems in both Camelback Road and Missouri Avenue. Both of these storm drain systems convey the 10-year frequency storm beginning at 59th Avenue and ending at the BH/GC FCP channel. Both of these storm drain alternatives were developed for the 10-year and 100-year storms. Also, models were generated for the scenario of only a Glendale system by eliminating the proposed system south of Camelback Road. A final alternative was developed to include a connection of the Sunset Detention Basin to the BH/GC FCP system in order to improve the facilities level of protection from a 10-year system to a 100-year system. The stage-storage relationship utilized for the Sunset Detention Basin, provided by WPA, was not modified for any alternatives. The stage discharge

relationship, with the corresponding reservoir routing, was modified to provide for a secondary discharge toward the BH/GC FCP.

3. *Storm Drain Routing*

Once an updated and checked base model was established, revisions were made to include the Camelback Road storm drain (CBSD) system. Similar modifications to that which was performed with the Bethany Home Road storm drain system, the south versus west street diversions, were adjusted. Due to the logic of the original HEC-1 model, it was not possible to simply revise street diversions and have reasonably accurate results for the Missouri Avenue storm drain (MSD) system. DMJM implemented a different approach to accomplish this task. This approach involved diverting a portion (upper half) of the total section runoff out, based upon prorated area, and then retrieving it later when performing the Camelback Road calculations. In conjunction with these diversions, similarly as was done with the Bethany Home Road and Camelback Road storm drain systems, the street diversions at approximately the half-mile locations were modified to simulate the MSD system. Alternatives were also developed using the CBSD and MSD models modified to route storm runoff for only Glendale.

4. *Detention Basins*

a) *91st Avenue Basin*

The hydrologic model developed by WPA for the Agua Fria Freeway did not include the proposed Bethany Home Road storm drain. Therefore, the peak flow from the DMJM HEC-1 model at the confluence of the Agua Fria Freeway was greater than the maximum allowable added discharge of 2,200 cfs per the IGA between ADOT and the FCD. Upon review of the hydrologic model, it was determined that adding the Bethany Home Road storm drain system and the corresponding timing of the hydrograph in the channel caused the increase in peak flow. DMJM proposed additional detention facilities to mitigate the peak flows and conform to the IGA. Sites included:

- BH/GC FCP at 97th Avenue (upstream of the Agua Fria Freeway channel confluence)
- The existing retention basin site between 91st and 87th Avenues (referred to as the 91st Avenue site)
- 83rd Avenue and Bethany Home Road
- 75th Avenue and Bethany Home Road
- The radio tower site at 75th Avenue and Camelback Road

Each of these sites, with the exception of the radio tower site, were tested by plotting the HEC-1 generated hydrograph from the DMJM model against the hydrographs generated from the WPA HEC-1 model. Storage volumes were estimated and the sites reviewed to identify if there was sufficient area to provide the required storage. It should be noted that the method described above was only an approximation. To gain a more accurate estimate of detention requirements, detention basin routings would need to be eventually added to the model in order verify the peak flows at the channel confluence. Ultimately, the 91st Avenue Detention Basin site was selected to mitigate the impact of the Bethany Home Road Storm Drain and conform to the ADOT IGA.

b) *Maryvale Detention Basin*

As part of the hydrologic and hydraulic analyses associated with the pre-design alternative evaluation, DMJM checked the original assumptions and calculations at the Maryvale Detention Basin (between Camelback Road and 67th Avenue). The detention basin calculations originally depicted a stage-discharge relationship based upon a multi-cell box culvert operating under inlet control conditions. However, based upon the original channel profiles, the proposed box culvert at Camelback Road would induce a significant tailwater condition

(outlet control) upon the MDB outlet culvert. In addition, the original HEC-1 modeling had assumed flows that combine at Camelback Road would add and immediately travel northwest. In actuality, the flows would be attenuated due to the road crossing geometry. This condition was worsened by the conflict with the existing 48-inch diameter sanitary sewer in Camelback Road which created a time dependant tailwater condition for the MDB outlet structure that is very difficult to model. To more accurately model these conditions, the model routing was adjusted such that the MDB would include inflow from Camelback Road storm drain system and the detention basin outlet structure was eliminated. The Camelback Road crossing now controls the stage in the MDB.

In order to fully review the Maryvale ADMS concept, the stage/elevation and storage relationships also were reviewed and confirmed. DMJM performed detailed calculations based on the ADMS digital terrain model and it was found that the calculated volumes were approximately 5% more than the original Maryvale ADMS volumes at maximum stage elevations. This small storage difference, by itself, does not significantly effect the peak flow rates or high water elevations.

Another important aspect that was investigated during the study was the definition of the maximum water surface elevation in the MDB. This issue was especially critical when considering the backwater effects created by downstream constraints. The elevation needed to be one that solves the project objective of removing adjacent residents from the 100-year floodplain. These elevations, coupled with the backwater effects, precipitated the need for decisions regarding the hydrologic alternative to be pursued for design as well as specific design criteria, such as freeboard. In response to direction defined at meetings with the FCD and the City of Phoenix, DMJM performed additional analyses to try and achieve the objective of mitigating the 100-year floodplain.

These objectives included a new target high water elevation at the MDB. This elevation was estimated to contain the proposed 100-year floodplain within the proposed public rights-of-way. Once the MDB high water elevation objective was met, DMJM was to pursue adjustments so that the high water elevation at the Sunset Detention Basin was below the Indian School Road low top of curb elevation.

DMJM was also directed to investigate an alternative that included the expansion of the MDB storage volume generated from an additional 10 residences (2.17 acres) adjacent to the original basin boundary. However, it was noted that this expansion should occur only if significant benefits were realized. As a result of these analyses, several important observations were made. Due to the "online" nature of the MDB, expansion of the basin's storage volume was less cost effective than increasing the MDB outlet (Camelback Road) culvert size. Also, if a relocation of the sanitary sewer in 75th Avenue was to occur, a much more hydraulically efficient culvert crossing can be constructed for Camelback Road. This would provide all of the hydrologic alternatives with lower high water elevations and/or culvert size reductions. The analyses, performed to this point, did not have alternatives that included sanitary sewer relocations. Other than 75th Avenue, other potential sanitary sewer relocations such as at 83rd Avenue and Camelback Road would also have significant project benefits.

At the direction of the FCD, DMJM performed a cost/benefit evaluation for relocating the existing sanitary sewers in conflict with the proposed project. After reviewing several alternatives, it was identified that siphoning the existing sanitary sewers was the most cost-effective solution for mitigating conflicts. New hydrologic design criteria were established for the MDB. The criteria were primarily driven by the decision that allows the existing sanitary sewers at 83rd Avenue, 75th Avenue, and Camelback Road to be siphoned under the BH/GC FCP facility. The revised design criteria for the MDB is outlined below:

- The target 100-year water-surface elevation at the MDB shall be 1-foot below the road(s) low point top of curb elevation (approximate elevation 1092.5).
- The target 100-year water-surface elevation at the SDB shall be 1-foot below the Indian School Road low point top of curb elevation (approximate elevation 1096.4).
- Do not modify the Grand Canal north bank overflow elevation (approximate elevation 1097.0).

- Achieving the target water-surface elevation at the MDB shall take precedence over achieving the target at the SDB.
- The MDB stage-storage relationship shall be modified such that the flattest side slope is to be used for the entire basin using the proposed profile and without acquiring additional properties.
- Hydrologic alternatives are permitted to increase the peak flow in Segments 4 and 5 over the base models; however, peak flow rates at 83rd Avenue shall be maintained below the HEC-1 model 100-year flows prior to these modifications.

Upon completion of this final pre-design hydrologic analyses, DMJM identified that the change in the design criteria to allow sanitary sewer siphons simplified the MDB hydrologic modeling as well as provided a more effective stormwater management solution. Without the use of siphons at 75th Avenue and Camelback Road the crossing would have required a 6 cell 12' x 6' box culvert. With the siphons, the crossing can be decreased in size to a 2 cell 8' x 7' box culvert. Similar savings were realized at the 83rd Avenue crossing. The resulting change in design criteria will save the project at least 2 million dollars in construction cost.

VI. Environmental Overview

A. General

The FCD contracted with Western Technologies, Inc. (WT) to perform a Phase I, Environmental Site Assessment for the Bethany Home/Grand Canal Flood Control Project. WT's project included the assessment of 100-foot corridors paralleling the north and south banks of the Grand Canal beginning at Indian School Road and ending at the Loop 101 Freeway. The scope of work implemented for this assessment meets the guidelines established by the American Society for Testing and Materials (ASTM) in ASTM Standard Practice E-1527.

Based on WT's evaluation of the collected data, WT concluded that this assessment has revealed no evidence of recognized environmental conditions in connection with the project. The following sites were identified as potentially requiring further evaluation for the reasons identified below:

- Texaco Express Lube, 6448 West Indian School Road – This site formerly operated as a gasoline service station that included 3 underground storage tanks (USTs). The site currently stores large quantities of lubrication oils.
- Weiss Guys Self-Service Car Wash, 4827 North 75th Avenue – This site, according to fire department records, reportedly contains a 1,000-gallon tank that stores fuel for a boiler. The exact location and condition of this tank is unknown.
- Microwave Transmission Tower, southeast corner of 75th Avenue and Camelback Road – There is a potential that a back-up power source involves a fuel storage system.
- SRP Electrical Substations, Northeast Corner of 75th Avenue and Camelback Road, and 1 half mile west of 83rd Avenue. These locales may use or store hazardous substances or petroleum products.
- Church's Trucking, 7904 West Missouri Road – This site stored materials outside and containers that could hold hazardous substances or petroleum products were noted.

According to the latest Arizona Department of Water Resources publication, the depth to groundwater in the area ranges from 120 to 180-feet below ground surface. The regional groundwater flow, based on a 50-foot contour interval, is to the northwest.

The Environmental Services Department of Maricopa County was contacted regarding septic systems adjacent to the project. As of the date of the draft report (January 11, 2000), WT had not received a response to their request regarding septic systems adjacent to the project. DMJM believed that the properties along Cavalier Drive are on septic systems and therefore, will require an addendum to the original report performed by WT.

B. Permits

During the course of the project, Glendale determined that accepting irrigation return flows (i.e., field drains) into the BH/GC FCP does not violate their National Pollution Discharge Elimination System (NPDES), Phase I, Storm Water Discharge Permit. However, since construction activities for the project will disturb more than 5 acres, a Storm Water Pollution Prevention Plan (SWPPP) will be required. The SWPPP will need to address Best Management Practices (BMP's) for storm water runoff during the construction of the project. The Contractor will also be required to submit a Notice of Intent (NOI) and Notice of Termination (NOT) form to the U.S. Environmental Protection Agency (EPA) for storm water discharges associated with this construction activity under the NPDES general permit.

DMJM contacted the U.S. Army Corps of Engineers (Corps) regarding "Waters of the U.S." within the project corridor. The Corps indicated they consider major SRP canals (i.e., Grand Canal) to be "Waters of the U.S." only at the outfall to a major watercourse (i.e., New River). Therefore, it was DMJM's understanding a 404 Permit was not required for the construction of this project.

VII. Geotechnical Overview

ATL, Inc. (ATL) performed the preliminary geotechnical investigation for the Bethany Home/Grand Canal Flood Control Project. The full letter report was provided in Appendix G. In general, ATL's scope of work was to perform 3 borings to depths of 20-feet below existing ground. The borings were located at the intersections of Bethany Home Road and 83rd Avenue, Camelback Road and 75th Avenue and Indian School Road on the north side of the Grand Canal. Soil samples were obtained from these borings and various tests were performed to determine the general soil profiles that might be encountered within the range of planned construction excavation depth for the proposed channel alignment.

The soils along the channel alignment were classified from brown, clayey sand to brown; sandy lean clay with some silt present at the southern end of the alignment. At the 2 southern boring locations, the soil pH and resistivity was considered corrosive for uncoated metal pipe. Consolidation of the soils was possible at the intersection of 75th Avenue and Camelback Road. In general, no swell potential was identified at the 3 boring locations. It should be noted that the soil consolidation and swell potential was to be evaluated in greater detail during the final design.

Some leakage from the Grand Canal was evident at Indian School Road as evidenced by the soft saturated soils encountered at this location. Some of this may be due to the fact that the boring was lòcated in close proximity to the Grand Canal (i.e., 9-feet east). Dewatering may be required at this location and ATL recommended that a construction contingency be implemented for this possibility. ATL also recommended that the contractor be prepared to sheet and shore canal side excavations in these areas since dewatering activities can create local areas of subsidence if water was drained from coarse grained, granular soils. ATL anticipates that dewatering of the excavation will be required when the excavation extends below the Grand Canal, or about 12-feet below grade. The contractor may have to be prepared to over-excavate wet soil and replace it with a granular material that will allow water to flow without substantial movement. ATL indicated that concrete lined channels may require more sophisticated soil drainage systems than the typical weephole and filter fabric against what was probably lean clay in the top 5 to 10-feet of the subgrade. ATL also recommended that box culvert construction be designed as retaining walls, where the magnitude of the lateral forces will depend on the type of material used as backfill.

VIII. Alternative Plan Description

A. General

Alternative plans consisted of 3 elements: the cross-section, the horizontal alignment and the profile. The vertical alignments, or profiles, were created based on the feasible channel depth due to utility location, surface materials, erosion potential and existing longitudinal slope. This information, combined with the peak flow rate "Q", and channel roughness coefficient or Manning "n" value, was used to determine stormwater velocities. The velocity, depth and design criteria of the channel were determining factors in the development of the numerous cross-sections. Each cross-section was applied to 1 or more segments. As seen in the results of the hydraulic analyses (See Appendix F) various combinations of alignments and cross-sections were applied. By mixing and matching horizontal alignments and cross-sections the Project Team was able to evaluate 31 100-year flood and 26 10-year flood scenarios. The 10-year scenarios were developed for only Glendale.

B. Horizontal Alignments

The horizontal alignment reflects the 2 dimensional map alignment of the project. The Maryvale ADMS, and subsequent studies, recommended that the flood control facility be placed just north of the Grand Canal alignment. The Project Team generally followed the recommended horizontal location varying it based on surrounding land uses, neighborhood viability, existing right-of-way, easements, circulation patterns and existing utilities. Multiple horizontal alignment options were created for segments 2, 5 and 8. The decision to vary from the recommended alignment was made due to public input, utility locations and available vacant land.

C. Vertical Alignment

The vertical alignment was referred to as the profile. The profile allowed a view of the longitudinal slope, which is the change in the invert elevation (vertical drop) of the channel or storm drain as it flows toward the west. The existing longitudinal slope of the land varied from segment to segment, at approximately 0.1%. However, the vertical slope of this project was not driven as much by the existing slope, but by the depth of existing utilities and the elevation of storm drains and irrigation overchutes. A controlling element of the profile was the Bethany Home Road storm drain. The depth of this storm drain, which was currently under design, set the profile of the BH/GC FCP channel near the intersection of 83rd Avenue and Bethany Home Road.

D. Cross-Sections

The material within the channel affects the velocity of the water, the side slopes and the integration of the project within the surrounding environment. Generally the materials used for channels can be broken down into 3 categories: natural, protected and concrete lined. For this project only natural (grass-lined) and concrete were selected as feasible materials to be studied.

Natural Channel – The natural channel cross-sections were the widest (See Figures 5 and 6). The cross-section was designed with a minimum 8-foot bottom and 4:1 side slopes. The 100-year floodwaters were to have 1-foot of freeboard. The existing SRP maintenance road would serve as channel access and as a multi-use trail. Any trail placed within the channel would be subject to flooding.

Concrete Channel – This material was used on the trapezoidal, vertical and box culvert cross-sections (See Figures 7 – 9). These cross-sections were developed in order to create the narrowest channel possible. Exposed concrete channels are not considered aesthetic due to the hard surface and the need for security fencing. Box culverts were considered non-invasive and very aesthetic.

Figure 5 – Natural Channel /Low Flow Channel, F

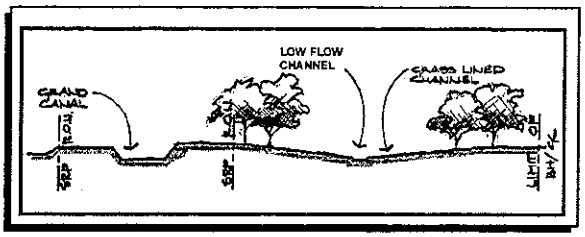


Figure 6 – Natural Channel w/Low Flow Pipe, I

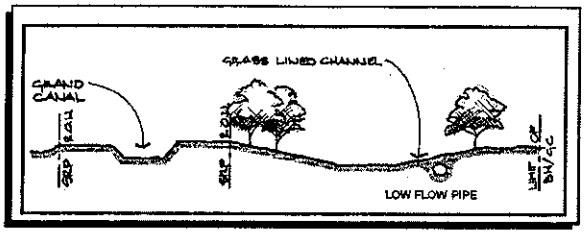


Figure 7 – Concrete Trapezoid Channel, E

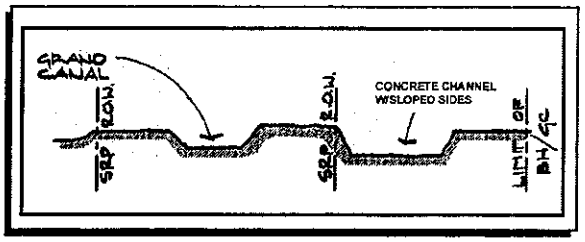


Figure 8 – Vertical Concrete Channel H

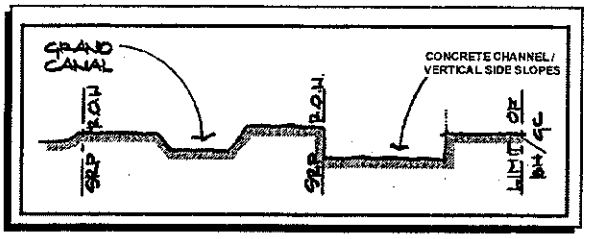


Figure 9 – Box Culvert / North of Grand Canal, D

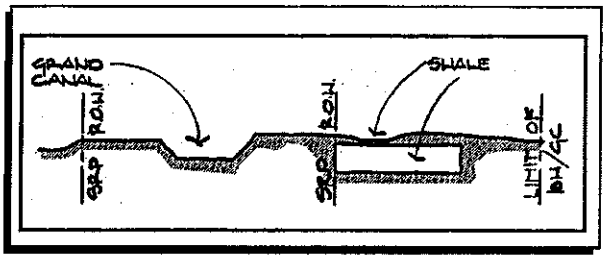
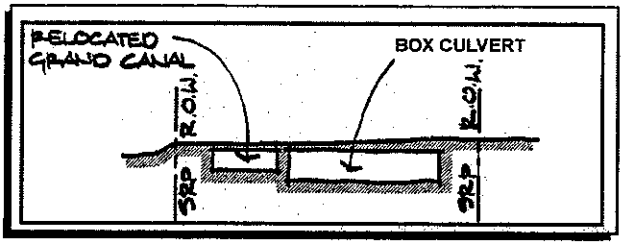


Figure 10 – Box Culvert / Relocated Grand Canal, G



E. Storm Drain Alternatives

1. Missouri Avenue Storm Drain

The proposed storm drain in Missouri Avenue, between the BH/GC FCP and 59th Avenue, was located in a predominantly residential area. The curb to curb roadway section varied between 44 and 57-feet. The location of existing utilities, roadway alignment and limited roadway width determined the horizontal location for the Missouri Avenue storm drain east of 75th Avenue. The alternative evaluated constructing the storm drain along the south curb of Missouri Avenue from 75th Avenue to 59th Avenue. The second alternative alignment between 75th Avenue and the BH/GC FCP was proposed to either align in 75th Avenue to the existing detention basin north of Camelback Road where it would connect with the BH/GC FCP or follow the Missouri alignment to the BH/GC FCP. Either alignment was subject to significant constructability and maintenance of residential traffic issues.

