Hawes Road Channel

"K & G"

Improvement Project Candidate Assessment Report

FCD 98-23 PCN #442-05-01

October 1999

Prepared for:

Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009

Prepared by:

PRIMATECH
ENGINEERS & CONSULTANTS

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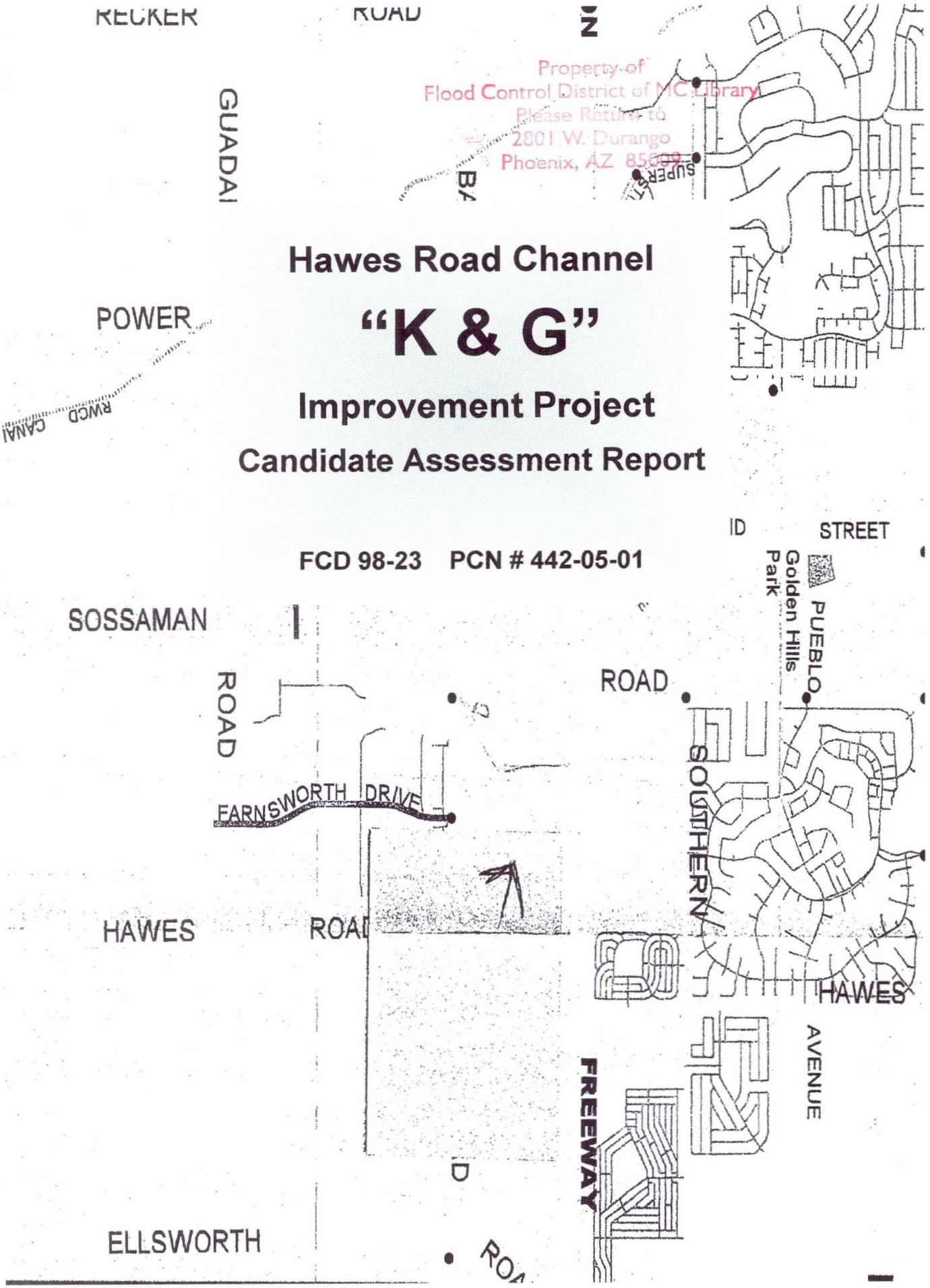

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EXECUTIVE SUMMARY

Project Requested By: Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009
Business Phone: (602) 506-1501

Recommended Project:

The District has defined that the purpose of the Candidate Assessment Report (CAR) process is "to review and analyze existing information and develop project data to serve as a planning tool for evaluation of projects submitted by outside agencies as well as projects submitted within the District for inclusion into the CIP program." The general goal of the CAR process is to identify several alternatives and evaluate the funding requirements for the potential projects. To address the concern to create more aesthetically pleasing areas throughout the Valley, the goal of the "Kinder and Gentler" ("K & G") process is to identify a kinder and gentler channel approach by incorporating data collected from the final CAR for the channel reach on Hawes Road form Apache Trail (i.e., Main Street) south to the Arizona Department of Transportation (ADOT) channel.

Two alternatives were requested for the Hawes Road Channel "K & G" Improvement Project. The first alternative included the design of the "K & G" channel within the right-of-way limits. The second alternative involved exploring the design of the "K & G" channel beyond the right-of-way limits at minimal costs and impacts to existing drainage structures and the community.

Problem Identification and Background:

The *East Mesa Area Drainage Master Plan (East Mesa ADMP),* prepared by Dibble & Associates in 1998, identified that existing and future drainage facilities along the Hawes Road alignment are an important part of the regional drainage plan. The concept presented in the East Mesa ADMP indicates that the future drainage improvements along the Hawes Road alignment will collect and convey storm water to existing regional drainage facilities, including the ADOT channel system along the north side of the Superstition Freeway, the Sossaman Channel, and the Southern Avenue Channel. The City of Mesa requested that the District continue to evaluate future drainage improvements along the Hawes Road alignment, beyond the master planning level, as part of the District's *Candidate Assessment Report* or CAR program.

The existing drainage system along Hawes Road is comprised of a system of earthen channels, concrete lined channels, box culverts at Southern Avenue and Broadway Avenue, and the flow bifurcation structure at Southern Avenue. Currently, the channel system has insufficient capacity to collect and convey major storm events, including the 100-year flood event as defined in the East Mesa Area Drainage Master Plan (East Mesa ADMP), prepared by Dibble & Associates in 1998. The channel system improvements are required to maintain an efficient regional drainage plan. In conjunction with such improvements, there is an opportunity to initiate a recreational feature and/or join such a feature with a potential park area.

Alternative/Options

Alternative 1 (Low Cost Alternative within Right-of-way Limits): – The basic premise of this alternative is to develop an aesthetically pleasing channel within the existing right-of-way and convey the 100-year flow event identified in the East Mesa ADMP. In summary, this alternative involves:

- Reach 0: Replace the existing channel system with a grass lined channel, redesign the channel at Southern Avenue, and redesign the mobile home residential bridge structure. Replace and relocate existing roadway to the east with "modified" residential street section.

- Reach 1: Replace existing channel system with a grass-lined channel and redesign channel at the west side of Hawes Road from Broadway Avenue to Pueblo Avenue. Replace existing roadway with "modified" residential street section. Modify Hawes Road alignment at the intersections of Southern Avenue, Emelita Avenue, Pueblo Avenue, and Coralbell Avenue.

- Reach 2: Replace existing channel with a grass-concrete lined channel aligned with the Broadway Road culverts. Replace and relocate existing roadway to the to the east with "modified" residential street section.

- Reach 3: New concrete channel system and box culvert under the eastbound lane of Apache Trail.

A 6-foot pedestrian path would be designed along the entire reach meandering through or along the perimeter of the channel.

Alternative 2 (High Cost Alternative beyond Right-of-Way Limits): – The basic premise of this alternative is to supplement the existing drainage facilities and future facilities being developed by the City of Mesa to provide a regional drainage system that conveys the 100-year flow event. This alternative will require additional right-of-way. In summary this alternative involves:

- Reach 0: Replace the existing channel system with a grass lined channel, redesign the channel at Southern Avenue, and redesign the mobile home residential bridge structure. Replace the existing residential roadway.

- Reach 1: Replace existing channel system with a grass-lined channel and redesign channel at the west side of Hawes Road from Broadway Avenue to Pueblo Avenue. Replace existing roadway with "modified" residential street section. Modify Hawes Road alignment at the intersections of Southern Avenue, Emelita Avenue, Pueblo Avenue and Coralbell Avenue. Acquire approximately 5 feet of right-of-way along the east side of Hawes Road.

- Reach 2: Replace the existing channel with a grass-lined channel and realign the Broadway Road culverts. Replace the roadway with a "modified" residential street section to the east side of the right-of-way. Acquire approximately 25 feet of right-of-way along the east side. Adjust the residential driveway entrances as necessary.

- Reach 3: New concrete channel system and box culvert under the eastbound lane of Apache Trail.

The channel top widths will meander by varying the channel side slopes. An 8-foot multi-use path will be designed along the top of the channel per City of Mesa requirements.

Conceptual Cost Estimate:

The conceptual cost estimate for Alternative 1 is $8,394,711.

The conceptual cost estimate for Alternative 2 is $9,812,012.

Listing of Probable Partners:

City of Mesa
55 North Center Street
P.O. Box 1466
Mesa, Arizona 85211-4466
Business Phone: (602) 948-7411

Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009
Business Phone: (602) 506-1501

Maricopa County Department of Transportation
2901 West Durango Street
Phoenix, Arizona 85009
Business Phone (602)

1. INTRODUCTION

1.1. Project Name/Title

Primatech, LLC was contracted by the Flood Control District of Maricopa County (District) to prepare the Candidate Assessment Report (CAR) for the Hawes Road Channel Improvement Project. As a supplemental analysis, Primatech, LLC has been contracted to provide a supplemental analysis for a Kinder and Gentler ("K & G") channel concept. The District's official project name and number is as follows: ***Hawes Road Channel Improvement Project: FCD 98-23: PCN# 442-05-01***.

1.2. General Description/Problem Identification

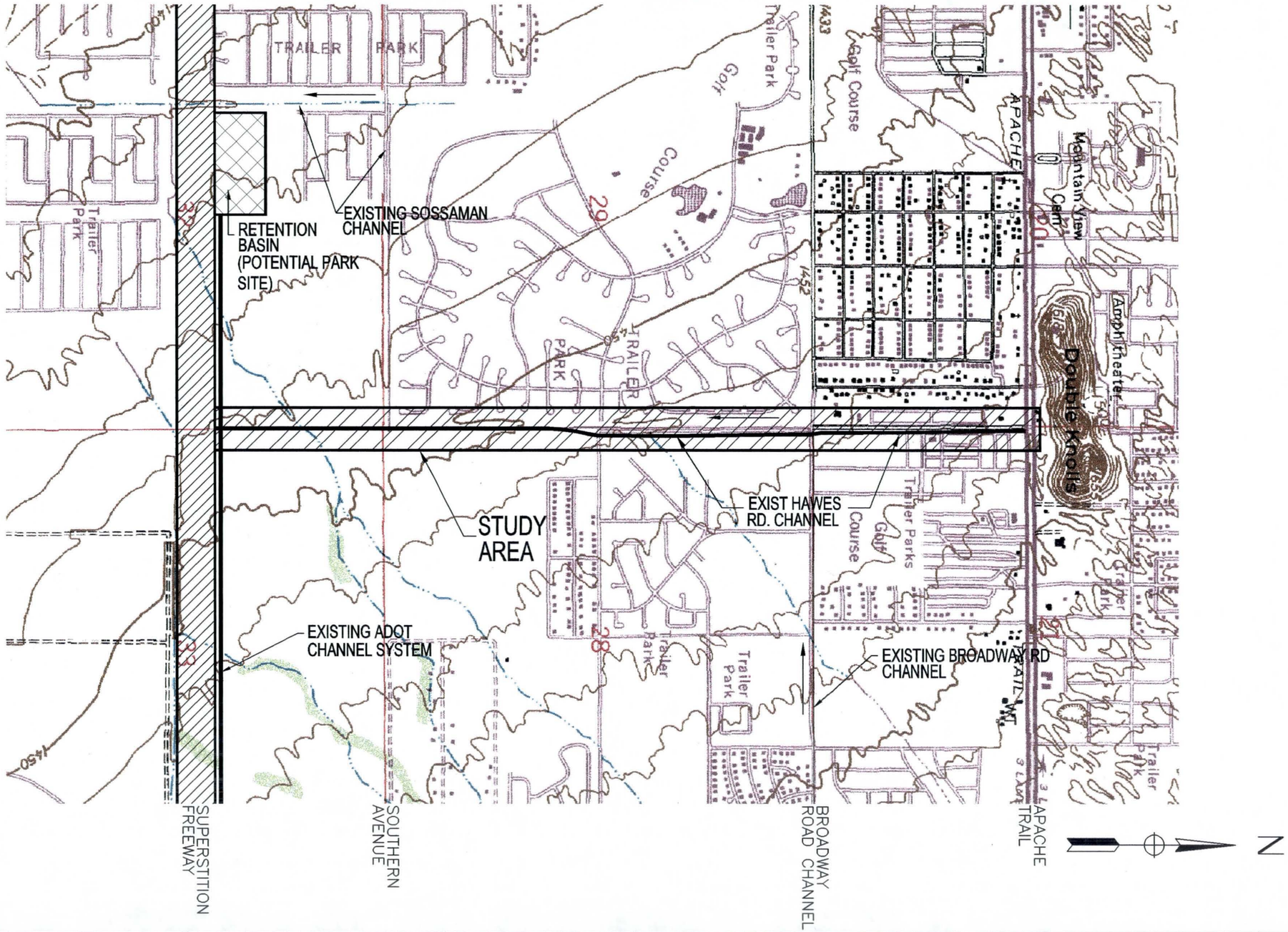
As explained in the Hawes Road Channel Improvement Project (CAR), the purpose of the Candidate Assessment Report process is "to review and analyze existing information and develop project data to serve as a planning tool for evaluation of projects submitted by outside agencies as well as projects submitted within the District for inclusion into the CIP program." The general goal of the CAR process is to identify several alternatives and evaluate the funding requirements for the potential projects. To address the concern to create more aesthetically pleasing areas throughout the Valley, the goal of the "K & G" process is to identify a kinder and gentler channel approach by incorporating data collected from the final CAR for the channel reach on Hawes Road from Apache Trail (i.e., Main Street) south to the Arizona Department of Transportation (ADOT) channel.

Currently, the channel system has insufficient capacity to collect and convey major storm events, including the 100-year flood event as defined in the East Mesa Area Drainage Master Plan (East Mesa ADMP), prepared by Dibble & Associates in 1998. The channel system improvements are required to maintain an efficient regional drainage plan. In conjunction with such improvements, there is an opportunity to initiate a recreational feature and/or join such a feature with a potential park area.

1.3. Location of the Project Area

As shown in Figure 1-1, the project area extends along the Hawes Road alignment from the Superstition Freeway north to Apache Trail. Figure 1-1 shows the location of other regional drainage facilities in the vicinity of the project area. A potential park area is proposed in this report, located at the Sossaman Channel basin, north of the ADOT channel.

The Hawes Road project area is located within Township 1 North, Range 7 East, Maricopa County, Arizona. More specifically, the Hawes Road alignment is between the Superstition Freeway (US 60) and Apache Trail and is located within Sections 20, 21, 22, 28, 29, 32, and 33.



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HAWES ROAD K & G
IMPROVEMENT PROJECT

PROJECT LOCATION MAP

Figure 1–1

2. DESIGN CRITERIA

2.1. Project Information

The initial step in the alternative investigation process involved identifying the parameters that influence the types and/or configurations of feasible flood control alternatives. The goal of this section is to identify the design criteria for "Kinder and Gentler" channel alternatives for the Hawes Road study area.

2.2. Design Discharge Requirements

The Hawes Road Channel will be required to maintain the 100-year flow rates documented in the East Mesa ADMP (Dibble, et. al., 1998) or a combination of the 100-year flow rate based on the East Mesa ADMP and future flow bifurcations (see Figure 2-1). The East Mesa ADMP (Dibble, et. al.) documents the last comprehensive hydrologic study that includes the Hawes Study Area. The design discharge information provided in the East Mesa ADMP reflects future (or build-out) land use conditions and the implementation of all other regional drainage facilities proposed in the East Mesa ADMP.

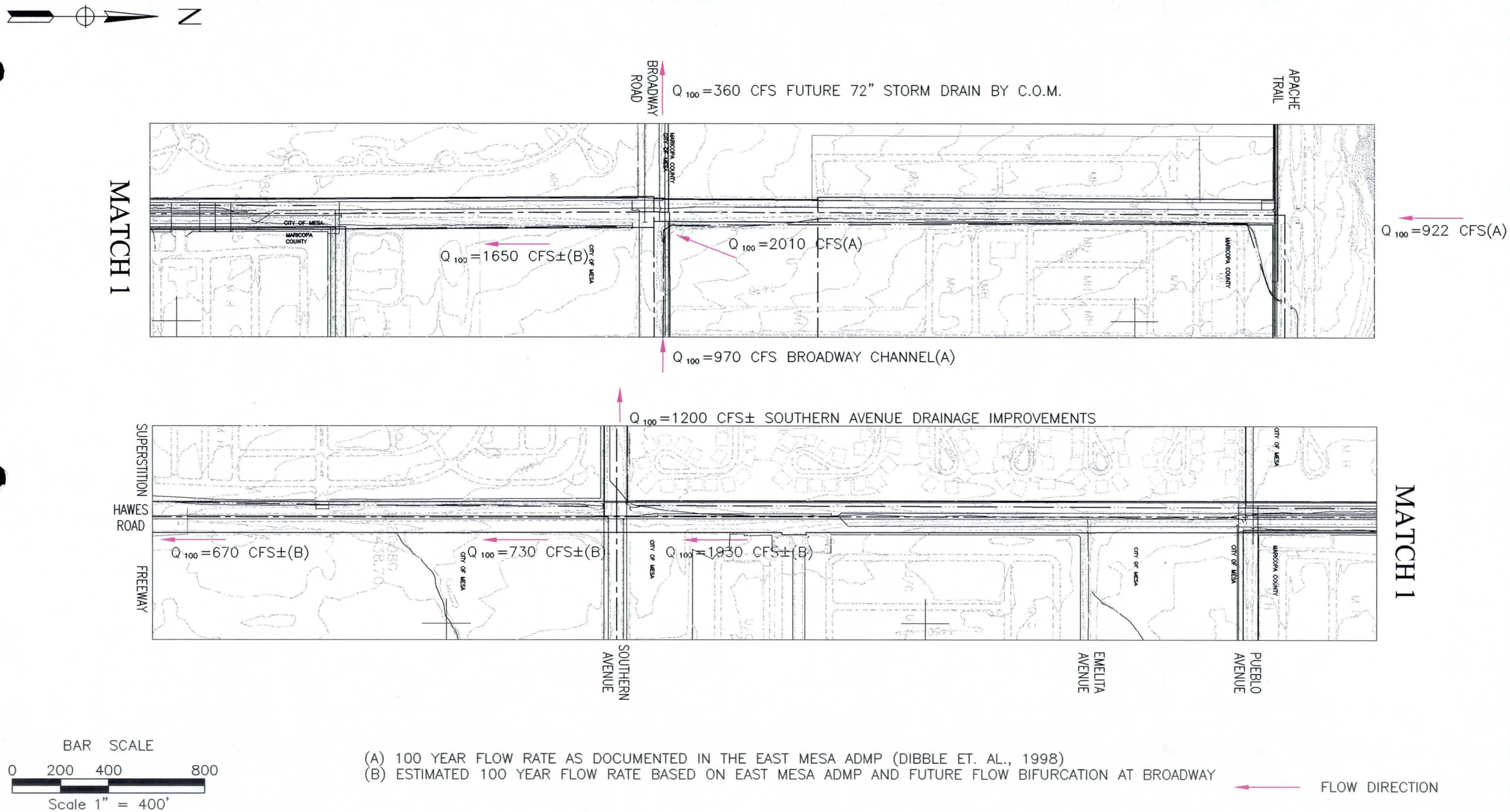
Based on the results of the previous hydrologic studies, the preliminary design discharges identified for the study area are summarized in Figure 2-1. These design discharges are consistent with the hydrologic analysis documented in the East Mesa ADMP. However, the computed peak flow rates shown south of Broadway Road have been reduced by approximately 360 cfs to reflect the capacity of the 72-inch storm drain proposed by the City of Mesa as shown in Figure 2-1. The 72-inch storm drain system down Broadway Road proposed by the City of Mesa was not reflected in the hydrologic analysis documented in the East Mesa ADMP.

To provide low cost maintenance, earth- or grass-lined channels should be stable for both low and high flow rates. The route should permit the use of a uniform and stable channel side slope; permit the maintenance of subcritical flow; and maintain constant channel properties such as width, side slopes, and depth. Because this condition is sometimes difficult to achieve, it can result in channels that are likely to move and, hence, result in ongoing risk and continuous maintenance.

2.3. Street Sections Preferred by MCDOT and City of Mesa

As discussed in the "Hawes Road Channel Improvement Project CAR," the City of Mesa has indicated that the preferred street section be a "modified" Major Collector Street, per City of Mesa Standards Detail M-19.1. For consistency, the Maricopa County Department of Transportation (MCDOT) has expressed consent with the City of Mesa design criteria. The "modified" Major Collector Street includes a 68-foot roadway width, curbs, and a 5-foot sidewalk on one side of the street.

The City of Mesa and MCDOT typical street section requirements are included in Appendix A as Typical Street Section (City of Mesa Detail M-19.1) and Typical Street Cross-Section (MCDOT Figure 3-1), respectively. The remaining available right-of-way with an improved grass- or earth-lined Hawes Road Channel may make it necessary to install a residential (local) street. Consistent with the collector, a "modified" Residential Street will include a 34-foot roadway width (if possible), curbs, and a 4-foot sidewalk.



(A) 100 YEAR FLOW RATE AS DOCUMENTED IN THE EAST MESA ADMP (DIBBLE ET. AL., 1998)
(B) ESTIMATED 100 YEAR FLOW RATE BASED ON EAST MESA ADMP AND FUTURE FLOW BIFURCATION AT BROADWAY

FLOW DIRECTION

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HAWES ROAD CHANNEL K & G IMPROVEMENT PROJECT

REQUIRED DESIGN DISCHARGES

Figure 2-1

2.4. Street/Traffic Design

Streets serve an important and necessary transport and drainage service. Even though the primary function of a street is the movement of traffic, traffic and drainage uses are compatible.

For transportation purposes, adequate tapers and turning lanes are necessary to maintain safe and efficient transitions and movement of traffic. The City of Mesa street transitions for an arterial street intersection are shown in Appendix A. There are currently no standard street transition details for residential streets.

2.5. Channel Lining Types and Erosion Protection Options

The choices of channel linings depend upon good hydraulic practice, environmental design, sociologic impact, basic project requirements, recognition of risks involved, maintenance, and economics. From an aesthetic standpoint, earth and/or grass lining is preferred and creates a "kinder and gentler" appeal.

Including the available and required right-of-way and the required flow capacity, important factors to consider for grass or earthen channels are channel stability and sediment transport capacity. Structural factors include costs, availability of material, and soil/erosion control. The neighborhood character and aesthetic requirements and the need for new green areas should be considered. Evaluation of street and traffic patterns and the need for open space shall be performed, along with all applicable policies and zoning ordinances. Important sociological impacts are the neighborhood social patterns and child population, pedestrian traffic, and recreational needs. The following describes three types of lining options.

The first lining type involves earthen channels, which include both bare earth and naturally vegetated channels. Revegetation will naturally occur after channel construction, or the channel may be landscaped to establish growth of indigenous plant materials. To be consistent with the natural surroundings, desert-like landscaping is preferred, with few grasses and other plant materials that are sparsely spaced. Vegetation will protect against both rain and wind erosion. Planting along the channel is generally limited to low maintenance desert varieties that survive on very little rainfall.

Earth channels are designed for subcritical flow ranges. The width to depth ratios are 4:1 (horizontal:vertical) which adds to highway safety. The maximum allowable velocity ranges from 2.5 fps to 6 fps, depending on soil type. The use of velocities over 5 fps is only allowable where good cover and proper maintenance can be obtained. Grade control is also a requirement of the design. For larger-sized channels and pedestrian used channels, an armored low flow channel may be required to achieve effective, low-maintenance. However, smaller channels may not require low-flow conditions. In order to increase channel stability, rip-rap toe protection may be used.

The second lining type involves grass-lined channels, which have the same side slope requirements as earth-lined channels. The root structure of the grass permits higher flow velocities and smaller sections. Non-irrigated, grass-lined channels will revert to earth-lined channels; therefore, grass-lined channels are required to be properly irrigated. Due to water conservation, grass-lined channels are preferred to be used as part of landscaping for smaller development tracts and as part of local and regional park schemes where multiple use activities are included.

Channel configuration constraints may make desired velocities unattainable for grass or earthen channels. Therefore a third lining option, a grass-concrete combination liner, could be substituted for the grass liner. The grass-concrete liner consists of interlocking concrete units.

Void spaces between the interlocking units allow for backfilling with topsoil and seeding and for irrigation systems. Such a system allows for maximum velocities that are twice those of grass or earth liners. In addition, the bearing capacity of the concrete would allow for mowing or the operation of other maintenance equipment. Brief product information on two grass-concrete liners is provided in Appendix B.

If the appropriate elevation clearance is available, a low flow channel may be desirable with the use of grass and/or earthen channels in order to incorporate hiking trails and other recreational activities. A low flow channel will help prevent erosion and direct low flows in a controlled manner.

2.6. Preferred Recreational Facilities-Pathways, Rest Areas, etc.

The Hawes Road area consists of medium to high-density residential neighborhoods. There are no nearby City of Mesa parks or recreational paths in the general vicinity of the Hawes Road Channel study area. There is discussion by the District that a potential park area could be located at the Sossaman Channel, within a detention/retention basin adjacent to the ADOT Channel (refer to Figure 1-1).

According to the City of Mesa General Plan, there is a desire to "meet the recreational and cultural needs of its residents by providing a diverse system of safe, functional, well-maintained, and aesthetically pleasing facilities." Mesa's "plan" desires beautification projects. Per the General Plan, there is currently a deficit of park land; the current ratio of park acreage per resident is below the goals predicted in the 1988 General Plan. A sense of community may be defined by a community's visual image, and landscaped streets and channels could create that sense of place.

Including landscaped features, the Hawes Road Channel could initialize a link between neighborhoods, and possibly to schools, parks, or other public places with the addition of other path-like facilities. Development of a pathway for bicycling or walking could contribute to a healthy lifestyle and the overall quality of life. A pathway could increase pedestrian safety. Trees or shrubbery could be planted to provide proper shading, but not so much as to compromise safety.

The City of Mesa does not currently have an official adopted Bicycle Plan. However, the City of Mesa is currently working on developing recreational use pathways and is interested in the development of new pathways where possible. The City of Mesa Bike Map is included in Appendix H. The City currently has a Traffic Safety Committee that reviews bicycle and pedestrian issues as they arise. The Committee currently adheres to the AASHTO standards and the "Arizona Bicycle Planning and Design Guidelines." The City of Mesa requires bike paths to be at least 8 feet wide, with a 3-foot buffer zone between the path and the roadway. The paths are also requested to be located at the top of the channel, at or above the high water level.

Aesthetic pathway and landscaped features are the preferred option for the installation and/or reconstruction of channels, washes, and retention tracts. However, funding for construction and maintenance is a major challenge. Current funding sources include the City's traffic and streets operating budget and federal grants.

2.7. Operation and Maintenance

Operation and maintenance responsibilities for grass or earthen channels are necessary to insure that the integrity of the channel is preserved and will function as designed. There are

procedures for basic channel surface maintenance, rodent control, and graffiti removal, which are important tasks necessary to maintain the function and aesthetics of the channel structure.

Vegetation control involves the removal or destruction of woody vegetation within the flow area of the channel, collection ditches, and bifurcation locations. Removal of trash or other objects that would impede flows is required. If grasses are established, the height should typically be maintained at six inches.

Removal of loose material deposition is required to obtain designed grades and cross- sections. Loose deposited materials are not permissible for use within the channel unless tested to meet the earthfill criteria in the construction specifications. Repair of eroded areas must be made by replacing lost material with compacted earth, or other suitable erosion resistant material, in accordance with the original construction specifications.

Inspection and repair may be necessary for roads, signage, fencing, and access gates for safety purposes. Rodent control is important in order to deter deep hole damage to the structure. Landscaping and irrigation should be maintained. In addition, graffiti should be removed as soon as possible to discourage repeated application.

Typical operation and maintenance consist of quarterly operational inspections, annual maintenance inspections, and a formal annual inspection. Such tasks help to list any discrepancies and to schedule repair, assign the repairs, and perform final inspections to insure all maintenance and repairs are completed satisfactorily. A complete annual inspection report is then kept for file. Regular maintenance also requires inspection during or after a major storm event and investigation and response to citizen complaints or inquiries.

Maintenance considerations are an important factor in open channel design. Grass-lined channels require irrigation and mowing. Earth-lined channels need to be kept clear of vegetation and debris. The required level of maintenance will need to be considered and assurance of the proper level of maintenance should be obtained for all designs.

Responsibility for maintenance should be determined and made clear in the planning stage. Written maintenance agreements should be provided if other agencies are involved. Plans must state who is responsible for landscape maintenance.

2.8. All Weather Road Access for Adjacent Properties

The typical street sections discussed in Section 2.3 should meet design requirements for storm drainage on urban type streets for the design storm. The streets should be designed to carry runoff from a 10-year peak storm between the curbs, without curb overtopping. Arterial streets and major collectors should be designed to concentrate the runoff spread to one lane. The peak flows from a 100-year storm are to be carried within the cross-section between the right-of-way limit lines, typically at a maximum depth of 8 inches. Curb openings or grade breaks may be required to deter runoff from flowing laterally along the access road and onto adjacent property.

Where Hawes Road intersects streets or access roads, the grade of the major street should be maintained. Curb openings or gutters may be used to transport runoff across local streets and into the channel. In order to eliminate flooding of access roads or adjacent property, the theoretical carrying capacity of each gutter approaching an intersection shall be calculated based upon the effective slope.

Gutter capacities are based on the theoretical capacity of a clean, unobstructed, continuous gutter section. Gutter flow in streets is necessary to transport runoff water to catch basins and

to drainage channels. An overall approach to storm runoff management includes using the street system to transport runoff from storms that are greater than the storm drain capacity.

Storm drainage within a street system serves to remove nuisance flows from the pavement during frequent return period storms to maintain safe and efficient movement of traffic and to protect adjacent properties from damage caused by large storm events.

3. DESIGN CONSTRAINTS

3.1. Project Constraints

The next step in the alternative investigation process involves identifying the constraints that influence the types and/or configurations channel alternatives. The goal of this section is to identify the project constraints for "Kinder and Gentler" channel alternatives for the Hawes Road study area.

3.2. Public Needs/Participation

A "Kinder and Gentler" channel/recreational area will give the Hawes Road Channel a sense of community atmosphere and will provide a pleasant transportation and drainage corridor for its citizens. The residents in the area would be informed of the potential designs proposed along the Hawes Road Channel. The public will be invited to participate in the decision process to address their recreation and cultural needs. The surrounding residents will benefit most from the project design improvements. To accomplish this, a public information meeting (open house) will be organized to address their public questions and concerns, and to provide information about the proposal. Issues may include:

- Safety
- Noise
- Traffic (Speed and Volume)
- Access Roadways (Residential)
- Landscape
- Maintenance
- Pedestrian Crossing/Access
- Pedestrian Use (Amenities)

3.3. Utility Relocation and Access Issues

3.3.1. Overhead Power Access Line Access

Currently, overhead electric lines provided by Salt River Project (SRP) run along Hawes Road (see Figure 3-1, (pocket). Electric lines extend along the east side of the Hawes Road Channel, from Apache Trail to approximately 0.4 mile south towards Broadway Road, along the west side of Hawes Road, and along the channel from Broadway Road to Southern Avenue. A 6-foot horizontal clearance from the top width limit of the channel to the existing utility poles is to be maintained. Safety issues will be coordinated with SRP during the project.

3.3.2. Water, Sewer, Telephone, and Gas Lines Within or Adjacent to Floodway

The existing major utilities within the study area are shown in Figure 3-1 (pocket). The public and private utility providers are as follows:

- City of Mesa - Water, Sewer, and Gas
- Southwest Gas Corporation – Natural Gas Lines
- Salt River Project – Electric Power
- U.S. West Communications – Telephone

Reconstruction of the streets and installation/improvement of a new channel will require the relocation of several utilities, dedicated easements for access, and advanced notice to reduce conflicts.

3.4. Street Configurations at Major Intersections Along Hawes Road

Installation of an earth- or grass-lined channel may require a greater channel width than that which is existing. Along Hawes Road, from Apache Trail to US 60, alignments and street grades at the major crossing streets and residential accesses shall be reevaluated. Although the goal by the City of Mesa is to maintain Hawes Road as a "modified" Major Collector with a sidewalk on one side of the street, recommendations are to create a residential roadway and sidewalk throughout the project length. Existing sidewalk is only located on the east side of Hawes Road, between Southern Avenue and Pueblo Avenue.

3.4.1. Broadway Road

The existing Hawes Road alignment will shift west in order to accommodate the new channel from Apache Trail to Broadway Road. The Hawes Road alignment will travel southeasterly as it intersects Broadway Road. Adequate tapers will need to be provided in accordance with the Maricopa County Department of Transportation and City of Mesa requirements. It is estimated that street grades will be maintained to match existing grades at the Broadway Road crossing.

3.4.2. Southern Avenue

At the Hawes Road and Southern Avenue intersection, the Hawes Road alignment should be redesigned along the east right-of-way. Adequate tapers will need to be provided in accordance with City of Mesa requirements. It is anticipated that street grades will be maintained to match existing grades at the Southern Avenue crossing.

3.4.3. Emelita Avenue

At the Hawes Road and Emelita Avenue intersection, Hawes Road will be designed along the east right-of-way. The intersection of Emelita Avenue and Hawes Road will also be relocated to the east. Adequate tapers will be provided in accordance with City of Mesa requirements. It is estimated that street grades will be maintained to match existing grades at the Emelita Avenue crossing.

3.4.4. Pueblo Avenue and Coralbell Avenue

The existing Hawes Road alignment will shift to the east in order to accommodate the new channel from Broadway Road to the discontinued Hawes Road at Pueblo Avenue. The intersections of Pueblo and Coralbell Avenues at Hawes Road will also be redesigned. It is probable that Pueblo Avenue and Coralbell Avenue roadway elevations will be raised due to uneven roadway alignments.

3.5. Summary of Evaluation Criteria / Primary Project Constraints

The project constraints that will influence the development and the criteria to be used in the evaluation of "K & G" alternatives are defined as follows:

1. Accommodate 100-year design discharges used in the "Hawes Road Channel Improvement Project CAR," as documented in the East Mesa ADMP (Dibble et. al., 1998), and to accommodate all existing and future drainage structures.

2. Accommodate adequate tapers and/or turning lanes for the appropriate street sections. The City of Mesa has indicated that the preferred street section for Hawes Road be a "modified" Major Collector Street (i.e., 68-foot roadway width, curbs, and a 5-foot sidewalk on one side of the street). The "modified" Major Collector Street section requires approximately 80 feet of right-of-way. Approximately 1.5 miles (i.e., 75%) of the 2-mile-long study area is located within the City of Mesa. Installation of an earth/grass channel may only accommodate a residential street section within the existing right-of-way.

3. Provide an aesthetically pleasing channel while accommodating the required design discharges and providing erosion control. A grass or grass-concrete liner is preferred for the Hawes Road Channel to create a park ambiance.

4. Minimize the impact on residents by locating proposed improvements within the existing right-of-way limits, and provide a beneficial recreational facility to include shaded rest areas and safety features within a pleasing environment.

5. Address public needs and include public opinions and ideas.

6. Develop an operation and maintenance program for the Hawes Road Channel "K & G" project.

7. Accommodate "K & G" designs to Hawes Road intersections at Broadway Road, Southern Avenue, Emelita Avenue, Pueblo Avenue, and Coralbell Avenue. Accommodate residential access between Apache Trail and Broadway Road and at the mobile home park entrance between Southern Avenue and US 60. Maintain all weather road access requirements for the 10-year and 100-year storm events.

8. Minimize the impacts on the existing utilities along Hawes Road.

4. ALTERNATIVE DEVELOPMENT AND EVALUATION

The conceptual design for the Hawes Road Channel "K & G" Improvement Project was prepared based on the objective of installing a new aesthetically pleasing channel and the maximum required peak discharges. Unlike the Candidate Assessment Report (CAR), the improvement of the channel does not include the option of partial replacement of the structure. The channel was divided into three major reaches that corresponded to the different flow rate of each reach. An extensive analysis was performed for each reach, the results of which are discussed below.

4.1. Channel Lining Options and Evaluation

Channel lining options were evaluated for three primary reaches within the study area. Table 4-1 summarizes the results of the preliminary evaluation for proposed options of earth, grass, and a grass-concrete combination, and Figures 4-1A through 4-1C display the approximate channel and roadway sections.

Initially, side slopes were set at 4:1 and freeboard was not considered (see Figures 4-1A through 4-1C). The results for all three reaches were comparable. Due to the larger allowable velocity, the grass-concrete liner option requires the least amount of right-of-way. However, a grass-concrete liner would be more costly. (Literature for two grass-concrete liners is included in Appendix B. Installation costs are provided in Appendix C, Conceptual Cost Estimates-Alternative 1.)

Reach 0: Reach 0 could be constructed using any of the three lining options. A discharge rate of 730 cfs and various lateral slopes indicate that there is sufficient width for a new channel and the residential street section. The side slope of the channel could be decreased, allowing additional width for the meandering sidewalk within the channel.

Reach 1: Applying the same criteria to Reach 1, there appears to be some constraints. The channel will need to be widened in order to accommodate the design discharge of 1930 cfs and an efficient lateral slope. The available width for a roadway ranges from 45.5 feet to 54.5 feet, which limits the roadway width to a residential or local street. Installation of a major collector is not possible without acquiring additional right-of-way.

Reach 2: The results for Reach 2 are similar to those of Reach 1. The design discharge is 922 cfs, and the available right-of-way is limited to 95 feet to 105 feet. Earth and grass channel linings would eliminate the installation of a residential street. A grass-concrete lining could be used, and the sidewalk can be located between the channel and street.

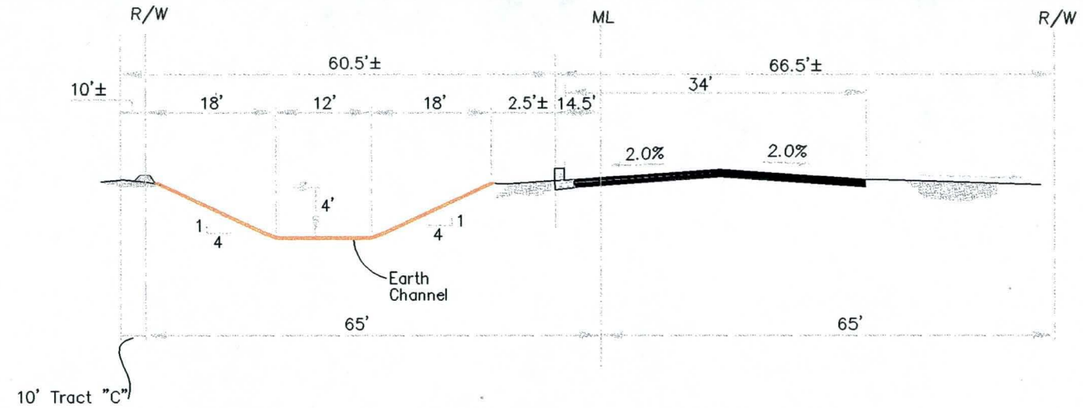
Figures 4-1A through 4-1C show that there is insufficient right-of-way for a major collector street and a grass/earthen lined channel. The minimal existing right-of-way will allow the installation of a residential street section with approximately 34 feet of pavement. It is anticipated that redesign of the roadway and existing channel will be necessary, regardless of what alternative is chosen.

The earth channel was ruled out due to the lack of "park ambiance." A grass channel will lower maintenance due to sediment transport. The grass lining option will be used for the conceptual alternatives, unless the installation of a grass-concrete combination liner is required to insure that the channel and street section remain within the right-of-way limits.

TABLE 4-1

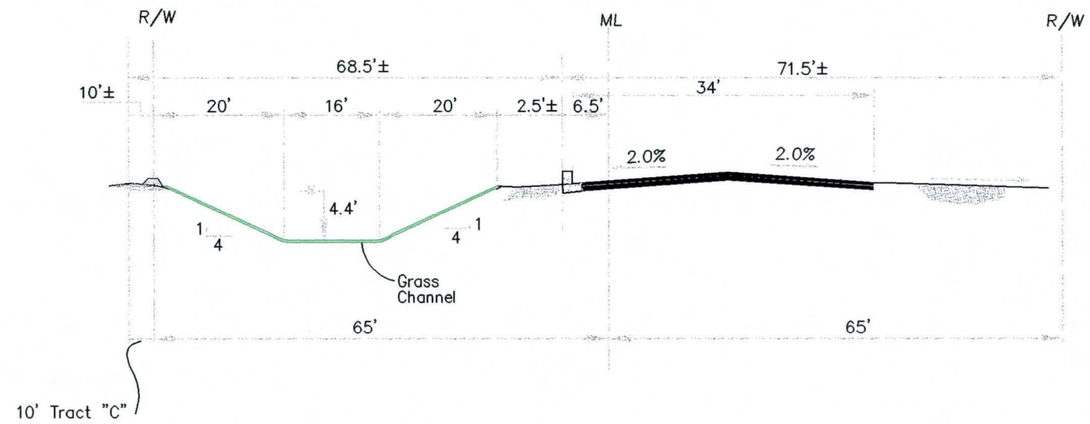
Channel Lining Options Evaluation

	Lining Type	Q100 (cfs)	Lateral Slope	Channel Side Slope	Channel Bottom Width (ft)	Required Top Width (ft)	Normal Depth (ft)	V100 (fps)
Reach 0	Earth	730	0.0018	4:1	30	53.38	2.92	4.92
	Grass	730	0.0022	4:1	16	49	4.12	4.48
	Grass-Concrete	730	0.0022	4:1	10	47	4.63	4.55
Reach 1	Earth	1800	0.0012	4:1	90	118	3.5	4.94
	Grass	1800	0.0023	4:1	20	72	6.5	6
	Grass-Concrete	1800	0.0033	4:1	16	67	6.29	6.95
Reach 2	Earth	922	0.0016	4:1	22	59	4.59	4.97
	Grass	922	0.0033	4:1	10	51	5.12	5.9
	Grass-Concrete	922	0.0049	4:1	8	47	4.88	6.86



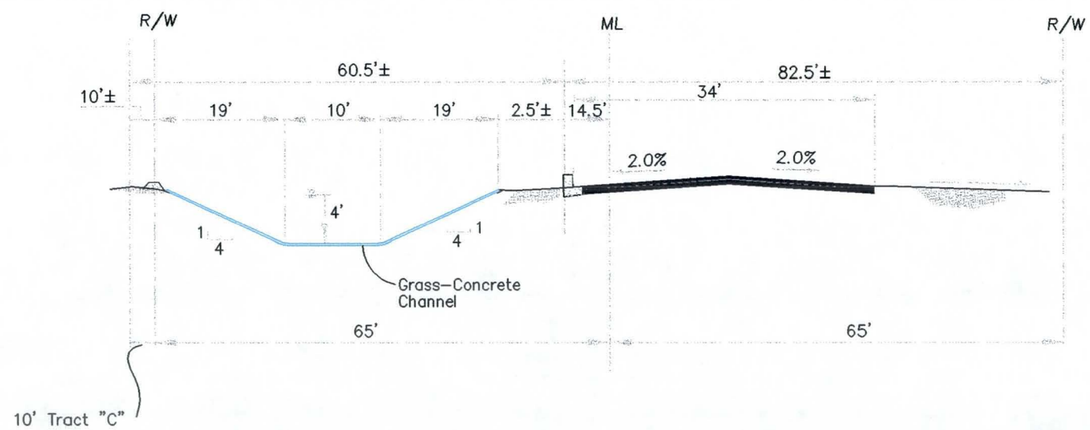
EARTH

S=0.0018
Q_{100}=600 CFS±
V=5.29



GRASS

S=0.0022
Q_{100}=600 CFS±
V=4.48



GRASSCRETE

S=0.0022
Q_{100}=600 CFS±
V=4.55

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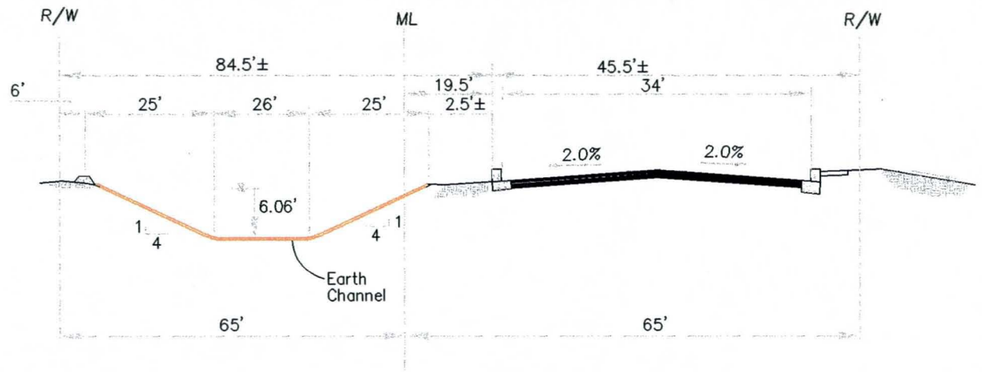
CHANNEL LINING OPTIONS & CONFIGURATIONS: REACH 0

Figure 4-1A



EARTH

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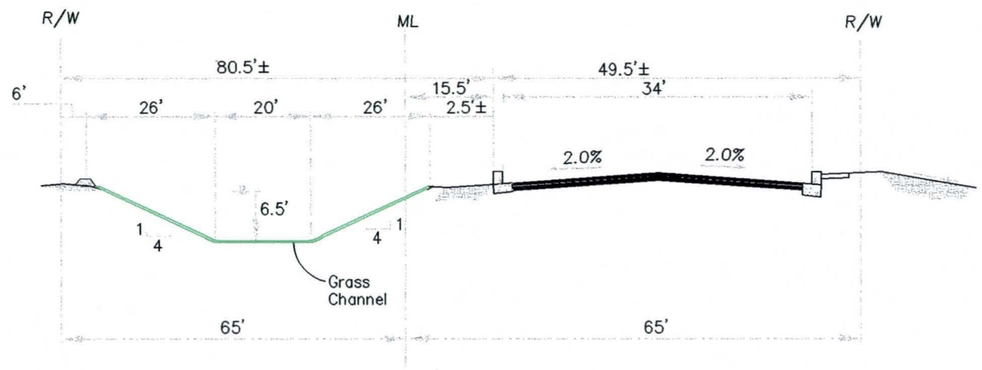
Q_{100}=1800 CFS±
V=5.91



GRASS

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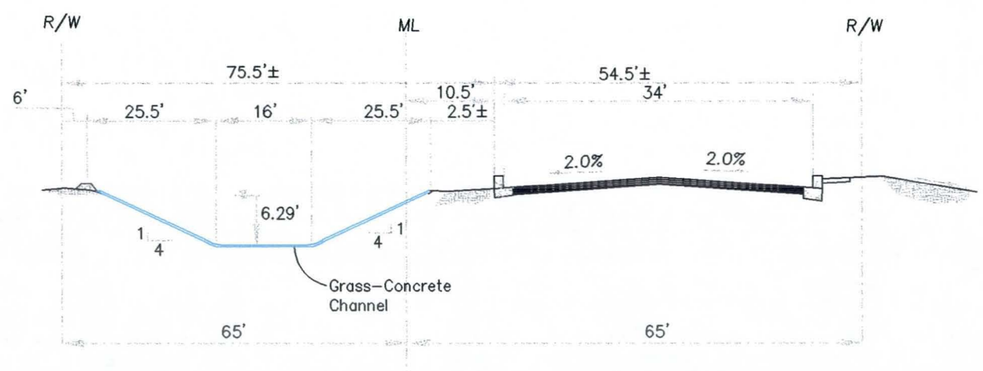
Q_{100}=1800 CFS±
V=6.0



GRASSCRETE

S=0.0018
Q_{100}=1800 CFS±
V=4.46

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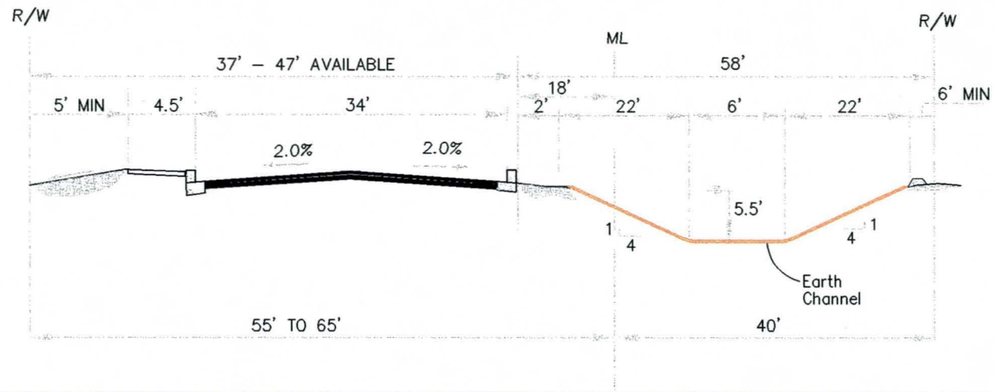
CHANNEL LINING OPTIONS &
CONFIGURATIONS:
REACH 1

Figure 4-1B



EARTH

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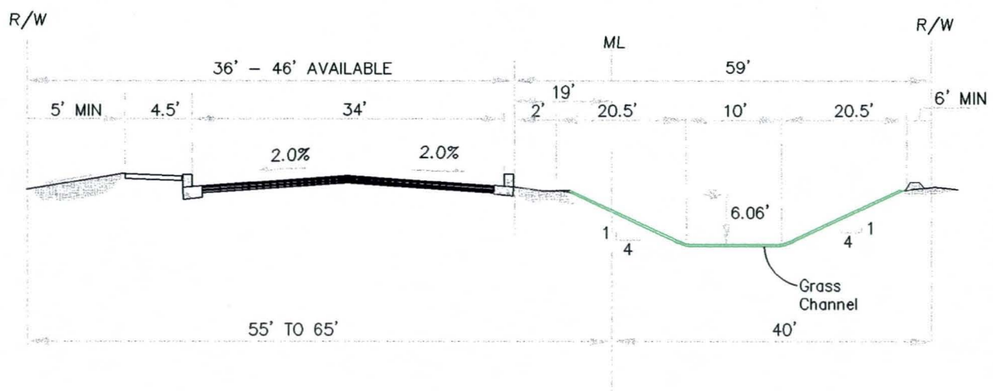
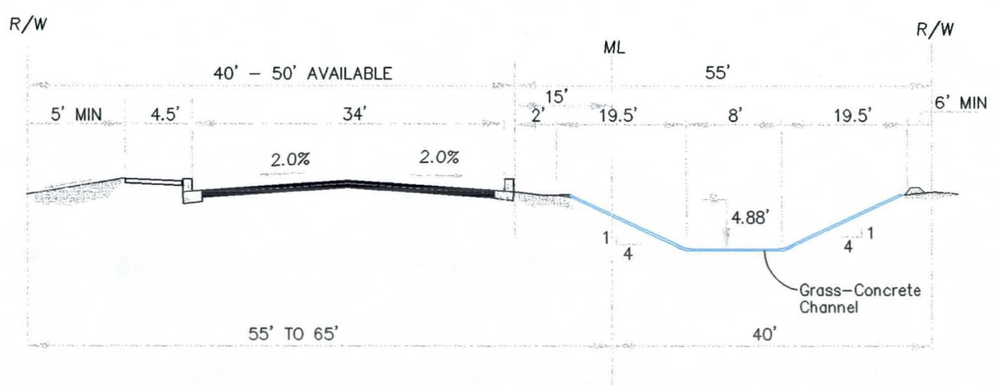
Q_{100}=922 CFS±
V=5.50



GRASS

S=0.0033
Q_{100}=922 CFS±
V=5.9



GRASSCRETE

S=0.0049
Q_{100}=922 CFS±
V=6.86

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CHANNEL LINING OPTIONS &
CONFIGURATIONS:
REACH 2

Figure 4–1C

4.2. *Alternative Development*

Given the project criteria and constraints, along with the channel analyses, two conceptual alternatives were developed for the Hawes Road Channel "Kinder and Gentler" project. One alternative is primarily limited to utilizing the existing right-of-way limits, and the other involves acquiring additional right-of-way.

4.2.1. Alternative 1

The basic premise of this alternative is to develop an aesthetically pleasing channel within the existing right-of-way and convey the 100-year flow event identified in the East Mesa ADMP. Proposed channel linings for Alternative 1 are shown in Figure 4-2. The proposed drainage facilities associated with Alternative 1 are shown schematically in Figure 4-3 (pocket). Conceptual hydraulic calculations are included in Appendix C. In summary, this alternative involves:

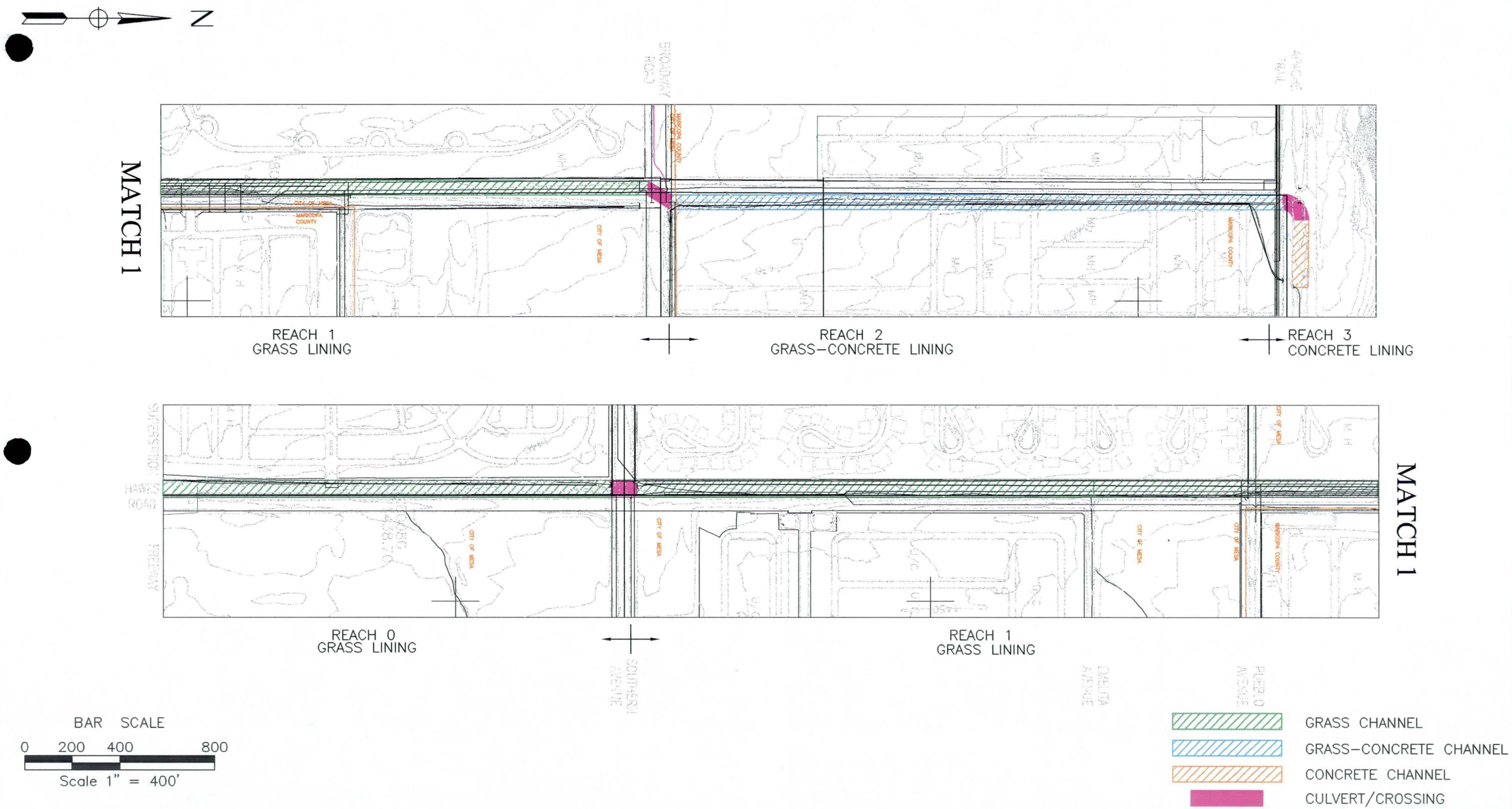
- Reach 0: Replace the existing channel system with a grass lined channel, redesign the channel at Southern Avenue, and redesign the mobile home residential bridge structure. Replace and relocate the roadway to the east.
- Reach 1: Replace the existing channel system with a grass-lined channel and redesign the channel at the west side of Hawes Road from Broadway Avenue to Pueblo Avenue. Replace the existing roadway with a "modified" residential street section. Modify the Hawes Road alignment at the intersections of Southern Avenue, Emelita Avenue, Pueblo Avenue, and Coralbell Avenue.
- Reach 2: Replace the existing channel with a grass-concrete lined channel aligned with the Broadway Road culverts. Replace and relocate the roadway to the to the east with a "modified" residential street section.
- Reach 3: New concrete channel system and box culvert under the eastbound lane of Apache Trail.

A 6-foot pedestrian path would be designed along the entire reach meandering through or along the perimeter of the channel. As an additional amenity, a basketball court could be installed over the channel at the undeveloped section of Hawes Road, between Pueblo Avenue and Emelita Avenue.

The conceptual cost estimate for Alternative 1 is $8,394,711. (See Appendix C.)

4.2.2. Alternative 2

The basic premise of this alternative is to develop an aesthetically pleasing channel and convey the 100-year flow event identified in the East Mesa ADMP. This alternative will require additional right-of-way. Four initial "sub-option" designs were briefly evaluated (see Figure 4-4). The sub-option evaluation utilized a decision matrix and considered constructibility issues (see Table 4-2, Hawes Road Channel K & G Improvement Project -Alternative 2 Evaluation Criteria and Decision Matrix, and Appendix E). The four Alternative 2 sub-options were as follows:



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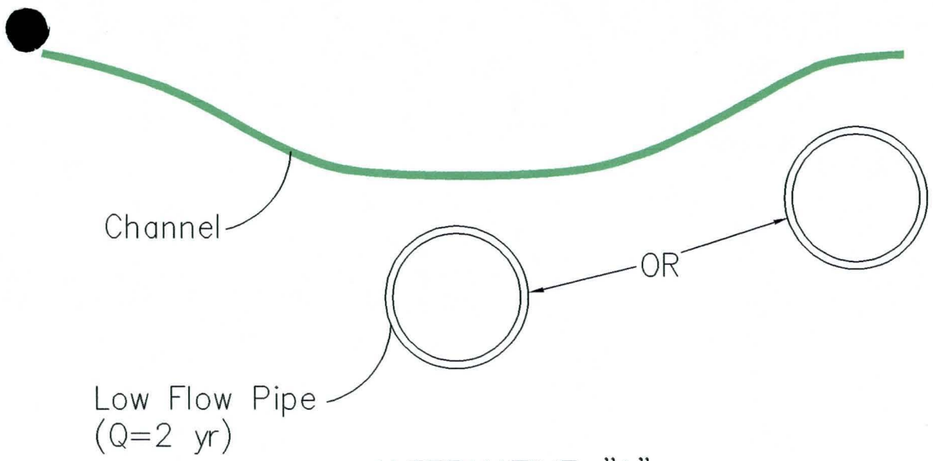
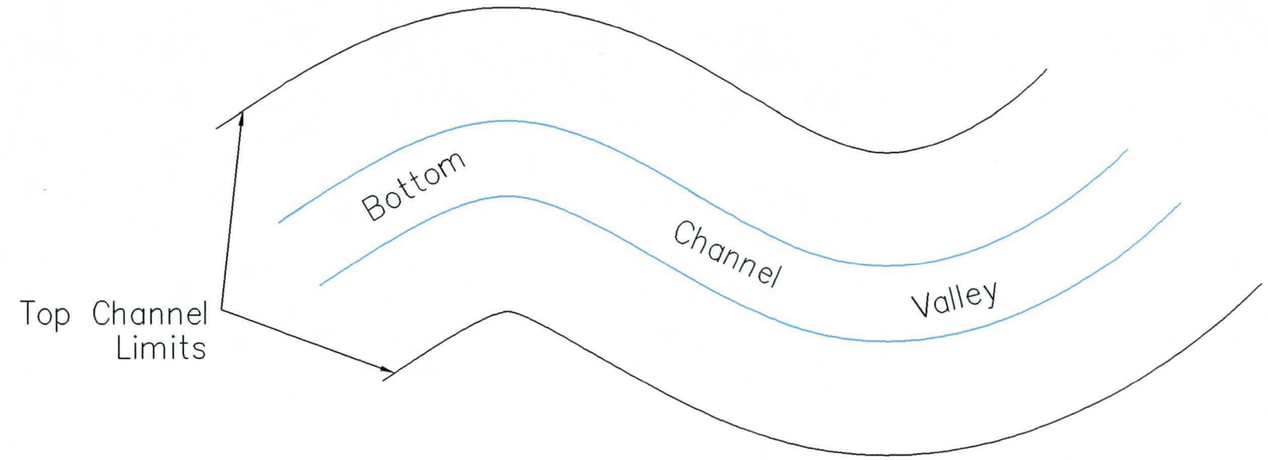
ALTERNATIVE NO. 1:
PROPOSED CHANNEL LININGS

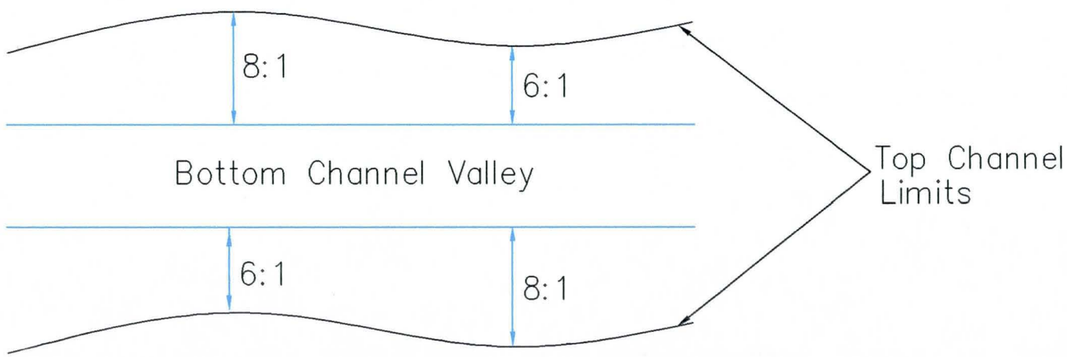
Figure 4–2



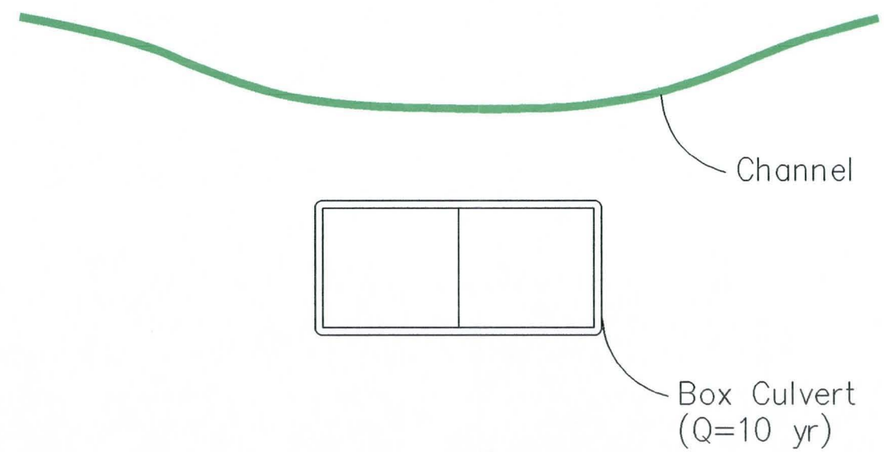
ALTERNATIVE "A"
LOW FLOW PIPE



ALTERNATIVE "B"
MEANDER CHANNEL VALLEY



ALTERNATIVE "C"
VISUALLY MEANDER CHANNEL
BY VARYING SIDE SLOPES



ALTERNATIVE "D"
BOX CULVERT

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ALTERNATIVE NO. 2
SUB-OPTIONS

Figure 4-4

- Alternative "A": Installation of a 72-inch low flow pipe beneath or along the new grass channel. (Further evaluation indicated that installation of pipe beneath the channel cannot be constructed due to the limited depth at the ADOT discharge location; the pipe would run adjacent to the channel.)
- Alternative "B": Meander the channel by meandering the channel valley; option would require right-of-way acquisition of at least 50 feet to meet design standards.
- Alternative "C": Meander the top limits of the channel by varying the side slopes; channel valley to remain constant, right-of-way acquisition required from Apache Trail to Southern Avenue.
- Alternative "D": Installation of box culverts beneath the channel to carry the 10-year discharge. (Further evaluation indicated that this option is not constructible due to the limited depth at the ADOT discharge location.)