The majority of the first alternative entirely on the Missouri alignment requires reconstruction of pavement, curb and gutter, sidewalk and residential driveways. Both alternatives require reconstruction of an existing 18" sewer line in 75th Avenue and a 48" sewer in 73rd Avenue. Alternative 2 was approximately 152-feet longer and requires a larger pipe diameter at the downstream end due to a milder slope. Hydraulic analyses indicate

that storm drain diameters ranging from 90-inches to 66-inches" are required for the first alternative and 102-inches to 66-inches for the second alternative.

2. *Camelback Storm Drain*

The proposed storm drain in Camelback Road was located between the proposed BH/GC FCP channel at 75th Avenue to 59th Avenue. This section of roadway was predominantly a residential area with frontage roads to the north and south of Camelback Road. The curb to curb roadway section varies between 66 and 68-feet. The location of existing utilities determined the alternatives to be evaluated for the Camelback Road storm drain. The majority of the proposed alignment was within the existing painted median in Camelback Road. A portion of the alignment at the downstream end was located within the south frontage road in order to avoid conflicts with an existing 48" sanitary sewer at 73rd Avenue.

The alternatives evaluated used the same horizontal alignment with different hydraulic conditions. The first alternative assumes no construction of the Missouri Avenue storm drain and the second alternative assumes construction of the Missouri Avenue storm drain. The hydraulic analyses indicate that storm drain diameters ranging from 102" to 84" are required for Alternative 1 and 90" to 72" for Alternative 2.

F. Evaluation Process

The purpose of the design development and evaluation process was to study the impact of a cross-section on a segment. After studying numerous channel configurations the Project Team selected the 6 cross-sections that were most feasible to be used in the Alternative Plans. The cross-sections were carefully assigned to the segments that the Project Team believed would gain maximum comparison benefit, from the "testing" process. Any cross-section could have been applied to any segment for evaluation. In some cases, such as the storm drains in segments 8 and 9, pipe culverts were the only cross-section studied because the alignment was within major a roadway. The "InRoads" program was used to define the construction limits of each proposed alternative based on the proposed design flows. The information generated by this process was in the Initial Alternative Plans.

At locations where proposed facilities cross existing utilities, DMJM compared profiles to identify potential conflicts. Conflict mitigation concepts were developed to relocate or reroute those utilities. Relocation concepts and costs for each utility in conflict with the BHOC were developed based on this information. Construction and relocation of costs for each utility with lines or structures in the path of the proposed flood control facilities were developed and the results were incorporated into the alternative plan comparison and ranking process.

G. Alternative Plans

The following subsection describes the Initial Alternative Plans that were developed by the Consultant Team with input from the FCD, the City of Phoenix, the City of Glendale and the community. These plans were developed in cross-section, plan and profile views. The plans present typical cross-sections used within each segment and the defining profile (See Appendix H, Under Separate Cover). The segments within the City of Glendale's jurisdiction (segments 1, 2, 3, 4, 5, 8 and 9) also include a 10-year flood control system in addition to the 100-year flood systems. The 10-year solution is what Glendale requires to create an outlet for proposed storm drains in Bethany Home Road, Missouri Avenue and/or Camelback Road. The 100-year solution is needed by the City of Phoenix in order to eliminate the 100-year floodplain. If Phoenix can not fund their portion of the project, Glendale may proceed independently with a 10-year solution.

All of the initial plans are designated with a segment and alternative number. DMJM has consistently identified each alternative with a unique code using alphanumeric characters to indicate a specific segment and alternative. For example, S1A1 indicates segment 1, alternative 1.

1. *Segment 1*

Segment 1 was located between the Loop 101 Freeway and 87th Avenue and has the least constraints of all of the segments. The land adjacent to the segment was generally agricultural or vacant. In areas where homes do exist there was enough space to align the facility and avoid residential property takes. The utility conflicts that occurred were at or near 91st Avenue and included four large electrical service boxes that would be relocated, as well as irrigation facilities. The cross-sections evaluated within this segment were not constrained by utilities, aesthetic issues or width. The cross-sections were based on connectivity to the BHOC (at the Loop 101) and upstream alternatives.

a) Segment 1, Alternative 1 (10-Year) Concrete Lined Channel

The channel cross-section was a concrete lined trapezoid with 2:1 side slopes. A 100-foot wide right-of-way would be needed to accommodate the cross-section through this segment. The channel width varied to a maximum width of 58-feet and a maximum depth of 9-feet. This alternative only accommodated the 10-year storm and only resolved Glendale's flooding problems. The existing SRP maintenance road was retained and a new 16-foot trail/maintenance road was added to the north side of the BH/GC FCP. Residential properties would not be acquired to accommodate this design.

Advantages

- Eliminates local flooding
- Limited right-of-way acquisition and no occupied property takes
- Minimal Disruption during construction
- Adequate safety
- Retains current circulation patterns
- Narrowest solution studied (100-foot right-of-way)
- Minimal impact to major utilities

Disadvantages

- Does not eliminated the 100-year floodplain
- Limits recreation opportunities
- Visible fence barriers

b) Segment 1, Alternative 2 (100-Year) Concrete Lined Channel

Alternative 2 applied the same cross-section as Alternative 1 only it accommodated 100-year floodwaters. The increase in flows resulted in a much larger right-of-way, approximately 300-feet wide east of 91st Avenue and 130-feet wide west of 91st Avenue. The difference between the 2 widths was due a proposed detention basin located between 91st Avenue and 87th Avenue. This detention basin was required for all 100-year systems to meet the maximum peak flow requirements of the ADOT IGA at the Agua Fria Freeway. The depth of the channel between the BHOC (Loop 101) and 91st Avenue was shallower than between 91st Avenue and 87th Avenue for all alternatives in Segment 1. The shallower flow depths were assumed to permit SRP irrigation and tailwater overchutes of the BH/GC FCP channel. No residential properties were impacted by this solution.

Advantages

- Eliminates the 100-year floodplain and local flooding
- Limited right-of-way acquisition and no occupied property takes
- Minimal Disruption during construction
- Adequate safety
- Retains current circulation patterns
- Narrowest solution studied (130-foot right-of-way)
- Limited impact to major utilities

Disadvantages

- Limited recreational opportunities
- Visible fence barriers

c) Segment 1, Alternative 3 (10-Year) Grass-Lined Channel with Concrete Low-Flow Channel

Alternative 3 tested a grass-lined channel with a low-flow trickle channel. The 10-year storm flow required a right-of-way of approximately 140-feet. The channel included a minimum bottom width of 12-feet and side slopes of 4:1. A trail/maintenance road was incorporated along the north bank of the channel. The existing Grand Canal maintenance road was maintained in its present condition. No residential property takes were required to accommodate this concept.

Advantages

- Eliminates local flooding
- No residential property takes
- Minimal Disruption during construction
- Retains current circulation patterns
- Minimal impact to major utilities
- Aesthetically appealing

Disadvantages

- Does not eliminate the 100-year floodplain
- Considerable right-of-way requirements
- High maintenance cost
- Standing water is likely

d) Segment 1, Alternative 4 (100-Year) Grass-Lined Channel with Concrete Low-Flow Channel

The 100-year storm flow was accommodated in a grass-lined channel. The right-of-way requirements varied from 230 to 300-feet in width. The channel required a minimum bottom width of 60-feet and side slopes of 4:1. A trail/maintenance road was incorporated along the north bank of the channel. The existing Grand Canal maintenance road was maintained in its present condition. No residential property was required to accommodate this concept.

Advantages

- Eliminates the 100-year floodplain and local flooding
- No residential property takes
- Minimal Disruption during construction
- Retains current circulation patterns
- Minimal impact to major utilities
- Recreation opportunities
- Aesthetically appealing

Disadvantages

- Considerable right-of-way requirements
- High maintenance cost
- Standing water is likely

e) Segment 1, Alternative 5 (10-Year) Grass-Lined Channel with Low-Flow Pipe

The 10-year flow was accommodated in a grass-lined channel with a low-flow pipe to minimize water and maximize recreation opportunities. The right-of-way requirements varied from 110 to 140-feet in width. The channel included a minimum bottom width of 12-feet and side slopes of 4:1. A trail/maintenance road was incorporated along the north bank of the channel. The existing Grand Canal maintenance road was maintained in its present condition. No residential property takes were required to accommodate this concept.

Advantages

- Eliminates local flooding
- No residential property takes
- Minimal Disruption during construction
- Retains current circulation patterns
- Minimal impact to major utilities
- Aesthetically appealing

Disadvantages

- Does not eliminate the 100-year floodplain
- Considerable right-of-way requirements
- High maintenance cost
- Standing water is likely

f) Segment 1, Alternative 6 (100-Year) Grass-Lined Channel with Low-Flow Pipe

The 100-year storm flow was accommodated with this alternative. A grass-lined channel with a low-flow pipe was used to minimize nuisance water and maximize recreation opportunities. The right-of-way requirements varied from 230 to 300-feet in width. The channel included a minimum bottom width of 60-feet and side

slopes of 4:1. A trail/maintenance road was incorporated along the north bank of the channel. The existing Grand Canal maintenance road was maintained in its present condition. No residential property takes were required to accommodate this concept.

Advantages

- Eliminates the 100-year floodplain and local flooding
- No residential property takes
- Minimal Disruption during construction
- Retains current circulation patterns
- Minimal impact to major utilities
- Maximizes recreation opportunities
- Aesthetically appealing
- Eliminates standing water

Disadvantages

- Considerable right-of-way requirements
- High maintenance cost

2. *Segment 1A*

Segment 1 A was the 91st Avenue roadway crossing and was a subset of Segment 1. Whether this segment was developed as a box culvert (S1A7) or a bridge (S1A8) was dependent on the alternatives selected both upstream and downstream. Typically, bridge structures cost more than box culvert solutions but bridges are considered more aesthetically appealing, open in appearance and a safer trail under-crossing. The road crossings were sized for both the 100-year (S1A9 and S1A10) and the 10-year (S1A7 and S1A8) design discharges. Regardless of which crossing was used, 4 large SRP electrical service boxes will need to be relocated due to their conflict with the proposed facility. The sizes of these crossings varied from a 3 cell 10'x6' box culvert to a 26' clear span bridge for the 10-year system. A 100-year system required a 5-cell 12'x8' box culvert or a 64' clear span bridge. All of the crossings are designed to preserve the existing SRP well at the northeast corner of 91st Avenue and the Grand Canal, northwest corner.

3. *Segment 2*

Segment 2 was located between 87th Avenue and 83rd Avenue. Four project alignments were investigated in this segment of the project at the request of the public, the FCD and the City of Glendale because of potential impact to residential properties bounding the north side of the Grand Canal. These residential properties are unique in that they are typically 1-acre lots with equestrian privileges. The first alignment parallels the north side of the Grand Canal. The second alignment locates the proposed project within the Grand Canal corridor and requires the relocation of the Grand Canal to the south. The third alignment locates the flood control facility within the Cavalier Drive right-of-way. The fourth alignment locates the facility south of the Grand Canal but requires underchutes at the crossings. Alternatives that involve the relocation of the Grand Canal requires the relocation of 12 Kv and 69 Kv power transmission lines. The alternative that involves placing a box culvert under Cavalier Drive will impact city, private and SRP services to the acre lot subdivision.

a) Segment 2, Alternative 1 (10-Year) Rectangular Concrete Channel North of the Grand Canal

Alternative 1was designed as a rectangular concrete lined channel that would convey the 10-year flows. The concrete channel had a bottom width of 19-feet. The vertical sides and would be fenced for safety. Access into the channel would be accommodated adjacent to major road crossings. Alternative 1 was designed very narrow to minimizes property impacts.

Advantages

- Eliminates local flooding
- Limited right-of-way acquisition
- Adequate safety
- Narrowest solution (50-foot right-of-way)
- No impact to major utilities

Disadvantages

- Does not eliminated the 100-year floodplain
- Residential property takes
- Minimal recreation opportunities
- Visible fence barriers
- Disruption during construction

b) Segment 2, Alternative 2 (100-Year) Rectangular Concrete Channel North of the Grand Canal

Alternative 2 was rectangular concrete lined channel that conveyed the 100-year floodwaters. The concrete channel has a bottom width of 34-feet. The channel had vertical sides that would be fenced for safety. Access into the channel would be accommodated adjacent to major road crossings.

Advantages

- Eliminates the 100-year floodplain and local flooding
- Limited right-of-way acquisition
- Adequate safety
- No impact to major utilities

Disadvantages

- Residential property takes
- Minimal recreation opportunities
- Visible fence barriers
- Disruption during construction

c) *Segment 2, Alternative 3 (10-Year) Rectangular Concrete Channel at the Grand Canal*

Alternative 3 required the relocation of the Grand Canal to the south. This alternative maintained the residential property line at the north SRP right-of-way. This resulted in an alignment that physically reconstructed the Grand Canal south of its current alignment and placed the flood control project in the current SRP right-of-way. This was a very expensive concept that created a major impact on SRP.

Advantages

- Eliminates local flooding
- Retains current circulation patterns

Disadvantages

- Does not eliminate the 100-year floodplain
- Minimal recreation opportunities
- Visible fence barriers
- High construction cost
- Major disruption to SRP facilities
- Residential property acquisition

d) *Segment 2, Alternative 4 (100-Year) Rectangular Concrete Channel at the Grand Canal*

Alternative 4 required the relocation of the Grand Canal to the south. This alternative maintained the residential property line at the north SRP right-of-way. This resulted in an alignment that physically moves the Grand Canal south of its current alignment and placed the flood control project in the current SRP right-of-way. This was a very expensive concept that created a major impact on SRP. The overhead power facilities may not need to be relocated with this alternative since the proposed channel was located north of the Grand Canal.

Advantages

- Eliminates 100-year floodplain and local flooding
- Retains current circulation patterns

Disadvantages

- Minimal recreation opportunities
- Visible fence barriers
- High construction cost
- Major disruption to SRP facilities
- Residential property acquisition

e) Segment 2, Alternative 5 (10-Year) Box Culvert North of the Grand Canal

Alternative 3 applied a box culvert cross-section north of the Grand Canal. The multi-cell box culvert was approximately 25-feet wide and was designed to accommodate the 10-year storm event. This was a narrow cross-section that has very limited impact on the adjacent residential properties. This alternative was also considered 1 of the more aesthetic and recreation friendly solutions since the top may be used in a variety of ways.

Advantages

- Eliminates local flooding
- Limited right-of-way acquisition
- Extremely safe
- Retains current circulation patterns
- Narrowest solution (25-foot right-of-way)
- No impact to major utilities
- Provides recreation opportunities
- Low construction cost

Disadvantages

- Does not eliminated the 100-year floodplain
- Disruption during construction
- Removal of existing vegetation and relocation of adjacent structures

f) Segment 2, Alternative 6 (100-Year) Box Culvert North of the Grand Canal

A box culvert cross-section was applied in this alternative. The multi-cell box culvert was approximately 50-feet wide and was designed to accommodate the 100-year storm event. This was a narrow cross-section, but still impacted adjacent residential properties. Alternative 6 was one of the most aesthetic, recreation and cost friendly solutions.

Advantages

- Eliminates the 100-year floodplain and local flooding
- Limited right-of-way acquisition
- Extremely safe
- Retains current circulation patterns
- Narrowest solution (60-foot right-of-way)
- No impact to major utilities
- Provides recreation opportunities

Disadvantages

- Disruption during construction

Disadvantages

- Disruption during construction
- Removal of existing vegetation and relocation of adjacent structures

g) Segment 2, Alternative 7 (10-Year) Box Culvert at the Grand Canal

Segment2, Alternative 7 utilized a multi-cell box culvert cross-section in conjunction with the southern realignment of the Grand Canal. This was the most costly option studied within Segment 2 for a 10-year solution. This concept preserved the existing backyards to the north and provides a narrow green belt over a narrow box culvert. The Grand Canal would need to be constructed within new right-of-way to the south.

Advantages

- Eliminates the local flooding
- Limited right-of-way acquisition
- Extremely safe
- Retains current circulation patterns
- Narrowest solution (25-foot right-of-way)
- Maximizes recreation opportunities

Disadvantages

- Disruption during construction
- Limits side flows
- High construction cost
- Major disruption to SRP facilities

h) Segment 2, Alternative 8 (100-Year) Box Culvert at the Grand Canal

- This alternative was the most costly of the designs studied within Segment 2 for the 100-year system. The alternative required the Grand Canal be reconstructed to the south within new SRP right-of-way. The multi-cell box culvert would be built between the new SRP alignment and the south property line of the existing residences. A landscaped trail system could be accommodated on top of the facility.