Based on the criteria shown in Table 4-2, Alternative "C" ranked the highest. Alternative "B" is not ideal due to the inconvenience to the residents and additional right-of-way considerations. Alternative "B" may be feasible if the roadway is eliminated. Due to limited buried depths, Alternative "D" cannot be constructed. Alternative "A" is constructible; however, the construction costs for pipe and utility relocations would be approximately two times as much as the right-of-way acquisition for Alternative "C". Sub-Alternative "C" is chosen as Alternative 2.

The proposed channel lining configuration for Alternative 2 is shown in Figure 4-5. The proposed drainage facilities associated with Alternative 2 are shown schematically in Figure 4-6 (pocket). In summary this alternative involves:

- Reach 0: Replace the existing channel system with a grass-lined channel, redesign the channel at Southern Avenue, and redesign the mobile home residential bridge structure. Replace the existing residential roadway.
- Reach 1: Replace the existing channel system with a grass-lined channel and redesign the channel at the west side of Hawes Road from Broadway Avenue to Pueblo Avenue. Replace the existing roadway with a "modified" residential street section. Modify the Hawes Road alignment at the intersections of Southern Avenue, Emelita Avenue, Pueblo Avenue, and Coralbell Avenue. Acquire approximately 5 feet of right-of-way along the east side of Hawes Road.
- Reach 2: Replace the existing channel with a grass-lined channel and realign the Broadway Road culverts. Replace the roadway with a "modified" residential street section to the east side of the right-of-way. Acquire approximately 25 feet of right-of-way along the east side. Adjust the residential driveway entrances as necessary.
- Reach 3: New concrete channel system and box culvert under the eastbound lane of Apache Trail.

Approximate meander lengths were calculated using the 2-year storm event. See Appendix F for computations. An 8-foot multi-use path will be designed along the top or meander throughout the channel per City of Mesa requirements. As an additional amenity, a basketball court will be installed over the channel. The proposed amenity is to be located at the undeveloped portion of Hawes Road, between Pueblo Avenue and Emelita Avenue.

The conceptual cost estimate for Alternative 2 is $9,812,012 (see Appendix C).

TABLE 4-2

Hawes Road Channel "K &G" Improvement Project - Alternative 2 Evaluation Criteria and Decision Matrix							
	1, 2 or 3	Above Average (+), Average (0) or Below Average (-) for Criteria					
Criteria:	***Weighting:***		***Alt. "A"***	***Alt. "B"***	***Alt. "C"***	***Alt. "D"***	
Level of Flood Protection	3		Yes	Yes	Yes	Yes	
Elimination of Floodprone Areas	3		Yes	Yes	Yes	Yes	
Overall Project Scheduling	3		Yes	No	Yes	No	
Public Involvement Needs	3		No	Yes	Yes	No	
Potential Benefits to Citizens	2		No	Yes	Yes	No	
Minimal Long-Term Maintenance	2		No	No	No	No	
Minimal Neighborhood Disturbance	2		Yes	No	Yes	No	
Minimal Short-Term Maintenance	1		No	Yes	No	Yes	
Project Feasibility and Benefited Area	1		No	No	Yes	No	
Minimal Inter Agency Involvement	1		No	No	Yes	Yes	
Minimal Construction Obstacles	1		No	No	Yes	No	
Total:			11	12	19	8	

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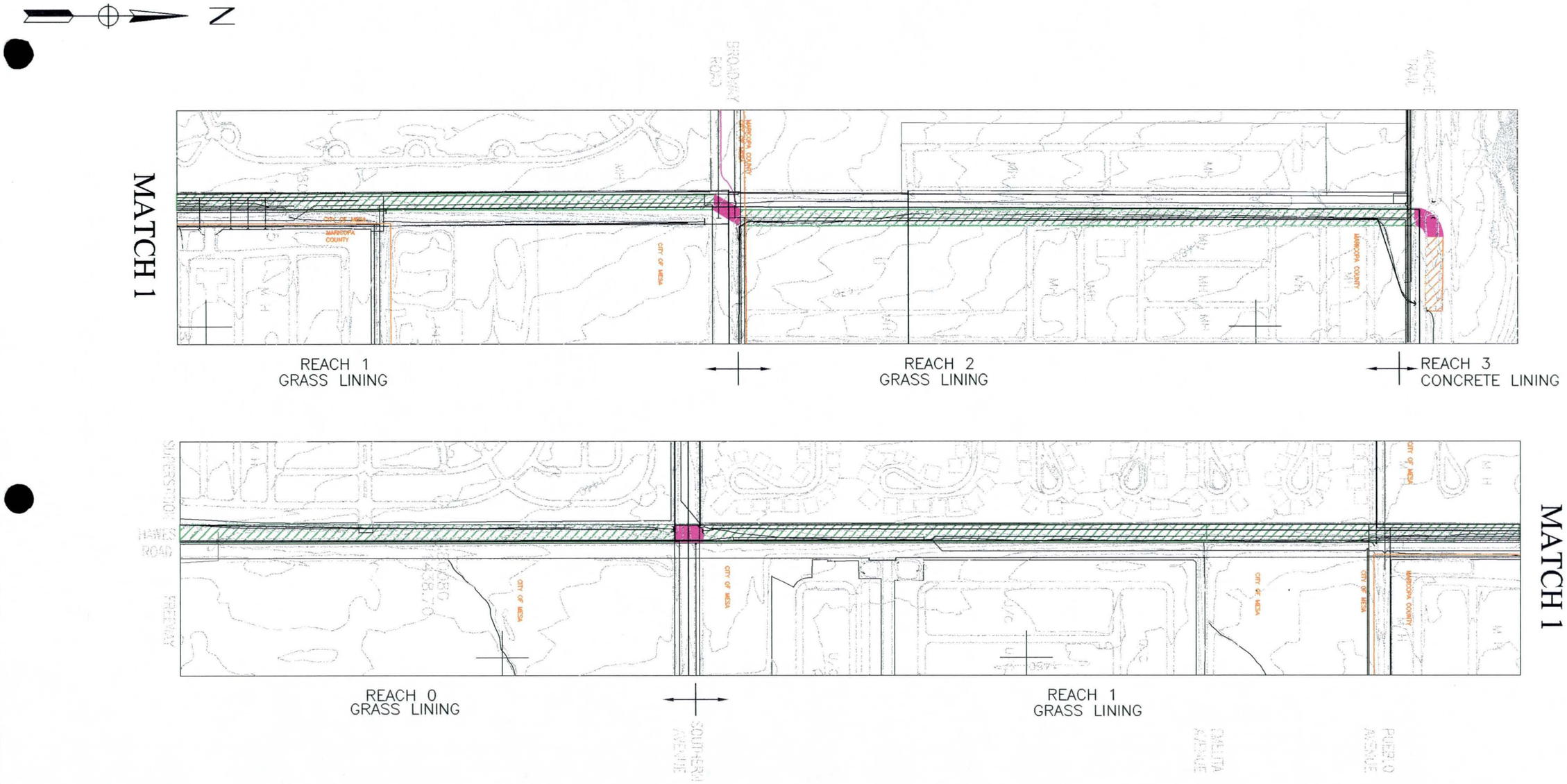

BAR SCALE

0 200 400 800

Scale 1" = 400'

GRASS CHANNEL

CONCRETE CHANNEL

CULVERT/CROSSING

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ALTERNATIVE NO. 2: PROPOSED CHANNEL LININGS

Figure 4–5

4.3. Preliminary Hydraulic Analysis

A preliminary hydraulic analysis was prepared for the two alternatives using the HEC-RAS River Analysis System by the US Army Corps of Engineers. The system is modeled to perform one-dimensional hydraulic calculations for a full network of natural and constructed channels. Summary outputs and hydraulic models are shown in Appendix G. The water surface profile modeling was developed using the 100-year design discharges from the East Mesa ADMP and the conceptual Figures 4-3 through 4-6. This analyses shows the surface profiles for the two alternatives.

4.4. Landscape Concept

Channel Landscape and Recreational Opportunities: The ultimate goal for the configuration of the channel is to convey the required amount of storm water run-off in a controlled manner to existing detention basins and other flood control systems, while at the same time providing for multiple uses in the form of landscape and recreational opportunities. The Hawes Road channel is approximately two miles in length from Apache Trail to US 60.

Integrate Channel with Future Park Facilities: The future channel would be located adjacent to existing neighborhoods, undeveloped properties, and US 60, and will flow under major and minor streets. There are several elements that could be incorporated into the overall channel layout.

- Several recreational opportunities exist within the two-mile reach of this channel.

  -The main recreational opportunity would be an ADA compliant path that would meander back and forth through the channel. This path could be used for several activities ranging from in-line skating to casual walks. Seating areas would be located throughout the length of the channel for individuals to rest and relax. There is potential for this path to connect to the future trails/paths in the area and the adjacent neighborhoods.

  -One concept proposed would allow for a portion of the channel to be covered, allowing for basketball and volleyball courts to be constructed.

  -Shade structures, grills, and picnic tables could be located in areas that would not be inundated with water and provide picnic areas for people to enjoy. These could be located throughout the channel and could be in conjunction with the proposed rest areas.

- The landscape for this area would vary throughout the two miles of the channel.

  -The landscape would be comprised primarily of tree material. This provides for the greatest impact to the viewer. Trees would be located to provide shade for the users of the recreational facilities, picnic areas, portions of the path, and the rest areas. Trees would also help to provide scale to the site.

  -Turf would be utilized in areas where recreational uses occur and at entry locations from the neighborhoods.

  -Native grasses will be utilized throughout the channel in select locations. The use of native grasses will provide a visual break along this two-mile reach.

-Native trees and shrubs will be used throughout most of the channel. Non-native species may be used in select locations depending upon the adjacent areas and the effect desired.

-The irrigation system for this channel would be powered by a solar irrigation controller. Both drip and spray irrigation would be utilized.

Visual landscape concepts are provided as Figures 4-7 through 4-9 (pockets). Solar powered lights and other safety features can be provided in the future. Lighting costs are not included in the overall conceptual cost estimates, but are included as line items in Appendix C.

4.5. Overview

Two options have been presented for the Hawes Road Channel "Kinder and Gentler" solution. If an aesthetically pleasing channel is opted along the study area, three major factors must be considered: 1) the opinions and desires of the public; 2) costs; and 3) the approval of a "modified" residential street section for Hawes Road from Apache Trail to US 60.

The City of Mesa is in need of developing public parks and recreational features. There is the potential for the District to develop a park within the Sossaman Channel basin. Linking the park and the channel would initiate a project within the Hawes Road area, and in return, would be beneficial to the surrounding residences. However, there is the possibility of residential relocation if Alternative 2 is chosen. An exhibit has been prepared showing the Hawes Road Study Area Plan. This exhibit shows a new grass-lined Hawes Road Channel along with public areas, parks/open spaces, and potential location of recreational areas.

The costs are presented in Appendix C. The estimated cost to develop a 10-acre park is $800,000. Comparing the park and channel costs, the Hawes Road project would be comparable per acre while improving drainage conditions in the study area and providing a major drainage project link between the CAP (5) Basin Project and the Southern Avenue project to the Sossaman Channel.

Installation of a grass-lined channel along Hawes Road would not permit the use of a "modified" Major Collector Street section within the available right-of-way. This segment of Hawes Road runs from Apache Trail, discontinues from Pueblo Avenue to Emelita Avenue, and continues south to its termination at US 60. Access to residential areas is limited. Per the preliminary *Red Mountain Freeway from Lindsay Road to Baseline Road Design Concept Report* prepared for the ADOT Highway Division by Parsons Brinckerhoff in 1988, there are no plans to utilize Hawes Road as an interchange for the future Red Mountain Freeway. Installation of a residential street section is a possibility if approved by the City of Mesa.

4.6. Participating Agencies

It is anticipated that the following agencies would participate in the Hawes Road Channel Improvement Project. The roles of each of the agencies may be defined in an Inter-Agency Agreement developed by the participating agencies.

Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009-6399
Business Phone: (602) 506-1501

City of Mesa
55 North Center Street
P.O. Box 1466
Mesa, Arizona 85211-4466
Business Phone: (602) 948-7411

Maricopa County Department of Transportation
2901 West Durango Street
Phoenix, Arizona 85009
Business Phone: (602) 506-4622

Arizona Department of Transportation
205 South 17th Avenue
Phoenix, Arizona 85007
Business Phone: (602) 255-8216

5. REFERENCES

City of Mesa, General Plan, May 6, 1996.

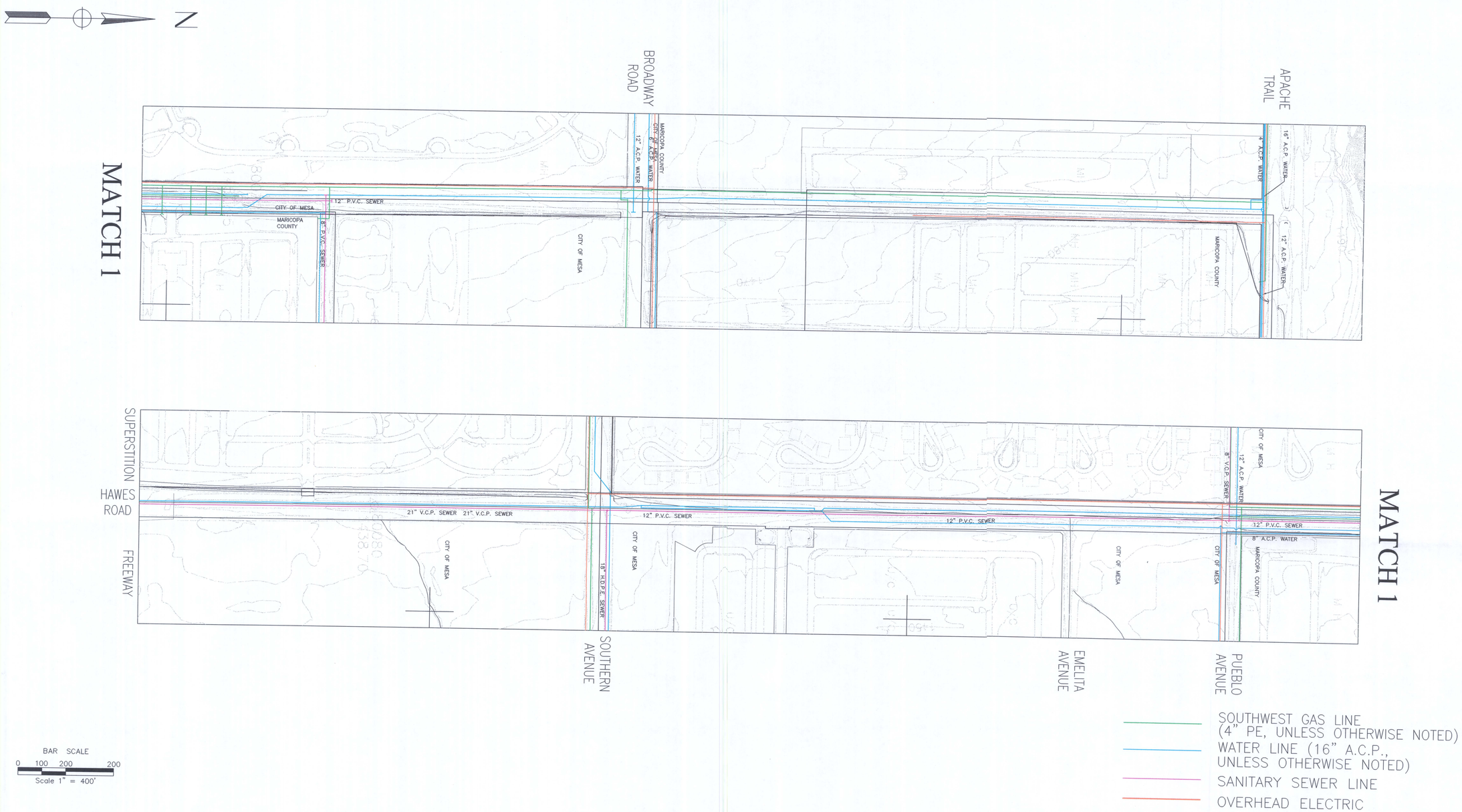
Dibble & Associates and Hoskin Engineering Consultants, *East Mesa Area Drainage Master Plan: FCD #95-32: Recommended Design Report,* Prepared for the Flood Control District of Maricopa County, July 1998.

Entellus, *Southern Avenue Drainage Improvements: Hydrology Review and Design Flows: City of Mesa Project No. 97-56.1,* Letter report sent to Mr. Les Broughton at the City of Mesa, May 8, 1997. (Provided in Appendix D)

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

Parsons Brinckerhoff, *Red Mountain Freeway from Lindsay Road to Baseline Road: Design Concept Report*, Prepared for the ADOT Highway Division, 1988.

Primatech Engineers, *Hawes Road Channel Improvement Project: FCD 98-23,* Prepared for the Flood Control District of Maricopa County, May 1999.



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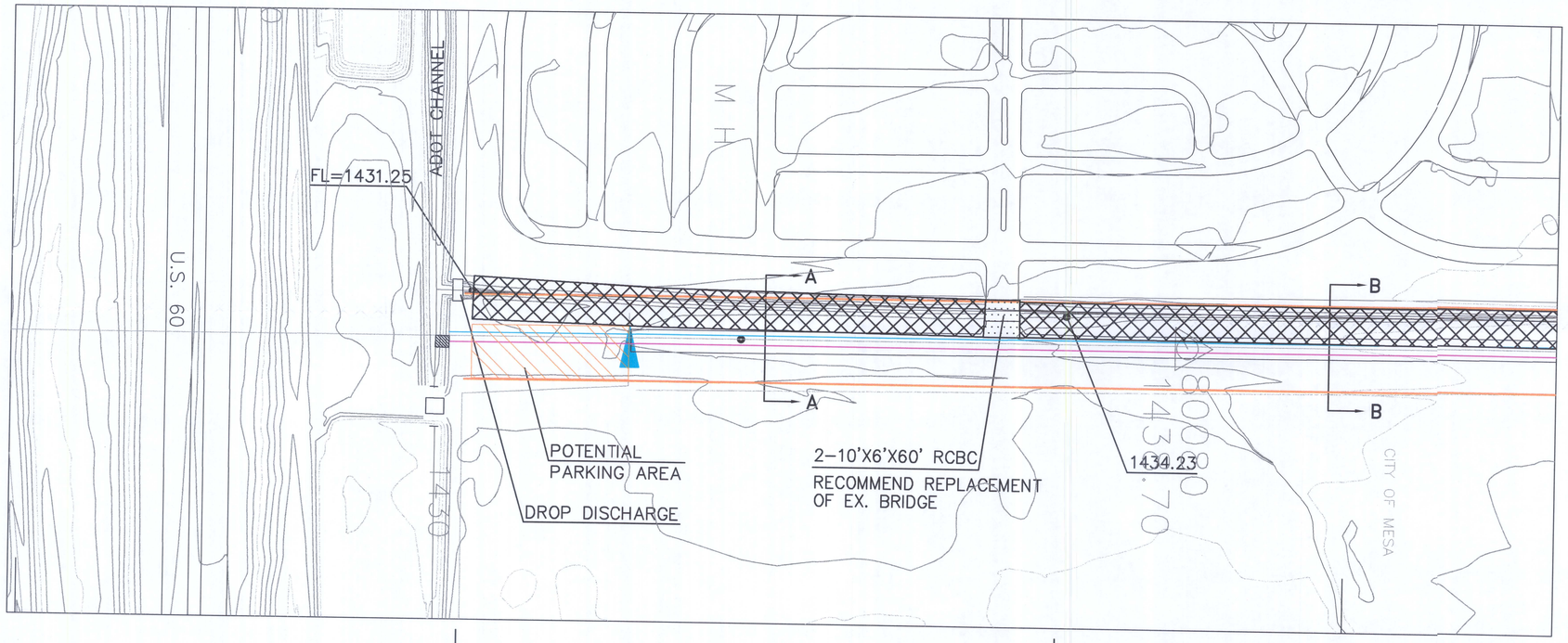
EXISTING UTILITIES

Figure 3–1

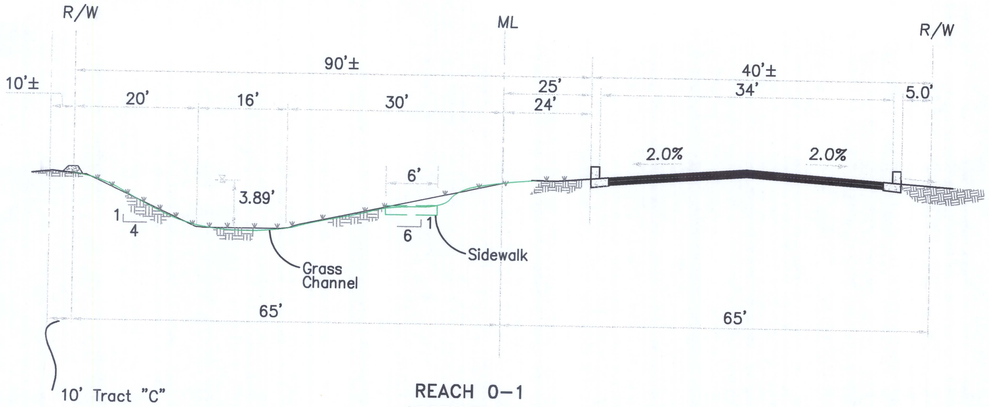


REACH 0-1

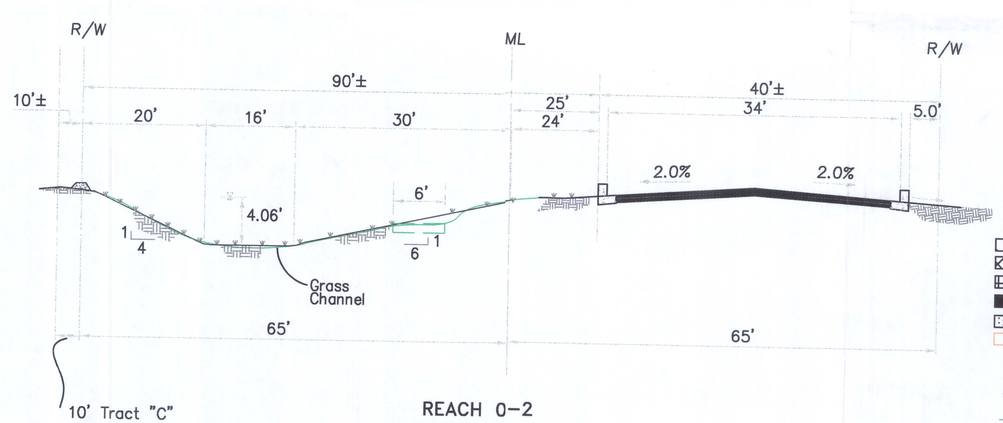
L=900'±
Q_{100}=670 CFS±
V=4.36 CFS±
GRASS LINING
S=0.0022

REACH 0-2

L=1,080'±
Q_{100}=730 CFS±
V=4.46 CFS±
GRASS LINING
S=0.0022



REACH 0-1
SECTION A-A

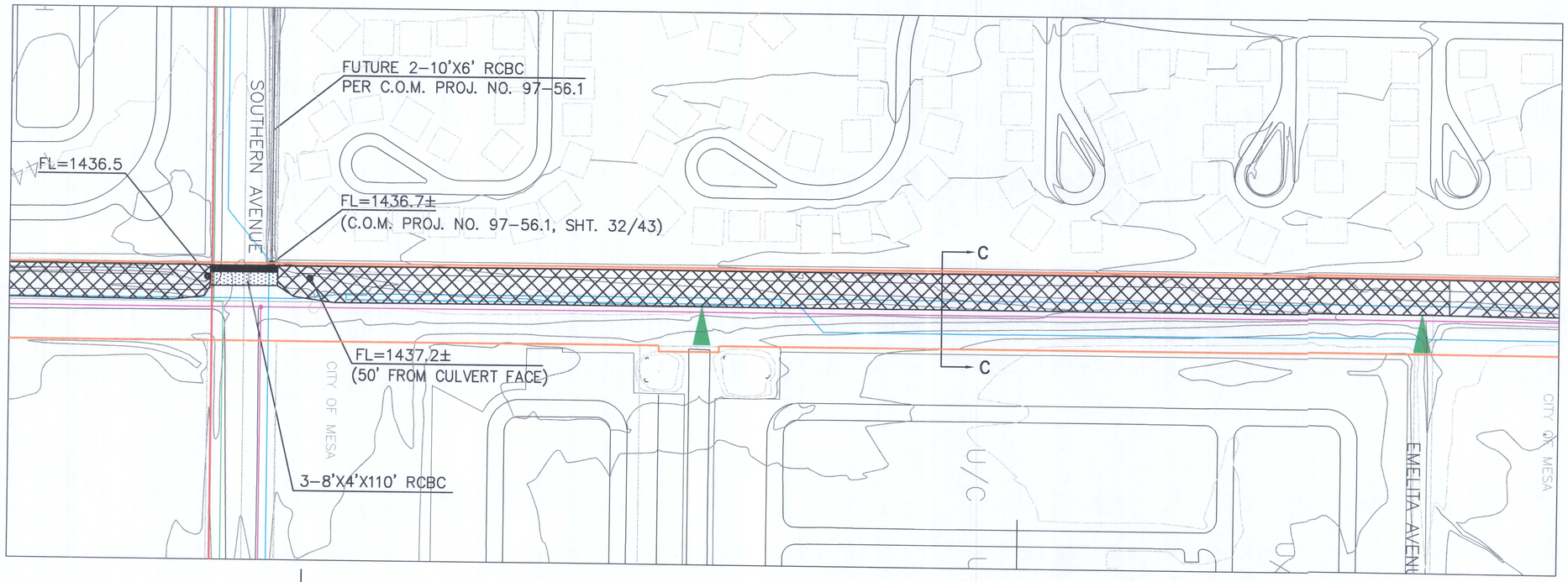


REACH 0-2
SECTION B-B

LEGEND

- PROPOSED NEW CONCRETE CHANNEL
- PROPOSED NEW GRASS CHANNEL
- PROPOSED NEW GRASS-CONCRETE CHANNEL
- EXISTING CULVERT TO REMAIN
- PROPOSED NEW CULVERT
- PROPOSED PARKING AREA
- PEDESTRIAN ACCESS LOCATION
- PROPOSED PEDESTRIAN ACCESS LOCATION
- SOUTHWEST GAS LINE
- WATER LINE
- SANITARY SEWER LINE
- OVERHEAD ELECTRIC
- EXISTING RIGHT OF WAY
- STORM DRAIN

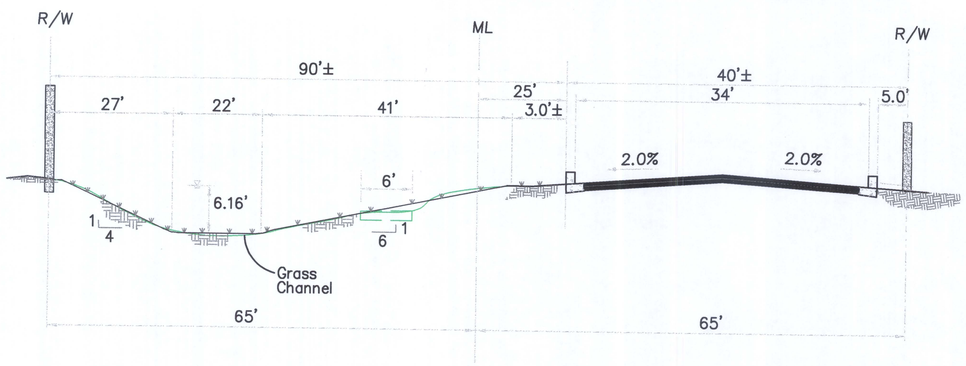
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY	COUNTY PROJECT NO. FCD98-23	HAWES ROAD K & G IMPROVEMENT PROJECT
	CONSULTANT PRIMATECH ENGINEERS & CONSULTANTS 2929 North 44th Street, Suite 228 Phoenix, Arizona 85018 (602) 952-2828	PROJECT DESCRIPTION ALTERNATIVE NO. 1 PLAN & SECTIONS FIGURE 4-3
		DRN. JMM DATE: 07-28-99 / DES. JMM DATE: 07-28-99 / CKD. DATE: / SCALE 1"=100' / SHEETS NO. 1 OF 4



REACH 0-2

REACH 1-1

L=4,900'±
Q_{100}=1,930 CFS±
V=5.94 CFS±
GRASS LINING
S=0.0024
1-2' DROP STRUCTURE (UNDER COURT)

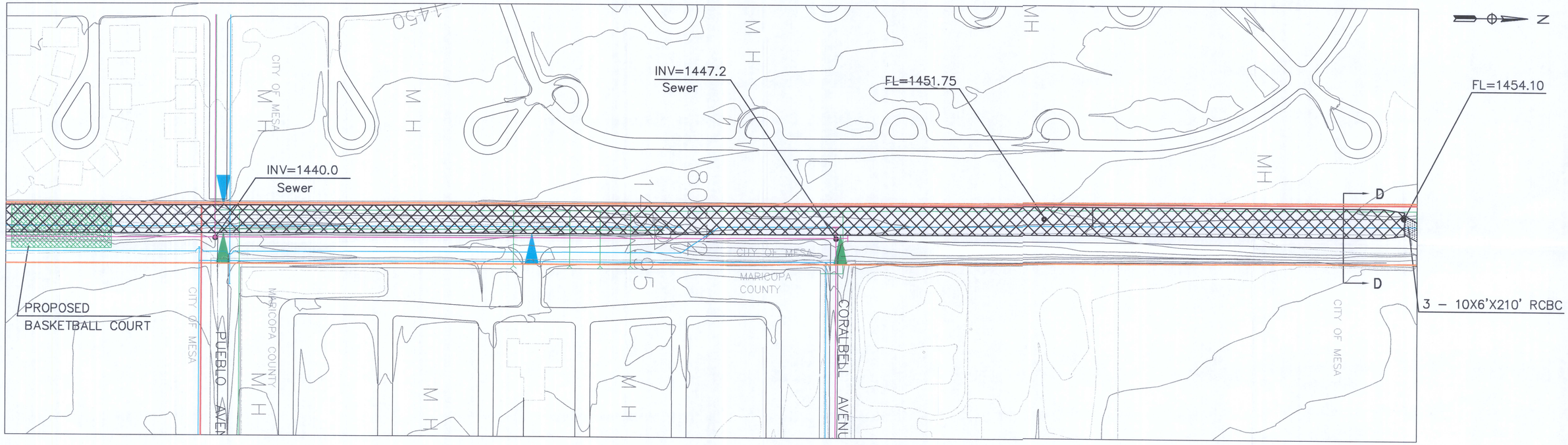


REACH 1-1
SECTION C-C

LEGEND

- PROPOSED NEW CONCRETE CHANNEL
- PROPOSED NEW GRASS CHANNEL
- PROPOSED NEW GRASS-CONCRETE CHANNEL
- EXISTING CULVERT TO REMAIN
- PROPOSED NEW CULVERT
- PROPOSED PARKING AREA
- PEDESTRIAN ACCESS LOCATION
- PROPOSED PEDESTRIAN ACCESS LOCATION
- SOUTHWEST GAS LINE
- WATER LINE
- SANITARY SEWER LINE
- OVERHEAD ELECTRIC
- EXISTING RIGHT OF WAY
- STORM DRAIN

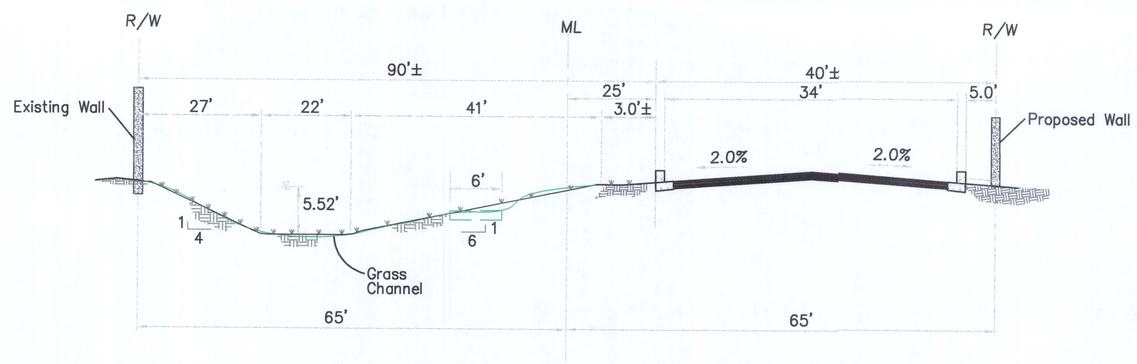
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY	COUNTY PROJECT NO. FCD98-13	HAWES ROAD K & G IMPROVEMENT PROJECT
	CONSULTANT PRIMATECH ENGINEERS & CONSULTANTS 2929 North 44th Street, Suite 228 Phoenix, Arizona 85018 (602) 952-2828	PROJECT DESCRIPTION ALTERNATIVE NO. 1 PLAN & SECTIONS FIGURE 4-3
		DRN. JMM DATE: 07-28-99 / DES. JMM DATE: 07-28-99 / CKD. DATE: / SCALE 1"=100' / SHEETS NO. 2 OF 4



REACH 1–2
(SEE SHEET 2 OF 4)

REACH 1–2

L=810'±
Q_{100}=1650 CFS±
V=6.0 CFS±
GRASS LINING
S=0.0028
CULVERTS: 3 – 10' X 6' X 210': S=0.0036



REACH 1–2
SECTION D–D

LEGEND

- PROPOSED NEW CONCRETE CHANNEL
- PROPOSED NEW GRASS CHANNEL
- PROPOSED NEW GRASS–CONCRETE CHANNEL
- EXISTING CULVERT TO REMAIN
- PROPOSED NEW CULVERT
- PROPOSED PARKING AREA
- PEDESTRIAN ACCESS LOCATION
- PROPOSED PEDESTRIAN ACCESS LOCATION
- SOUTHWEST GAS LINE
- WATER LINE
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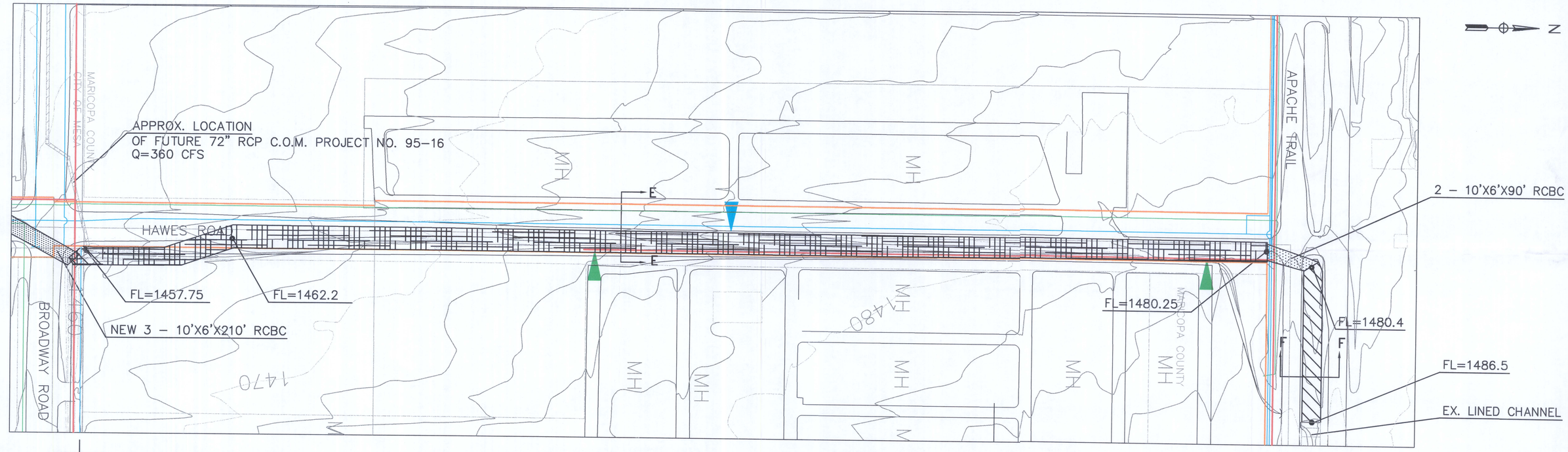
- EXISTING RIGHT OF WAY
- STORM DRAIN

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY	COUNTY PROJECT NO. FCD98–23	HAWES ROAD K & G IMPROVEMENT PROJECT
	CONSULTANT PRIMATECH ENGINEERS & CONSULTANTS 2929 North 44th Street, Suite 228 Phoenix, Arizona 85018 (602) 952–2828	PROJECT DESCRIPTION ALTERNATIVE NO. 1 PLAN & SECTIONS FIGURE 4–3
		DRN. JMM DATE: 07–28–99 / DES. JMM DATE: 07–28–99 / CKD. DATE: / SCALE 1"=100' / SHEETS NO. 3 OF 4



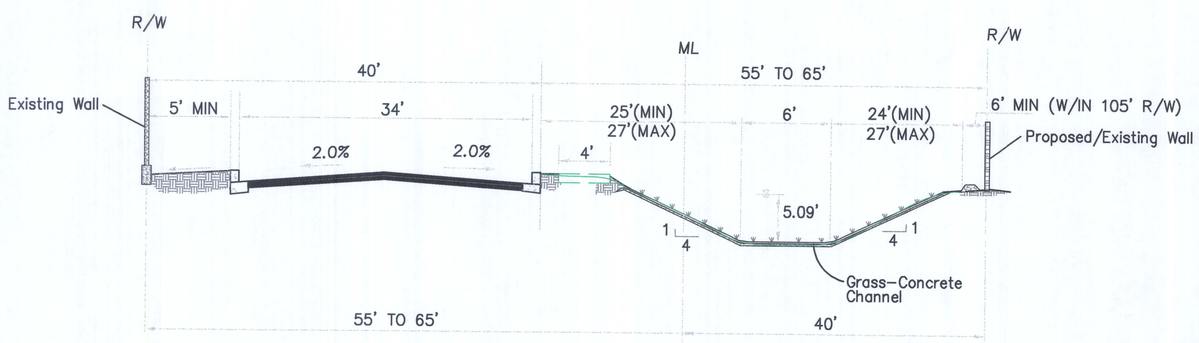
REACH 1-2

REACH 2

L=2550'±
Q_{100}=922 CFS±
V=6.88 CFS±
S=0.0049 W/ 5-2' DROP STRUCTURES
GRASSCRETE LINING
n=0.03

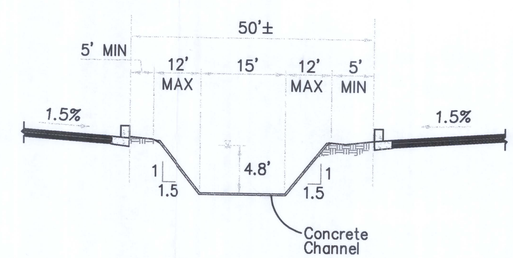
REACH 3

L=415'±
Q_{100}=922 CFS±
CULVERT: 1 - 10' X 6' X 90'
S=0.0016/W 2-3' DROPSTRUCTURES
CONCRETE LINING
N=0.015



REACH 2

SECTION E-E



REACH 3-3

SECTION F-F

NTS

Q_{100}=922 CFS

LEGEND

- PROPOSED NEW CONCRETE CHANNEL
- PROPOSED NEW GRASS CHANNEL
- PROPOSED NEW GRASS-CONCRETE CHANNEL
- EXISTING CULVERT TO REMAIN
- PROPOSED NEW CULVERT
- PROPOSED PARKING AREA
- PEDESTRIAN ACCESS LOCATION
- PROPOSED PEDESTRIAN ACCESS LOCATION
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- WATER LINE
- SANITARY SEWER LINE
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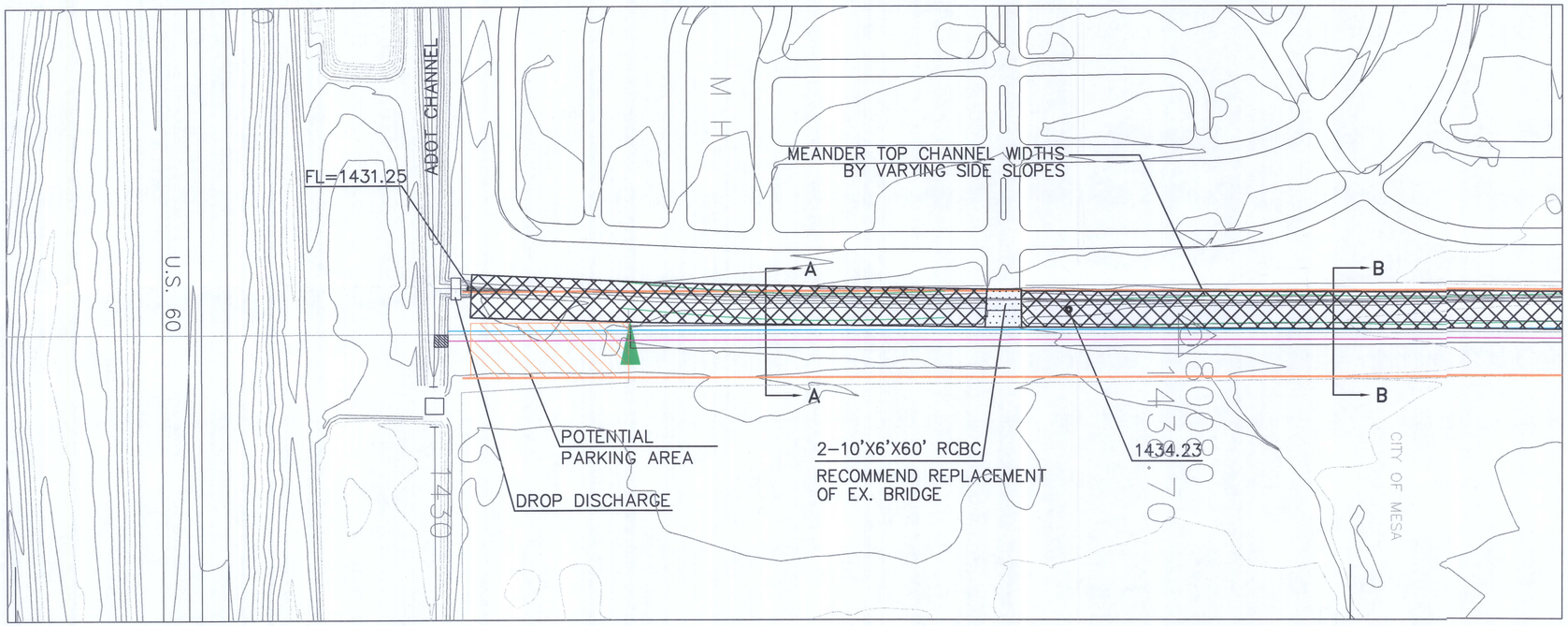
- EXISTING RIGHT OF WAY
- STORM DRAIN

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY	COUNTY PROJECT NO. FCD98-23	HAWES ROAD K & G IMPROVEMENT PROJECT
	CONSULTANT PRIMATECH ENGINEERS & CONSULTANTS, 2929 North 44th Street, Suite 228, Phoenix, Arizona 85018, (602) 952-2828	PROJECT DESCRIPTION ALTERNATIVE NO. 1 PLAN & SECTIONS FIGURE 4-3
		DRN. JMM DATE: 07-28-99 / DES. JMM DATE: 07-28-99 / CKD. DATE: / SCALE 1"=100' / SHEETS NO. 4 OF 4

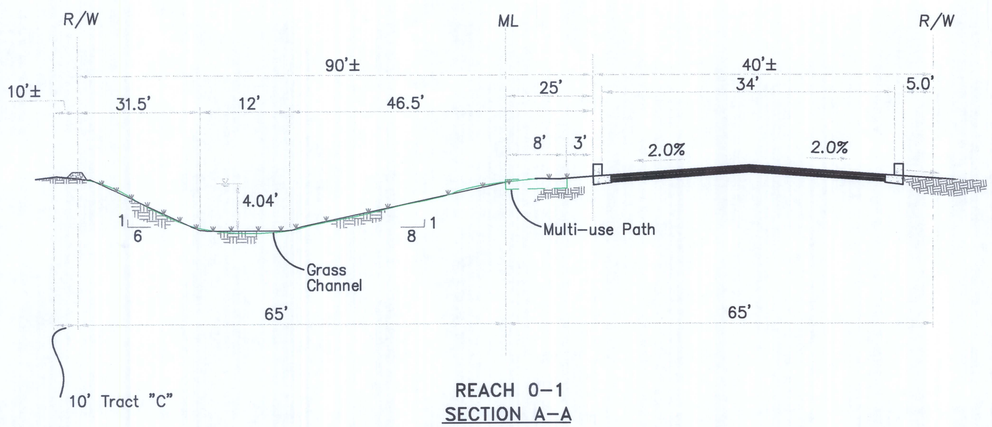


REACH 0-1

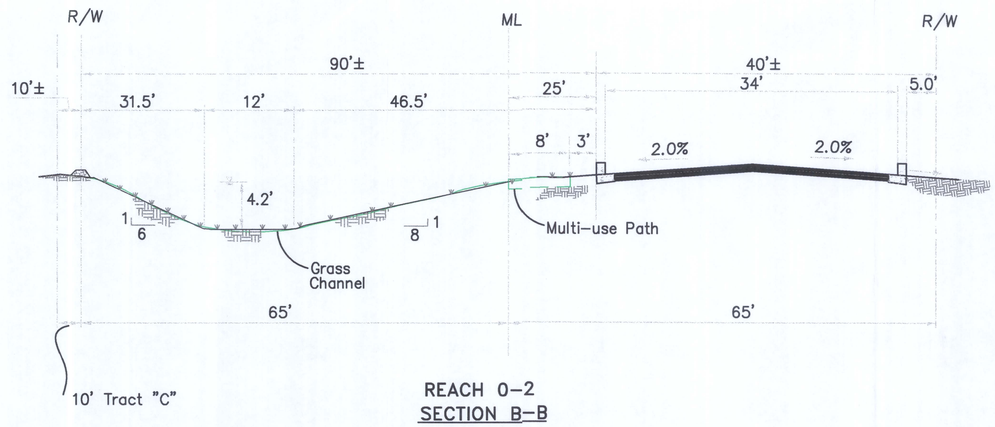
L=900'±
Q_{100}=670 CFS±
V=4.36 CFS±
GRASS LINING
S=0.0022

REACH 0-2

L=1,080'±
Q_{100}=730 CFS±
V=4.46 CFS±
GRASS LINING
S=0.0022



REACH 0-1
SECTION A-A

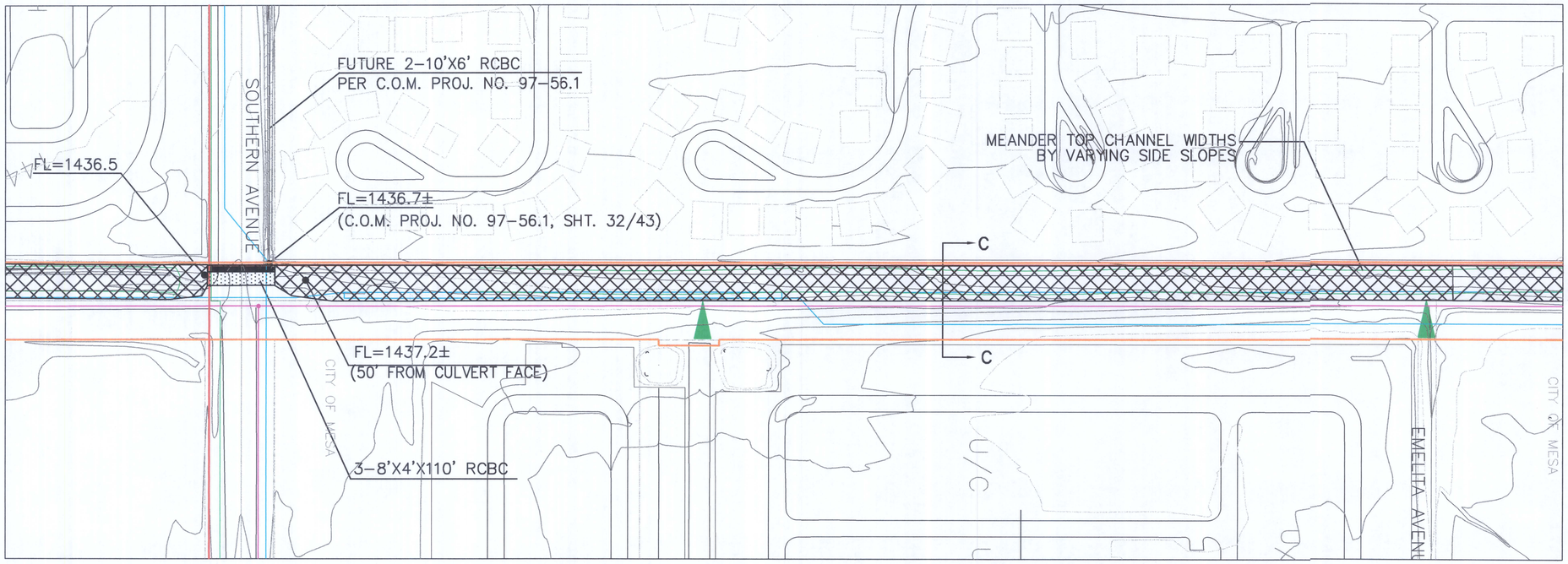


REACH 0-2
SECTION B-B

LEGEND

- PROPOSED NEW CONCRETE CHANNEL
- PROPOSED NEW GRASS CHANNEL
- PROPOSED NEW GRASS-CONCRETE CHANNEL
- EXISTING CULVERT TO REMAIN
- PROPOSED NEW CULVERT
- PROPOSED PARKING AREA
- PEDESTRIAN ACCESS LOCATION
- PROPOSED PEDESTRIAN ACCESS LOCATION
- SOUTHWEST GAS LINE
- WATER LINE
- SANITARY SEWER LINE
- OVERHEAD ELECTRIC
- EXISTING RIGHT OF WAY
- STORM DRAIN

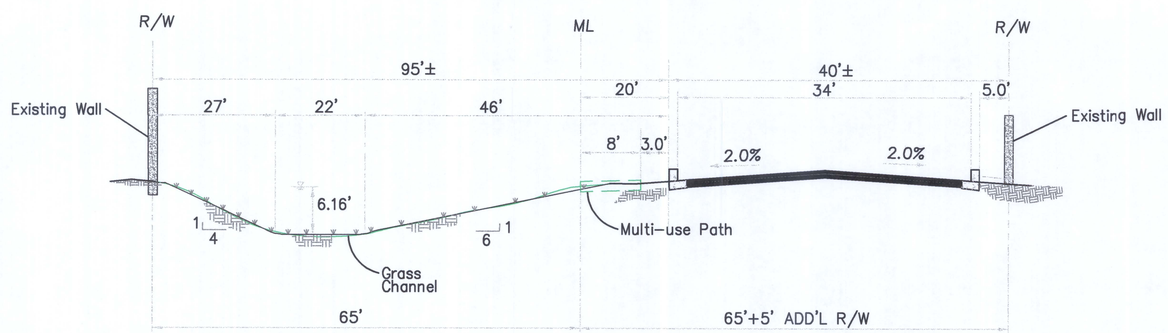
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY	COUNTY PROJECT NO. FCD98-23	HAWES ROAD K & G IMPROVEMENT PROJECT
	CONSULTANT PRIMATECH ENGINEERS & CONSULTANTS, 2929 North 44th Street, Suite 228, Phoenix, Arizona 85018, (602) 952-2828	PROJECT DESCRIPTION ALTERNATIVE NO. 2 PLAN & SECTIONS FIGURE 4-6
		DRN. JMM DATE: 07-28-99 / DES. JMM DATE: 07-28-99 / CKD. DATE: / SCALE 1"=100' / SHEETS NO. 1 OF 4



REACH 0-2

REACH 1-1

L=4,900'±
Q_{100}=1,930 CFS±
V=5.94 CFS±
GRASS LINING
S=0.0024
1-2' DROP STRUCTURE (UNDER COURT)



REACH 1-1
SECTION C-C

LEGEND

- PROPOSED NEW CONCRETE CHANNEL
- PROPOSED NEW GRASS CHANNEL
- PROPOSED NEW GRASS-CONCRETE CHANNEL
- EXISTING CULVERT TO REMAIN
- PROPOSED NEW CULVERT
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- PEDESTRIAN ACCESS LOCATION
- PROPOSED PEDESTRIAN ACCESS LOCATION
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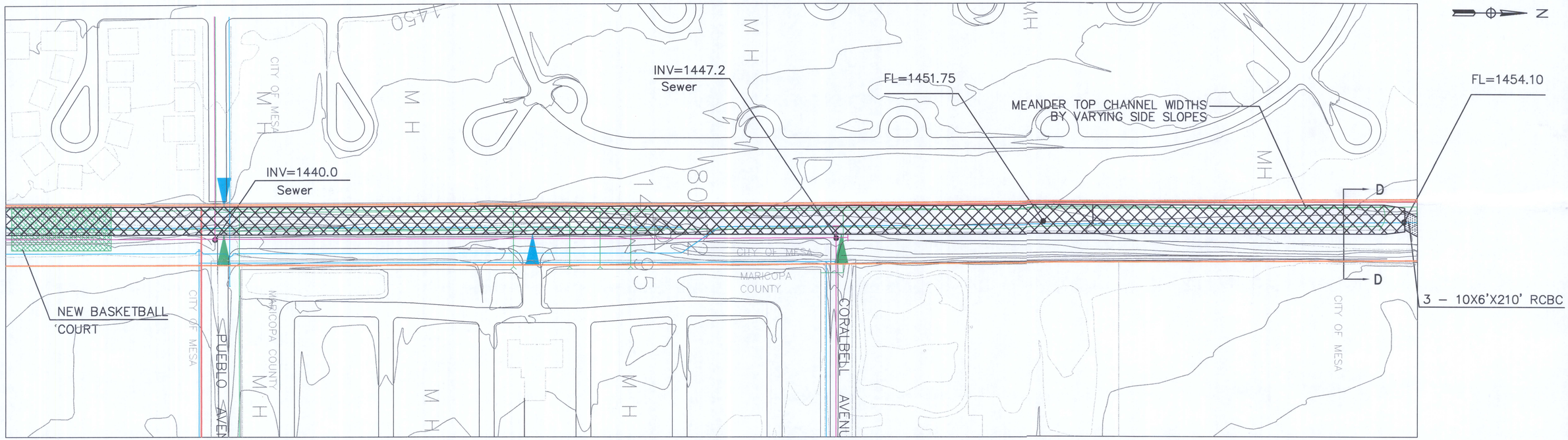
- WATER LINE
- SANITARY SEWER LINE
- OVERHEAD ELECTRIC
- EXISTING RIGHT OF WAY
- STORM DRAIN

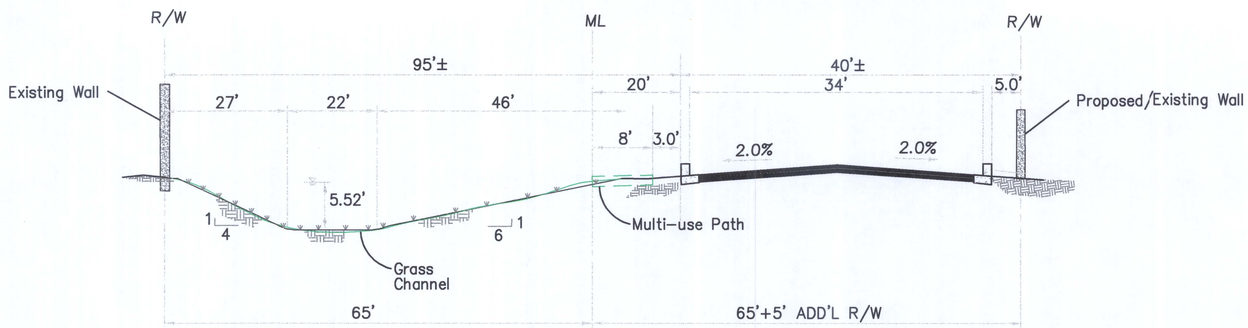
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY	COUNTY PROJECT NO. FCD98-13	HAWES ROAD K & G IMPROVEMENT PROJECT
	CONSULTANT PRIMATECH ENGINEERS & CONSULTANTS, 2929 North 44th Street, Suite 228, Phoenix, Arizona 85018, (602) 952-2828	PROJECT DESCRIPTION ALTERNATIVE NO. 2 PLAN & SECTIONS FIGURE 4-6
		DRN. JMM DATE: 07-28-99 / DES. JMM DATE: 07-28-99 / CKD. DATE: / SCALE 1"=100' / SHEETS NO. 2 OF 4



REACH 1–1
(SEE SHEET 2 OF 4)

REACH 1–2

L=810'±
Q_{100}=1650 CFS±
V=6.0 CFS±
GRASS LINING
S=0.0024
CULVERTS: 3 – 10' X 6' X 210': S=0.0036



REACH 1–2
SECTION D–D

LEGEND

- PROPOSED NEW CONCRETE CHANNEL
- PROPOSED NEW GRASS CHANNEL
- PROPOSED NEW GRASS–CONCRETE CHANNEL
- EXISTING CULVERT TO REMAIN
- PROPOSED NEW CULVERT
- PROPOSED PARKING AREA
- PEDESTRIAN ACCESS LOCATION
- PROPOSED PEDESTRIAN ACCESS LOCATION
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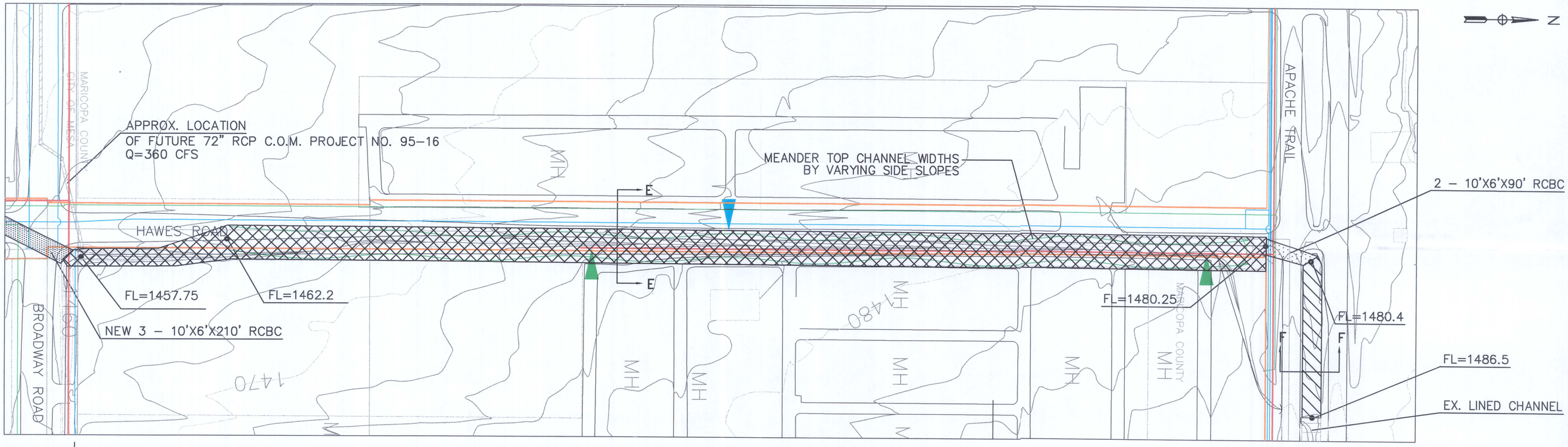
- WATER LINE
- SANITARY SEWER LINE
- OVERHEAD ELECTRIC
- EXISTING RIGHT OF WAY
- STORM DRAIN

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY	COUNTY PROJECT NO. FCD98–23	HAWES ROAD K & G IMPROVEMENT PROJECT
	CONSULTANT PRIMATECH ENGINEERS & CONSULTANTS, 2929 North 44th Street, Suite 228, Phoenix, Arizona 85018, (602) 952–2828	PROJECT DESCRIPTION ALTERNATIVE NO. 2 PLAN & SECTIONS FIGURE 4–6
		DRN. JMM DATE: 07–28–99 / DES. JMM DATE: 07–28–99 / CKD. DATE: / SCALE 1"=100' / SHEETS NO. 3 OF 4



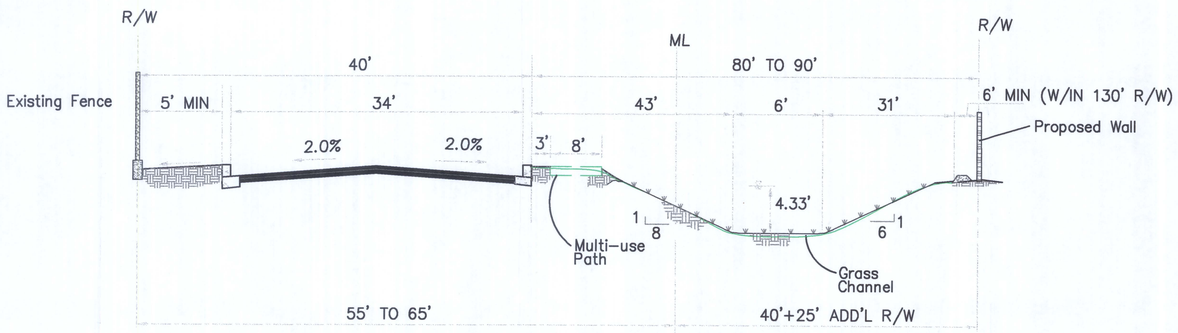
REACH 1-2

REACH 2

L=2550'±
Q_{100}=922 CFS±
V=6.88 CFS±
S=0.0045 W/ 5-2' DROP STRUCTURES
GRASS LINING
n=0.03

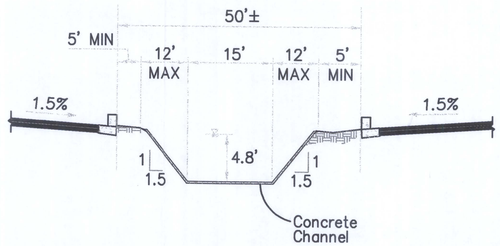
REACH 3

L=415'±
Q_{100}=922 CFS±
CULVERT: 1 - 10' X 6' X 90'
S=0.0016/W 2-3' DROPSTRUCTURES
CONCRETE LINING
N=0.015



REACH 2

SECTION E-E



REACH 3-3

SECTION F-F

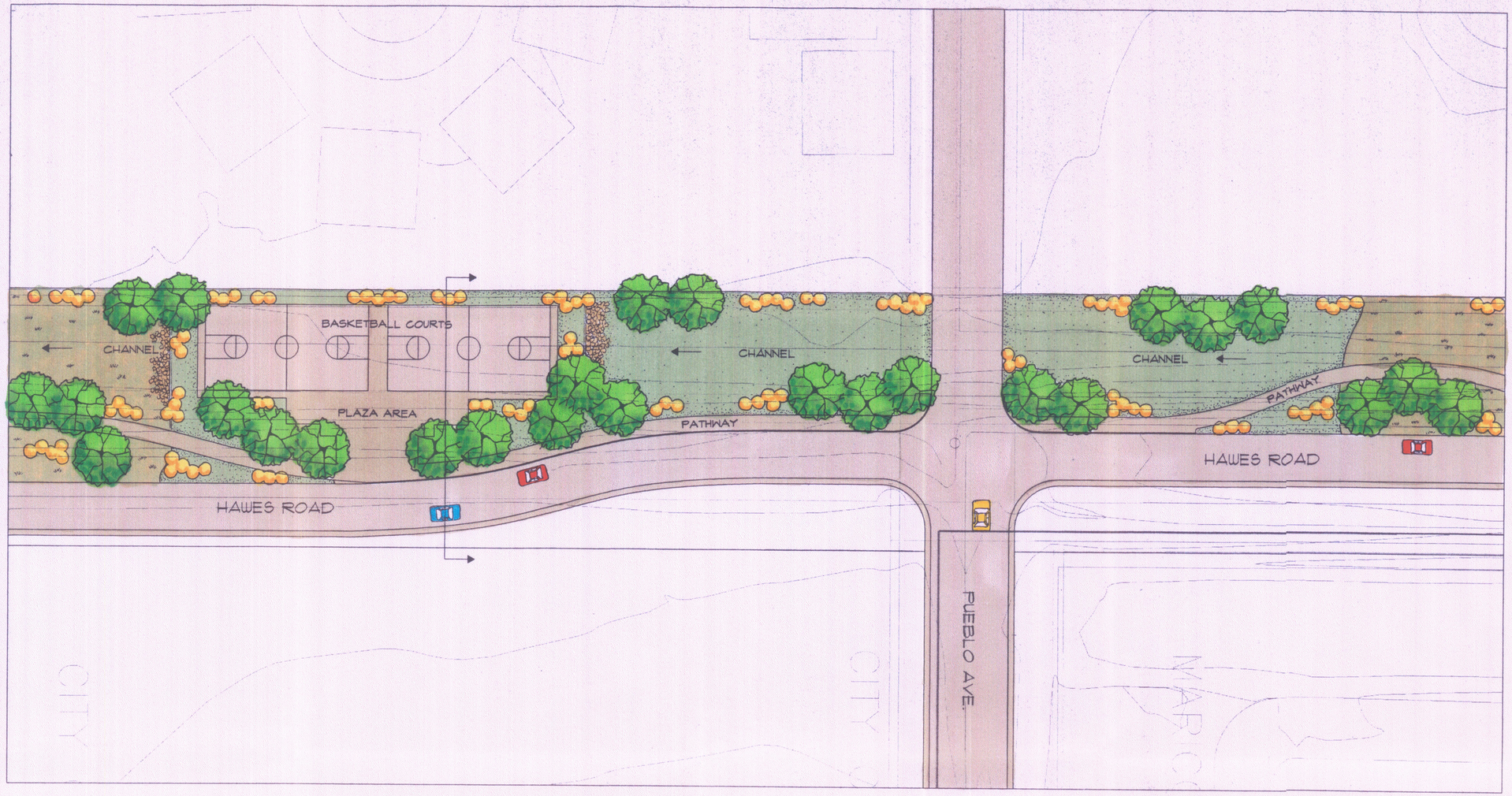
NTS

Q_{100}=922 CFS

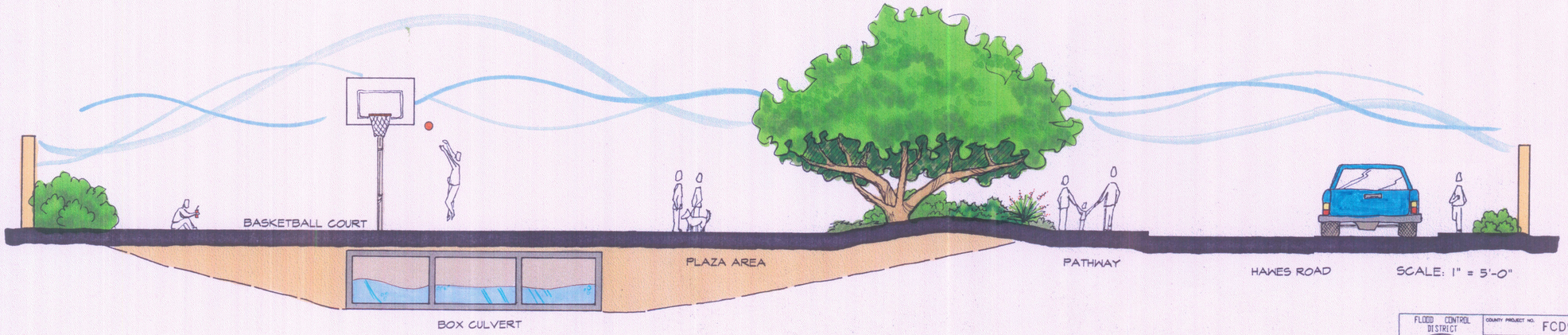
LEGEND

- PROPOSED NEW CONCRETE CHANNEL
- PROPOSED NEW GRASS CHANNEL
- PROPOSED NEW GRASS-CONCRETE CHANNEL
- EXISTING CULVERT TO REMAIN
- PROPOSED NEW CULVERT
- PROPOSED PARKING AREA
- PEDESTRIAN ACCESS LOCATION
- PROPOSED PEDESTRIAN ACCESS LOCATION
- SOUTHWEST GAS LINE
- WATER LINE
- SANITARY SEWER LINE
- OVERHEAD ELECTRIC
- EXISTING RIGHT OF WAY
- STORM DRAIN