Advantages

- Eliminates the floodplain and local flooding
- Limited right-of-way acquisition
- Extremely safe
- Retains current circulation patterns
- Narrowest solution (50-foot right-of-way)
- Maximizes recreation opportunities

Disadvantages

- Disruption during construction
- High construction cost
- Major disruption to SRP facilities

i) Segment 2, Alternative 9 (10-Year) Grass-Lined Channel North of the Grand Canal

Alternative 9 studied the impact of creating a greenbelt north of the existing Grand Canal alignment. The natural, grass-lined channel would be constructed to accommodate the 10-year storm event. The bottom of the channel had a minimum 8-foot bottom width with a low-flow concrete trickle channel. This option required a full take of the residences on the south side of Cavalier Drive.

Advantages

- Eliminates local flooding
- No impact to major utilities
- Aesthetically appealing
- Wide open channel corridor
- Maximizes recreation opportunities

Disadvantages

- Does not eliminate the 100-year floodplain
- Residential property takes (homes and businesses)
- High maintenance cost
- Standing water is likely

j) Segment 2, Alternative 10 (100-Year) Grass-Lined Channel North of the Grand Canal

Alternative 10 was the widest cross-section studied within Segment 2 and would require a full take of the residences south of Cavalier Drive. The channel was designed to accommodate the low-flow within a low flow trickle channel and the 100-year storm event in a 50-foot-wide natural, grass-lined channel.

Advantages

- Eliminates the floodplain and local flooding
- No impact to major utilities
- Aesthetically appealing
- Wide open channel
- Maximizes recreation opportunities

Disadvantages

- Residential property takes (homes and businesses)
- High maintenance cost
- Standing water is likely

k) Segment 2, Alternative 11 (10-Year) Grass-Lined Channel at the Grand Canal

Alternative 11 was a grass-lined cross-section placed on the Grand Canal alignment. This option required the reconstruction of the Grand Canal south of its current location. The greenbelt would be constructed between the new SRP alignment and the south property line of the residences to the north. The width of the greenbelt would be approximately 130-feet, which was enough to accommodate the 10-year storm event. This was a very costly alternative due to the reconstruction costs associated with the Grand Canal.

Advantages

- Eliminates local flooding
- Retains current circulation patterns
- Aesthetically appealing
- Wide open channel
- Maximizes recreation opportunities

Disadvantages

- High maintenance cost
- Standing water during storm events
- Disruption during construction
- High construction cost
- Major disruption to SRP facilities

l) Segment 2, Alternative 12 (100-Year) Grass-Lined Channel at the Grand Canal

Alternative 12 was the grass-lined cross-section placed on the Grand Canal alignment. This option requires the reconstruction of the Grand Canal south of its current location. The greenbelt would be constructed between the new SRP alignment and the south property line of the residences to the north. The width of the greenbelt would be approximately 190-feet, which was just enough to accommodate the 100-year storm event. Portions of 6 residential properties would be required at the west end of the segment. This was a very costly alternative due to the construction costs related to the Grand Canal.

Advantages

- Eliminates the 100-year floodplain and local flooding
- Retains current circulation patterns
- Aesthetically appealing
- Wide open channel
- Maximizes recreation opportunities

Disadvantages

- High maintenance cost
- Standing water during storm events
- Disruption during construction
- High construction cost
- Major disruption to SRP facilities

m) Segment 2, Alternative 13 (10-Year) Box Culvert under Cavalier Drive

This option accommodated the 10-year flood and evaluated a multi-cell box culvert under Cavalier Drive. This alignment would require the removal of 1 residence, but would be extremely difficult to construct. The Cavalier Drive right-of-way was irregular and the roadway was not consistently constructed centered on the property boundaries. The box culvert cross-section for this alternative was approximately 25-feet wide and would require additional right-of-way and/or construction easements.

Advantage

- Eliminates local flooding
- Limited right-of-way acquisition
- Extremely safe
- Retains current circulation patterns
- Narrow solution

Disadvantages

- Major disruption during construction
- Expensive flow interceptor system

n) Segment 2, Alternative 14 (100-Year) Box Culvert under Cavalier Drive

This option tested a multi-cell box culvert under Cavalier Drive. This alignment would require the acquisition of 1 residence and would be extremely difficult to construct. The Cavalier Drive right-of-way was irregular and the roadway was not consistently constructed centered on the property boundaries. The box culvert cross-section, approximately 40' wide, was sized to accommodate the 100-year floodwaters. Alternative 14 would require approximately 25-feet of additional right-of-way.

Advantage

- Eliminates the 100-year floodplain and local flooding
- Limited right-of-way acquisition
- Extremely safe
- Retains current circulation patterns
- Narrow solution

Disadvantages

- Major disruption during construction
- Expensive flow interception system

o) Segment 2, Alternative 15 (10-Year) Grass-Lined Channel South of the Grand Canal

Alternative 15 was included at the request of the FCD. This option studied the feasibility of constructing an open channel south of the Grand Canal. The 10-year floodwaters would be conveyed under the Grand Canal using box culverts at the upstream and downstream limits of the segment. The cross-section studied for this alternative was a grass-lined greenbelt and was approximately 150-feet wide. This alternative was not an expensive alternative to construct, but limits the interception capacity of the flood control system due to the Grand Canal barrier to the north.

Advantages

- Retains current circulation patterns
- Aesthetically appealing
- Wide open channel
- Maximizes recreation opportunities
- Separates recreational uses from residential properties

Disadvantages

- High maintenance cost
- Standing water is likely
- Difficult to intercept flood waters
- Requires additional rights-of-way

p) Segment 2, Alternative 16 (100-Year) Grass-Lined Channel South of the Grand Canal

The option was the same as Alternative 15 except accommodated the 100-year flood. The grass-lined greenbelt was approximately 200-feet wide. This alternative was not an expensive alternative to construct, but limits the interception capacity of the flood control system due to the natural Grand Canal barrier to the north.

Advantages

- Eliminates the 100-year floodplain
- Retains current circulation patterns
- Aesthetically appealing
- Wide open channel
- Maximizes recreation opportunities
- Separates recreational uses from residential properties

Disadvantages

- High maintenance cost
- Standing water was likely
- Requires additional rights-of-way

4. Segment 3

Segment 3 was the 83rd Avenue roadway crossing. The final design of this segment was dependent on the alternative selected to the east and west of the roadway. The 2 cross-sections studied were a multi-cell box culvert or a clear span bridge. These cross-sections were sized based on the 100-year flood (S3A3, S3A4, S3A7 and S3A8) and the 10-year flood (S3A1, S3A2, S3A5 and S3A6). Their horizontal location varied based on either an alignment north or south of the Grand Canal. It was assumed that an alternative located on the Grand Canal alignment would utilize a similar alternative as the northern alignment solution. Cost and Project Team preference will likely decide the selection of a box culvert or bridge. Significant utility relocations will be required at the intersection of Bethany Home Road and 83rd Avenue. These utility relocations include 2 water lines, sewer lines, underground telephone, SRP irrigation facilities and overhead power.

Advantages of a Bridge

- Aesthetically pleasing wide open span
- Clear views underneath (Safety)

Disadvantages of a bridge

- More complex construction techniques
- Typically higher construction costs

Advantages of a Box Culvert

- Simplified construction techniques
- Typically lower construction costs

Disadvantages of a Box Culvert

- Limited visibility through the structure (Safety)

5. Segment 4

Segment 4 consisted of the alignment north of the Grand Canal between 83rd Avenue and 75th Avenue. The proposed project within this segment would impact a City of Glendale park and potentially a SRP well site. The alternatives studied varied from little or no impact on the existing development to terminating roadways and eliminating homes. All of the alternatives assumed that an open channel would be required along Bethany Home Road to intercept the City of Glendale's future storm drain currently under design and the concentrated flood flows at the intersection with 83rd Avenue. During the final design of this facility, an alternative method of intercepting and conveying the flood flows would be developed in coordination with a relocation solution for Bethany Home Road. The City of Glendale could not define a recommended alignment for Bethany Home Road at the time of this report and a roadway alignment study was outside the scope-of-work for this study.

a) Segment 4, Alternative 1 (10-Year) Rectangular Concrete Channel

This alternative evaluated a rectangular concrete line channel. The concrete channel was approximately 35-feet wide. The channel was protected by security fencing on both sides. The SRP maintenance road to the south was retained and a new maintenance road was added to the north of the project alignment. This roadway would also be used as an integrated trail system linked with the existing City of Glendale park.

Advantages

- Eliminates local flooding
- Narrow cross-section
- Limited right-of-way acquisition
- Adequate safety
- No residential property takes

Disadvantages

- Does not eliminate the 100-year floodplain
- Reduces recreation opportunities
- Visible fence barriers
- Disruption during construction

b) Segment 4, Alternative 2 (100-Year) Rectangular Concrete Channel

Alternative 2 evaluated the 100-year flow with a rectangular concrete-lined channel between 83rd Avenue and Camelback Road. The concrete channel was approximately 50-feet wide and protected by security fencing on both sides. The SRP maintenance road to the south was retained and a new maintenance road was added to the north. This maintenance road would also be used as an integrated trail system, linked with the existing City of Glendale Park.

Advantages

- Eliminates 100-year floodplain and local flooding
- Narrow cross-section
- Limited right-of-way acquisition
- Adequate safety
- No residential property takes

Disadvantages

- Reduces recreation opportunities
- Visible fence barriers
- Disruption during construction

c) Segment 4, Alternative 3 (10-Year) Grass-Lined Channel with Low-Flow Pipe

This alternative was designed to convey 10-year floodwaters within a grass-lined natural channel. The facility would be typically 125 wide with a minimum 8-foot bottom width. There was a low-flow pipe located on the

low side of the cross-section to accommodate nuisance water. The capture of nuisance water in a low flow pipe will allow for more recreation opportunities with little or no impact from the flood control facility. In addition, the maintenance road would connect to the existing park trail system and provide a link to the Sun Circle Trail.

Advantages

- Eliminates local flooding
- Aesthetically appealing

Disadvantages

- Does not eliminate the 100-year floodplain
- Residential property takes
- Street and city utility reconstruction
- High maintenance cost
- Disruption during construction
- High construction cost

d) Segment 4, Alternative 4 (100-Year) Grass-Lined Channel with Low-Flow Pipe

This alternative was designed to convey 100-year floodwaters within a grass-lined natural channel. The channel width was typically 125-feet with a minimum 8-foot bottom width. A low-flow pipe was included to eliminate nuisance water from the channel. The capture of nuisance water in a low flow pipe would allow for more recreation opportunities with little or no impact from the flood control facility. In addition, the maintenance road would connect to the existing park trail system and provide a link to the Sun Circle Trail.

Advantages

- Eliminates local flooding and the 100-year floodplain
- Aesthetically appealing

Disadvantages

- Residential property takes
- Street and city utility reconstruction
- High maintenance cost
- Disruption during construction
- High construction cost

e) Segment 4, Alternative 5 (10-Year) Box Culvert

This alternative tested a box culvert cross-section for a 10-year design storm. This cross-section was considered the most aesthetic of the cross-sections and the most versatile. There were drainage inlets located along the top of the structure allow for the collection of contributing flows. A trail/maintenance road would meander around the inlets and link into existing trail system.

Advantages

- Eliminates local flooding
- Limited right-of-way acquisition
- Extremely safe
- Retains current circulation patterns
- Narrowest solution (15-foot right-of-way)
- No impact to major utilities
- Maximizes recreation opportunities

Disadvantages

- Does not eliminate the 100-year floodplain
- Disruption during construction

f) Segment 4, Alternative 6 (100-Year) Box Culvert

A multi-cell box culvert cross-section was evaluated with this alternative. The box culvert required approximately 30-feet to accommodate the 100-year design storm. This was one of the most aesthetic, recreation and cost friendly solutions.

Advantages

- Eliminates the 100-year floodplain and local flooding
- Limited right-of-way acquisition
- Extremely safe
- Retains current circulation patterns
- Narrowest solution (30-foot right-of-way)
- No impact to major utilities
- Maximizes recreation opportunities

Disadvantages

- Disruption during construction

6. Segment 5 (100-Year)

Segment 5 was the intersection of 75th Avenue and Camelback Road. This intersection carries a lot of traffic and has many underground utilities within the street right-of-way. The Grand Canal passes through this intersection on a diagonal and further limits the placement of the proposed facility. Two alignments were investigated within this segment. The first alignment paralleled the Grand Canal through the SRP Grasmoen Substation. The second alignment, originally developed by the FMS, goes around the Grasmoen Substation. This alignment was located between the rear property line of the residential homes to the north, through a multi-family structure on the east and the substation to the southwest. Regardless of the alignment, the cross-sections studied for the 100-year system was a box culvert. The 10-year system would utilize a large diameter pipe for either alignment. No pedestrian underpasses were considered at this roadway crossing due to the

length of the crossing, safety, availability of space due to utility conflicts, and costs. All pedestrian and bicycles would be directed to cross at the intersection.

All of the alternatives would impact numerous utilities within 75th Avenue and Camelback Road. Utilities requiring relocation in 75th Avenue included underground electric and telephone, natural gas, water, irrigation, and sewer. The sewer would require a siphon for the BH/GC FCP crossing. Utilities requiring relocation in Camelback Road include underground telephone, several water lines, natural gas, and 2 sewer lines. One sanitary sewer siphon would be required for the BH/GC FCP crossing. The alignment parallel to the Grand Canal would require the relocation of a SRP well site at the northeast corner of the intersection.

This segment was evaluated by the FCD independently with each of the cities. Both evaluations recommend the alignment parallel to the Grand Canal.

a) Grand Canal Alignment (Alternatives 1 and 2)

Advantages

- Eliminates local flooding
- Eliminates floodplain (100-year solution)
- Limited right-of-way acquisition
- Extremely safe
- Retains current circulation patterns

Disadvantages

- Major traffic disruption during Construction
- Significant utility relocations

b) FMS Alignment (Alternatives 3 and 4)

Advantages

- Eliminates local flooding
- Eliminates floodplain (100-year solution)
- Extremely safe
- Retains current circulation patterns

Disadvantages

- Significant traffic disruption during Construction
- Significant utility relocations
- Residential property acquisition
- Public safety considerations

7. Segment 6A

Segment 6A was located between Camelback Road and 73rd Avenue. This transition segment was impacted by an existing radio station transmission towers and guy wires. The radio station was recently purchased and was

currently operating. Each of the 3 towers not only have supporting guy wires, but also underground transmission radial wires that radiate out on 3 degree increments around each tower. Construction around this facility would need to be carefully coordinated with the radio station in order not to permanently impact their transmitting ability.

a) Segment 6A, Alternative 1 (100-Year) Grass-Lined Channel with Low-Flow Pipe

Alternative 1 evaluated a grass-lined channel, with a low flow pipe, to accommodate the 100-year design storm. This alternative was studied in order to maximize trail connectivity and continuity. The typical cross-section width was 100-feet starting 10-feet inside the existing SRP right-of-way. This alternative would effectively shut down the radio station operations.

Advantages

- Eliminates local flooding and the 100-year floodplain
- Aesthetically appealing
- Wide channel
- Maximizes recreation opportunities

Disadvantages

- Residential property takes
- High maintenance cost
- High construction cost
- Significant impact to the radio transmission towers (relocate transmission towers to another site or purchase of the station and FCC license)

b) Segment 6A, Alternative 2 (100-Year) Rectangular Concrete Channel

Alternative 2 evaluated the 100-year conveyance of a rectangular concrete lined channel. The channel would be sited almost entirely on SRP right-of-way and maintain the SRP 30-foot wide maintenance road. The facility would require approximately 25-feet of additional right-of-way adjacent to the SRP right-of-way depending on the location of the trail/maintenance road. The channel be fenced for safety and accessed by an adjacent maintenance road. This design would require the relocation of guy wires and underground wiring for 1 of the 3 radio towers. It was believed that this impact could be mitigated through proper design coordination.

The Project Team did discuss a box culvert solution for this segment. It was estimated that a box culvert solution would increase the project cost approximately $350,000. The advantage of a box culvert is that the solution would provide a more open/multi-use space with possibly smaller right-of-way requirements. The City of Phoenix has indicated they will make a decision as to whether to pursue this alternative prior to the final design.

Advantages

- Eliminates local flooding and the 100-year floodplain
- Narrow cross-section
- Limited right-of-way acquisition
- Adequate safety

Disadvantages

- Reduces recreation opportunities
- Visible fence barriers
- Minimized impact to adjacent radio transmission towers (relocation of guy wires and underground wiring)

8. *Segment 6B*

Segment 6B was located between 73rd Avenue and 67th Avenue. It was identified in the Maryvale ADMS as an ideal location for a flood control retention basin. The retention basin was needed to mitigate the quantity of downstream floodwaters to be conveyed through the City of Glendale. The basin was conceptually located in a linear shape adjacent to the north bank of the Grand Canal. The need for this basin was reinforced during the development of the alternative cross-sections. Each of the cross-section widths developed became extremely wide due to the enormous amount of water that accumulates in this neighborhood during storm events. The necessary width of the flood control facility resulted in the removal of homes regardless of the type of facility studied. Therefore, each of the alternatives resulted in a full taking of most all of the homes directly north of the Grand Canal. In addition, SRP overhead electric lines and sanitary sewers are located on the north bank of the Grand Canal along the full extent of this segment.

a) Segment 6B, Alternative 3 (100-Year) Grass-Lined Detention Basin with Concrete Low-Flow

This alternative evaluated a natural grass-lined detention basin with a concrete low-flow channel. The typical width of this cross-section was 100-feet. This dimension was measured from the edge of the SRP right-of-way north and included the existing alley. The resulting impact was a 70-foot property take into the existing lots. Due to the size of the lot, no usable land would remain and the full lot would be purchased. The alternative plans depict a grass-lined linear park south of Coolidge Street paralleling the Grand Canal.

Advantages

- Eliminates local flooding and the 100-year floodplain
- Aesthetically appealing
- Wide open channel
- Optimizes recreation opportunities

Disadvantages

- Residential property takes
- High maintenance cost
- Standing water is likely
- Disruption during construction

b) Segment 6B, Alternative 4 (100-Year) Underground Box Culvert Detention Basin

Alternative 4 evaluated a box culvert cross-section in order to minimize impacts on the adjacent residences. The typical width of the box culvert was determined to be 80-feet. Even if 50-feet of the SRP right-of-way was utilized, the remaining 30-foot impact would still result in full taking of the adjacent residential properties. The alternative plans show a linear park placed on top of the box culvert. The park would be fully visible from Highland, Coolidge and Turney Avenue. This was the most expensive solution to the flooding problem for any segment and alternative.

Advantages

- Eliminates the 100-year floodplain and local flooding
- Extremely safe
- Retains current circulation patterns
- Narrowest solution (80-foot right-of-way)
- Maximizes recreation opportunities

Disadvantages

- Disruption during construction
- Very expensive to construct

9. *Segment 6C*

Segment 6C was the roadway crossing at 67th Avenue. The Grand Canal passes under 67th Avenue at this location parallel to the Grand Canal. There are existing high pressure gas lines within the right-of-way that would need to be lowered regardless of the alternative selected. Other utilities impacted in this segment include 2 irrigation pipes, underground telephone, storm drains and a water line. There was also a potential for a pedestrian underpass at this location, connecting Segments 6B and 7. Whether a box culvert or a bridge is selected would be dependent on the alternatives recommended for segment 6B and 7.

Disadvantages of a Bridge (100 Year)

- Typically more complex construction
- Highest construction cost

Advantages of a Box Culvert (100 Year)

- Lower construction costs

10. *Segment 7*

Segment 7 was located between 67th Avenue and Indian School Road. Residential homes back onto an alley, which parallels the Grand Canal. There are existing overhead electrical, water and sewer lines in the alley as well as garbage dumpsters. These services would need to be relocated or protected in place depending on the cross-section selected.

a) Segment 7, Alternative 1 (100-Year) Rectangular Concrete Channel

This alternative evaluated the impact of a rectangular concrete lined channel. The channel was estimated to be approximately 8-feet wide and 8-feet deep. The channels steep vertical sides would require fencing on both sides. A 16-foot wide maintenance road/alley would be constructed on the north side of the facility allowing for the replacement of City services. This alternative was fairly narrow and would minimally or temporally impact the existing residences.

Advantages

- Eliminates local flooding and the 100-year floodplain
- Sunset Detention Basin provides 100-year flood protection
- Limited right-of-way acquisition

- Adequate safety
- Minimal impact to major utilities

Disadvantages

- Reduced recreation opportunities
- Visible fence barriers
- Disruption during construction

b) Segment 7, Alternative 2 (100-Year) Box Culvert

Alternative 2 evaluated the impact of a box culvert within Segment 7. The box culvert cross-section required similar right-of-way as the rectangular concrete channel. There would be no impact to the existing residential properties. Existing City service would be reconstructed, relocated or protected in place. City trash collection service from the alley could be discontinued in favor of street collection and the alley could be converted into a trail section along the Grand Canal.

Advantages

- Eliminates the 100-year floodplain and local flooding
- Sunset Detention Basin provides 100-year flood protection
- Extremely safe
- Retains current circulation patterns
- Narrowest solution (20-foot right-of-way)
- Impact to major utilities

Disadvantages

- Disruption during construction
- Moderately expensive floodwater interception system (storm drain system)

c) Segment 7, Alternative 3 (100-Year) Grass-Lined Channel with Concrete Low-Flow Channel

A 110-foot grass-lined natural channel was the third alternative evaluated in Segment 7. The facility would abut the existing SRP right-of-way and extends 88-feet to the north. This resulted in a full taking of the adjacent residential properties along 66th Drive as well as the neighborhood church.

Advantages

- Eliminates local flooding and the 100-year floodplain
- Sunset Detention Basin provides 100-year flood protection
- Aesthetically appealing
- Wide open channel
- Maximizes recreation opportunities

Disadvantages

- Residential and commercial property takes

- High maintenance cost
- Standing water is likely
- Disruption during construction

11. Segment 7A

Segment 7A studied the design impact of a box culvert versus a bridge crossing at Indian School Road. The selection of either option was dependent on the cross-section recommended in segment 7 and the development of the Sunset Detention Basin. The Sunset Detention Basin would collect local storm water that ponds south of Indian School Road adjacent to the Grand Canal.

Disadvantages of a Bridge (100-Year)

- Typically more expensive to construct

Advantages of a Box Culvert (100-Year)

- Lower construction costs

12. Segment 8 (10-Year)

To mitigate the local flooding problems in Glendale, 2 storm drain systems were investigated as part of this project to be connected into the BH/GC FCP channel. The City of Glendale has initiated a storm drain project within Bethany Home Road that would connect to the BH/GC FCP channel at or around 83rd Avenue. An additional storm drain was needed south of Bethany Home Road to carry additional floodwaters to the flood control facility. An alignment in Camelback Road was the first choice. However, due to the number of existing utilities within Camelback Road there was question as to whether the storm drain would fit within the existing right-of-way. Therefore, the Missouri Avenue storm drain alignment was evaluated to see whether it would significantly reduce the size of a potential storm drain in Camelback Road. As a result, Segment 8 was created to study the feasibility of a storm drain within the Missouri Avenue alignment.

The Missouri storm drain would be constructed from 59th Avenue, west, to the BH/GC FCP channel. The available right-of-way varies between 80-feet and 110-feet. Due to existing utilities within the existing roadway right-of-way, the storm drain would be located to the south of the existing mid-section line. The maximum pipe size was estimated to be 90 inches in diameter. This element of the project would greatly impact access during construction to many homes and schools along Missouri Avenue. Many of the residences face the street and have no other means of access. This would cause undue hardship during construction and possibly constitute a taking.

A second alignment was considered for the Missouri Avenue storm drain. Alternative 1 maintained the Missouri Avenue alignment from 59th Avenue to the Grand Canal. The difference between alternative 1 and 2 was the horizontal alignment from 75th Avenue to the Grand Canal. At 75th Avenue, the second alternative would proceed south on 75th Avenue and outfall to the BH/GC FCP channel through an existing detention basin north of Camelback Road. Both alternatives achieve the same objective and have similar impacts. The 75th Avenue alignment has more utility issues to negotiate but does not impact as many residences as Alternative 1.

The Project Team determined that the cost of the Missouri Avenue storm drain does not warrant the reduced pipe size for the Camelback Road storm drain.

13. Segment 9 (10-Year)

The Camelback Road storm drain would be constructed from 59th Avenue to 75th Avenue where it would empty into the BH/GC FCP channel. The maximum diameter of the pipe would be approximately 102 inches

located south of the existing section line. There are significant utilities within Camelback Road. However there was room, to the south of the section line, to accommodate a 102-inch storm drain. This construction would temporarily impact homes and businesses in the general area, but would not result in a taking. The realization that the entire storm drain could fit within Camelback Road eliminated the need for the Missouri Avenue alignment and resulted in a project cost savings.

IX. Evaluation of Alternative Plans

A. Issue Development

The citizens of Glendale and Phoenix were given the opportunity to participate in a series of public meetings that provided background information on the project and the work to be completed. During these meetings, the Project Team distributed questionnaires to the public (See Appendix D). The questionnaires listed potential issues and asked if the public had any additional issues or comments. The public was requested to prioritize their issues in order of their importance from 1 to 6, using each number only once. Requesting that the public rank their top 6 issues required the participants to make difficult choices and produce a true prioritization. The Project Team was on hand to assist the public with understanding the questionnaire and the issues presented. The public was allowed to take the questionnaires home and to think about their responses if they desired. The completed questionnaire could be given to the Project Team at the meetings, mailed or e-mailed to the FCD prior to the first of November. The Project Team logged in the questionnaire responses.

For tracking purposes, each questionnaire was numbered upon receipt. The input provided on the questionnaires was then transferred to a spreadsheet with the tracking number. The spreadsheet listed the respondent's address, top 6 priorities, whether they pay flood insurance and whether they live in the 100-year floodplain. During this process it became very obvious that the citizens of Glendale and Phoenix had differing points of views and priorities regarding issues. The Project Team determined that a different set of priorities would need to be used for each city during the evaluation process. A spreadsheet was developed to tabulate the ranking scores for each issue allowing the Project Team to clearly determine the top 10 issues for both Glendale and Phoenix (See Table 2 and 3).

The Project Team added 7 technical issues to the evaluation matrix. The technical issues were the same for both cities and represented issues that the Project Team found to be critical to the success of the project. The technical issues were not prioritized by the Project Team, but were given appropriated weights in relation to the public issues and project priorities. The public's issues were both ranked and weighted based on the questionnaire responses.

Weighting allows issues of greater or lesser importance to be identified. A weight of 5 was given to the top community issue and a weight of 1 was given to the lowest. Based on the statistical distribution of points received from the public, the rest of the weights were assigned on a straight scale (See Table 2). The weight was then multiplied with the score given to an alternative during the evaluation process. The weight creates a broader gap between the high and the low score enabling a recommended alternative to be clearly identified.

Table 2 – City of Glendale Evaluation Matrix Issues

Priority	Public Issues	Weight
1	Minimize removal of homes and businesses	5
2	Provide for pedestrian/equestrian trail system	3
3	Optimize appearance	3
4	Provide recreational opportunities (soccer/playground)	2
5	Develop the widest (greenbelt/open space)	2
6	Move canal south	2
7	Minimize disruption to community during construction	1
8	Eliminate local flooding	1
9	Eliminate the floodplain/need for flood insurance	1
10	Maximize safety during flood events	1

Priority	Team Issues	Weight
	Minimize impact on quality of life	5
	Minimize construction cost	5
	Maximize safety of constructed project	4
	Minimize maintenance	3
	Minimize disruption to SRP facilities	3
	Minimize duration of standing water in multi-use areas	2
	Minimize traffic impacts during construction	1

Table 3 – City of Phoenix Evaluation Matrix Issues

Priority	Public Issues	Weight
1	Minimize removal of homes and businesses	5
2	Eliminate local flooding	5
3	Eliminate the floodplain/need for flood insurance	5
4	Maximize safety during flood events	3
5	Minimize disruption to community during construction	3
6	Develop the narrowest solution	2
7	Optimize appearance	2
8	Provide for pedestrian/equestrian trail system	1
9	Provide recreational opportunities (soccer/playground)	1
10	Maximize access/circulation during flood events	1
Priority	**Team Issues**	**Weight**
	Minimize impact on quality of life	5
	Minimize construction cost	5
	Maximize safety of constructed project	4
	Minimize maintenance	3
	Minimize disruption to SRP facilities	2
	Minimize duration of standing water in multi-use areas	2
	Minimize traffic impacts during construction	1

B. Evaluation Team

The Evaluation Team consisted of 2 project engineers, 2 project planners, 1 to 2 City representatives and 1 to 2 FCD representatives. The team was kept small, but diverse for varying viewpoints during group discussions. Discussions between group members often will lead to a new understanding of an issue or of a solution. A group scoring process also tends to discourage political bias or personal preference. Each of the group members was reminded that the process was to remain as clear cut as possible and that consistency between issues, segments and alternatives was paramount.

The evaluation team for Glendale's segments differed from the evaluation team for Phoenix's segments. This allowed for the participation of key city representatives during the evaluation process for their jurisdiction. This way the city was able to send personnel who represented departments, issues or segments of importance to the City. The Project Team members were the same during the evaluation process to maintain consistency and project understanding.

C. Evaluation Criteria

The public issues and the technical issues were the basis for the evaluation criteria. The key factor in the evaluation process was the creation of a numerical scoring scale. The scoring scales were based from 1 – 5. The attributes assigned to each score were grounded in facts, figures and information that helped ranking one situation as better than another. The scores of 1, 3 and 5 were very clear cut and defined. The scores of 2 and 4 represented gray areas where there were slight variations between alternatives, but not drastic differences of good or bad. The Project Team attempted to avoid the scoring of an issue based on subjectivity or an answer that did not seem to fit any category. The following are the issues and the evaluation criteria used during this process:

1. Glendale Public Issues

a) Minimize removal of homes and business

The Glendale public ranked this issue as they're highest priority. The Glendale community did not want the project to impact their existing properties or lifestyles. The point total for this issue in the questionnaire spreadsheet was so far above the other issues totals that the straight scaled used to determined weighting was heavily skewed. This issue earned a weight of 5. One weight of 4 was assigned. The other issues were assigned between a 3 and a 1 weight because the community was more dispersed in their prioritization scoring of these issues.

The Project Team's evaluation criteria were broken into 3 clear-cut categories: a full take necessitated the removal of an occupied structure or the permanent debilitation of a business operation. A partial take was defined by the limited taking of land, but not of occupied structures and a 0 take was the construction of the project within existing public or quasi-public right-of-way.

5 = No takes

3 = Partial takes

1 = Full takes

b) Provide for pedestrian/equestrian trail system

Trails and recreation were key issues for the Glendale public. Many equestrians in the area use the SRP maintenance trail to access the County trail system along the Agua Fria River. Many others utilize the existing SRP maintenance road for recreation purposes and wanted to maintain their existing access or have the creation of new trails. This issue was ranked 2 and given a weight of 3.

5 = There is a multi-use trail provided and linked into other trail systems

3 = There is a multi-use trail provided for portion of this project/not linked

1 = There is no trail provided

c) Optimize Appearance

Many of the homes in the Glendale segments are less than 10 years old and well maintained. It was very important to the community that the new flood control facility be aesthetically appealing and well kept. The Evaluation Team believed that a below ground project was the best because no negative aspects of the facility would be visible. The community ranked this issue a 3 with a weight of 3.

5 = The channel is a box culvert below grade

3 = The channel is grass-lined

1 = The channel is concrete

d) Provide recreational opportunities (soccer/playgrounds)

Many members of the public envisioned this project as a linear greenbelt with playfields and playgrounds connected by trails. These comments were reflected in the prioritization process in which it was ranked as the 4th highest priority and assigned a weight of 2.

5 = There is adequate area to accommodate playfields

3 = There is adequate area to accommodate playgrounds

1 = There is no excess area available for recreation

e) Develop the widest (greenbelt/open space) solution

Once again the citizens of Glendale re-emphasized the importance of recreation facilities. This issue ranked 5th, closely behind recreational opportunities. This issue was also given a weight of 2. The evaluation factors were determined by a comparison of the alternatives studied within a segment. The widest received a 5 the narrowest received a 1 and the remaining alternatives were scored as a function of their relative widths.

5 = The widest solution

3 = The second widest solution

1 = The narrowest solution

f) Move the Canal South

The owners north of the Grand Canal were very active participants in this project. As a group they created a write-in issue that scored enough points to become the 6th issue in the list of priorities. Move the canal south represented the belief by the residents in Segment 2 that there was not enough right-of-way between the Grand Canal and their rear property line to construct the BH/GC FCP facility. Their solution was to use the Grand Canal as the flood control corridor and to construct a new Grand Canal to the south of the exiting alignment. Another option, proposed by the FCD, would be to construct the BH/CG channel south of the Grand Canal and minimize disruption of existing SRP facilities. The residents stated that they did not want their properties impacted when there was vacant land to the south. This issue was ranked 6th and weighted a 2 and specifically applied to Segment 2.

5 = the BH/GCFCP is shifted south of the Grand Canal

3 = The Grand Canal is shifted south

1 = the BH/GCFCP is aligned north of the Grand Canal

g) Minimize disruption to community during construction

Issue was ranked number 7 and primarily related to noise and dust. This issue was weighted a 1 and was generally important only to those directly adjacent to the proposed facility. This issue was difficult to score due to varying construction methods, construction styles and access. After much discussion it was determined that a grass-lined channel created dust and noise for a greater period of time than other types of construction. The box culvert required a longer construction period, but created less earthwork and could be prefabricated off-site. The vertical lined concrete channel was the most time consuming because it had to be entirely constructed on site.

5 = The construction methods are simplistic and short in duration

3 = The construction methods are moderate in difficulty and duration

1 = The construction methods are difficult and time consuming

b) Eliminate local flooding

This issue ranked number 8 and was important to the City of Glendale. The City desires to construct a series of storm drains to mitigate local flooding during frequent storm events. The storm drains must have an outfall. The BH/GC FCP channel would provide the necessary outfall for these drains as well as neighborhood flooding adjacent to the Grand Canal. This issue weighted a 1.

5 = Flooding is eliminated

1 = Flooding is not eliminated

i) Eliminate the floodplain/need for flood insurance

The residents of Glendale are not impacted by the 100-year floodplain, but recognize the need to mitigate the existing problem. This issue ranked 9 and received a weight of 1. The alternatives that provided an outfall for the 100-year storm design discharges eliminated the floodplain. The 10-year design storm system options did not.

5 = The floodplain s eliminated

1 = The floodplain is not eliminated

j) Maximize safety during flood events

This issue ranked number 10 and was weighted a 1. The Evaluation Team determined that this issue could be divided into 2 sub-issues, velocity and side slopes. The swiftness of the flowing water (feet per second, fps) and the ability for someone to escape the channel during a storm event are key to the overall safety of the project. The Team determined that if the channel was enclosed it would be of the least risk to the community and the velocity of the water or the side slope were inconsequential design factors. The greater the water velocity in an open channel, the greater the risk. It was more difficult to escape the channel with a steep slope. The scores for each of the sub-categories were averaged so as not to give this issue more weight than other issues without sub-categories. The average score was then multiplied by the weight.

Velocity

5 = The channel is fenced/enclosed

3 = The channel velocity is less than 7 fps

1 = The channel velocity is greater than 7 fps

Side Slopes

5 = The channel is enclosed

3 = Channel side slopes are flatter than or equal to 3:1

1 = Channel side slopes are steeper then 3:1

2. Phoenix Public Issues

a) Minimize removal of homes and business

This issue was the number 1 priority for the public in both Glendale and Phoenix. A weight of a 5 was also assigned to this issue. The community clearly did not want to impact existing structures or lifestyles; however, in Phoenix this issue was not as unanimously important as it was in Glendale. Therefore, the weighting factors were more evenly distributed among the Phoenix issues.

Three clear-cut categories were used for the determination of this issue. A full take was the necessary removal of a residential structure or the permanent relocation of a business operation. A partial take was defined by the limited taking of land, but not of residential structures and a 0 take was the construction of the project within existing public or quasi-public right-of-way.

5 = No takes

3 = Partial takes

1 = Full takes

b) Eliminate local flooding

This issue was ranked 2nd and was very important to the citizens of Phoenix. Many of the residents in the project area have experienced local flooding and/or pay flood insurance. The local residents recognize that something needs to be done. However, they ask that the FCD limit the impact of the facility on the neighborhoods as much as possible. This issue was weighted a 5 based on the community prioritization process.