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY	COUNTY PROJECT NO. FCD98-23	HAWES ROAD K & G IMPROVEMENT PROJECT
CONSULTANT: PRIMATECH ENGINEERS & CONSULTANTS, 2929 North 44th Street, Suite 228, Phoenix, Arizona 85018, (602) 952-2828	PROJECT DESCRIPTION: ALTERNATIVE NO. 2 PLAN & SECTIONS FIGURE 4-6	
	DRN. JMM DATE: 07-28-99 / DES. JMM DATE: 07-28-99 / CKD. DATE:	SCALE 1"=100' / SHEETS NO. 4 OF 4

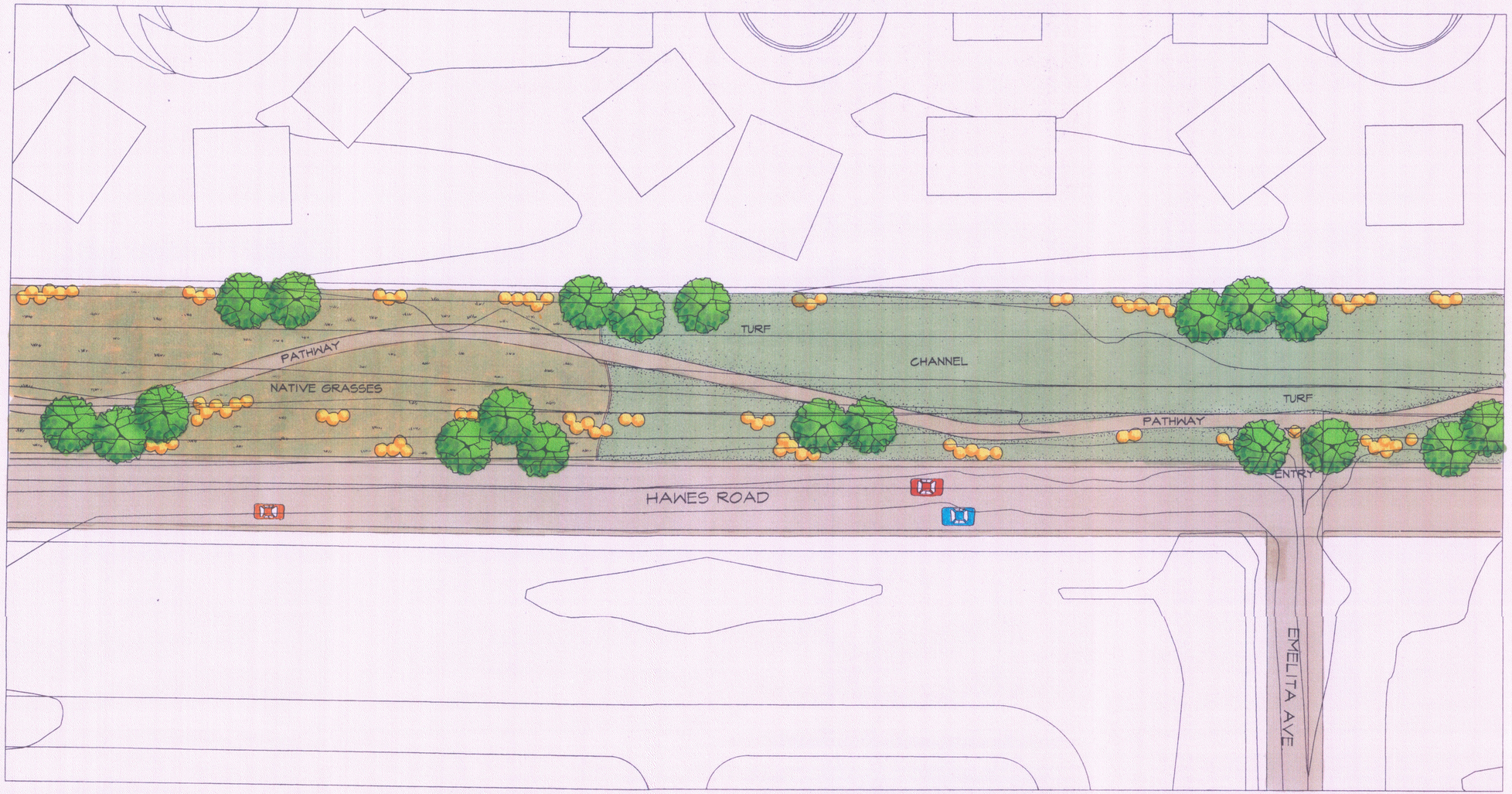


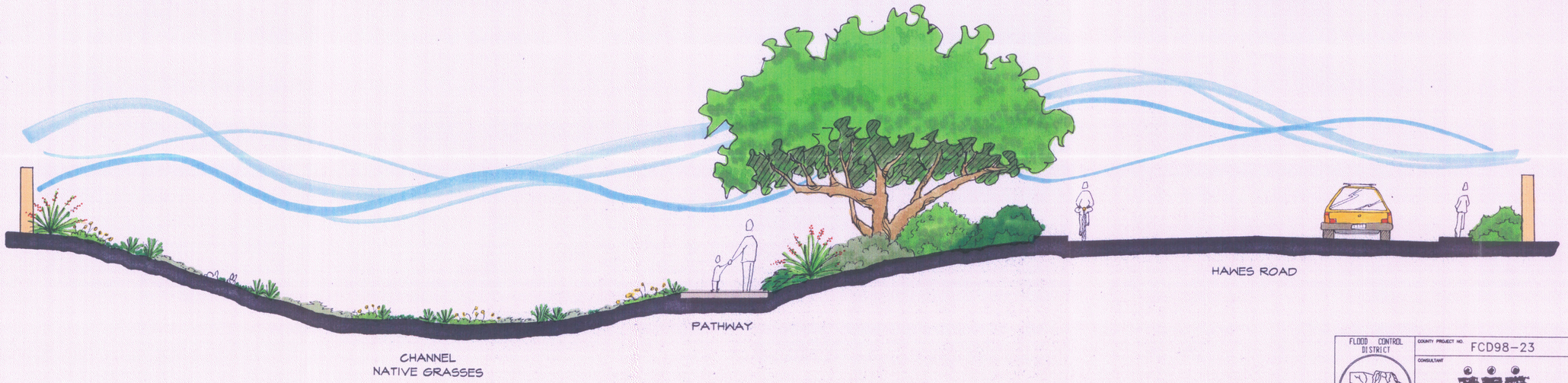
SCALE: 1" = 30'-0"



SCALE: 1" = 5'-0"

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY	COUNTY PROJECT NO. FCD98-23	HAWES ROAD K & G IMPROVEMENT PROJECT
	CONSULTANT: Logan Simpson Design Inc. 3818 South 48th Avenue, Suite 200 Tempe, Arizona 85281 602-897-1343 FAX 345-8232	PROJECT DESCRIPTION: CITY OF MESA PARK-SITE
		DRN. MAH DATE: 7-26-99 / SCALE: AS SHOWN / SHEETS
		DES. SL/MH DATE: 7-26-99
		CKD. SL DATE: 7-26-99 / NO. 1 OF 2





FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

COUNTY PROJECT NO. FCD98-23

CONSULTANT

Logan Simpson Design Inc.
398 South Mill Avenue, Suite 200
Tempe, Arizona 85281
602-967-1343 fax 966-8232

HAWES ROAD K & G IMPROVEMENT PROJECT

PROJECT DESCRIPTION

RECREATIONAL GREENWAY

DRN. MAH DATE: 7-16-99	SCALE	SHEETS
DES. SL/MH DATE: 7-16-99	AS SHOWN	NO. 2 OF 2
CKD. SL DATE: 7-16-99		

Appendix A

City of Mesa and Maricopa County Department of Transportation Standard Details

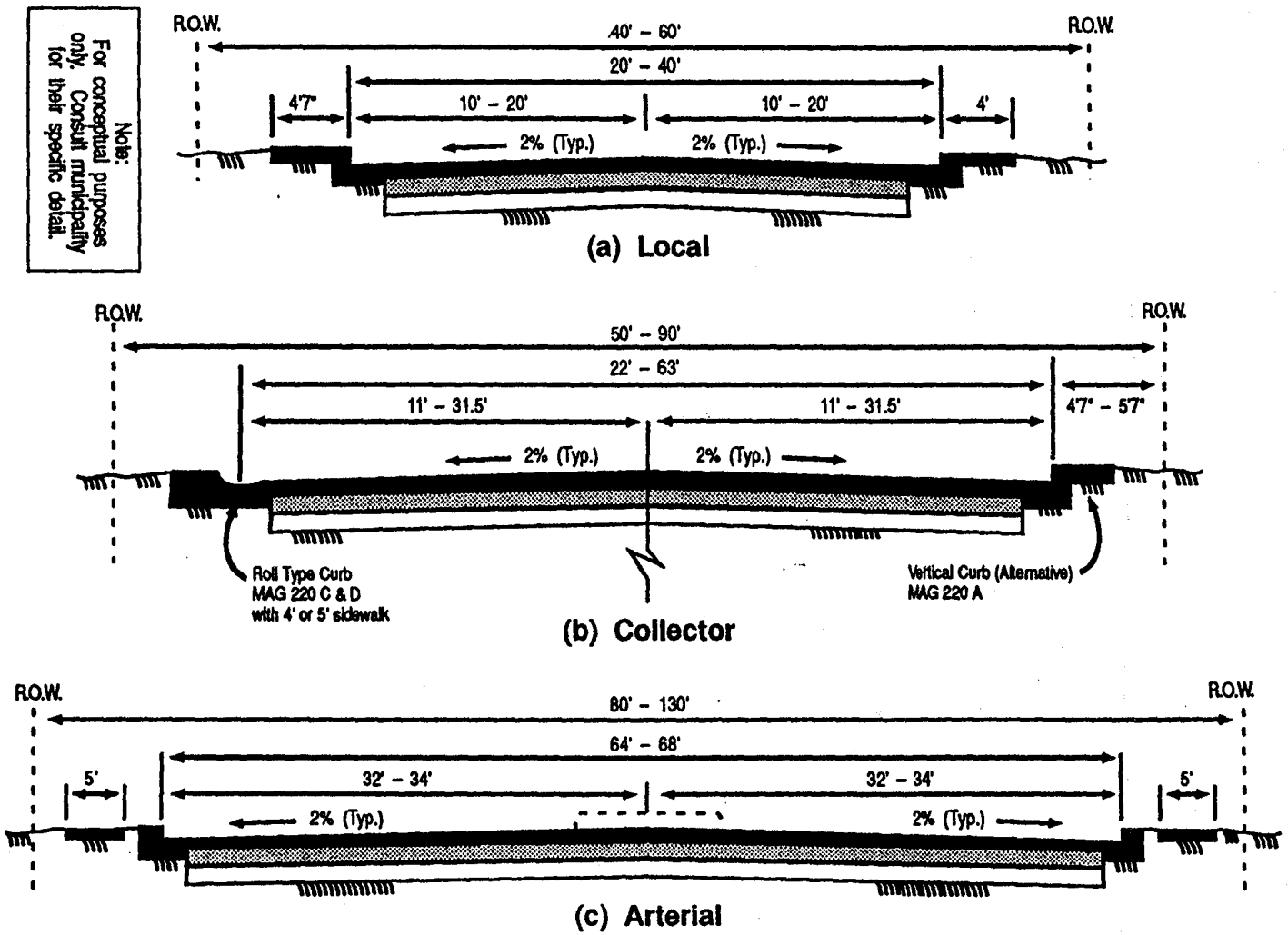


Figure 3.1
Typical Street Cross Section

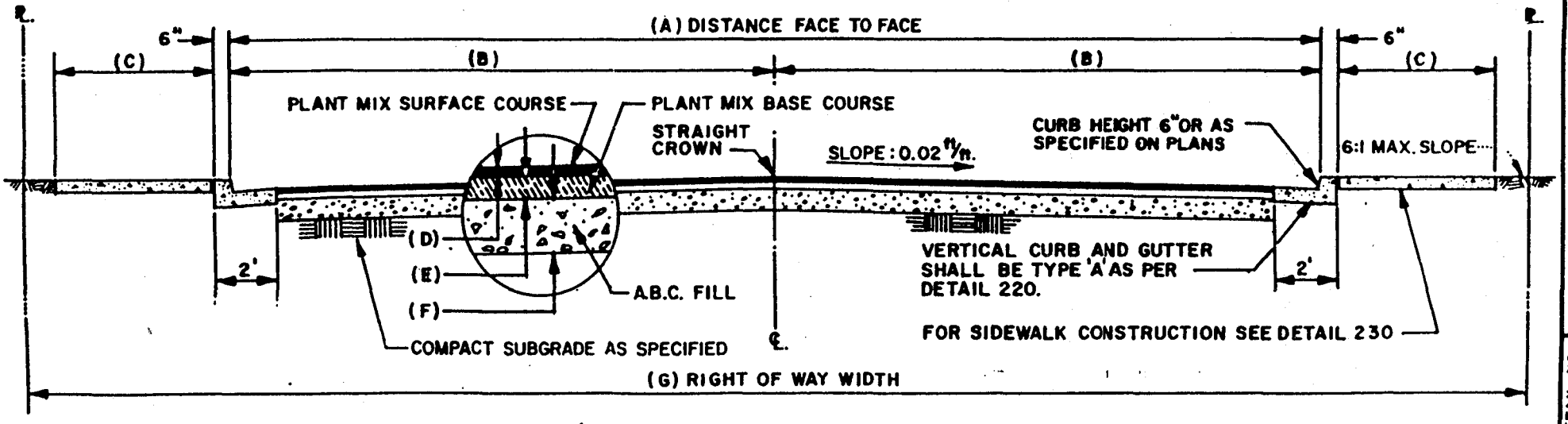
NOTES

1. ALL STREETS TO BE CONSTRUCTED WITH A STRAIGHT CROWN OF 0.02 ft/ft.
2. WHERE 10" A.B.C. IS REQUIRED, IT IS TO BE INSTALLED IN (2) TWO EQUAL LAYERS.
3. A.B.C. FILL TO CONFORM TO SUB-SECTION 702.2 (AGGREGATE BASE).
4. ⚠1 ASPHALT CONCRETE SURFACE COURSE TO CONFORM TO MIX 'D-1/2', ASPHALT CONC. BASE COURSE TO CONFORM TO MIX 'A 1 1/2' AS PER SECT. 710.
5. SIDEWALK MAY BE DELETED IN HEAVY INDUSTRIAL AREAS WITH APPROVAL OF CITY ENGINEER ONLY.

PAVEMENT TABLE

	ROADWAY (WIDTH)		SIDEWALK (WIDTH)	SURFACE COURSE (DEPTH)	BASE COURSE (DEPTH)	A.B.C. FILL (DEPTH)	RIGHT OF WAY (WIDTH)
	FACE TO FACE (A)	℄ TO FACE (B)	(C)	(D)	(E)	(F)	(G)
RESIDENTIAL STREET	34'	17'	4'	1"	1·1/2"	5·1/2"	50'
COLLECTOR STREET	40' TO 48'	20' TO 24'	5'	1"	1·1/2"	5·1/2"	60' TO 80'
MAJOR COLLECTOR STREET *	64' TO 68'	32' TO 34'	5'	1·1/2"	2·1/2"	10" SEE NOTE 2	90' TO 110'
ARTERIAL STREET	88'	44'	5'	1·1/2"	2·1/2"	10" SEE NOTE 2	110' TO 130'
INDUSTRIAL / COM. STREET	44' TO 48'	22' TO 24'	4' SEE NOTE 5	1·1/2"	2·1/2"	10" SEE NOTE 2	60' TO 80'

* ALSO SOME ARTERIALS WITH CITY APPROVAL

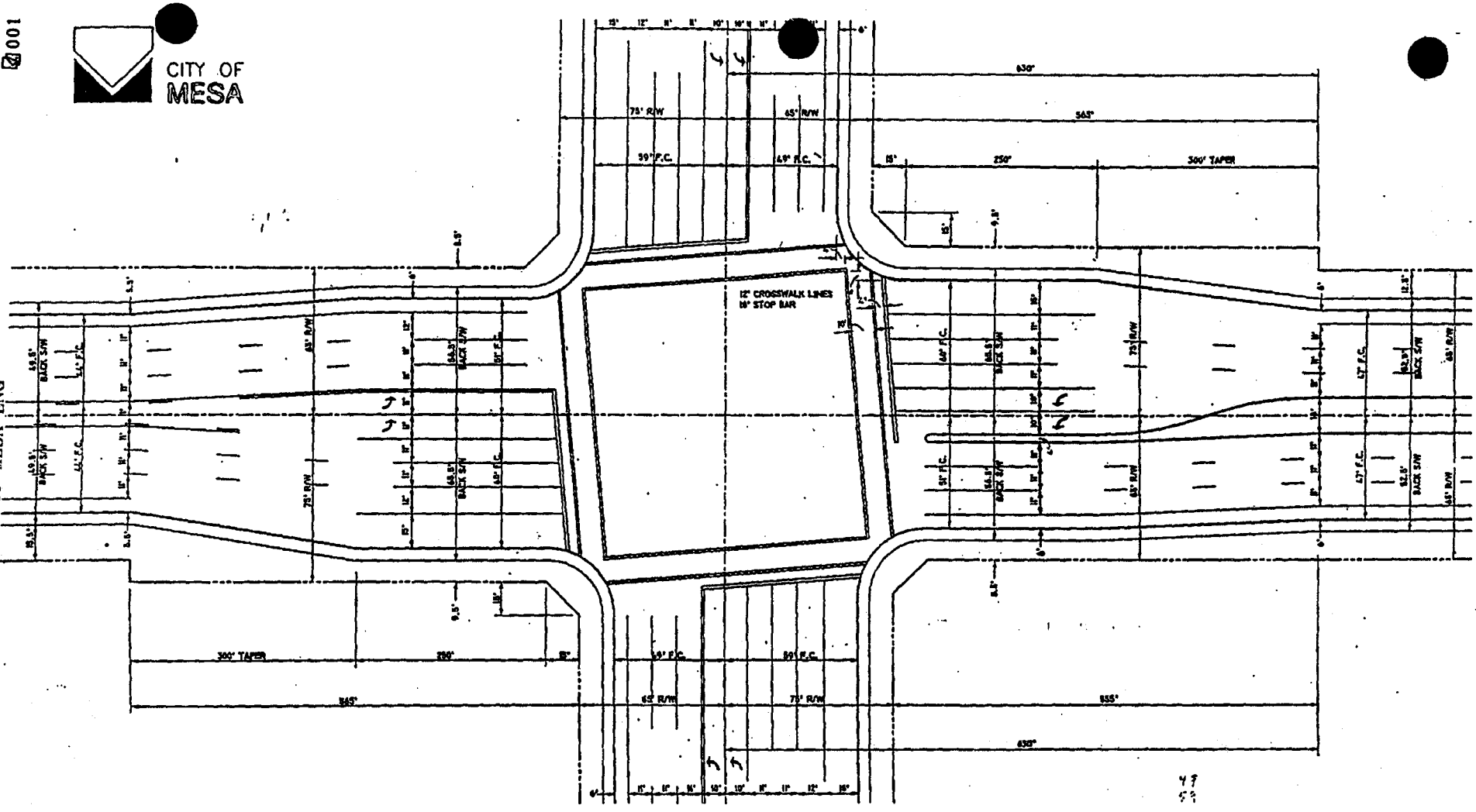


TYPICAL STREET SECTION

DETAIL NO. M-19.1

REV. 3-1-92 ⚠1 CHANGED B-1 TO A 1 1/2

CITY OF MESA



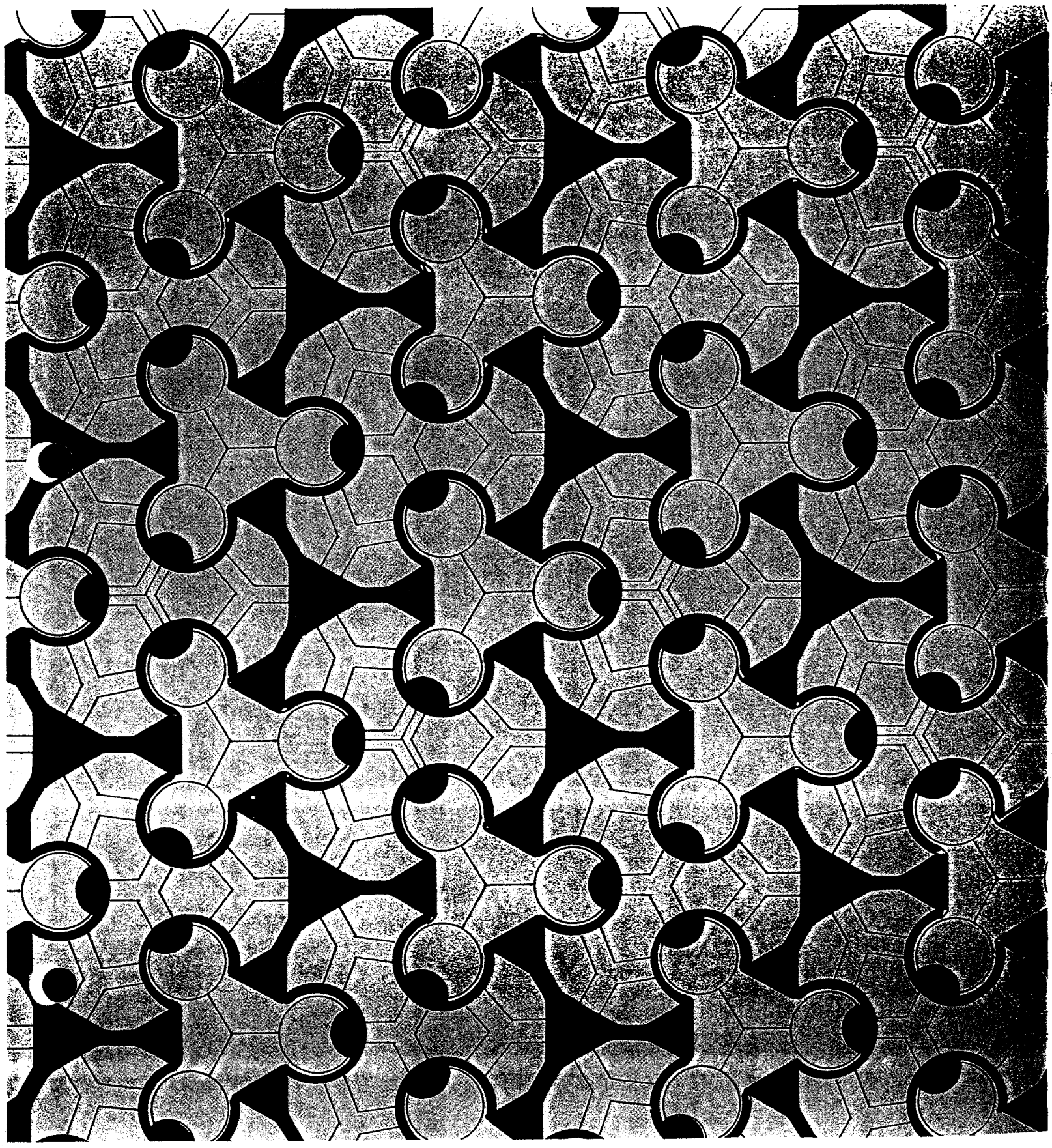
ARTERIAL STREET INTERSECTION

Appendix B

Grass-Concrete Linings

Tri-lock

ARTICULATED EROSION CONTROL SYSTEM*



Tri-lock

ARTICULATED EROSION CONTROL SYSTEM*

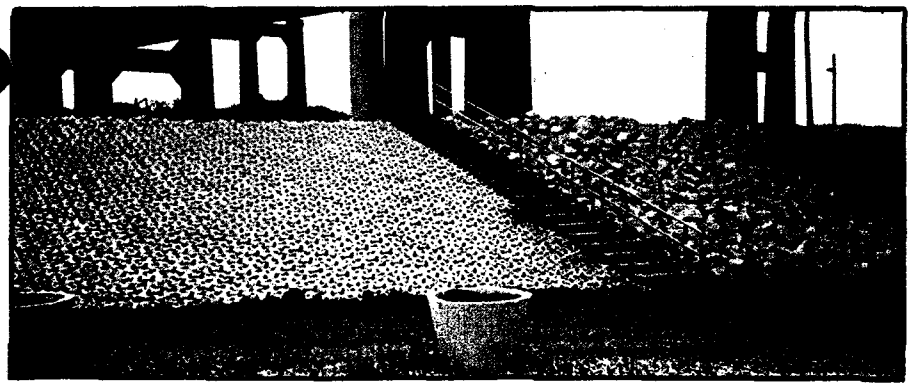
AN INTRODUCTION TO TRI-LOCK

The TRI-LOCK EROSION CONTROL SYSTEM represents the most advanced and versatile system in the erosion control industry. TRI-LOCK provides the engineered alternative to conventional erosion control materials for revetment and channel protection as an effective, economical and environmentally sound method of combating severe erosion problems.

TRI-LOCK is a flexible, permeable erosion control system that has the capacity to allow revegetation. It employs a superior, specially engineered woven filter fabric in combination with an interlocking articulated concrete block armor. TRI-LOCK is a system of pre-cast concrete blocks made up of two components: a "lock block" and a "key block." Each component is keyed into the other components, giving both stability and integrity.

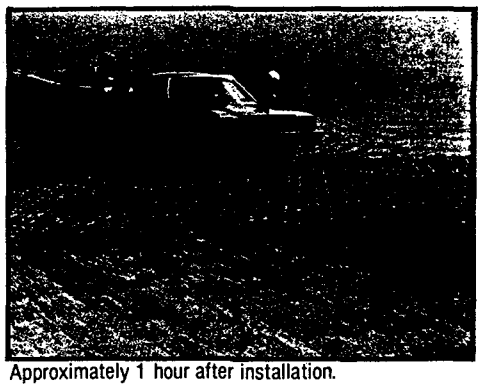
TRI-LOCK blocks are manufactured for ease of installation. TRI-LOCK is normally installed in dry conditions by hand placing on to filter fabric. Where site conditions dictate (i.e. underwater applications) TRI-LOCK can be supplied on pre-assembled mats utilizing special installation techniques and conventional construction equipment. In either application, the TRI-LOCK SYSTEM is easily installed with minimal manpower and equipment.

The TRI-LOCK SYSTEM, a total membrane of erosion control, varies from any other system in that it is completely self-contained. TRI-LOCK offers an additional, significant advantage over other systems through its unique shape. Its structure and shape give it the ability to negotiate changes of direction without the necessity of added labor or additional product applications.

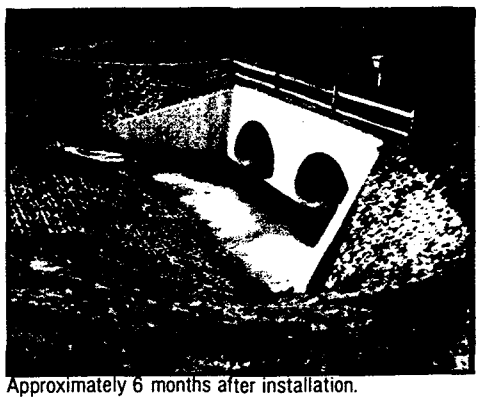


TRI-LOCK blocks are hand placed over TRI-LOCK fabric. A 1" diameter steel pipe is employed to position blocks as needed for correct alignment.

Approximately 12 months after installation.



Approximately 1 hour after installation.



Approximately 6 months after installation.

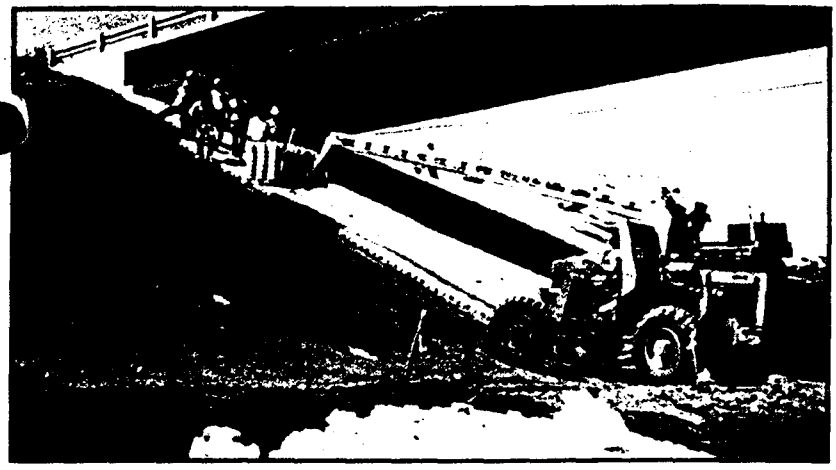
USES FOR TRI-LOCK

- *Coastal Shoreline Protection*
- *Lake Shoreline Protection*
- *Reservoir Embankment Protection*
- *River Bank Protection*
- *Channel Lining*
- *Culvert Inlet and Outfall Protection*
- *Drainage Ditch Lining*
- *Spillway Lining*
- *Dike and Levee Protection*
- *Pipeline and Buried Cable Watercourse Crossing Protection*
- *Bridge Abutment Protection*
- *Slope Protection*
- *Boat Launching Ramps*
- *Parking Areas*

*U.S. PAT. # RE 32,663

Tri-lock

ARTICULATED EROSION CONTROL SYSTEM*



Use of telescoping lift is used to spot pallets.