5 = Flooding is eliminated

1 = Flooding is not eliminated

c) Eliminate the floodplain/need for flood insurance

The residents of Phoenix are impacted by the 100-year floodplain and/or pay flood insurance. They recognize the need to mitigate the exiting problem. This issue ranked 3 and received a weight of 5. All of the alternatives designed for the segment within Phoenix mitigate the 100-year floodplain. Therefore, all the alternatives scored a 5.

5 = The floodplain is eliminated

1 = The floodplain is not eliminated

d) Maximize safety during flood events

This issue ranked number 4 with the public and earned it a weighting factor of 3. The Evaluation Team determined that this issue could be divided into 2 sub-issues, velocity and side slopes. The swiftness of the flowing water and the ability for someone to escape the channel during a storm event are key to the overall safety of the project. The Team determined that if the channel was enclosed it would be of the least risk to the community and the velocity of the water or the side slope was inconsequential design factors. The greater the water velocity in an open channel, the greater the risk. It was more difficult to escape the channel with a steep slope. The scores for each of the sub-categories were averaged so as not to give this issue more weight than other issues without sub-categories. The average score was then multiplied by the weight.

Velocity

5 = The channel is fenced/enclosed

3 = The channel velocity is less than 7 fps

1 = The channel velocity is greater than 7 fps

Side Slopes

5 = The channel is enclosed

3 = Channel side slopes are flatter than or equal to 3:1

1 = Channel side slopes are steeper then 3:1

e) Minimize disruption to community during construction

This issue ranked number 5 and primarily related to noise and dust. This issue was weighted a 3 and was expressed as a concern by many people. In additions to concerns about dust and noise, there were also issues regarding pedestrian circulation and accessibility to school and public services. Special consideration will need to be given to these issues during final design and construction administration.

This issue was difficult to score due to varying construction methods, construction styles and access. After much discussion it was determined that a grass-lined channel created dust and noise for a greater period of time than other types of construction. The box culvert required a longer construction period, but created generated less earthwork and could be prefabricated off-site. The vertical lined concrete channel was the most time consuming because it had to be entirely constructed on site.

5 = The construction methods are simplistic and short in duration

3 = The construction methods are moderate in difficulty and duration

1 = The construction methods are difficult and time consuming

f) Develop the narrowest solution

The citizens of Phoenix specifically identified this issue and gave it ranking of 6 and a weight of 2. They wanted the flood control facility, but wanted it to impact their neighborhoods as little as possible. The community believed that the narrowest channel would cause the least impact. However, during the development of the alternatives it was determined that size of the facility needed within Phoenix was extremely large. The impact of the facility on the community was unavoidable.

5 = The narrowest solution

3 = The second narrowest solution

1 = The widest solution

g) Optimize Appearance

The Phoenix neighborhoods are between 20 and 30 years old. These areas have deteriorated over time and are showing their age. A facility that is questionable in it's aesthetic appeal many have negative impacts on these neighborhoods. An appealing project would help the property values and character of the community. The Evaluation Team believed that a below grade project was the best because no negative aspects of the facility would be visible. A grass-lined channel would also be considered aesthetic and a concrete structure would be the least appealing. The community ranked this as the 7th most important issue and gave it a weight of 2.

5 = The channel is a box culvert below grade

3 = The channel is grass-lined

1 = The channel is concrete

h) Provide for pedestrian/equestrian trail system

Trails and recreation were important to the citizens of Phoenix, but they were looked upon as an additional amenity, not a necessity. This issue was ranked eighth and assigned a weight of 1.

5 = There is a multi-use trail provided and linked into other trail systems

3 = There is a multi-use trail provided for portion of this project/not linked

1 = There is no trail provided

i) Provide recreational opportunities (soccer/playgrounds)

The citizens of Phoenix liked the idea of additional recreational opportunities, but recognized that they were not integral to the success of the project. This issue ranked ninth and assigned a weight of 1.

5 = There is adequate area to accommodate playfields

3 = There is adequate area to accommodate playgrounds

1 = There is no excess area available for recreation

j) Maximize access during flood events

The public ranked this issue as tenth and gave it a weight of 1. This issue was unique to the Phoenix Residents. The neighborhoods in Phoenix have experienced significant flooding over the years where access became a major issue. The Project Team solved these issues by providing for the 100-year flood within the flood control facility. After construction of the project little to no ponding will occur in the local streets or yards.

5 = Emergency vehicles have clear and unencumbered access

3 = Streets maybe flooded but passable for large vehicles only

1 = Streets are flooded and may be impassible

3. Project Team Issues

a) Impact on the quality of life

This was the first of the technical issues developed by the Project Team. This issue evaluated whether the alternative could have a positive or detrimental effect on the existing community. The Evaluation Team asked themselves a series of questions:

- Is there an impact on land use?
- Is the general condition of the neighborhood impacted?
- Is there a potential loss of revenue or a gain in revenue due to the elimination of flood insurance?
- Is there any removal from the commercial tax base?
- Is there a loss of population due to property takes?

All of these sub-issues were evaluated as a whole. This issue was considered important and was assigned a rank of 1 and weight of a 5.

5 = Positive impact

1 = Negative impact

b) Minimize construction cost

Construction costs were considered important by the Project Team and therefore, ranked number 2 and assigned a weight of 5. Construction costs were determined based on a number of different issues:

- Land acquisition
- Residential relocation

- Estimated severance damages
- Utility relocation
- Facility construction
- Landscaping
- Traffic control
- Construction administration and engineering

The construction costs were determined for each alternative. The scoring was determined using a straight scale. Some segments only studied 2 options. The highest cost alternative scored a 1 and the second alternative's score was determined based on a percent scale difference from the highest cost.

5 = Low

3 = Moderate

1 = High

c) Maximize safety of the constructed project

The Project Team regarded the safety of the constructed project as a very important issue. This issue ranked 3rd and weighted it a 4. This issue differs from public issue 10 in that the public issue addresses the safety of the project during flooding (involving moving water) and the other was concerned with everyday safety. The Evaluation Team believed that the safest project was one that was not visible or accessible. The next safest was a channel which was continually fences and the least safe was an open channel accessible by the public.

5 = The facility is enclosed

3 = The facility is fenced

1 = The facility is open

d) Minimize maintenance

The issue of maintenance, while not the most important issue, was a very important design issue to consider. The Project Team ranked it 4th and gave it a weight of 3. The cost of maintaining a project can be both expensive and time consuming. Operations and maintenance budgets are limited and the Cities must determine the amount of time and effort they can promise toward a proposed project. The Cities must also determine which internal department will be responsible for the project (i.e. Streets and Transportation or Parks and Recreation). The Evaluation Team determined that the easiest channel to maintain was concrete. The fencing would keep debris and vandalism to a minimum and the concrete channel would only require periodic repairs. The grass-lined facility was determined to be the most expensive to maintain due to the weekly maintenance and irrigation requirements.

5 = The facility is a fenced concrete channel

3 = The facility is enclosed

1 = The facility is grass-lined

e) Minimize duration of standing water in recreation areas

As mentioned in the preceding issue, the City must determine which internal department will be given the responsibility of the facility once construction was completed by the FCD. Parks and Recreation Departments tend to accept projects that are landscaped, have multiple recreation opportunities and are over 10 acres in

land area. Maximization of use was very important and was given the rank of 5 and the weight of 2 for evaluation purposes. If standing water occurs in the facility on a regular basis, the water will limit recreational use and make the facility less appealing. In order to mitigate these issues in the grass-lined channel, low flow pipes or low flow trickle channels were added to the cross-sections. These elements of the cross-sections will convey the low-flow water away from useful open space. The low flow pipe was determined to be more effective at removing nuisance water than the low flow trickle channel and therefore scored a 5.

5 = No standing water

1 = Standing water

f) Minimize disruption to SRP facilities

The project corridor was full of SRP facilities. These facilities range from water wells, to irrigation and field drain pipe lines and ditches, to electric transmission lines, electrical substations and the Grand Canal. The cost of impacting these utilities was not just measured by the loss of revenue or inconvenience to SRP, but the impact on SRP consumers as well. In addition, the impact on the SRP facilities can also be evaluated based on whether it was a temporary disruption in service or a relocation of services. The costs associated with these issues were taken into consideration as part of a cost issue. This issue focuses on function and service. It was assigned a rank of 6th and was given the weight of 2.

5 = SRP facilities are not impacted

3 = SRP facilities are impacted

1 = SRP facilities are relocated

g) Minimize traffic impacts during construction

During the public involvement process many citizens expressed their concerns regarding the impact on regional and local circulation patterns during the construction of this project. The Project Team agreed that this was a very important issue to the community and included it in the technical issue evaluation with a rank of 7 and a weight of 1. The BH/GC FCP will be a very large channel and is not quickly constructed within streets laiden with utilities. Some alternatives are more simply constructed than others, are located in less congested areas or located in an area that has limited existing vehicular circulation.

5 = Traffic is not impacted during construction

3 = Limited access during construction

1 = Street closure during construction

D. Evaluation Matrix

The numerical evaluation process produced a matrix for each segment and alternative (See Appendix I). The matrix listed the score given to each evaluation issue and/or sub-issue. A total score for each alternative was tabulated and listed at the end of each segment sheet. Only the 100-year systems were evaluated using the matrix. It was assumed that the results would be similar for the10-year systems. The following is an overview of the matrix and its outcome:

1. Segment 1 (97th Avenue to 87th Avenue)

Three alternatives were evaluated for Segment 1. The concrete lined channel scored the lowest due to lack of recreation opportunities and aesthetics, which were important issues to the Glendale community. The grass-lined channel scored very well within these issues, but scored lower for issues pertaining to the width of the facility and safety. Overall the grass-lined channel with a low flow trickle channel scored the highest by 10 points over the grass-lined facility with a low flow pipe.

2. *Segment 1A (91st Avenue Road Crossing)*

Segment 1A compared a box culvert to a bridge crossing at 91st Avenue. The 2 crossings were similar on most issues except, safety, disruption to the community and cost. The biggest difference occurred in the cost category where the bridge was significantly higher in cost. This evaluation was informational, but the ultimate cross-section will be determined by the channel determined due to the cross-section selected upstream and downstream of 91st Avenue and FCD/City funding.

3. *Segment 2 (87th Avenue to 83rd Avenue)*

Eight alternatives were evaluated within Segment 2. Alternatives 2 and 4 were concrete channels. Alternatives 6, 8, and 14 were box culverts and Alternatives 10, 12 and 16 were grass-lined facilities. The horizontal alignments varied greatly between these alternatives as did aesthetics and required right-of-way. The box culvert located north of the Grand Canal received the highest evaluation score, winning by 8 points. This alternative required minimal right-of-way, impacted few if any SRP facilities, provided opportunities for trails and was considered aesthetic. A minimal amount of land would need to be taken from the properties to the north, but this small strip would not permanently damage the real estate value of their property or its ability to support livestock.

4. *Segment 3 (83rd Avenue Road Crossing)*

Segment 3 was not evaluated. The Evaluation Team believed that this Segment was totally dependent on the selected alternatives for Segments 2 and 4. Independent evaluation of the cross-section and alignments would have no bearing on the final recommended alternative.

5. *Segment 4 (83rd Avenue to 75th Avenue)*

Three alternatives were evaluated in this segment. The box culvert scored over 20 points higher than the vertical lined concrete channel and 80 points higher than the natural channel. This drastic difference in score was due to the size of the channel and the impact of an open channel facility on the neighborhood park. The box culvert scored very high due to limit land acquisitions, recreational opportunities, safety, relative ease of maintenance and little impact or disruption to the neighborhood.

6. *Segment 5 (75th Avenue and Camelback Road Intersection)*

Both Glendale and Phoenix evaluated segment 5. The Glendale Evaluation scored the Grand Canal alignment alternative 19 points higher than the FMS alignment that looped around the Grasmoen Substation. The scores were all very close, but the weight of the scores emphasized the differences and helped to highlight the differences. The Phoenix evaluation also scored the Grand Canal alignment alternative higher, but only by 6 points. These scores varied due to the differing issues between the 2 cities as well as the weights developed by the public.

7. *Segment 6A (Camelback Road to 73rd Avenue)*

Segment 6A studied the connection of Segment 6B to Segment 5, past the existing radio transmission tower site. The evaluation scored the rectangular channel 43 points higher that the natural cross-section. The major factors influencing this evaluation outcome were the impact on the commercial property, the cost of right-of-way and safety.

8. *Segment 6B (73rd Avenue to 67th Avenue)*

The evaluation of the alternatives for Segment 6B studied a natural grass-lined detention facility and a box culvert detention facility. Both alternatives greatly impacted the adjacent community. Evaluation of the 2 alternatives generated only a 5-point differential with the box culvert identified as the selected alternative. The

box slightly provided better safety, aesthetic appeal and recreation opportunities. Though the box culvert scored higher than the grass-lined alternative, either alternative would be a viable option for this segment. Although a viable solution, a box culvert may not be reasonable given the high relative construction cost.

9. *Segment 6C (67th Avenue Road Crossing)*

The final decision of whether a bridge or a box culvert was more viable at 67th Avenue will ultimately be based on the cross-sections selected both upstream and downstream. The Evaluation Team evaluated the roadway crossing simply to see if one alternative was dramatically better than the other alternative. The 2 alternatives scored almost identically with the box culvert winning by 6 points. At this location, there was little difference between options.

10. *Segment 7 (67th Avenue to Indian School Road)*

Segment 7 evaluated a box culvert; concrete lined channel and a grass-lined channel. The box culvert scored higher by 21 points over the concrete channel and 73 points over the grass-lined channel. The box culvert scored very high due to minimal property takes, the ability to replace existing services and utilities as well as providing recreation opportunities in an unobtrusive manner.

11. *Segment 7A (Indian School Road Crossing)*

This evaluation compared a box culvert to a bridge at the Indian School Road crossing. Currently the Sunset Detention Basin is designed to provide 10-year flood protection. This alternative would provide the ultimate connection to the Sunset Detention Basin and 100-year protection instead of 10-year. If the connection is made the alternative solution that scored the highest was the box culvert. The primary difference between the 2 alternatives was cost.

12. *Segment 8 and 9 (Missouri Avenue Storm Drain and the Camelback Storm Drain)*

The Evaluation Team did not complete a formal evaluation of Segments 8 and 9. The informal discussion centered on whether there was space within the Camelback Road right-of-way to accommodate a large storm drain. The preliminary design of Segment 9 concluded that there was enough room within the Camelback Road right-of-way to accommodate the required 102-inch storm drain. Therefore, Segment 8, or the Missouri Road storm drain was not cost effective.

E. Summary

Adding weighted subtotals derived the overall score that was considered the matrix recommended alternative. A cost estimate for each segment and alternative was generated to assist in the evaluation of technical issue 2. The lowest cost alternatives, for each segment, were added to determine the lowest construction cost possible. The highest construction costs were added to determine the maximum construction cost based on the design scenarios. Once the evaluation was complete, the highest scoring alternative for each segment was determined (See Table 4). A cost estimate for this design scenario was calculated using the cost estimates generated for the evaluation process (See Table 5). The cost estimate does not represent a final design construction amount, but it provides a comparative project total cost estimate that includes design, construction, utilities, landscape, traffic control, and a 20% contingency (See Appendix J).

Table 4 – Matrix Selected Alternative

Segment	Location	Cross-Section	Alignment	Score/Possible Total (Percent)	Comments
1	97th Ave. to 87th Ave.	Grass-lined Trapezoidal Channel/Low Flow Channel	North of the Grand Canal	141/220 (64%)	Won by 16 points
1A	91st Ave.	Tie between a bridge and a box	North of the Grand Canal	154/220 (70%)	The box is more cost effective
2	87th Ave. to 83rd Ave.	Box Culvert	North of the Grand Canal	157/220 (71%)	Minor impacts
3	83rd Ave	Not evaluated		N/A	
4	83rd Ave. to 75th Ave.	Box Culvert	North of the Grand Canal	173/220 (79%)	Minor impacts
5	75th Ave. and Camelback Rd.	Box Culvert	Parallel to the Grand Canal	141/220 (64%) 191/250 (77%)	Safest and shortest distance
6A	Camelback Rd. to 73rd Ave.	Vertical Concrete Channel	North of the Grand Canal	180/250 (72%)	Minimized adjacent impacts
6B	73rd Ave. to 67th Ave.	Box Culvert	North of the Grand Canal	175/250 (70%)	The alternatives only differed by 5
6C	67th Ave.	Box Culvert	North of the Grand Canal	199/250 (80%)	
7	67th Ave. to Indian School Rd.	Box Culvert	North of the Grand Canal	209/250 (84%)	Minimized impacts
7A	Indian School Rd.	Box Culvert	North of the Grand Canal	197/250 (79%)	Cost effective
8	Missouri Ave.	N/A		N/A	Not effective
9	Camelback Rd.	102-inch Storm Drain	South of Camelback Rd Section Line	N/A	

Table 5 – Cost Comparison

Segment / Location	Highest Estimate (in Millions)	Type of Conveyance Facility (Cross-Section)	Lowest Estimate (in Millions)	Type of Conveyance Facility (Cross-Section)	Matrix Selected Estimate	Type of Conveyance Facility (Cross-Section)
Segment 1 Loop 101 to 87th Ave. Alignment	$8.64	Grass-lined Trapezoidal Channel/Low Flow Pipe	$7.60	Grass-lined Trapezoidal Channel/Low Flow Channel	$7.60	Grass-lined trapezoidal Channel/Low Flow Channel
Segment 1A 91st Ave. Crossing	$1.27	Clear Span Bridge	$1.08	Box Culvert	$1.,08	Clear Span Bridge
Segment 2 87th Ave. to the Grand Canal	$10.78	Box South of Grand Canal	$4.53	Vertical Concrete Channel North of the Grand Canal	$6.53	Box Culvert North of the Grand Canal
Segment 3 87th Ave. Crossing	$1.00	Clear Span Bridge	$0.56	Box Culvert	$0.56	Box Culvert
Segment 4 Grand Canal to 75th Ave.	$13.70	Grass-lined Trapezoidal Channel/Low Flow Pipe	$7.68	Vertical Concrete Channel	$11.78	Box Culvert
Segment 5 75th Ave. and Camelback Rd. Crossing	$2.44	Box Culvert at the Flood Mitigation Study Alignment	$2.22	Box Culvert at Grand Canal	$2.22	Box Culvert at Grand Canal
Segment 6A Camelback Rd to 73rd Ave.	$6.86	Grass-lined Trapezoidal Channel/Low Flow Pipe	$1.46	Vertical Concrete Channel	$1.46	Vertical Concrete Channel
Segment 6B 73rd Ave to 67th Ave.	$30.32	Box Culvert	$11.82	Grass-lined Trapezoidal Channel/Low Flow Channel	$30.32	Box Culvert

Segment / Location	Highest Estimate (in Millions)	Type of Conveyance Facility (Cross-Section)	Lowest Estimate (in Millions)	Type of Conveyance Facility (Cross-Section)	Matrix Selected Estimate	Type of Conveyance Facility (Cross-Section)
Segment 6C 67th Ave. Crossing	$0.45	Clear Span Bridge	$0.43	Box Culvert	$0.43	Box Culvert
Segment 7 67th Ave. to Indian School Rd.	$5.89	Grass-lined Trapezoidal Channel/Low Flow Channel	$1.79	Box Culvert	$1.79	Box Culvert
Segment7A Indian School Rd Crossing	$0.27	Clear Span Bridge	$0.21	Box Culvert	$0.21	Box Culvert
Segment 9 Camelback Rd. Storm Drain	$6.03	Storm Drain	$6.03	Storm Drain	$6.03	Storm Drain
Total	**$87.65**		**$45.42**		**$70.03**	

X. Recommended Alternative

A. Recommended Alternative Development

Once the matrix evaluation process was completed the Project Team presented the finding to the City of Phoenix, the City of Glendale and the FCD for review and comment. Generally, the matrix recommended alternatives were accepted as the recommended solution. However, for Segments 2 and 6, the matrix recommended alternatives were not well received by the public, the FCD and the cities. The matrix evaluation process was a numerically based process and does not consider such elements as emotions, etc. The same methodology and criteria was used to evaluate each of the alternatives within a given segment, regardless of any special conditions or considerations. If any of the reviewing parties were concerned with one of the matrix recommend alternatives, the country or cities could override the matrix recommendation and possibly redefine another alternative for further evaluation.

1. Segment 2, Additional Alternative Development

The City of Glendale believed that the matrix outcome for Segment 2 would not be well received by the property owners north of the Grand Canal. The FCD and the City of Glendale determined that it would be appropriate to have an additional small group meeting with the affected residents within Segment 2. The intent of the meeting was to present the matrix recommended alternative and all the alternatives studied to date. On April 6, 2000 a neighborhood meeting was held at TT Traw Associates, on the corner of 83rd Avenue and Bethany Home Road. Generally, the residents accepted any project alignment as long as it was south of the Grand Canal. The participants signed a petition to that effect during the meeting and presented it to the FCD. No alternative north of the Grand Canal was acceptable to the residents. With the strong feedback given to the FCD and City of Glendale, the Project Team developed additional alternatives south of the Grand Canal and initiated meetings with the property owner.

At the request of the FCD, DMJM developed 4 additional alternatives for Segment 2, aligned south of the Grand Canal. These alternatives were developed to a lesser level of detail than the previous alternatives. All of the alternatives, 17 through 20, were aligned south of the SRP Welborn substation unless noted. Cost estimates for each of the alternatives are provided in Appendix J. The conceptual layout of these alternatives is included in Appendix H. The advantages and disadvantages for each of these additional alternatives is very similar to those previously defined for similar conveyance cross-sections. A brief description of each additional alternative investigated is provided below:

Alternative 17, (100-Year) Box Culvert 1000' South of the Grand Canal

This alternative investigated a box culvert solution for the 100-year flood located approximately 1000-feet south of the Grand Canal and the Bethany Home Road Alignment. The concept was to site the facility under a future roadway corridor.

Alternative 18, (100-Year) Rectangular Concrete Channel South of the Grand Canal

This alternative was investigated to determine the feasibility of a minimum right-of-way solution for the 100-year system. This alternative resulted in significantly higher costs for this segment of the project.

Alternative 19, (100-Year) Box Culvert South of the Grand Canal

This alternative identified the cost of a box culvert system south of the Grand Canal for 100-year flood protection. Construction costs for this alternative were also significantly higher than other alternatives.

Alternative 20, (100-Year) Grass-Lined Channel South of the Grand Canal

The difference between alternative 20 and alternative 16 is that the grass-lined channel side slopes were flattened from a 4:1 to a 6:1. A variation of this alternative (20B) considered aligning the channel north of the Welborn substation at the west end of the segment.

5. *Segment 1, Loop 101 to 87th Avenue Alignment)*

Segment 1 is proposed as a open grass-lined channel with a horse trail on the south, adjacent to the Grand Canal, and a multi-use trail along the north side of the project (See Figures 11 and 12). A meandering concrete low-flow channel is proposed in the bottom of the facility. The right-of-way width required for improvements is estimated at approximately 230' with 6:1 side slopes, west of 91st Avenue. A bridge is proposed at the 91st Avenue crossing. The bridge structure was not graphically depicted, but is described as an open concrete structure designated as a pedestrian and equestrian underpass.

East of 91St Avenue (Segment 1A), the project is envisioned as a grass-lined channel along the north bank of the Grand Canal (See Figure 13). The proposed design reconfigures the existing ADOT retention basin into a detention basin between 91st Avenue and 87th Avenue. This off-line detention basin will meet the flow limitations into the downstream channel at the Loop 101 Freeway. The embankment located between the channel and the basin is proposed for use as a pedestrian trail. The equestrian trail is proposed along the south boundary of the project adjacent to the Grand Canal.

6. *Segment 2 and 3, (87th Avenue Alignment to 83rd Avenue and Bethany Home Road)*

Starting approximately 800-feet west of the 87th Avenue alignment, the BH/GC FCP is proposed to turn south, crossing under the Grand Canal and south around the SRP Welborn Substation (See Figure 14 and 15). Just south of the SRP Welborn Substation the alignment turns east and then veers northeast to realign along the south bank of the Grand Canal. The equestrian trail follows the BH/GC FCP across the Grand Canal. The equestrian trail is planned along the south bank of the Grand Canal with the pedestrian trail along the south BH/GC FCP right-of-way. The right-of-way for these improvements are shown at 230-feet with a 6:1 grass-lined side slope. The channel crosses 83rd Avenue within a bridge structure that will accommodate pedestrians and equestrians alike. At 83rd Avenue, south of the Grand Canal, 2 private properties are to be acquired. These residential property impacts were unavoidable with the southern alignment. At the eastern boundary of these properties the BH/GC FCP crosses under the Grand Canal and aligns parallel with the north bank.

7. *Segment 4, (83rd Avenue and Bethany Home Road to 75th Avenue)*

Segment 4 is recommend as a box culvert (See Figure 16). The existing Glendale City Park will be replaced on top of the box culvert (See Figure 17). The pedestrian trail will still meander throughout the park and the equestrian trail will be located along the north bank of the Grand Canal. The only noticeable changes to the existing park landscape will be drainage inlets incorporated into the park. Surplus excavated dirt from the box culvert construction maybe used to fill in low areas or retention basins such as the one at 75th Avenue and Camelback Road.

There is one existing residential property within Segment 4 that will be impacted by the construction. At this point in time it is not known whether the structure will be impacted or not. The total impact of the project on the residence will be determined during final design.

a) Segment 2, Alternative Selection

After several meetings with the property owner south of the Grand Canal, the FCD and the City of Glendale reached an agreement to locate the BH/GC FCP south of the Grand Canal within Segments 2 and 3. The selected conveyance facility was a grass-lined channel with 6:1 (horizontal to vertical) side slopes and an averaged depth of 12-feet with a bottom width of 40-feet. This alternative (S2A20) required approximately 230' of right-of-way south of the Grand Canal and around the SRP Welborn substation. The channel would cross under the Grand Canal in a 3-10'x8' concrete box culvert east of 83rd Avenue and west of the 87th Avenue alignment in a 6-10'x5' concrete box culvert.

2. Segment 6, Alternative Development

The City of Phoenix and the FCD were concerned about the matrix evaluation outcome for Segment 6. The highest-ranking cross-section, the box culvert detention basin, scored 256 points, only 5 higher than the natural grass-lined detention basin, which scored 251. The two alternatives both required the acquisition of the same number of homes, but the box culvert scored slightly higher for safety, aesthetics and multi-use opportunities. The significant difference between the two alternatives was in the cost. The box culvert was significantly more expensive to construct than the open grass-lined detention basin. The FCD and the City of Phoenix did not believe that the costs associated with placing the detention basin underground would allow the project to be feasible. Therefore, the FCD and the City of Phoenix selected the grass-lined detention basin as the recommended alternative for Segment 6.

3. Roadway Crossing and Multi-Use Underpasses

The costs of a bridge or a box culvert were fairly similar for most roadway crossings, as was the impact of construction. Therefore, the Project Team postponed making the final roadway crossing alternative decision until all of the adjacent segment cross-sections were finalized. Once the channel cross-sections and alignments were determined, the Project Team was able to finalize the roadway crossings that had not been evaluated in the matrix process (See Table 6). Knowing the adjacent channel cross-section made the decision between a bridge or a box culvert more relevant to the overall project.

Table 6 – Recommended Roadway Crossings

Crossing Locations	Structure Type	Span by Height (feet)	Pedestrian/Multi Use Underpass
91st Avenue	Bridge	64 x 9	Yes
83rd Avenue	Bridge	32 x 15	Yes
75th Avenue	Box Culvert	2 barrel – 8 x 7	No
67th Avenue	Box Culvert	8 x 7	Yes
Indian School Road	Box Culvert	8 x 6	Yes

The City of Phoenix has experience retrofitting multi-use underpasses to existing flood control facilities such as the Arizona Canal Diversion Channel. The City of Phoenix requested that the 67th Avenue and Indian School Road crossings incorporate trail underpasses. The only roadway not recommended for an underpass was the intersection of 75th Avenue and Camelback Road. The length of the underpass would be in excess of 560-feet. The Project Team believed that pedestrian safety through such a long narrow structure could easily be compromised with no easy view corridors for police or access for emergency vehicles. In addition, there was a size constraint placed on the facility due to existing utilities and the remaining space underneath the intersection. Therefore, the flood control project had to be kept as narrow as possible. All pedestrian,

equestrian and multi-use traffic will have to cross this intersection at the traffic signal. The City of Glendale is constructing a pedestrian/multi-use bridge over the Grand Canal at the north east corner of this intersection.

Additional multi-use crossings may be required at the proposed Grand Canal crossings along the east side of 83rd Avenue and along the west side of the 87th Avenue alignments. The alignment and size of each multi-use crossing will be determined during final design

4. Storm Drain Alternatives

The Project Team presented all of the hydraulic modeling and the preliminary storm drain design for segments 8 and 9 to the City of Phoenix, the City of Glendale and the FCD during the matrix evaluation process. The findings indicated that the required 102-inch storm drain, needed to carry flood water from 59th Avenue west, could be accommodated within the existing Camelback Road right-of-way. The ability to construct the storm drain within the Camelback Road right-of-way eliminates the Missouri Avenue storm drain alternative.

The recommended alignment located the 102-inch storm drain along the south side of the Camelback Road centerline from 59th Avenue to 67th Avenue. The Camelback Road storm drain, in conjunction with the BH/GC FCP would significantly help alleviate frequent flooding in the Maryvale Village and downtown Glendale. The Project Team agreed that a single Camelback Road storm drain was the most logical, cost-effective solution and should be the recommended storm drain alternative.

B. Connection to the Sunset Detention Basin

Currently, the Sunset Detention Basin provides a 10-year level of flood protection. Connecting to the BH/GC FCP would increase the Sunset Detention Basin to a 100-year level of protection. Three alternatives for the connection of the Maryvale Detention Basin to the Sunset Detention Basin were studied. These alternatives included a rectangular concrete lined channel, concrete box culvert and trapezoidal grass-lined channel. DMJM identified the following benefits of connecting to the Sunset Detention Basin:

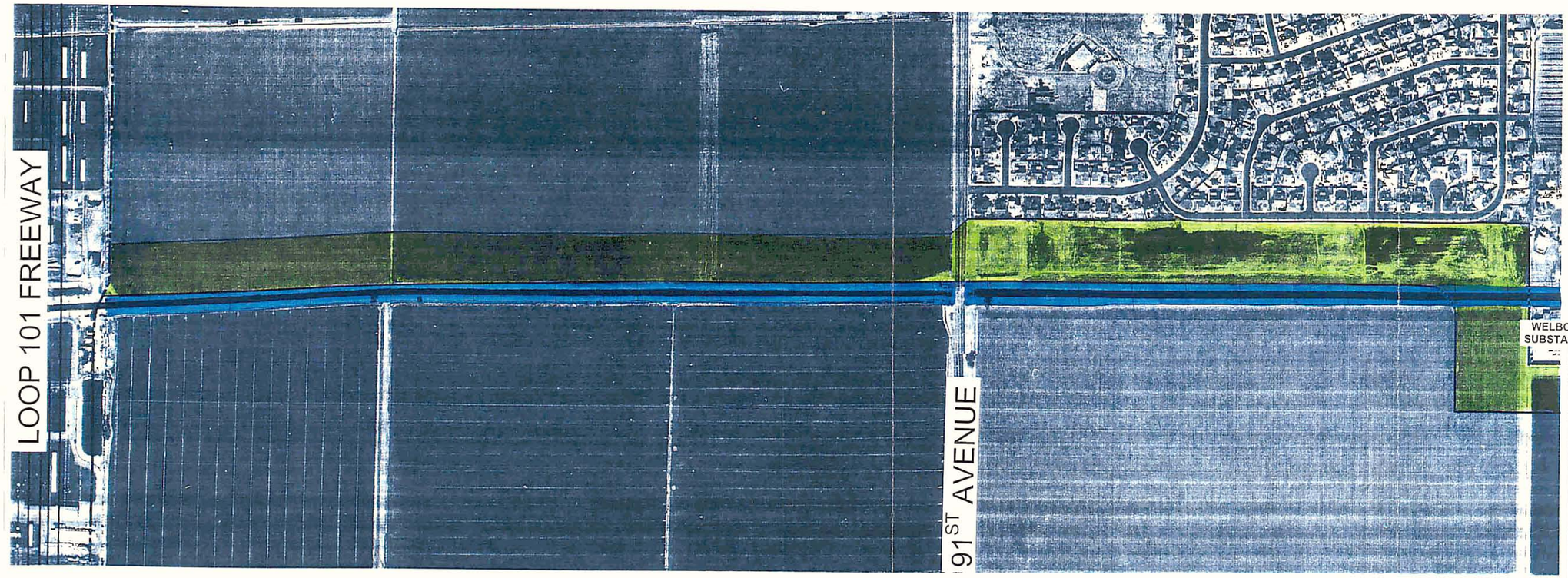
- Reduction or elimination of the floodplain upstream of the Grand Canal for a greater distance.
- Elimination of Grand Canal bank overtopping and the potential for flooding of properties downstream of the canal.
- Minimization of maintenance associated with flows exceeding the current Sunset Detention Basin design storm.
- Provisions for a multi-purpose trail/corridor link.

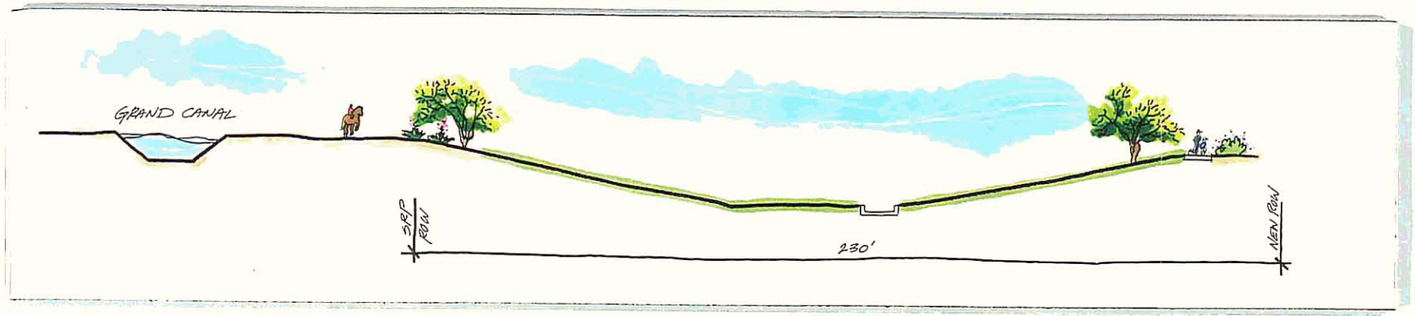
Both the City of Phoenix and the FCD agreed to plan for and develop the connection to the Sunset Detention Basin.

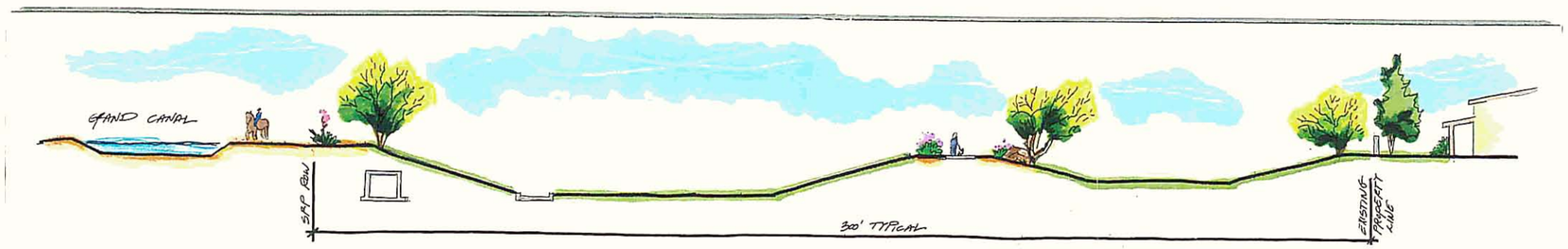
C. Recommended Alternative

A large portion of the recommended alternative was planned as an above grade natural channel (See Appendix H, under separate cover). The similarity between segment cross-sections helped simplify segment transitions and the landscape themes. The visual continuity of the project will help enhance the feeling of the open space and the trail linkages.