Spreader bar and crane are used to position pre-assembled mats.

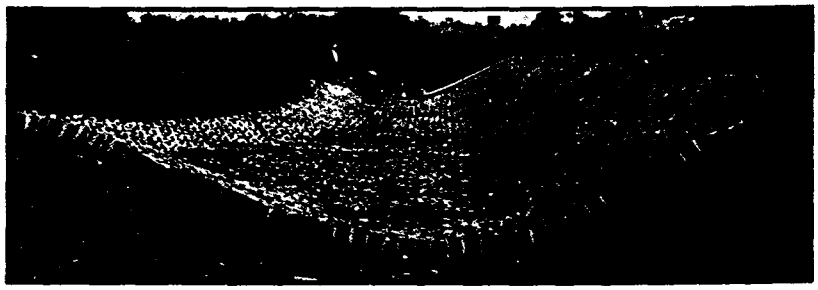
TRI-LOCK Characteristics

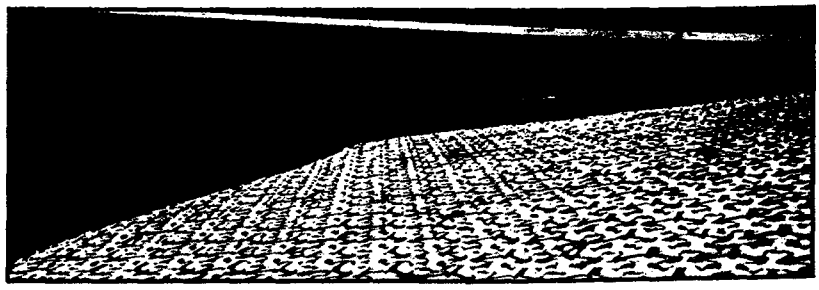
- **Stability:** Highly stable, long lasting revetment. TRI-LOCK is available in a variety of sizes and weights for maximum protection with differing wave climates or flow velocities.
- **Flexibility:** Flexibility is achieved by a bevel at the interlock of the TRI-LOCK block enabling the system to conform to changing land contours and grades.
- **Permeability:** TRI-LOCK has adequate open area to relieve any hydrostatic pressure across the revetment. Voids are evenly and closely spaced.
- **Revegetation:** The voids in the TRI-LOCK system should be filled with top soil and seeded with grass or other vegetation to restore the embankment to its natural state. The TRI-LOCK SYSTEM will actually promote this regrowth process. There are no projections or abrupt uneveness, permitting easy maintenance with conventional grass cutting equipment.
- **Access:** The eveness of TRI-LOCK revetments provides a safe surface for both vehicle and pedestrian traffic.
- **Design Features:** TRI-LOCK is made from concrete, nothing else...no metal to corrode, no other fastening device subject to abrasion, just concrete, made as required for the conditions to be encountered.

  TRI-LOCK is a total membrane, not a set of separate mats functioning independently. Every unit in the TRI-LOCK systems is firmly locked into the adjacent units allowing the entire revetment to act as one. This feature, as well as enhancing the hydraulic characteristics, prevents revetment failure.

ADVANTAGES OF TRI-LOCK

- *Economically competitive with other types of erosion control systems*
- *Does not require cables or additional anchoring*
- *Ability to negotiate changes in direction*
- *Ability to go around structures and not effect integrity of system*
- *Sheet flow on run-off areas does not form linear channels.*
- *Relieves hydrostatic pressure, prevents loss of soil.*
- *Manufactured at or near jobsite*
- *Uniform installation enhances attractiveness*
- *Fully flexible and conforms to changes in subgrade*
- *Available in mat form for machine installation*





Views showing TRI-LOCK installations on berms and bridges.

Tri-lock SPECIFICATIONS:

ARTICULATED EROSION CONTROL SYSTEM*

TRI-LOCK BLOCKS	4010	4015	4020
HEIGHT	4 in.	6 in.	8 in.
MODULE	16 in.	16 in.	16 in.
WEIGHT PER SQ. FT. (Approx.)	32 lbs.	45 lbs.	60 lbs.
WEIGHT OF BLOCK PAIR (Approx.)	50 lbs.	70 lbs.	90 lbs.

CONCRETE STRENGTH, 4000 psi
OPEN AREA (Approx.) 20%

TRI-LOCK MATS

Available Dimensions:			
STANDARD WIDTH	4 ft.-8 in.	4 ft.-8 in.	Information available upon request
STANDARD LENGTHS	16 ft.	16 ft.	
	18 ft.-8 in.	18 ft.-8 in.	

NOTE: Special lengths made to order in large quantities.

MAT WEIGHTS			
PER LINEAR FOOT	150 lbs.	210 lbs.	Varies
16 FT. MAT	2400 lbs.	3360 lbs.	
18 FT.-8 IN. MAT	2800 lbs.	3900 lbs.	

GENERAL SPECIFICATIONS

TRI-LOCK flexible erosion control systems shall be comprised of three directional interlocking concrete components of the sizes shown above, overlaying a filter fabric, as specified.

The TRI-LOCK System may be hand assembled on the bank by interlocking the components in a manner that allows maximum flexibility but discourages vertical movement of any single component.

The concrete components shall be precast units having a compressive strength of not less than 4,000 psi. The oven-dry weight shall be not less than 125 lbs. per cubic foot, except that not more than 5% of components on any single mat shall be accepted under this minimum. Compressive testing shall be conducted on cubes cut from random samples of TRI-LOCK components, per ASTM C-140.

The carrier filter fabric shall be of sufficient strength to support not less than 1½ times the weight of the mat when slung by lifting at the ends. The carrier filter fabric shall consist of a suitable fabric, as separately specified, reinforced if required for the duty of the carrier as indicated above. A side flap of not less than 9" shall be provided to assure overlap of the filter panels assuring integrity of the filter blanket.

INSTALLATION

TRI-LOCK is installed by contractor's personnel using standard equipment whether the system is installed by hand placing or through the use of pre-assembled mats. A TRI-LOCK representative is generally available to advise and assist the contractor. It is not necessary for the contractor's crew to have previous experience or special skills in order to economically install TRI-LOCK.

Site Preparation: Before placing the TRI-LOCK system, the slope shall be inspected to insure that it is free from obstructions such as tree roots, projecting stones or other foreign matter. Voids or soft areas should be filled with suitable materials and well compacted. Although some variation in contour will be allowed, no sudden changes in level can be accepted. Hand dress where necessary.

TRI-LOCK revetment systems are normally backfilled with topsoil at the rate of 1 cu. yd. of topsoil to 225 sq. ft. (4" blocks). In the event that revegetation is not provided for, then the revetment may be backfilled to an average of 2" cover on the filter fabric for the protection of the filter fabric against UV rays. This backfilling should be executed within 7 days of completion of revetment. Average material required will be 1 cu. yd. to 450 sq. ft.

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*U.S. PAT. # RE. 32.663
FOREIGN COUNTRY PATENTS APPLIED FOR

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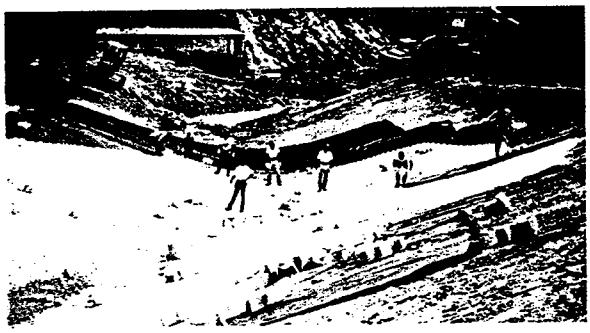
FORM 063

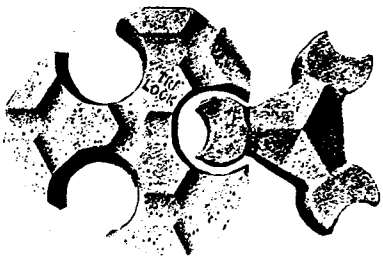
Tri-Lock

CONTROL SYSTEM

When erosion had eaten away at the soil and exposed the concrete foundations and pipes of townhomes along the Spring Branch Creek, the Harris County Flood Control District, Houston, TX knew it had a severe erosion problem. The water in the creek was moving at a velocity



of 12 fps. The homes adjacent to the channel were being threatened by severe erosion which could result in catastrophic damages. The creek is lined on one side with townhomes and on the other, the Commonwealth Bank Building.
The Harris County Flood Control District needed a permanent solution to the problem. Typical solutions for erosion of this magnitude include concrete slope paving, wire mesh gabion baskets or rip-rap. All of these were rejected on the basis of non-pleasing aesthetics, cost and potential for injury to area children. Local American Excelsior representatives approached the district with TRI-LOCK. Presentations were also made to the area homeowners' association. Both groups agreed on TRI-LOCK to correct the erosion problem.



TRI-LOCK is a flexible, permeable erosion control system that has the capacity to allow revegetation. It consists of interlocking articulated concrete block armor made up of "lock blocks" and "key blocks" which link together for both stability and integrity. TRI-LOCK has adequate open area to relieve hydrostatic pressure through the revetment, and employs a specially-engineered woven geotextile fabric. It can abut existing structures and negotiate changes in direction without interruption and the need for added labor or grouted zippers (joints). This flexibility is achieved by a three-directional interlock of the TRI-LOCK system.

Benefits:

- "Lock" and "Key" blocks interlock for stability and integrity in severe conditions
- Can negotiate changes in terrain without disrupting interlock
- Eliminates habitats for vermin (rats, snakes, etc.)
- Relieves hydrostatic pressure and prevents loss of soil
- Minimizes risk of personal injury and liability
- Cost effective compared to other alternatives
- Can support vegetation to provide a natural appearance

PRIOR TO TRI-LOCK INSTALLATION
Erosion caused by a 12 fps water velocity flow had eaten away at the soil and exposed the concrete foundations and pipes of the Commonwealth Bank Building and homes along Spring Branch Creek.

AFTER TRI-LOCK INSTALLATION
After installation, the block was back-filled with soil and seeded to give a natural appearance.

TRI-LOCK is normally installed in dry conditions by hand placing the blocks onto geotextile fabric. For underwater applications, it can be supplied on pre-assembled mats utilizing special installation techniques and conventional construction equipment. Expensive cables or additional anchoring are not normally required for installation.

"The geometry of the site and the environmental sensitivity of the area gave us an opportunity to try TRI-LOCK on this project," says Mr. Gary Green, Construction Manager, Harris County Flood Control District. "We never really considered other products for the Spring Branch Creek project because of these factors. Traditional erosion control methods, such as slope pavement, were out of the question."

Green further adds, "The residents in the area were very conscious of environmental issues and they wanted an erosion control solution that would not detract from the look of their property. We needed to provide erosion control, yet at the same time allow vegetation to grow through it."

J-Mac Incorporated, Houston, TX, installed the system. The 65,000 sq. ft. project was done in two phases. The west side of the project, where the townhomes sat, occupied approximately 40,000 square feet and the east side of the project consisted of approximately 25,000 square feet. Six inch TRI-LOCK block pairs (#4015) were used on the site.

American Excelsior personnel supervised the installation of the TRI-LOCK, offering technical assistance on subgrade preparation, geotextile placement and block installation. The TRI-LOCK blocks were placed across the bottom of the channel and terminated in trenches to assure that the system would remain stable during the design event. In dry areas, the blocks were hand-placed onto geotextile fabric. In areas below the waterline, TRI-LOCK was laid in preassembled mat form with the use of a spreader-bar. It was then back-filled with soil and seeded to give a natural appearance to the surrounding area.

At A Glance:

Project:	Drainage Channel Protection
Location:	Spring Branch Creek, Houston, TX
Product:	TRI-LOCK #4015 (6" thick)
Application:	Slopes and channel
Job Size:	65,000 sq. ft. of block
Manufacturer:	American Excelsior Company

American Excelsior Company

EARTH SCIENCE DIVISION
AN EMPLOYEE OWNED COMPANY

850 Avenue H East
Arlington, TX 76011
817-640-1555, 800-777-SOIL
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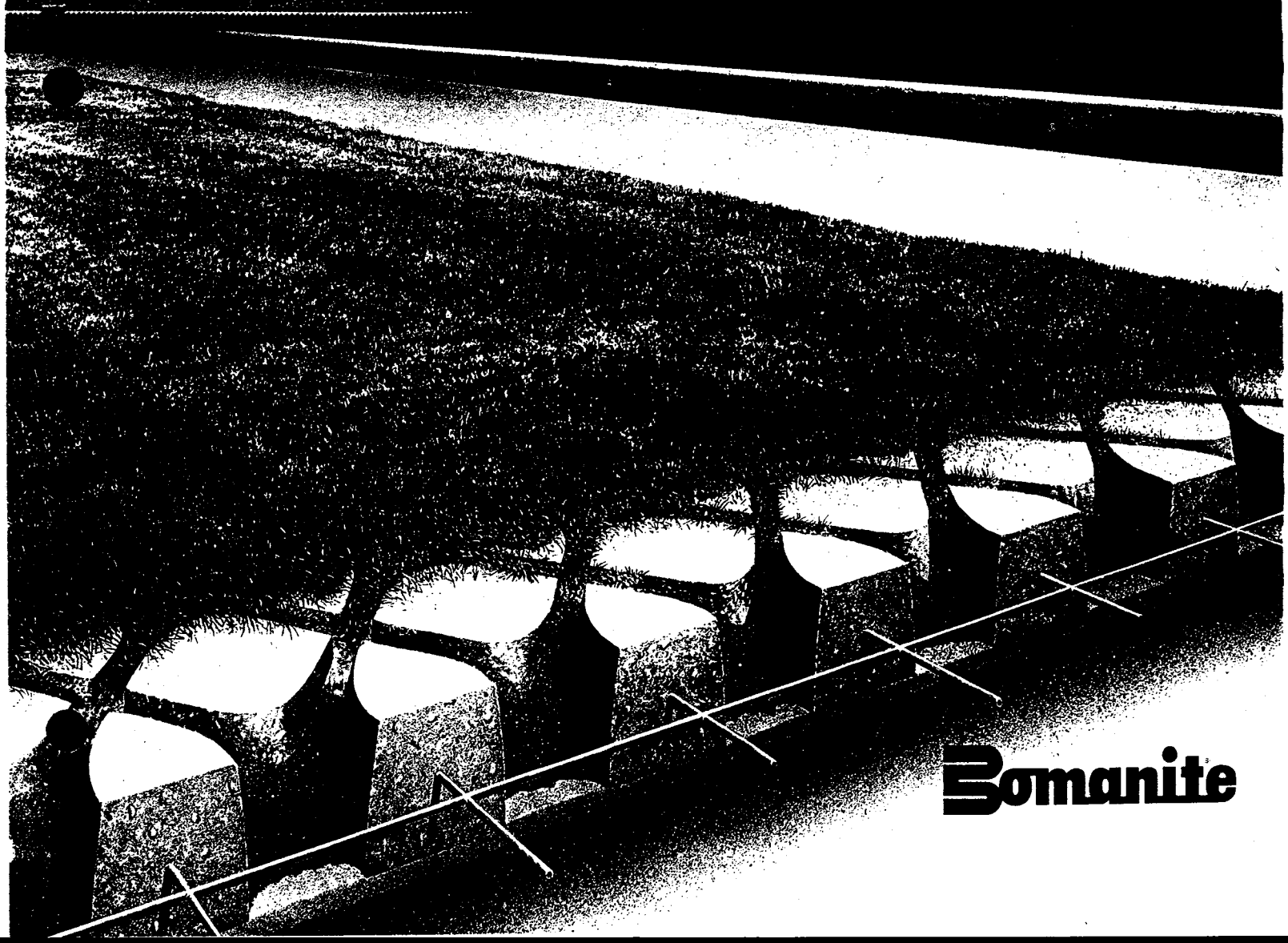

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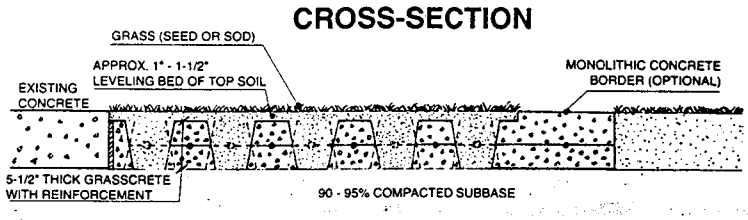


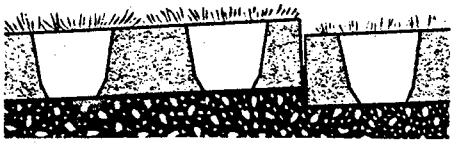
Cast-in-place, Monolithic, Continuously

New Grasscrete offers a significant advantage over original Grasscrete. Reusable formers (instead of single-use formers) are used to produce new Grasscrete, resulting in significant cost reduction and improved appearance. Grasscrete is now competitively priced with precast porous paver products. Grasscrete, long used for emergency vehicle access and parking, is now used increasingly for applications including erosion control, reduction of stormwater runoff and meeting landscape zoning requirements.

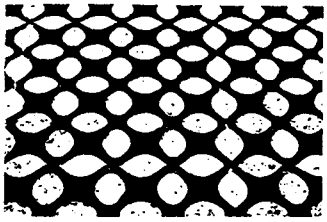
Grasscrete is a cast-in-place, monolithic, continuously reinforced grass/concrete porous pavement system. It can be used anywhere an impervious paving method is used, e.g. driveways, parking lots, access routes, embankments, drainage ditches, storage areas for heavy materials and vehicles etc.

Because of its structural integrity and continuous reinforcing, Grasscrete is not subject to differential settlement, which can occur with precast products.

Precast porous pavers are susceptible to differential settlement resulting in an uneven surface.



Grasscrete monolithic porous pavement stays flat under the heaviest traffic even when the sub-base is saturated with water.



Grasscrete surface before soil placed and grass planted.

CONTROLS EROSION

REDUCES STORMWATER RUNOFF
MEETS GREENSPACE ZONING REQUIREMENTS

Reinforced Grass/Concrete Porous Pavement

Grasscrete is a superb solution to problems created by the alteration of natural stormwater runoff patterns. By reducing runoff, Grasscrete actually increases ground water recharge through infiltration, while improving the quality of the water supply and preventing erosion due to storms and floods. This "non-point source" pollution is the subject of an increasing number of state and local statutes. As the result of impervious surfaces in dense urban development, many state and local authorities are no longer allowing developers to increase the amount of runoff to sewer systems.

In water management applications including erosion control, Grasscrete is a viable, cost-effective solution. At Ruby Creek in San Jose, California, Grasscrete is much more attractive for local residents than a plain concrete storm channel. Grasscrete allows infiltration while releasing hydrostatic pressure and doesn't require the subdrainage system necessary with solid concrete.

TEST REPORTS AVAILABLE

1. Load Test: 66,000 lb. Grumman Fire Truck; Ladder extended 100 ft. at 90 degrees with 800 lbs. in basket and outriggers extended. Soil was fully saturated.
   Equivalent load on outriggers: 208,700 lbs.
   Maximum deflection: .065 inches
2. Permeability Test: Different soils and rainfall were tested, up to about 2 inches per hour. Percolation through Grasscrete about equal to control sample with no concrete.

Grasscrete Contractors have been specially selected and trained by BOMANITE Corporation to increase their skills and experience, insuring a finished job of the highest quality. Grasscrete Contractors are members of the BOMANITE International Society, a worldwide network of exceptionally skilled concrete contractors. Reusable formers and steel reinforcing mesh are first positioned. Concrete is placed, and after initial setting, the formers are removed. After the concrete has sufficiently hardened, the openings in the Grasscrete slab are filled with soil and planted with grass seed or sod.

Concrete is placed

Formers are removed

Bomanite CORPORATION

P.O. Box 599
Madera, CA 93639-0599
Telephone: (209) 673-2411
Fax: (209) 673-8246
http://www.bomanite.com

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The activities of the Bomanite International Society are coordinated by Bomanite Corporation. The Corporation also provides services and technical assistance to its member contractors, and to architects, designers and engineers specifying Bomanite®, Bomacron®, Grasscrete and Solarpave™.

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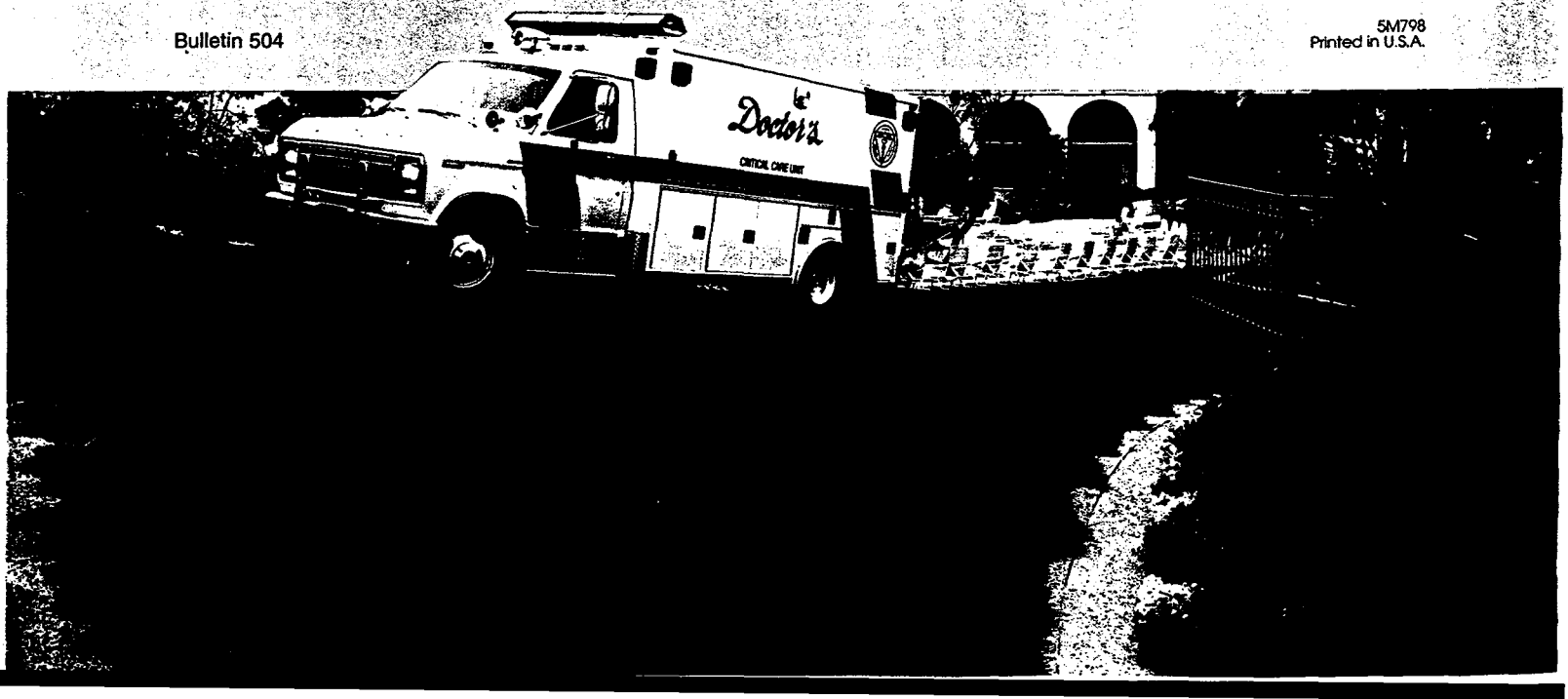

Suggested Grasscrete® Specification

The GRASSCRETE contractor is licensed and trained by Bomanite® Corporation, P.O. Box 599, Madera, CA 93639-0599. The work is usually called out in a section of the specifications separate from concrete and landscaping (Section 2 under Erosion Control 02370 and Porous Pavement 02795).

SECTION _____: GRASSCRETE

1. Scope. All work in this section shall be designated as GRASSCRETE in the plans. The work shall include all labor, materials, equipment and transportation required to install GRASSCRETE.

2. Contractor. The Contractor for this work shall be licensed by Bomanite Corporation, P.O. Box 599, Madera, CA 93639-0599, (209) 673-2411.

3. Subgrade. The subgrade for GRASSCRETE shall be prepared for expected loading and drainage requirements. Subgrade for vehicle traffic shall be in accordance with local concrete street specifications. (NOTE: Because of the wide variety of soil types, weather and anticipated loading, it is not possible to recommend one specific subgrade design. The specifier should keep in mind that GRASSCRETE is porous, and much of the water that falls on the surface will pass through to the subgrade. For most applications, except for very heavy loads, native soil having a minimum "R" Value of 30 and a compaction of 95% will provide a suitable subgrade. In areas having poor soil and/or very heavy anticipated loads, 4" or more of soil should be excavated and replaced with compacted base rock.)

4. Concrete Mix. The concrete shall have a minimum compressive strength of 3,000 psi in 28 days (except in severe freeze-thaw areas or for vehicles weighing 10 tons or more, in which case it should be 4,000 psi). Portland Cement shall conform to ASTM C 150, Type I, II, or V. Aggregates shall conform to ASTM C 33 and be 3/8" minus. Mixing water shall be fresh, clean and potable. In freeze-thaw areas, air entrainment of 6.5% to 8.5% shall be provided. Water reducing admixtures and/or super-plasticizers are permitted and shall conform to ASTM C 494.

5. Slab Design. The GRASSCRETE slab shall have a minimum thickness of 5-1/2". Where used for emergency vehicle access roads, all edges shall be a monolithic concrete border having a minimum width of 12".

6. Reinforcement. The GRASSCRETE shall be continuously reinforced with _____welded wire fabric chaired between 2–3" above the subgrade. (Refer to the following table for guidelines on the selection of reinforcement.)

Intended Use	Welded Wire Mesh
a) Erosion control, parking lots, driveways, access roads for vehicles weighing 10 tons or less.	6" x 6"-10 ga. x 10 ga. (6 x 6-W1.4 x W1.4)
b) Regular use by vehicles weighing more than 10 tons and access roads for fire apparatus with outriggers.	6" x 6"-6 ga. x 6 ga. (6 x 6-W2.9 x W2.9)

7. Construction Process.

a) Subgrade shall be leveled to a uniform plane 5-1/2" below the final grade of the finished slab.
b) Welded wire fabric shall be chaired.
c) GRASSCRETE formers shall be placed on the subgrade.
d) Concrete shall be placed and leveled to the top of the GRASSCRETE formers. The concrete surface shall have a heavy, rough broom finish.
e) GRASSCRETE formers shall be withdrawn after the concrete has hardened sufficiently.
f) Slab shall be cured with suitable curing membrane. Do not use chemicals harmful to growth of grass.

8. Joints. Expansion joints or felt/paper shall be provided wherever a GRASSCRETE slab abuts to other concrete or structures. In traffic areas, steel dowels shall be used to transfer loads between adjacent slabs.

9. Soil and Seed. Holes are to be filled and 1" of topsoil is to cover the GRASSCRETE surface for seeding or sod suitable for your local conditions. (NOTE: Typically done by landscape contractor rather than GRASSCRETE contractor.)

10. Traffic. No traffic of any kind shall be permitted on the GRASSCRETE slab until fourteen days after placing of concrete and only after soil is placed in holes. Thereafter, vehicles shall be permitted, providing they do not exceed the weight capacity for the slab.

BOMANITE CORPORATION 7 GRASSCRETE 98 2

Suggested Grasscrete® Specification

ADDITIONAL DATA:

1. Grass Coverage. Surface area is 47% concrete and 53% hole. Grass usually covers much of the concrete in areas not subject to regular vehicle traffic.

2. Adjoining Edges. All adjoining hard surfaces must be abutted at 1" below to allow for topsoil and growth of grass.

3. Maintenance. GRASSCRETE requires watering and mowing as would be normal for any lawn. Irrigation must be provided in dry climates to keep the grass healthy. Mowing needs are less in areas of frequent traffic. The grass roots are protected by concrete and are not damaged by vehicle use.

4. Alternate to Planting Grass. Holes may be filled and covered with crushed stone, seashells, etc. to provide drainage.

5. Drainage. GRASSCRETE drains at about the same rate as would an ordinary lawn in the same location. The presence of concrete has little effect on the drainage; the soil and the slope are the controlling factors. A test report by an independent laboratory on infiltration rates is available upon request.

6. Load Test Report. A test report by an independent laboratory on a fire truck load test is available upon request. A 33 ton Grumman fire apparatus with outriggers was tested with a horizontal extension of 100 feet of its man-lift with 800 pounds of weight in the man-lift. (Note that GRASSCRETE is a continuously reinforced monolithic slab, and therefore has flexural strength, unlike unit pavers.)

7. Fire-Lane Access. It is recommended that a 12" border be used at perimeters of GRASSCRETE monolithic to GRASSCRETE driving surface.

8. Alternate Reinforcement. It is acceptable to substitute steel reinforcing bar of equivalent reinforcement value for the welded wire steel fabric. However, this will usually raise the cost because of the additional labor required.

9. Concrete Volume. GRASSCRETE is 60% concrete by volume and 40% void area, not including widened edges and solid borders.

10. Slope Paving. GRASSCRETE can be readily installed on slopes as steep as 3:1. Steeper slopes are more difficult and costly and 2:1 is the steepest that could be possible.

11. Curved Areas. GRASSCRETE formers are square and are used most effectively in rectangular areas free of obstruction. GRASSCRETE may be used in curved areas and areas having obstructions, but there may be some design limitations and increases in unit costs.

NOTE: GRASSCRETE is not designed to be a finished surface.

IMPORTANT NOTE: This specification supersedes all GRASSCRETE specifications published prior to July 1, 1998.