The recommended alternative was woven together and presented to the community at the third and final Pre-Design Study public meeting. The public meetings were held on consecutive nights, July 18, 2000 at the Christ Presbyterian Church (located in Phoenix) and July 19, 2000 at the Glendale City Hall (located in Downtown Glendale). Presentation boards depicting the recommended alternative were displayed. Numerous Project Team members including the FCD, the City of Phoenix, the City of Glendale, SRP and DMJM, were available to answer project related questions.







87TH AVENUE ALIGNMENT

legend

- GRAND CANAL
- BH/GC WIDTH (VARIES)

vicinity map

Figure 11 – Segment 1, Plan and Section

Scale: 1" = 200'

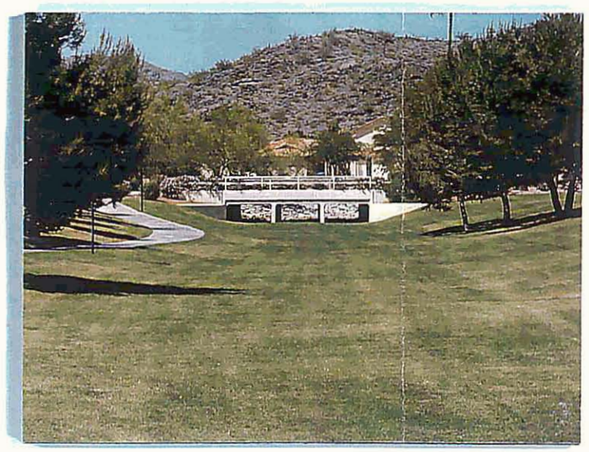
bethany home / grand canal flood control project

segment 1 recommended alternative

FLOOD CONTROL DISTRICT of MARICOPA COUNTY

DMA 50 YEARS

Existing Condition



Potential Greenbelt Treatment

Potential Node/Rest Area Treatment

Figure 12 – Segment 1, Perspective

Segment 1
(Loop 101 to 91st Avenue)

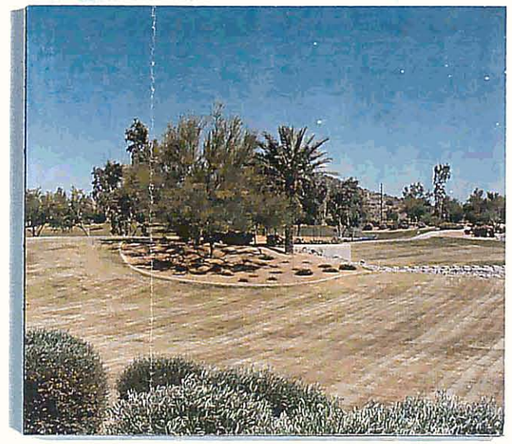
bethany home / grand canal
flood control project

JULY 2000

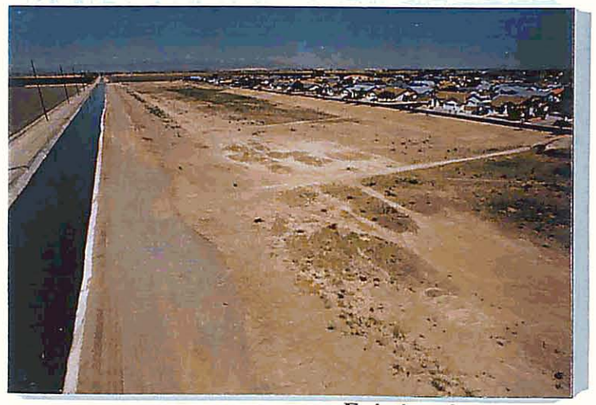
FLOOD CONTROL DISTRICT of MARICOPA COUNTY

DMM 50 YEARS

Potential Greenbelt Treatment



Potential Greenbelt Treatment



Existing Condition

Potential Bridge/Underpass Treatment

Figure 13 – Segment 1, Perspective

The examples presented on this exhibit show possible treatments that may be used within this segment of the project. They do not necessarily reflect the actual or final design of the project elements.

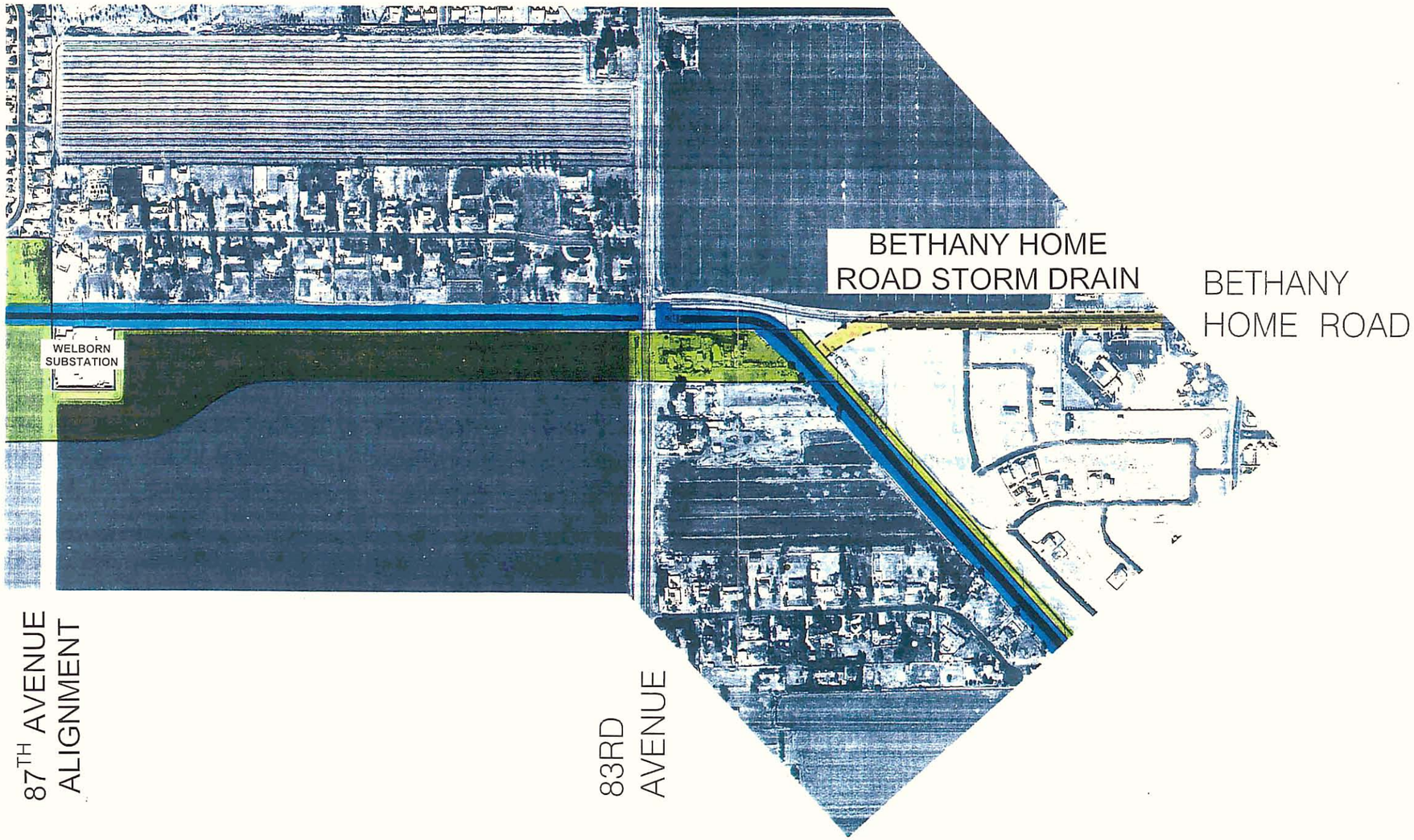
JULY 2000

bethany home / grand canal flood control project

Segment 1
(91st Avenue to 87th Avenue)

FLOOD CONTROL DISTRICT of MARICOPA COUNTY

DMJM 50 YEARS



legend

- GRAND CANAL
- BH/GC WIDTH (VARIES)

vicinity map

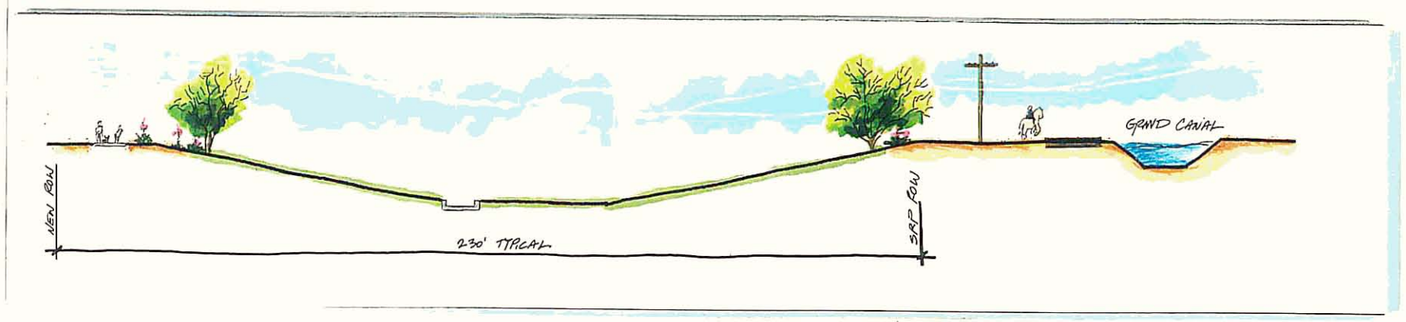


Figure 14 – Segment 2 and 3, Plan and Section

Scale: 1" = 200'
JULY 2000

bethany home / grand canal
flood control project

segment 2 & 3 recommended alternative

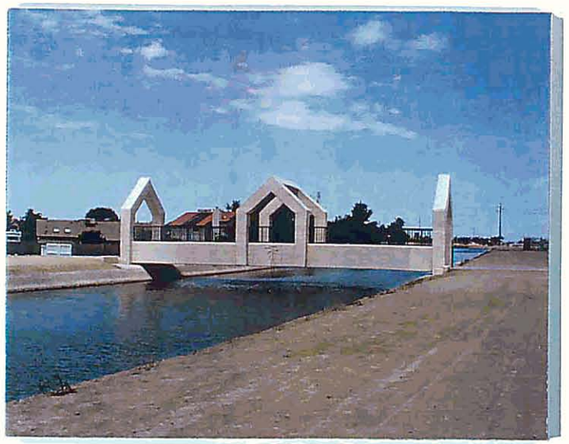
FLOOD CONTROL DISTRICT of MARICOPA COUNTY

DMJM 50 YEARS

Existing Condition

Potential Greenbelt Treatment

Potential Greenbelt Treatment



Potential Bridge Treatment

Figure 15 – Segment 2, Perspective

The examples presented on this exhibit show possible treatments that may be used within this segment of the project. They do not necessarily reflect the actual or final design of the project elements.

JULY 2000

Segment 2
(87th Avenue to 83rd Avenue)

bethany home / grand canal
flood control project

FLOOD CONTROL DISTRICT of MARICOPA COUNTY

DMJM

50 YEARS

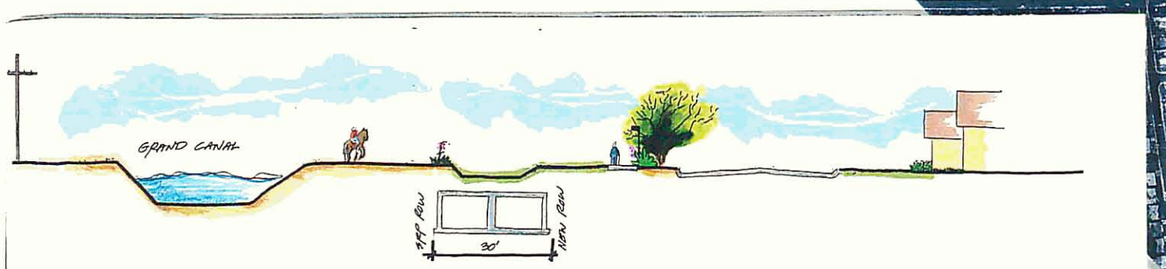
BETHANY HOME
ROAD STORM DRAIN

83RD AVENUE

MISSOURI
AVE

75TH
AVENUE

CAMELBACK ROAD
STORM DRAIN



segment 4
recommended alternative

bethany home / grand canal
flood control project

legend

- GRAND CANAL
- BH/GC WIDTH (VARIES)

vicinity map

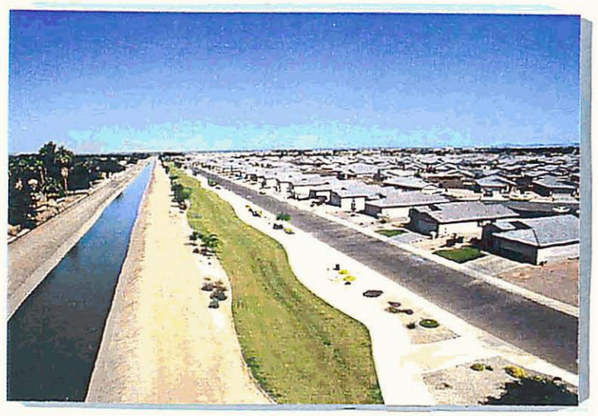
Figure 16 – Segment 4, Plan and Section
Scale: 1" = 200'
JULY 2000

FLOOD CONTROL DISTRICT of MARICOPA COUNTY

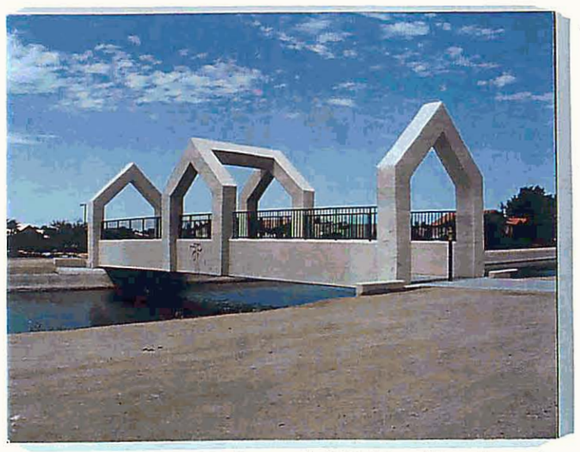
DMJM
50 YEARS

Potential Greenbelt Treatment

Potential Greenbelt Treatment



Existing Condition



Potential Bridge Treatment

Figure 17 – Segment 4, Perspective

The examples presented on this exhibit show possible treatments that may be used within this segment of the project. They do not necessarily reflect the actual or final design of the project elements.

JULY 2000

Segment 4

(83rd Avenue to 75th Avenue)

8. *Segment 5 and 6 (75th Avenue to 67th Avenue)*

The intersection of 75th Avenue and Camelback Road is Segment 5 (See Figure 18). The BH/GC FCP will be conveyed through a 565-foot long box culvert underneath the intersection paralleling the Grand Canal. Due to adjacent land uses, utility and distance constraints it is not possible to provide for a pedestrian/equestrian underpass. The trail system is planned to cross the intersection at grade and follow the north bank of the Grand Canal into Segment 6A.

The channel adjacent Segment 6A to the existing radio station is designed as narrow as possible to minimize impacts to the transmission towers, guy wires and underground radial wires. The pedestrians and equestrian trails will be located on either side of the vertical walled concrete lined channel. The trails will be separated from the channel by security fencing. Safety and minimal property impact were the guiding criteria for the recommended alternative. East of 73rd Avenue, the channel enlarges into the Maryvale Detention Basin.

The Maryvale Detention Basin (Segment 6B) is designed to capture storm flows and remove the surrounding neighborhoods from the 100-year floodplain (See Figure 19 and 20). The volume of floodwaters, minimum profile of the channel and the adjacent existing street elevations determined the size of the basin. Based on the engineering evaluation of the above criteria, the removal of 72 homes adjacent to the Grand Canal is required. The Maryvale Detention Basin will be constructed as a meandering grass-lined channel with interwoven pedestrian/multi-use trails. The equestrian trail remains along the north side of the Grand Canal as proposed in previous segments.

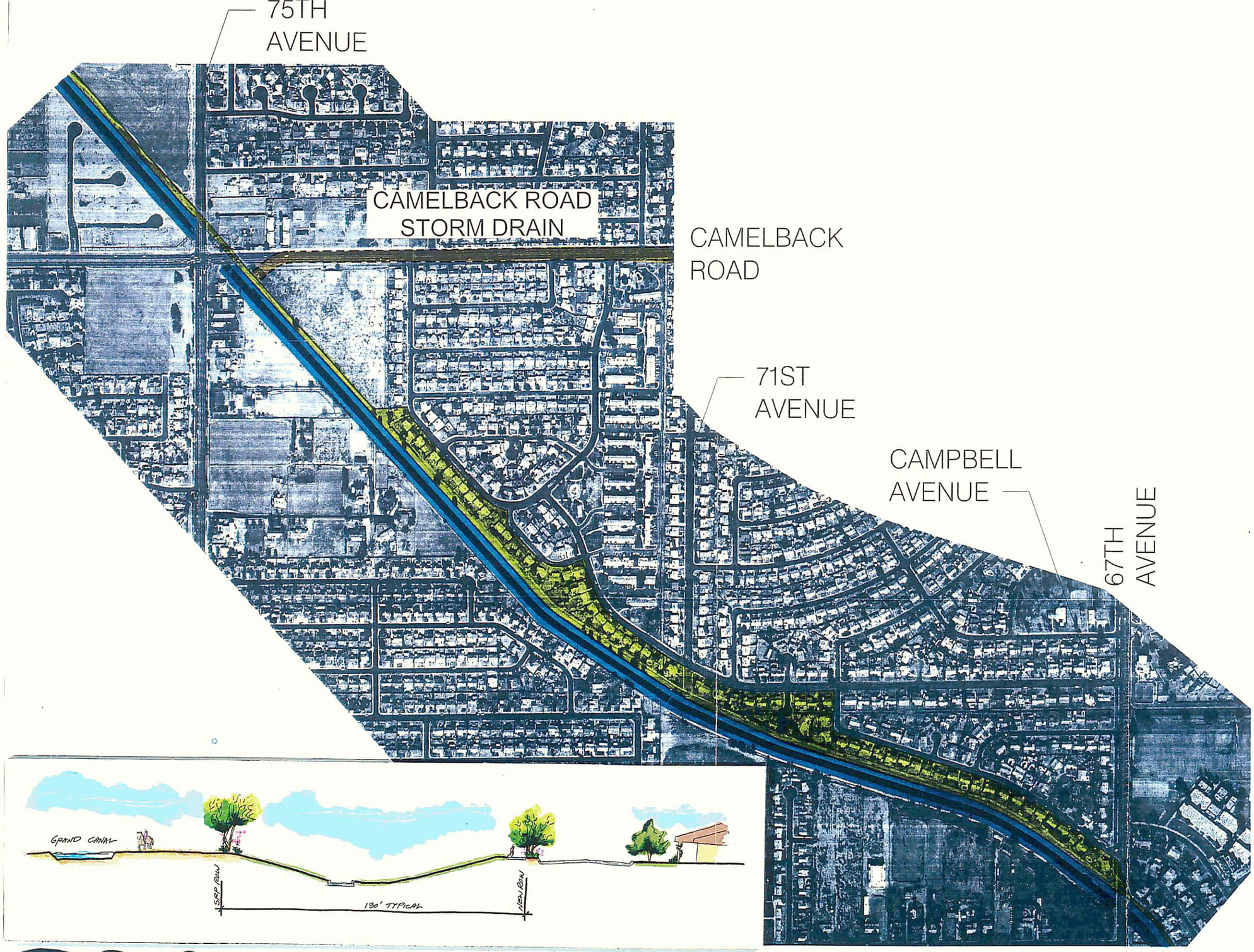
The Maryvale Detention Basin is planned to connect to Segment 7 via a box culvert at 67th Avenue (Segment 6C). The box culvert will accommodate floodwaters with a separate multi-use underpass.