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For more information, including a list of Members of the BOMANITE International Society, contact:

BOMANITE CORPORATION
P.O. Box 599
Madera, CA 93639-0599
(209) 673-2411
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Appendix C

Conceptual Cost Estimates

Appendix C

Conceptual Cost Estimates

Alternative 1

Hawes Road Channel "Kinder & Gentler" Improvement Project

Estimated Unit Costs

ID CODE	Item/Description		Units	Unit Cost	Source/Comment
	Concrete Channel Lining (6") - Trapezoidal		CY	$290.00	ADMP
	Grass-Concrete Channel Lining		SY	$65.00	TriLock
	Grass Channel/Incl. 6" Topsoil & Shaping		CY	$15.00	Estimated
	Earthwork/Channel Excavation		CY	$11.00	ADMP
	Grouted Rip Rap Drop Structures		SF	$65.00	Estimated
	Concrete Box Culvert		CY	$370.00	Bid Tab: FCD 97-01
	Concrete Headwall		CY	$630.00	Bid Tab: FCD 97-38
	Pnuematically Place Mortar		CY	$175.00	Bid Tab: FCD 97-38
	Landscaping (Turf, Trees, Shrubs & Irrigation)		AC	$25,000.00	Logan Simpson Design, Inc
	Bermuda Grass		AC	$3,800.00	Bid Tab: FCD 95-18
	Remove Box Culvert		EA	$45,000.00	Bid Tab: FCD 97-33
	Remove Shotcrete Channel Lining		LF	$60.00	Estimated
	Remove Existing Asphalt Concrete		SY	$2.50	Estimated
	Land Acquisition Cost - Residential		SF	$0.99	ADMP
	Land Acquisition Cost - Commercial		SF	$2.97	Estimated
	Mobile Home Relocation Costs		EA	$15,000.00	Estimated
	Concrete Curb & Gutter		LF	$9.00	Bid Tab: FCD 97-33
	Asphalt Concrete Pavement/ Base Course		SY	$15.00	Estimated
	Painting and Striping				
	Water Line Relocation (12")		LF	$100.00	Bid Tab: FCD 97-01
	Water Line Relocation (6" +/-)		LF	$70.00	Estimated
	Water Line Relocation (1.5")		LF	$20.00	Bid Tab: FCD 97-01
	Sanitary Sewer Replacement (15" DIP)		LF	$150.00	Bid Tab: FCD 97-01
	Gas Line Relocation		LF	$35.00	Estimated
	Lighting		EA	$75.00	Estimated

PRIMATECH
ENGINEERS & CONSULTANTS

Project: **Hawes Road Channel K & G Improvements**
Alternative 1: Conceptual Cost Estimate

Project No. FCD 98-23

ID #	Item/Description	Quantity	Units	Unit Cost	Amount
REACH 0-1: SUPERSTITION FREEWAY TO MOBILE HOME PARK ENTRANCE Q100 =670		**900**	**LF**		
	Concrete Channel Removal	900	LF	$60.00	$54,000
	Asphalt Concrete Removal	600	LF	$2.50	$1,500
	Earthwork/Channel Excavation	6,625	CY	$11.00	$72,875
	Remove Existing Box Culverts	1	EA	$45,000.00	$45,000
	Water Line Relocation (12")	860	LF	$100.00	$86,000
	Sanitary Sewer Replacement	860	LF	$150.00	$129,000
	Asphalt Concrete Replacement/Base Course	3,400	SY	$15.00	$51,000
	Concrete Curb & Gutter	1,800	LF	$9.00	$16,200
	Concrete Box Culvert: 2-10'x6'x60'	276	CY	$370.00	$102,120
	Grass Channel Earthwork, incl. 6" Topsoil and Shaping	6,600	SY	$15.00	$99,000
	6' Sidewalk	1,125	LF	$12.00	$13,500
	Signing and Striping	900	LF	$10.00	$9,000
	Hand Rail/Fencing (@ culvert)	200	LF	$35.00	$7,000
	Landscaping (Turf, Trees, Shrubs & Irrigation)	1.86	AC	$25,000.00	$46,500
	Sub-Total				$732,695

PRIMATECH
ENGINEERS & CONSULTANTS

Project: **Hawes Road Channel K & G Improvements**
Alternative 1: Conceptual Cost Estimate Project No. FCD 98-23

ID #	Item/Description	Quantity	Units	Unit Cost	Amount
REACH 0-2: MOBILE HOME PARK ENTRANCE TO SOUTHERN AVE. Q100 = 730 cfs		**1,080**	**LF**		
	Concrete Channel Removal	1,080	LF	$60.00	$64,800
	Asphalt Concrete Removal	4,080	LF	$2.50	$10,200
	Earthwork/Channel Excavation	6,224	CY	$11.00	$68,464
	Gas Line Relocation	50	LF	$35.00	$1,750
	Water Line Relocation (12")	1,080	LF	$100.00	$108,000
	Sanitary Sewer Replacement	1,080	LF	$150.00	$162,000
	Asphalt Concrete Replacement/Base Course	4,080	SY	$15.00	$61,200
	Concrete Curb & Gutter	2,160	LF	$9.00	$19,440
	Concrete Box Culvert: 2-8'x4'x110'	271	CY	$370.00	$100,270
	Grass Channel Earthwork, incl. 6" Topsoil and Shaping	7,920	SY	$15.00	$118,800
	6' Sidewalk	1,350	LF	$12.00	$16,200
	Hand Rail/Fencing (@culvert)	250	LF	$35.00	$8,750
	Signing and Striping	1,080	LF	$10.00	$10,800
	Landscaping (Turf, Trees, Shrubs & Irrigation)	2.23	AC	$25,000.00	$55,750
	Sub-Total				$806,424

PRIMATECH
ENGINEERS & CONSULTANTS

Project: **Hawes Road Channel K & G Improvements**
Alternative 1: Conceptual Cost Estimate Project No. FCD 98-23

ID #	Item/Description	Quantity	Units	Unit Cost	Amount
REACH 1-1: SOUTHERN AVENUE TO EX. Dip Section Q100 = 1930 cfs		**4,900**	**LF**		
	Concrete Channel Removal	1,900	LF	$60.00	$114,000
	Asphalt Concrete Removal	4,200	LF	$2.50	$10,500
	Earthwork/Channel Excavation	54,575	CY	$11.00	$600,325
	Gas Line Relocation	4,900	LF	$35.00	$171,500
	Water Line Relocation	4,900	LF	$100.00	$490,000
	Sanitary Sewer Replacement	3,900	LF	$150.00	$585,000
	Asphalt Concrete Replacement/Base Course	15,870	SY	$15.00	$238,050
	Concrete Curb & Gutter	8,400	LF	$9.00	$75,600
	Grass Channel Earthwork, incl. 6" Topsoil and Shaping	48,130	SY	$15.00	$721,950
	6' Sidewalk	6,125	LF	$12.00	$73,500
	1-2' Drop Structure	33	CY	$65.00	$2,145
	Concrete Box Culvert: 3-10'x6'x210'	1,400	CY	$65.00	$91,000
	Basketball Court	2	EA	$4,000.00	$8,000
	Signing and Striping	4,900	LF	$10.00	$49,000
	Hand Rail/Fencing (@ culvert)	250	LF	$35.00	$8,750
	Landscaping (Turf, Trees, Shrubs & Irrigation)	10.12	AC	$25,000.00	$253,000
	Sub-Total				$3,492,320

PRIMATECH
ENGINEERS & CONSULTANTS

Project: **Hawes Road Channel K & G Improvements**
Alternative 1: Conceptual Cost Estimate Project No. FCD 98-23

ID #	Item/Description	Quantity	Units	Unit Cost	Amount
REACH 1-2: Dip Section to BROADWAY ROAD Q100 = 1650 cfs		**810**	LF		
	Asphalt Concrete Removal	810	LF	$2.50	$2,025
	Earthwork/Channel Excavation	10,954	CY	$11.00	$120,494
	Remove Existing Box Culverts	1	EA	$45,000.00	$45,000
	Gas Line Relocation	810	LF	$35.00	$28,350
	Water Line Relocation	810	LF	$100.00	$81,000
	Asphalt Concrete Replacement/Base Course	3,060	SY	$15.00	$45,900
	Concrete Curb & Gutter	1,620	LF	$9.00	$14,580
	Grass Channel Earthwork, incl. 6" Topsoil and Shaping	8,209	SY	$15.00	$123,135
	6' Sidewalk	1,013	LF	$12.00	$12,156
	Concrete Box Culvert: 3-10'x6'x210'	1,400	CY	$65.00	$91,000
	Signing and Striping	810	LF	$10.00	$8,100
	Hand Rail/Fencing (@ culvert)	250	LF	$35.00	$8,750
	Landscaping (Turf, Trees, Shrubs & Irrigation)	1.67	AC	$25,000.00	$41,750
	Sub-Total				$622,240

PRIMATECH
ENGINEERS & CONSULTANTS

Project: **Hawes Road Channel K & G Improvements**
Alternative 1: Conceptual Cost Estimate Project No. FCD 98-23

ID #	Item/Description	Quantity	Units	Unit Cost	Amount
REACH 2: BROADWAY ROAD to APACHE TRAIL Q100 = 922 cfs		**2,550**	**LF**		
	Asphalt Concrete Removal	2,550	LF	$2.50	$6,375
	Earthwork/Channel Excavation	14,235	SY	$11.00	$156,585
	Gas Line Relocation	50	LF	$35.00	$1,750
	Water Line Relocation	50	LF	$100.00	$5,000
	Asphalt Concrete Replacement/Base Course	9,633	SY	$15.00	$144,495
	Concrete Curb & Gutter	5,100	LF	$9.00	$45,900
	Grass-Concrete Channel, incl. 6" Topsoil and Shaping	17,397	SY	$15.00	$260,955
	6' Sidewalk	2,550	LF	$12.00	$30,600
	5-2' Drop Structures	160	CY	$65.00	$10,400
	Bermuda Grass	3.9	AC	$3,800.00	$14,820
	Gas Line Relocation	120	LF	$35.00	$4,200
	Signing and Striping	2,550	LF	$10.00	$25,500
	Lighting (100' Spacing)	25	EA	$75.00	$1,875
	Landscape (Trees, Shrubs & Irrigation)	5.23	AC	$25,000.00	$130,750
	Sub-Total				$839,205

PRIMATECH
ENGINEERS & CONSULTANTS

Project: **Hawes Road Channel K & G Improvements**
Alternative 1: Conceptual Cost Estimate Project No. FCD 98-23

ID #	Item/Description	Quantity	Units	Unit Cost	Amount
REACH 3: Main Street/Apache Blvd. Channel: Q100 = 922 cfs		**365**	**LF**		
	Concrete Channel Lining (6") - Trap Channel BW=15', z=1.5, D=6.3'	255	CY	$290.00	$73,899
	Drop Structure(s): Three - 2.0'	97	SY	$65.00	$6,334
	Concrete Box Culvert: 2-10'x6'x90'	207	CY	$370.00	$76,590
	Earthwork/Channel Excavation	2,640	CY	$11.00	$29,042
	Hand Rail/Fencing - 2 sides of channel	730	LF	$35.00	$25,550
	Concrete Curb & Gutter (sides adjacent to channel only)	730	LF	$9.00	$6,570
	Asphalt Concrete Pavement/ Base Course (2 Lanes - 28' wide)	280	SY	$15.00	$4,200
	Remove Existing Asphalt Concrete (28' Wide')	280	SY	$2.50	$700
	Signing and Striping				
	Sub-Total				$222,884
	Sub-Total: Hawes Road Channel				$6,715,768
	Engineering and Contigencies	25%			$1,678,942
	Grand Total: Hawes Road Channel from the Superstition Freeway to Main Street				**$8,394,711**

Appendix C

Conceptual Cost Estimates

Alternative 2

Hawes Road Channel "Kinder & Gentler" Improvement Project

Estimated Unit Costs

ID CODE	Item/Description		Units	Unit Cost	Source/Comment
	Concrete Channel Lining (6") - Trapezoidal		CY	$290.00	ADMP
	Grass-Concrete Channel Lining		SY	$65.00	TriLock
	Grass Channel/Incl. 6" Topsoil & Shaping		CY	$15.00	Estimated
	Earthwork/Channel Excavation		CY	$11.00	ADMP
	Grouted Rip Rap Drop Structures		SF	$65.00	Estimated
	Concrete Box Culvert		CY	$370.00	Bid Tab: FCD 97-01
	Concrete Headwall		CY	$630.00	Bid Tab: FCD 97-38
	Pnuematically Place Mortar		CY	$175.00	Bid Tab: FCD 97-38
	Landscaping (Turf, Trees, Shrubs & Irrigation)		AC	$25,000.00	Logan Simpson Design, Inc
	Bermuda Grass		AC	$3,800.00	Bid Tab: FCD 95-18
	Remove Box Culvert		EA	$45,000.00	Bid Tab: FCD 97-33
	Remove Shotcrete Channel Lining		LF	$60.00	Estimated
	Remove Existing Asphalt Concrete		SY	$2.50	Estimated
	Land Acquisition Cost - Residential		SF	$0.99	ADMP
	Land Acquisition Cost - Commercial		SF	$2.97	Estimated
	Mobile Home Relocation Costs		EA	$15,000.00	Estimated
	Concrete Curb & Gutter		LF	$9.00	Bid Tab: FCD 97-33
	Asphalt Concrete Pavement/ Base Course		SY	$15.00	Estimated
	Painting and Striping				
	Water Line Relocation (12")		LF	$100.00	Bid Tab: FCD 97-01
	Water Line Relocation (6" +/-)		LF	$70.00	Estimated
	Water Line Relocation (1.5")		LF	$20.00	Bid Tab: FCD 97-01
	Sanitary Sewer Replacement (15" DIP)		LF	$150.00	Bid Tab: FCD 97-01
	Gas Line Relocation		LF	$35.00	Estimated
	Lighting		EA	$75.00	Estimated

PRIMATECH
ENGINEERS & CONSULTANTS

Project: **Hawes Road Channel K & G Improvements**
Alternative 2: Conceptual Cost Estimate

Project No. FCD 98-23

ID #	Item/Description	Quantity	Units	Unit Cost	Amount
REACH 0-1: SUPERSTITION FREEWAY TO MOBILE HOME PARK ENTRANCE Q100 =670		**900**	**LF**		
	Concrete Channel Removal	900	LF	$60.00	$54,000
	Asphalt Concrete Removal	600	LF	$2.50	$1,500
	Earthwork/Channel Excavation	6,854	CY	$11.00	$75,394
	Remove Existing Box Culverts	1	EA	$45,000.00	$45,000
	Water Line Relocation (12")	860	LF	$100.00	$86,000
	Sanitary Sewer Replacement	860	LF	$150.00	$129,000
	Asphalt Concrete Replacement/Base Course	3,400	SY	$15.00	$51,000
	Concrete Curb & Gutter	1,800	LF	$9.00	$16,200
	Grass Channel Earthwork, incl. 6" Topsoil and Shaping	9,068	SY	$15.00	$136,020
	8' Multi-use Path	900	LF	$15.00	$13,500
	Concrete Box Culvert: 2-10'x6'x60'	276	CY	$370.00	$102,120
	Signing and Striping	900	LF	$10.00	$9,000
	Hand Rail/Fencing (@ culvert)	200	LF	$35.00	$7,000
	Landscaping (Turf, Trees, Shrubs & Irrigation)	1.86	AC	$25,000.00	$46,500
	Sub-Total				$772,234

PRIMATECH
ENGINEERS & CONSULTANTS

Project: **Hawes Road Channel K & G Improvements**
Alternative 2: Conceptual Cost Estimate Project No. FCD 98-23

ID #	Item/Description	Quantity	Units	Unit Cost	Amount
REACH 0-2: MOBILE HOME PARK ENTRANCE TO SOUTHERN AVE. Q100 = 730 cfs		**1,080**	**LF**		
	Concrete Channel Removal	1,080	LF	$60.00	$64,800
	Asphalt Concrete Removal	4,080	LF	$2.50	$10,200
	Earthwork/Channel Excavation	8,487	CY	$11.00	$93,357
	Gas Line Relocation	50	LF	$35.00	$1,750
	Water Line Relocation (12")	1,080	LF	$100.00	$108,000
	Sanitary Sewer Replacement	1,080	LF	$150.00	$162,000
	Asphalt Concrete Replacement/Base Course	4,080	SY	$15.00	$61,200
	Concrete Curb & Gutter	2,160	LF	$9.00	$19,440
	Grass Channel Earthwork, incl. 6" Topsoil and Shaping	10,884	SY	$15.00	$163,260
	8' Multi-use Path	1,080	LF	$15.00	$16,200
	Concrete Box Culvert: 2-8'x4'x110'	271	CY	$370.00	$100,270
	Signing and Striping	1,080	LF	$10.00	$10,800
	Hand Rail/Fencing	250	LF	$35.00	$8,750
	Landscaping (Turf, Trees, Shrubs & Irrigation)	2.23	AC	$25,000.00	$55,750
	Sub-Total				$875,777

PRIMATECH
ENGINEERS & CONSULTANTS

Project: **Hawes Road Channel K & G Improvements**
Alternative 2: Conceptual Cost Estimate Project No. FCD 98-23

ID #	Item/Description	Quantity	Units	Unit Cost	Amount
REACH 1-1: SOUTHERN AVENUE TO EX. Dip Section Q100 = 1930 cfs		**4,900**	**LF**		
	Concrete Channel Removal	1,900	LF	$60.00	$114,000
	Asphalt Concrete Removal	4,200	LF	$2.50	$10,500
	Earthwork/Channel Excavation	54,575	CY	$11.00	$600,325
	Gas Line Relocation	4,900	LF	$35.00	$171,500
	Water Line Relocation	4,900	LF	$100.00	$490,000
	Sanitary Sewer Replacement	3,900	LF	$150.00	$585,000
	Asphalt Concrete Replacement/Base Course	15,870	SY	$15.00	$238,050
	Concrete Curb & Gutter	8,400	LF	$9.00	$75,600
	Grass Channel Earthwork, incl. 6" Topsoil and Shaping	52,539	SY	$15.00	$788,085
	8' Multi-use Path	4,900	LF	$15.00	$73,500
	1-2' Drop Structure	33	CY	$65.00	$2,145
	Concrete Box Culvert: 3-10'x6'x210'	1,400	CY	$65.00	$91,000
	Basketball Court	2	EA	$4,000.00	$8,000
	Signing and Striping	4,900	LF	$10.00	$49,000
	Hand Rail/Fencing (@ culvert)	250	LF	$35.00	$8,750
	Land Acquisition (Assume Residential Zoning)	24,502	SF	$2.99	$73,261
	Landscaping (Turf, Trees, Shrubs & Irrigation)	10.12	AC	$25,000.00	$253,000
	Sub-Total				$3,631,716

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Project: **Hawes Road Channel K & G Improvements**
Alternative 2: Conceptual Cost Estimate Project No. FCD 98-23

ID #	Item/Description	Quantity	Units	Unit Cost	Amount
REACH 1-2: Dip Section to BROADWAY ROAD Q100 = 1650 cfs		**810**	**LF**		
	Asphalt Concrete Removal	810	LF	$2.50	$2,025
	Earthwork/Channel Excavation	10,954	CY	$11.00	$120,494
	Remove Existing Box Culverts	1	EA	$45,000.00	$45,000
	Gas Line Relocation	810	LF	$35.00	$28,350
	Water Line Relocation	810	LF	$100.00	$81,000
	Asphalt Concrete Replacement/Base Course	3,060	SY	$15.00	$45,900
	Concrete Curb & Gutter	1,620	LF	$9.00	$14,580
	Grass Channel Earthwork, incl. 6" Topsoil and Shaping	8,667	SY	$15.00	$130,005
	8' Multi-use Path	810	LF	$15.00	$12,150
	Concrete Box Culvert: 3-10'x6'x210'	1,400	CY	$65.00	$91,000
	Signing and Striping	810	LF	$10.00	$8,100
	Hand Rail/Fencing (@ culvert)	250	LF	$35.00	$8,750
	Land Acquisition (Assume Residential Zoning)	4,050	SF	$0.99	$4,010
	Landscaping (Turf, Trees, Shrubs & Irrigation)	1.67	AC	$25,000.00	$41,750
	Sub-Total				$633,114

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Project: **Hawes Road Channel K & G Improvements**
Alternative 2: Conceptual Cost Estimate

Project No. FCD 98-23

ID #	Item/Description	Quantity	Units	Unit Cost	Amount
REACH 2: BROADWAY ROAD to APACHE TRAIL Q100 = 922 cfs		**2,550**	**LF**		
	Asphalt Concrete Removal	2,550	LF	$2.50	$6,375
	Earthwork/Channel Excavation	19,481	SY	$11.00	$214,291
	Gas Line Relocation	50	LF	$35.00	$1,750
	Water Line Relocation	50	LF	$100.00	$5,000
	Asphalt Concrete Replacement/Base Course	9,633	SY	$15.00	$144,495
	Concrete Curb & Gutter	5,100	LF	$9.00	$45,900
	Grass Channel Earthwork, incl. 6" Topsoil and Shaping	22,889	SY	$15.00	$343,335
	8' Multi-use Path	2,550	LF	$15.00	$38,250
	5-2' Drop Structures	160	CY	$65.00	$10,400
	Gas Line Relocation	120	LF	$35.00	$4,200
	Signing and Striping	2,550	LF	$10.00	$25,500
	Hand Rail/Fencing	250	LF	$35.00	$8,750
	Land Acquisition (Assume Residential Zoning) 1,100 LF	27,500	SF	$0.99	$27,225
	Land Acquisition (Assume Commercial Zoning) 1,450 LF	36,250	SF	$2.97	$107,663
	Residential Relocation Costs	40	EA	$15,000.00	$600,000
	Landscape (Trees, Shrubs & Irrigation)	5.23	AC	$25,000.00	$130,750
	Sub-Total				$1,713,884

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Project: **Hawes Road Channel K & G Improvements**
Alternative 2: Conceptual Cost Estimate Project No. FCD 98-23

ID #	Item/Description	Quantity	Units	Unit Cost	Amount
REACH 3: Main Street/Apache Blvd. Channel: Q100 = 922 cfs		**365**	**LF**		
	Concrete Channel Lining (6") - Trap Channel BW=15', z=1.5, D=6.3'	255	CY	$290.00	$73,899
	Drop Structure(s): Three - 2.0'	97	SY	$65.00	$6,334
	Concrete Box Culvert: 2-10'x6'x90'	207	CY	$370.00	$76,590
	Earthwork/Channel Excavation	2,640	CY	$11.00	$29,042
	Hand Rail/Fencing - 2 sides of channel	730	LF	$35.00	$25,550
	Concrete Curb & Gutter (sides adjacent to channel only)	730	LF	$9.00	$6,570
	Asphalt Concrete Pavement/ Base Course (2 Lanes - 28' wide)	280	SY	$15.00	$4,200
	Remove Existing Asphalt Concrete (28' Wide')	280	SY	$2.50	$700
	Sub-Total				$222,884
	Sub-Total: Hawes Road Channel				$7,849,609
	Engineering and Contigencies	25%			$1,962,402
	Grand Total: Hawes Road Channel from the Superstition Freeway to Main Street				**$9,812,012**

Appendix D

Alternative 1 Conceptual Design

Alternative 1, Reach 0-1
Worksheet for Trapezoidal Channel

Project Description	
Project File	d:\mfc023\alt1.fm2
Worksheet	Alternative1-REACH0-1
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Channel Slope	0.002200	ft/ft
Left Side Slope	4.000000	H : V
Right Side Slope	6.000000	H : V
Bottom Width	20.00	ft
Discharge	670.00	cfs

Results		
Depth	3.89	ft
Flow Area	153.63	ft^2
Wetted Perimeter	59.73	ft
Top Width	58.93	ft
Critical Depth	2.61	ft
Critical Slope	0.010807	ft/ft
Velocity	4.36	ft/s
Velocity Head	0.30	ft
Specific Energy	4.19	ft
Froude Number	0.48	
Flow is subcritical.		

Alternative 1, Reach 0-2
Worksheet for Trapezoidal Channel

Project Description	
Project File	d:\mfc023\alt1.fm2
Worksheet	Alternative1-REACH0-2
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Channel Slope	0.002200	ft/ft
Left Side Slope	4.000000	H : V
Right Side Slope	6.000000	H : V
Bottom Width	20.00	ft
Discharge	730.00	cfs

Results		
Depth	4.06	ft
Flow Area	163.56	ft^2
Wetted Perimeter	61.43	ft
Top Width	60.59	ft
Critical Depth	2.74	ft
Critical Slope	0.010670	ft/ft
Velocity	4.46	ft/s
Velocity Head	0.31	ft
Specific Energy	4.37	ft
Froude Number	0.48	
Flow is subcritical.		

Alternative 1, Reach 1-1
Worksheet for Trapezoidal Channel

Project Description	
Project File	d:\mfc023\alt1.fm2
Worksheet	Alternative1-REACH1-1
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Channel Slope	0.002600	ft/ft
Left Side Slope	4.000000	H : V
Right Side Slope	6.000000	H : V
Bottom Width	22.00	ft
Discharge	1,930.00	cfs

Results		
Depth	6.04	ft
Flow Area	315.45	ft^2
Wetted Perimeter	83.66	ft
Top Width	82.42	ft
Critical Depth	4.46	ft
Critical Slope	0.009296	ft/ft
Velocity	6.12	ft/s
Velocity Head	0.58	ft
Specific Energy	6.62	ft
Froude Number	0.55	
Flow is subcritical.		

Alternative 1, Reach 1-2
Worksheet for Trapezoidal Channel

Project Description	
Project File	d:\mfc023\alt1.fm2
Worksheet	Alternative1-REACH1-2
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Channel Slope	0.002800	ft/ft
Left Side Slope	4.000000	H : V
Right Side Slope	6.000000	H : V
Bottom Width	22.00	ft
Discharge	1,650.00	cfs

Results		
Depth	5.52	ft
Flow Area	273.47	ft²
Wetted Perimeter	78.29	ft
Top Width	77.16	ft
Critical Depth	4.11	ft
Critical Slope	0.009505	ft/ft
Velocity	6.03	ft/s
Velocity Head	0.57	ft
Specific Energy	6.08	ft
Froude Number	0.57	
Flow is subcritical.		

Alternative 1, Reach 2
Worksheet for Trapezoidal Channel

Project Description	
Project File	d:\mfc023\alt1.fm2
Worksheet	Alternative1-REACH2
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Channel Slope	0.004900	ft/ft
Left Side Slope	4.000000	H : V
Right Side Slope	4.000000	H : V
Bottom Width	6.00	ft
Discharge	922.00	cfs

Results		
Depth	5.09	ft
Flow Area	134.02	ft^2
Wetted Perimeter	47.95	ft
Top Width	46.69	ft
Critical Depth	4.37	ft
Critical Slope	0.009995	ft/ft
Velocity	6.88	ft/s
Velocity Head	0.74	ft
Specific Energy	5.82	ft
Froude Number	0.72	
Flow is subcritical.		

Alternative 1, Reach 3
Worksheet for Trapezoidal Channel

Project Description	
Project File	d:\mfc023\alt1.fm2
Worksheet	Alternative1-REACH3
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.013	
Channel Slope	0.001600	ft/ft
Left Side Slope	1.500000	H : V
Right Side Slope	1.500000	H : V
Bottom Width	15.00	ft
Discharge	922.00	cfs

Results		
Depth	4.41	ft
Flow Area	95.21	ft^2
Wetted Perimeter	30.89	ft
Top Width	28.22	ft
Critical Depth	4.22	ft
Critical Slope	0.001869	ft/ft
Velocity	9.68	ft/s
Velocity Head	1.46	ft
Specific Energy	5.86	ft
Froude Number	0.93	
Flow is subcritical.		

Appendix E

Alternative 2 Selection and Conceptual Design

Hawes Road Channel K &G - Phase2 - Alternative 2 Evaluation Criteria and Decision Matrix

	1, 2 or 3	Above Average (+), Average (0) or Below Average (-) for Criteria					
Criteria:	***Weighting:***		***Alt. "A"***	***Alt. "B"***	***Alt. "C"***	***Alt. "D"***	
Level of Flood Protection	3		Yes	Yes	Yes	Yes	
Elimination of Floodprone Areas	3		Yes	Yes	Yes	Yes	
Overall Project Scheduling	3		Yes	No	Yes	No	
Public Involvement Needs	3		No	Yes	Yes	No	
Potential Benefits to Citizens	2		No	Yes	Yes	No	
Minimal Long-Term Maintenance	2		No	No	No	No	
Minimal Neighborhood Disturbance	2		Yes	No	Yes	No	
Minimal Short-Term Maintenance	1		No	Yes	No	Yes	
Project Feasibility and Benefited Area	1		No	No	Yes	No	
Minimal Inter Agency Involvement	1		No	No	Yes	Yes	
Minimal Construction Obstacles	1		No	No	Yes	No	
Total:			11	12	19	8	

PRIMATECH

ENGINEERS & CONSULTANTS

Alternative 2, Reach 0-2, Grass Liner
Worksheet for Trapezoidal Channel

Project Description	
Project File	d:\mfc023\flowmstr\alt2.fm2
Worksheet	reach0-2meander
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Channel Slope	0.002200	ft/ft
Left Side Slope	8.000000	H : V
Right Side Slope	6.000000	H : V
Bottom Width	12.00	ft
Discharge	730.00	cfs

Results		
Depth	4.20	ft
Flow Area	173.68	ft^2
Wetted Perimeter	71.37	ft
Top Width	70.76	ft
Critical Depth	2.94	ft
Critical Slope	0.010892	ft/ft
Velocity	4.20	ft/s
Velocity Head	0.27	ft
Specific Energy	4.47	ft
Froude Number	0.47	
Flow is subcritical.		

Reach 0-1, 3(8'X4'X110') Culvert
Worksheet for Rectangular Channel

Project Description	
Project File	d:\mfc023\flowmstr\alt2.fm2
Worksheet	REACH0-2-CULVERT2
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.013	
Channel Slope	0.002200	ft/ft
Bottom Width	8.00	ft
Discharge	244.00	cfs

Results		
Depth	3.69	ft
Flow Area	29.48	ft^2
Wetted Perimeter	15.37	ft
Top Width	8.00	ft
Critical Depth	3.07	ft
Critical Slope	0.003621	ft/ft
Velocity	8.28	ft/s
Velocity Head	1.06	ft
Specific Energy	4.75	ft
Froude Number	0.76	
Flow is subcritical.		

Alternative 2, Reach 1-1, Grass Liner
Worksheet for Trapezoidal Channel

Project Description	
Project File	d:\mfc023\flowmstr\alt2.fm2
Worksheet	reach1-1meander
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Channel Slope	0.002400	ft/ft
Left Side Slope	6.000000	H : V
Right Side Slope	4.000000	H : V
Bottom Width	22.00	ft
Discharge	1,930.00	cfs

Results		
Depth	6.16	ft
Flow Area	324.91	ft^2
Wetted Perimeter	84.83	ft
Top Width	83.56	ft
Critical Depth	4.46	ft
Critical Slope	0.009296	ft/ft
Velocity	5.94	ft/s
Velocity Head	0.55	ft
Specific Energy	6.70	ft
Froude Number	0.53	
Flow is subcritical.		

Alternative 2, Reach 1-1, Grass Liner
Worksheet for Trapezoidal Channel

Project Description	
Project File	d:\mfc023\flowmstr\alt2.fm2
Worksheet	reach1-2meander
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Channel Slope	0.002400	ft/ft
Left Side Slope	6.000000	H :-V
Right Side Slope	4.000000	H :-V
Bottom Width	22.00	ft
Discharge	1,650.00	cfs

Results		
Depth	5.72	ft
Flow Area	289.44	ft^2
Wetted Perimeter	80.38	ft
Top Width	79.20	ft
Critical Depth	4.11	ft
Critical Slope	0.009505	ft/ft
Velocity	5.70	ft/s
Velocity Head	0.51	ft
Specific Energy	6.23	ft
Froude Number	0.53	
Flow is subcritical.		

Alternative 2, Reach 2, Grass Liner
Worksheet for Trapezoidal Channel

Project Description	
Project File	d:\mfc023\flowmstr\alt2.fm2
Worksheet	reach2meander
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Channel Slope	0.004500	ft/ft
Left Side Slope	8.000000	H : V
Right Side Slope	6.000000	H : V
Bottom Width	6.00	ft
Discharge	922.00	cfs

Results		
Depth	4.33	ft
Flow Area	157.45	ft^2
Wetted Perimeter	67.30	ft
Top Width	66.67	ft
Critical Depth	3.64	ft
Critical Slope	0.010517	ft/ft
Velocity	5.86	ft/s
Velocity Head	0.53	ft
Specific Energy	4.87	ft
Froude Number	0.67	
Flow is subcritical.		

Alternative 2, Reach 3, Concrete Liner
Worksheet for Trapezoidal Channel

Project Description	
Project File	d:\mfc023\flowmstr\alt2.fm2
Worksheet	Alternative1-Concrete-3
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.015	
Channel Slope	0.001600	ft/ft
Left Side Slope	1.500000	H : V
Right Side Slope	1.500000	H : V
Bottom Width	15.00	ft
Discharge	922.00	cfs

Results		
Depth	4.41	ft
Flow Area	95.21	ft^2
Wetted Perimeter	30.89	ft
Top Width	28.22	ft
Critical Depth	4.22	ft
Critical Slope	0.001869	ft/ft
Velocity	9.68	ft/s
Velocity Head	1.46	ft
Specific Energy	5.86	ft
Froude Number	0.93	
Flow is subcritical.		

Appendix F

Meander Length Calculations Using 2-Year Storm Event

PRIMATECH Engineers

Job No. MF2023 Project HAWES KIG Sheet ____ of ____

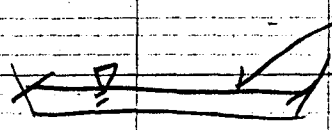
Subject ALT 2 "MEANDER" LENGTHS

By JMM Date 7-2-99 Checked By ____ Date ____

REACH O

100-YR Q = 730 CFS

2-YR Q = Q_{100} × 0.15 ≈ 110 CFS



BANKFULL WIDTH = 40' FOR 2-YR STORM

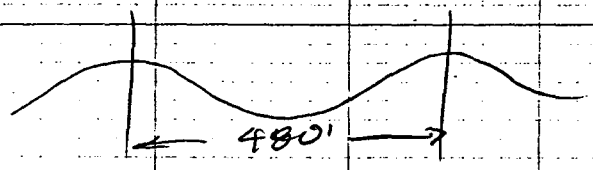
TOTAL LENGTH ≈ 1880' (1480 TOT)

1 MEANDER LENGTH = 10-14 BANKFULL WIDTHS

USE 12 (AVG)

40' × 12 = 480' PER MEANDER LENGTH

$\frac{1880'}{480'}$ = 3.9 → USE 3.5 MEANDERS



Alternative 2, Reach 0, Bankfull
Worksheet for Trapezoidal Channel

Project Description	
Project File	d:\mfc023\alt2.fm2
Worksheet	reach0bankfull
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Channel Slope	0.002200	ft/ft
Left Side Slope	8.000000	H : V
Right Side Slope	6.000000	H : V
Bottom Width	12.00	ft
Discharge	139.00	cfs

Results		
Depth	1.97	ft
Flow Area	50.87	ft^2
Wetted Perimeter	39.89	ft
Top Width	39.60	ft
Critical Depth	1.26	ft
Critical Slope	0.013787	ft/ft
Velocity	2.73	ft/s
Velocity Head	0.12	ft
Specific Energy	2.09	ft
Froude Number	0.42	
Flow is subcritical.		