9. *Segment 7 (67th Avenue to Sunset Detention Basin)*

The amount of floodwaters that accumulate in Segment 7 was previously determined in the Maryvale ADMS to be significantly less than the quantity of ponding in Segment 6. Therefore the width of the channel within Segment 7 is much narrower than in Segment 6 (See Figure 21 and 22). The 8-foot wide box culvert is proposed within the existing alley and will encroach on a small portion of the SRP right-of-way. The existing residential properties adjacent to the alley will not be impacted. There will be some change to utility services and garbage collection. The garbage collection will be moved to the street on a permanent basis. Public vehicular access to the alley will no longer be allowed. Existing utilities in the alley will be relocated at no cost to the residents. The alley will become a landscaped multi-use trail located on top of the box culvert. The equestrian trail is proposed adjacent to the Grand Canal within the SRP right-of-way. The BH/GC FCP, Segment 7, will connect to the Sunset Detention Basin through a box culvert. Segment 7A, the Indian School Road crossing, will provide a multi-use under crossing as well as a flood conveyance box culvert.

10. *Segment 9 (Camelback Road Storm Drain)*

The proposed storm drain system is depicted as a 102-inch pipe culvert within Camelback Road. The size of the storm drain will vary from the 102-inch at 75th Avenue to 84-inch at 59th Avenue.



legend

- GRAND CANAL
- BH/GC WIDTH (VARIES)

vicinity map

Figure 18 – Segment 5 and 6, Plan and Section

Scale: 1" = 200'
JULY 2000

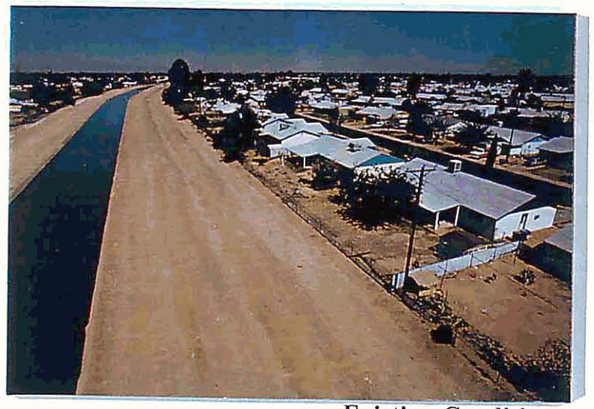
segment 5 & 6 recommended alternative

bethany home / grand canal flood control project

FLOOD CONTROL DISTRICT of MARICOPA COUNTY

DMM 50 YEARS

Potential Greenbelt Treatment



Existing Condition

Potential Greenbelt Treatment

Figure 19 – Segment 6B, Perspective

The examples presented on this exhibit show possible treatments that may be used within this segment of the project. They do not necessarily reflect the actual or final design of the project elements.

JULY 2000

Segment 6
(75th Avenue to 67th Avenue)

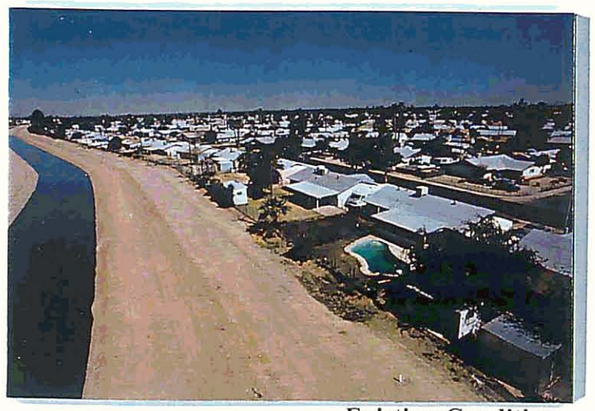
bethany home / grand canal
flood control project

FLOOD CONTROL DISTRICT of MARICOPA COUNTY

DMJM 50 YEARS

Potential Greenbelt Treatment

Potential Bridge/Underpass Treatment



Existing Condition

Potential Greenbelt Treatment

Figure 20 – Segment 6B, Perspective

The examples presented on this exhibit show possible treatments that may be used within this segment of the project. They do not necessarily reflect the actual or final design of the project elements.

Segment 6

(75th Avenue to 67th Avenue)

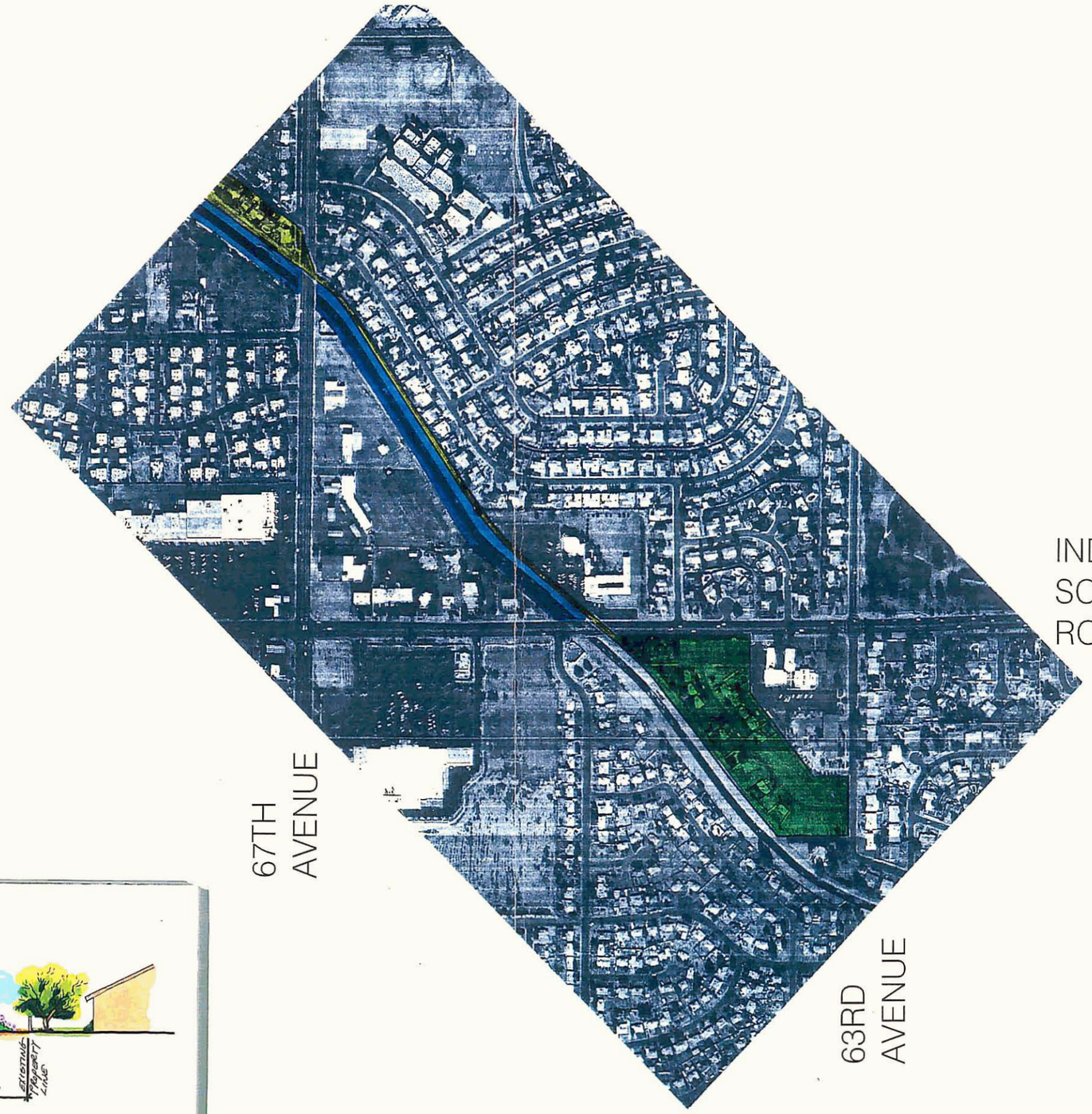
bethany home / grand canal
flood control project

JULY 2000

FLOOD CONTROL DISTRICT of MARICOPA COUNTY

DMJM

50 YEARS



legend

- GRAND CANAL
- BH/GC WIDTH (VARIES)
- FUTURE SUNSET DETENTION BASIN (not a part of this project)

vicinity map

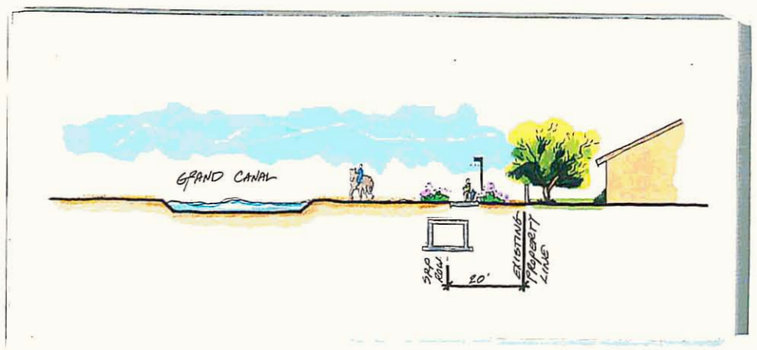


Figure 21 – Segment 7, Plan and Section

Scale: 1" = 200'
JULY 2000

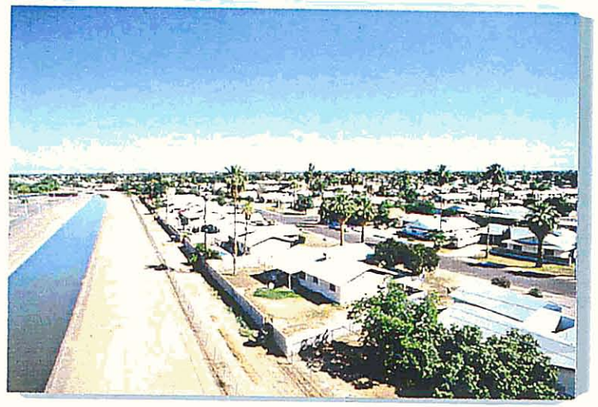
bethany home / grand canal
flood control project

segment 7 recommended alternative

FLOOD CONTROL DISTRICT of MARICOPA COUNTY

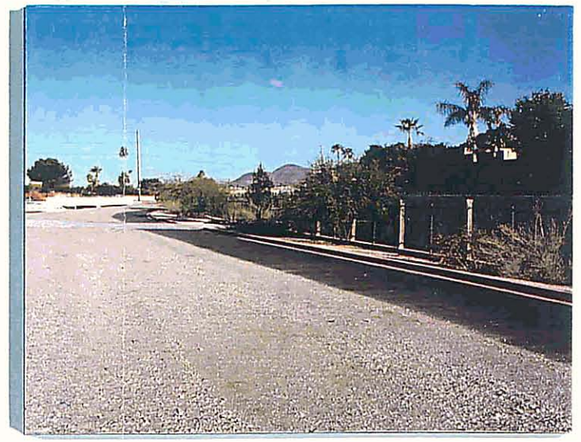
DMJM

50 YEARS



Existing Condition

Potential Greenbelt Treatment



Potential Greenbelt Treatment

Potential Bridge/Underpass Treatment

Figure 22 – Segment 7, Perspective

The examples presented on this exhibit show possible treatments that may be used within this segment of the project. They do not necessarily reflect the actual or final design of the project elements.

JULY 2000

Segment 7
(67th Avenue to Indian School Rd.)

bethany home / grand canal
flood control project

FLOOD CONTROL DISTRICT of MARICOPA COUNTY

DMJM 50 YEARS

D. Recommended Alternative Conclusion

The Recommended Alternative was generally well received at the third and final public meeting. Since no changes were made as a result of the public meeting, the Pre-Design Study engineering plans were completed (See Table 7). Table 7 shows the type of conveyance facility, approximate right-of-way width required and the cost for the recommended improvements within each segment. The BH/GC FCP is a necessary improvement to the west valley drainage system and will improve the overall effectiveness of the existing drainage system by providing an outlet to the New River. The initial cost estimate the 100-year Recommended Alternative was determined to be approximately $54.6 million. The cost estimates include construction engineering, right-of-way acquisition, relocation and administration costs for the completed project. The constructed project, as planned in the Pre-Design Study, will remove 745 structures from the floodplain and eliminate the need for flood insurance. A total of 75 structures (2 in Segment 2, 1 in Segment 4 and 72 in Segment 6) were identified for acquisition. The FCD will assist each of the residents with the relocation process and pay fair market value for each of the properties identified for acquisition.

Table 7 – Recommended Alternative

Segment	Location	Type of Conveyance Facility (Cross-Section)	Approximate Right-of-Way Width Required	Cost Estimate (in Millions)
1	Loop 101 to the 87th Ave. Alignment	Grass-lined Trapezoidal Channel	230 to 300-feet	$7.65
1A	91st Avenue Crossing	Clear Span Bridge	NA	$1.36
2	87th Ave. Alignment to the Grand Canal	Grass-lined Trapezoidal Channel	230-feet	$8.99
3	83rd Avenue Crossing	Clear Span Bridge	NA	$1.12
4	Grand Canal to 75th Ave.	Box Culvert	NA	$10.73
5	75th Ave. and Camelback Rd. Crossing	Box Culvert	20-feet	$2.06
6A	Camelback Rd. to 73rd Ave.	Vertical Concrete Channel	25-feet	$1.28
6B	Camelback Rd. to 67th Ave.	Grass-lined Trapezoidal Detention Basin	Varies	$12.74
6C	67th Avenue Crossing	Box Culvert	NA	$0.48
7	67th Avenue to Indian School Rd.	Box Culvert	20-feet	$1.78
7A	Indian School Rd. Crossing	Box Culvert	NA	$0.39
9	Camelback Road Storm Drain	Pipe Culvert	NA	$6.08
TOTAL				**$54.66**

XI. Conclusion

Upon approval by the FCD and the cities of Phoenix and Glendale of the Pre-DesignStudy, DMJM will begin final design. Final design of the project will take approximately one year to complete. The final design process will include but is not limited to construction plan and specification development, utility coordination, final cost estimating, FEMA CLOMR documentation, landscape planning and design and public involvement. The final design will accommodate 100-year floodwaters within the flood control facility from the Loop 101 to the Sunset Detention Basin.

Pending approval of the March 2001 City of Phoenix bond issue, the Glendale portion of the project and construction will most likely proceed in 2002. The construction will be phased over several years, starting at the Loop 101 Freeway and progressing east. The public will be updated by means of meetings and/or newsletters throughout the development of the project.

XII. Technical References

Field survey notebooks and hardcopy for the horizontal and vertical control for aerial mapping and topographic verification from Collins/Pina, 2000.

Draft Alternative Initial Plans (half size 11"x17"), February 2000.

InRoads Computer Program, Version 7.0 Design Files for the Alternative Plan Development.

MicroStation, Version SE, Computer Aided Drafting Program for the Alternative Plan Development.

XIII. References

Arizona Department of Transportation Construction Costs 1999.

City of Phoenix – General Land Use Maps

City of Glendale – General Land Use Maps

City of Phoenix – Bike Routes City of Glendale – Bike Routes City of Phoenix – Street Hierarchy Maps

City of Glendale – Street Hierarchy Maps City of Phoenix Special Improvement District Map

City of Glendale Special Improvement District Map

City of Phoenix - Major Traffic Flow Average Weekday Traffic

City of Glendale - Major Traffic Flow Average Weekday Traffic City of Phoenix Trails Plans

City of Glendale Trails Plans

Maricopa County Trails Plans

City of Phoenix Street Improvement Program

City of Glendale Street Improvement Program

City of Phoenix - Water and Sewer Quarter Section Maps.

City of Glendale – Water and Sewer Quarter Section Maps

City of Phoenix Zoning Maps

City of Glendale Zoning Maps

Cox Cable – Routing Maps

Drainage Design Manual for Maricopa County, Arizona, Volume I – Hydrology, Revised January 1995.

Drainage Design Manual for Maricopa County, Arizona, Volume I – Hydraulics, Revised January 1996.

Drainage Design Manual for Maricopa County, Arizona, Volume III – Erosion Control, January, 1993.

FCD – HEC-1 for the Maryvale ADMS

FCD Landscape and Maintenance Policy.

FCD- Maintenance Road and Fencing Standards. FCD – Sample Acquisition Cost,. FCD – Project Bid Tabulations

Southwest Gas – Quarter Section Maps SRP – Grand Canal and Irrigation Facility As-Builts

SRP – Right-of-Way Maps