PRIMATECH Engineers

Job No. MF2023 Project HAWES K & G Sheet ____ of ____

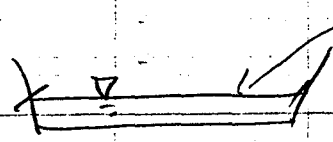
Subject ALT 2 "MEANDER" LENGTHS

By JMM Date 7-2-99 Checked By ____ Date ____

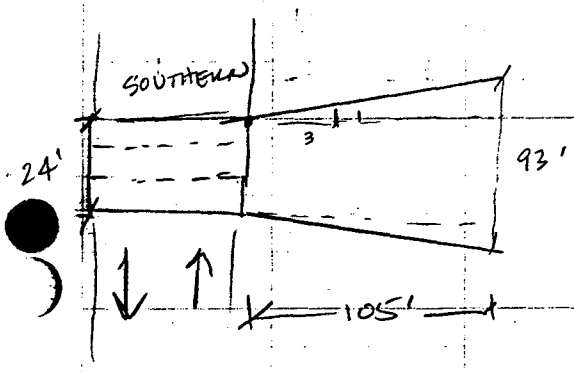
REACH 1

100-YR Q = 1930 CFS (MAX)

2-YR Q ≈ Q_{100} × 0.15 = 290 CFS



BANKFULL WIDTH = 46' FOR 2-YR STORM



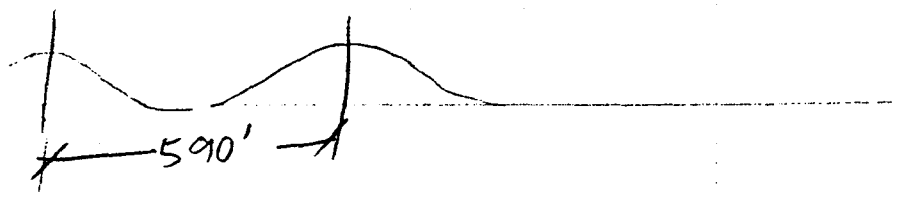
TOTAL LENGTH ≈ 4900 - 105' - 50'
≈ 4,745'

1 MEANDER LENGTH = 10 - 14 BANK FULL WIDTHS

USE 12 (AVG)

46' × 12 = 552' PER MEANDER LENGTH

$\frac{4,745'}{552'}$ = 8.6 → 8 MEANDERS



USE 590'

Alternative 2, Reach 1, Bankfull
Worksheet for Trapezoidal Channel

Project Description	
Project File	d:\mfc023\alt2.fm2
Worksheet	reach1bankfull
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Channel Slope	0.002400	ft/ft
Left Side Slope	6.000000	H : V
Right Side Slope	4.000000	H : V
Bottom Width	22.00	ft
Discharge	290.00	cfs

Results		
Depth	2.41	ft
Flow Area	81.98	ft^2
Wetted Perimeter	46.58	ft
Top Width	46.08	ft
Critical Depth	1.55	ft
Critical Slope	0.012381	ft/ft
Velocity	3.54	ft/s
Velocity Head	0.19	ft
Specific Energy	2.60	ft
Froude Number	0.47	
Flow is subcritical.		

PRIMATECH Engineers

Job No. MFC023 Project HAWES KING Sheet ____ of ____

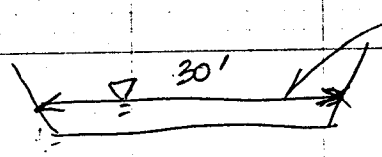
Subject ALT 2 "MEANDER" LENGTHS

By JMM Date 7-2-99 Checked By ____ Date ____

REACH 2

100-YR Q = 922 CFS (MAX)

2-YR Q ≈ Q_{100} × 0.15 = 110 CFS



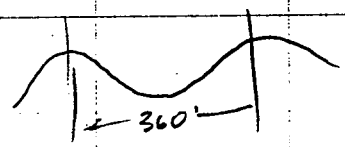
BANKFULL WIDTH FOR 2-YR STORM

TOTAL LENGTH ≈ 2,200'
(SUBTRACT RIPRAP)

1 MEANDER LENGTH = 10-14 WIDTHS
USE 12

30' × 12 = 360' PER MEANDER LENGTH

$\frac{2,200}{360}$ = 6.11 MEANDERS



Alternative 2, Reach 2, Bankfull
Worksheet for Trapezoidal Channel

Project Description	
Project File	d:\mfc023\alt2.fm2
Worksheet	reach2meander
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Channel Slope	0.004500	ft/ft
Left Side Slope	8.000000	H : V
Right Side Slope	6.000000	H : V
Bottom Width	6.00	ft
Discharge	922.00	cfs

Results		
Depth	4.33	ft
Flow Area	157.45	ft^2
Wetted Perimeter	67.30	ft
Top Width	66.67	ft
Critical Depth	3.64	ft
Critical Slope	0.010517	ft/ft
Velocity	5.86	ft/s
Velocity Head	0.53	ft
Specific Energy	4.87	ft
Froude Number	0.67	
Flow is subcritical.		

Appendix G

HEC-RAS Conceptual Hydraulic Analysis

Appendix G

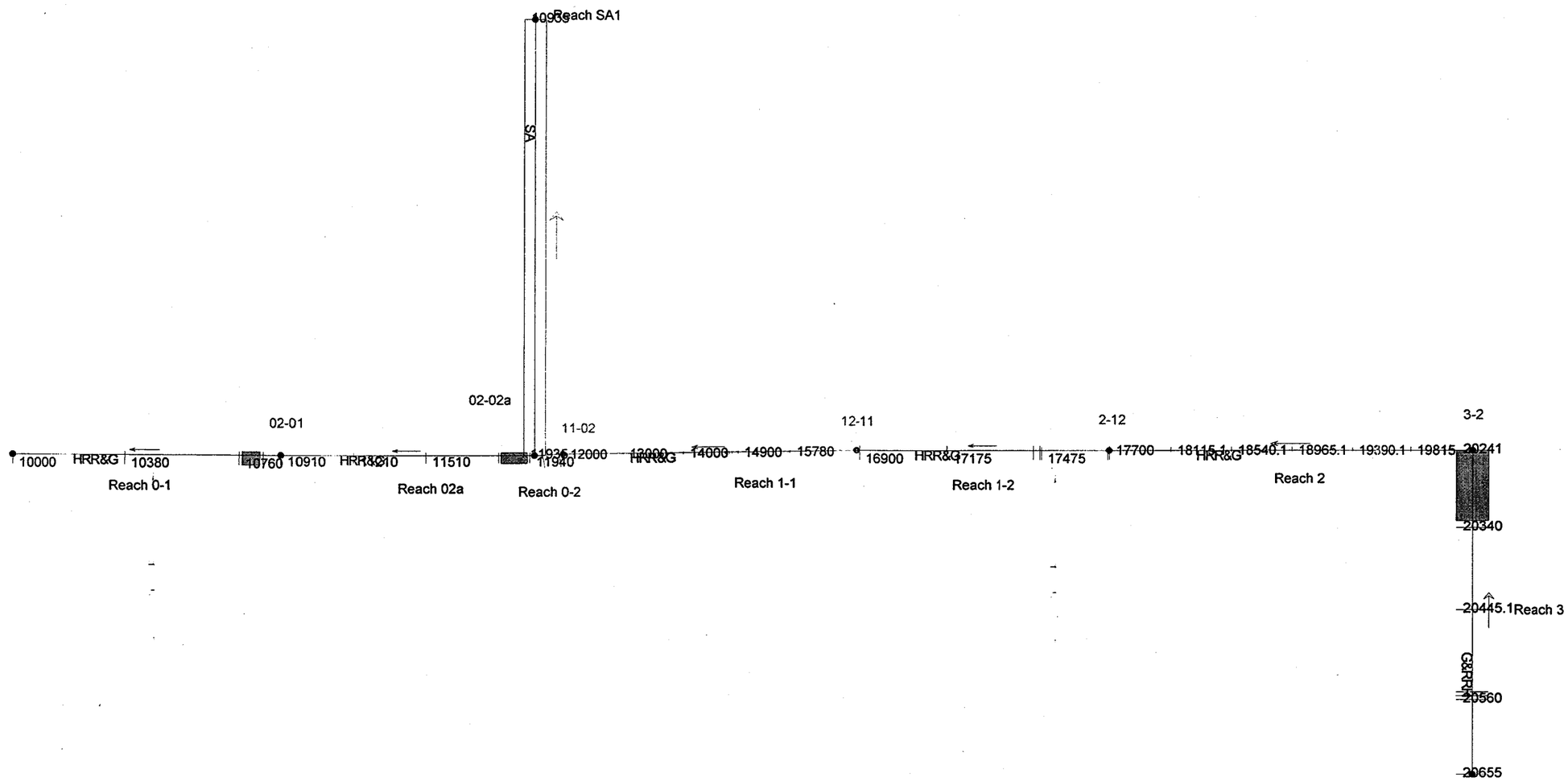
HEC-RAS Conceptual Hydraulic Analysis

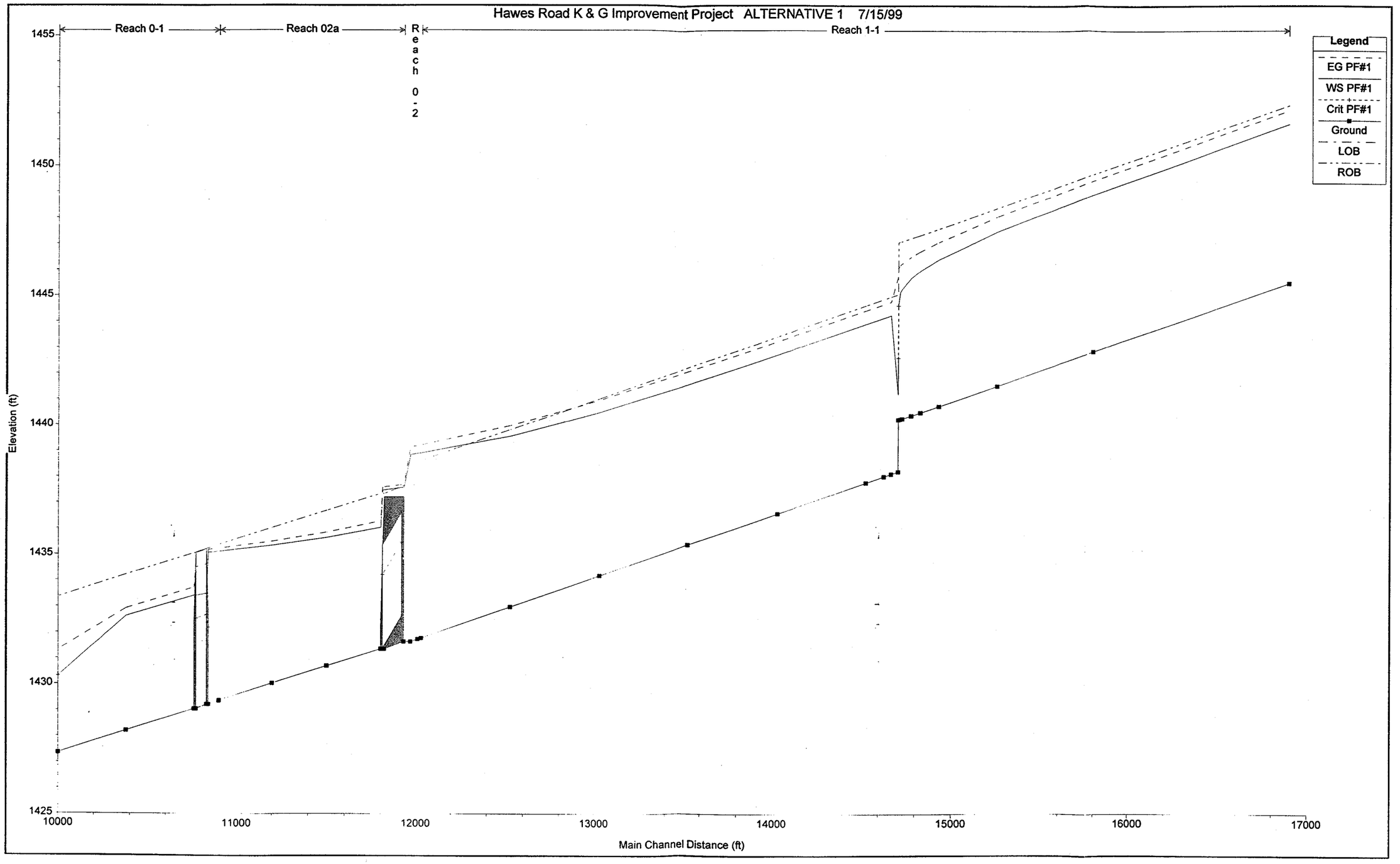
Alternative 1

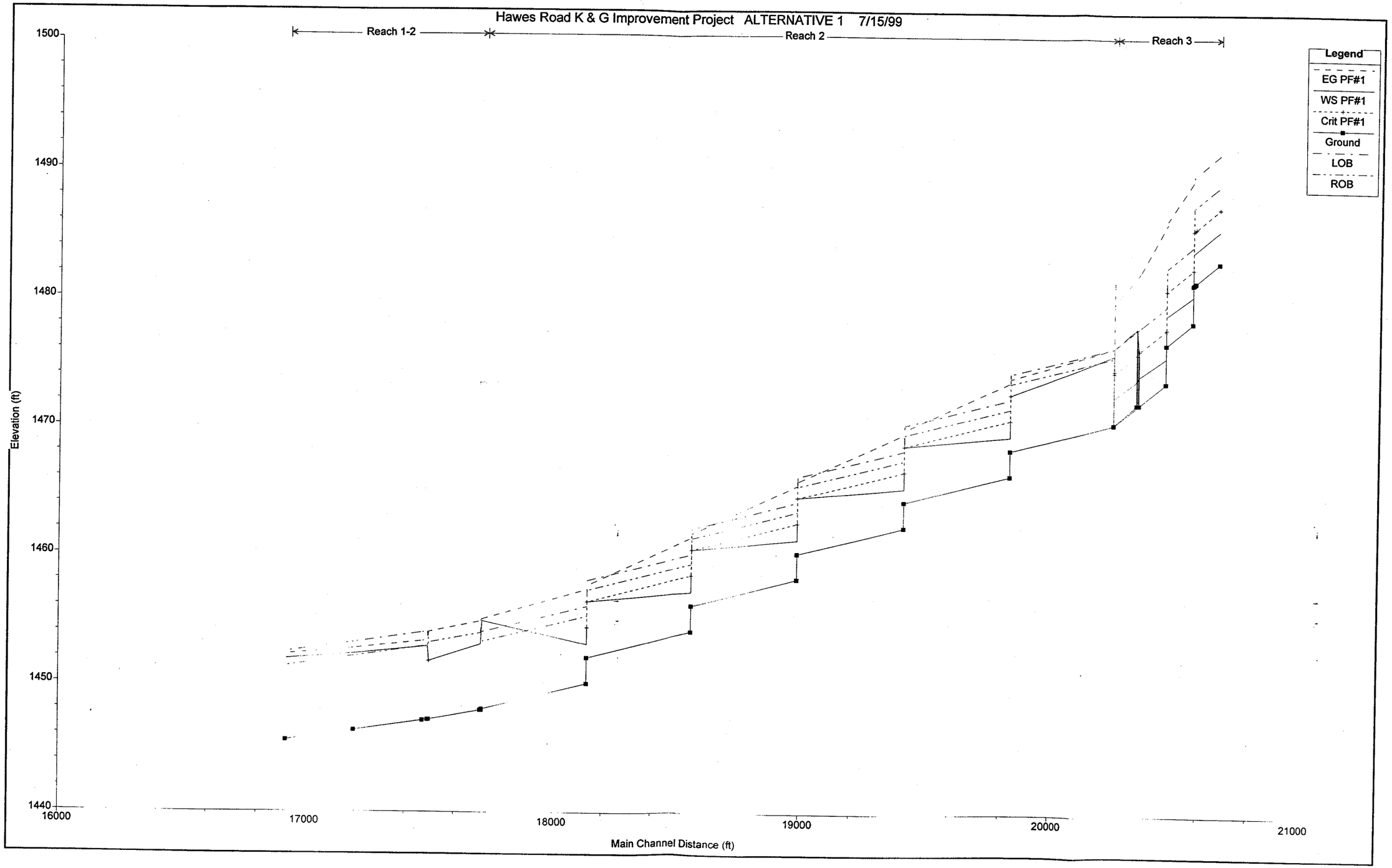
Hawes Road K&G Improvement Plan

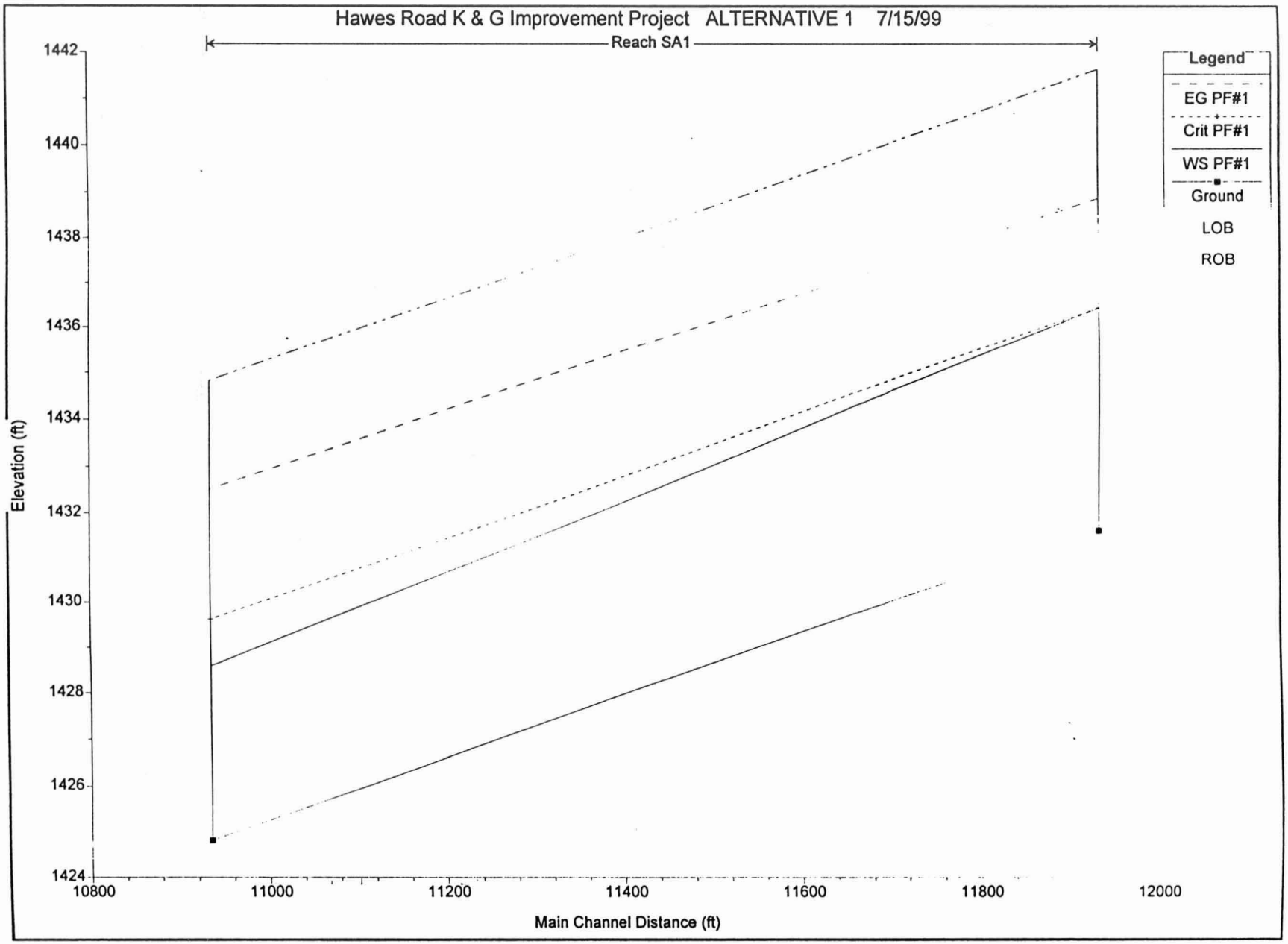
Alternative 1

Geometry




Hawes Road K & G Improvement Project ALTERNATIVE 1 7/15/99
Reach 0-1
Reach 02a
Reach 0-2
Reach 1-1
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
LOB
ROB
Elevation (ft)
1455
1450
1445
1440
1435
1430
1425
10000
11000
12000
13000
14000
15000
16000
17000
Main Channel Distance (ft)


Hawes Road K & G Improvement Project ALTERNATIVE 1 7/15/99
Reach 1-2
Reach 2
Reach 3
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
LOB
ROB
Elevation (ft)
1500
1490
1480
1470
1460
1450
1440
16000
17000
18000
19000
20000
21000
Main Channel Distance (ft)


Hawes Road K & G Improvement Project ALTERNATIVE 1 7/15/99
Reach SA1
Legend
EG PF#1
Crit PF#1
WS PF#1
Ground
LOB
ROB
Elevation (ft)
1442
1440
1438
1436
1434
1432
1430
1428
1426
1424
10800
11000
11200
11400
11600
11800
12000
Main Channel Distance (ft)

HEC-RAS Plan: Alternative1

River	Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
SA	Reach SA1	11935	1200.00	1431.62	1436.42	1436.42	1438.85	0.004045	12.49	96.08	20.00	1.00
SA	Reach SA1	10935	1200.00	1424.82	1428.59	1429.62	1432.52	0.008240	15.90	75.48	20.00	1.44
HRR&G	Reach 3	20655	922.00	1483.04	1485.55	1487.25	1491.52	0.016021	19.61	47.02	22.52	2.39
HRR&G	Reach 3	20560	922.00	1481.51	1484.02	1485.72	1489.95	0.015842	19.54	47.20	22.54	2.38
HRR&G	Reach 3	20555	922.00	1481.43	1483.95	1485.64	1489.87	0.015826	19.53	47.21	22.55	2.38
HRR&G	Reach 3	20550.1	922.00	1481.36	1483.87	1485.57	1489.83	0.015991	19.60	47.05	22.52	2.39
HRR&G	Reach 3	20550	922.00	1478.36	1480.47	1482.57	1489.49	0.029353	24.11	38.25	21.32	3.17
HRR&G	Reach 3	20445.1	922.00	1476.68	1478.97	1480.89	1486.36	0.021860	21.81	42.28	21.88	2.76
HRR&G	Reach 3	20445	922.00	1473.68	1475.66	1477.89	1486.10	0.036404	25.93	35.56	20.94	3.51
HRR&G	Reach 3	20340	922.00	1472.00	1474.21	1476.21	1482.26	0.024794	22.76	40.50	21.63	2.93
HRR&G	Reach 3	20331	Culvert									
HRR&G	Reach 3	20241	922.00	1470.42	1472.53	1474.63	1481.53	0.029264	24.08	38.29	21.32	2.93
HRR&G	Reach 2	20240	922.00	1470.40	1475.81		1476.39	0.003548	6.13	153.07	75.52	0.62
HRR&G	Reach 2	19815.1	922.00	1468.32	1472.68	1472.68	1473.94	0.010123	9.02	102.19	40.88	1.01
HRR&G	Reach 2	19815	922.00	1466.32	1469.37	1470.68	1473.64	0.051843	16.58	55.59	30.42	2.16
HRR&G	Reach 2	19390.1	922.00	1464.24	1468.60	1468.60	1469.86	0.010123	9.02	102.19	40.88	1.01
HRR&G	Reach 2	19390	922.00	1462.24	1465.29	1466.60	1469.56	0.051843	16.58	55.59	30.42	2.16
HRR&G	Reach 2	18965.1	922.00	1460.16	1464.52	1464.52	1465.78	0.010123	9.02	102.19	40.88	1.01
HRR&G	Reach 2	18965	922.00	1458.16	1461.21	1462.52	1465.48	0.051843	16.58	55.59	30.42	2.16
HRR&G	Reach 2	18540.1	922.00	1456.07	1460.43	1460.43	1461.69	0.010123	9.02	102.19	40.88	1.01
HRR&G	Reach 2	18540	922.00	1454.07	1457.12	1458.43	1461.39	0.051843	16.58	55.59	30.42	2.16
HRR&G	Reach 2	18115.1	922.00	1451.99	1456.35	1456.35	1457.61	0.010123	9.02	102.19	40.88	1.01
HRR&G	Reach 2	18115	922.00	1449.99	1453.04	1454.35	1457.31	0.051843	16.58	55.59	30.42	2.16
HRR&G	Reach 2	17700	922.00	1447.96	1454.81		1454.96	0.000586	3.14	300.82	109.00	0.27
HRR&G	Reach 1-2	17690	1650.00	1447.89	1454.69		1454.95	0.000922	4.08	407.68	99.18	0.34
HRR&G	Reach 1-2	17685	1650.00	1447.88	1452.97		1454.78	0.003011	10.80	152.84	30.00	0.84
HRR&G	Reach 1-2	17475	1650.00	1447.14	1451.68	1451.68	1453.96	0.004698	12.10	136.31	30.00	1.00
HRR&G	Reach 1-2	17470	1650.00	1447.13	1452.82		1453.31	0.002333	5.58	295.59	81.83	0.52
HRR&G	Reach 1-2	17450	1650.00	1447.07	1452.78		1453.26	0.002305	5.56	296.86	81.99	0.51
HRR&G	Reach 1-2	17175	1650.00	1446.30	1452.24		1452.67	0.001917	5.22	316.35	85.49	0.47
HRR&G	Reach 1-2	16900	1650.00	1445.53	1451.84		1452.19	0.001451	4.75	348.59	91.32	0.42
HRR&G	Reach 1-1	16880	1930.00	1445.48	1451.61		1452.13	0.002389	5.80	332.62	88.48	0.53
HRR&G	Reach 1-1	15780	1930.00	1442.84	1448.90		1449.44	0.002502	5.91	326.36	87.34	0.54
HRR&G	Reach 1-1	15225	1930.00	1441.50	1447.45		1448.03	0.002679	6.08	317.24	85.66	0.56
HRR&G	Reach 1-1	14900	1930.00	1440.72	1446.39		1447.06	0.003246	6.57	293.74	81.59	0.61
HRR&G	Reach 1-1	14800	1930.00	1440.48	1445.95		1446.70	0.003774	6.95	277.88	79.52	0.65
HRR&G	Reach 1-1	14750	1930.00	1440.36	1445.67		1446.49	0.004297	7.29	264.90	77.79	0.70
HRR&G	Reach 1-1	14700	1930.00	1440.24	1445.25		1446.24	0.005511	7.98	241.73	74.59	0.78
HRR&G	Reach 1-1	14690	1930.00	1440.22	1445.12		1446.18	0.006039	8.26	233.75	73.46	0.82

HEC-RAS Plan: Alternative1 (Continued)

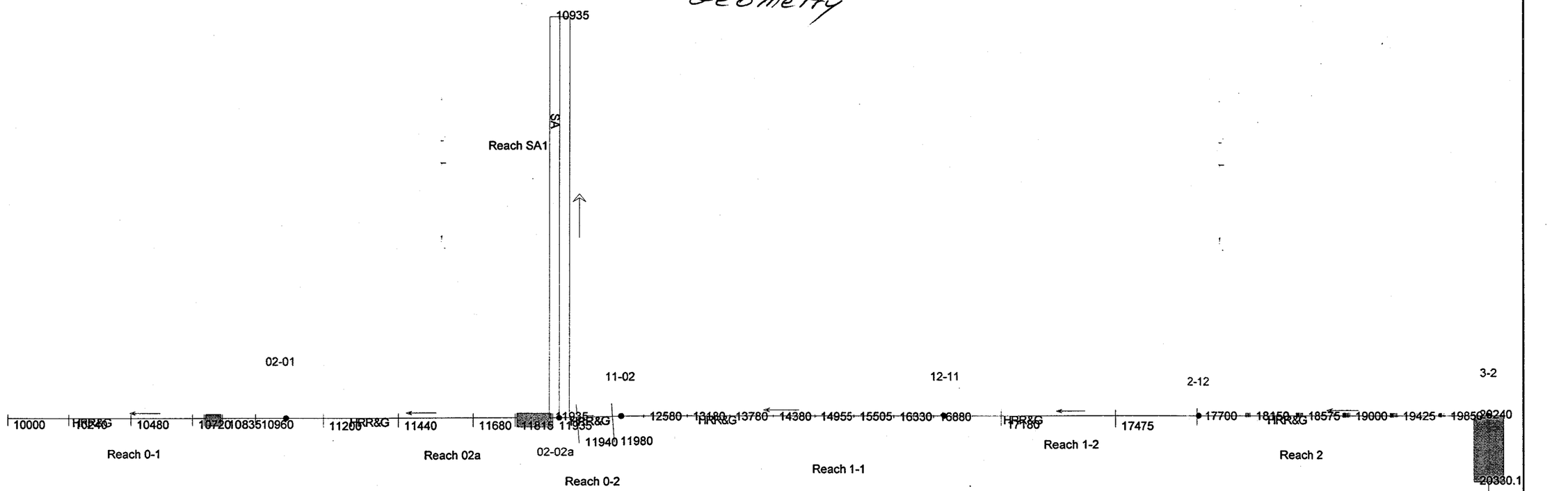
River	Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
HRR&G	Reach 1-1	14680	1930.00	1440.20	1444.61	1444.61	1446.07	0.009369	9.70	198.98	68.30	1.00
HRR&G	Reach 1-1	14679	1930.00	1438.19	1441.18	1442.58	1445.73	0.044821	17.13	112.68	53.40	2.08
HRR&G	Reach 1-1	14640	1930.00	1438.10	1444.22		1444.75	0.002396	5.81	332.22	88.41	0.53
HRR&G	Reach 1-1	14600	1930.00	1438.00	1444.13		1444.65	0.002389	5.80	332.60	88.48	0.53
HRR&G	Reach 1-1	14500	1930.00	1437.76	1443.89		1444.41	0.002387	5.80	332.71	88.50	0.53
HRR&G	Reach 1-1	14000	1930.00	1436.56	1442.71		1443.22	0.002362	5.78	334.17	88.76	0.52
HRR&G	Reach 1-1	13500	1930.00	1435.36	1441.56		1442.06	0.002289	5.70	338.50	89.54	0.52
HRR&G	Reach 1-1	13000	1930.00	1434.16	1440.48		1440.95	0.002117	5.52	349.51	91.48	0.50
HRR&G	Reach 1-1	12500	1930.00	1432.96	1439.55		1439.96	0.001776	5.14	375.42	95.90	0.46
HRR&G	Reach 1-1	12000	1930.00	1431.76	1438.90		1439.21	0.001195	4.48	434.27	127.78	0.38
HRR&G	Reach 0-2	11980	1930.00	1431.72	1438.89		1439.18	0.001300	4.46	444.60	145.00	0.39
HRR&G	Reach 0-2	11940.5	1930.00	1431.63	1438.84		1439.13	0.001241	4.39	451.33	145.00	0.38
HRR&G	Reach 02a	11940	730.00	1431.63	1437.57	1434.58	1437.67	0.000690	2.61	280.25	99.67	0.27
HRR&G	Reach 02a	11930	Culvert									
HRR&G	Reach 02a	11810	730.00	1431.34	1436.02		1436.27	0.001565	3.98	183.27	62.26	0.41
HRR&G	Reach 02a	11510	730.00	1430.68	1435.64		1435.84	0.001233	3.64	200.66	65.31	0.37
HRR&G	Reach 02a	11210	730.00	1430.02	1435.33		1435.49	0.001029	3.24	225.55	76.52	0.33
HRR&G	Reach 02a	10910	730.00	1429.36	1435.09		1435.21	0.000797	2.80	260.50	90.73	0.29
HRR&G	Reach 0-1	10900	730.00	1429.34	1435.09		1435.21	0.000786	2.78	262.33	91.41	0.29
HRR&G	Reach 0-1	10840	730.00	1429.21	1435.05	1432.16	1435.16	0.000739	2.70	270.83	94.52	0.28
HRR&G	Reach 0-1	10830	Culvert									
HRR&G	Reach 0-1	10760	730.00	1429.03	1433.39		1433.70	0.002131	4.46	163.56	59.05	0.47
HRR&G	Reach 0-1	10380	730.00	1428.20	1432.61		1432.91	0.002032	4.39	166.46	59.53	0.46
HRR&G	Reach 0-1	10000	730.00	1427.36	1430.31	1430.31	1431.33	0.010751	8.08	90.36	45.18	1.01

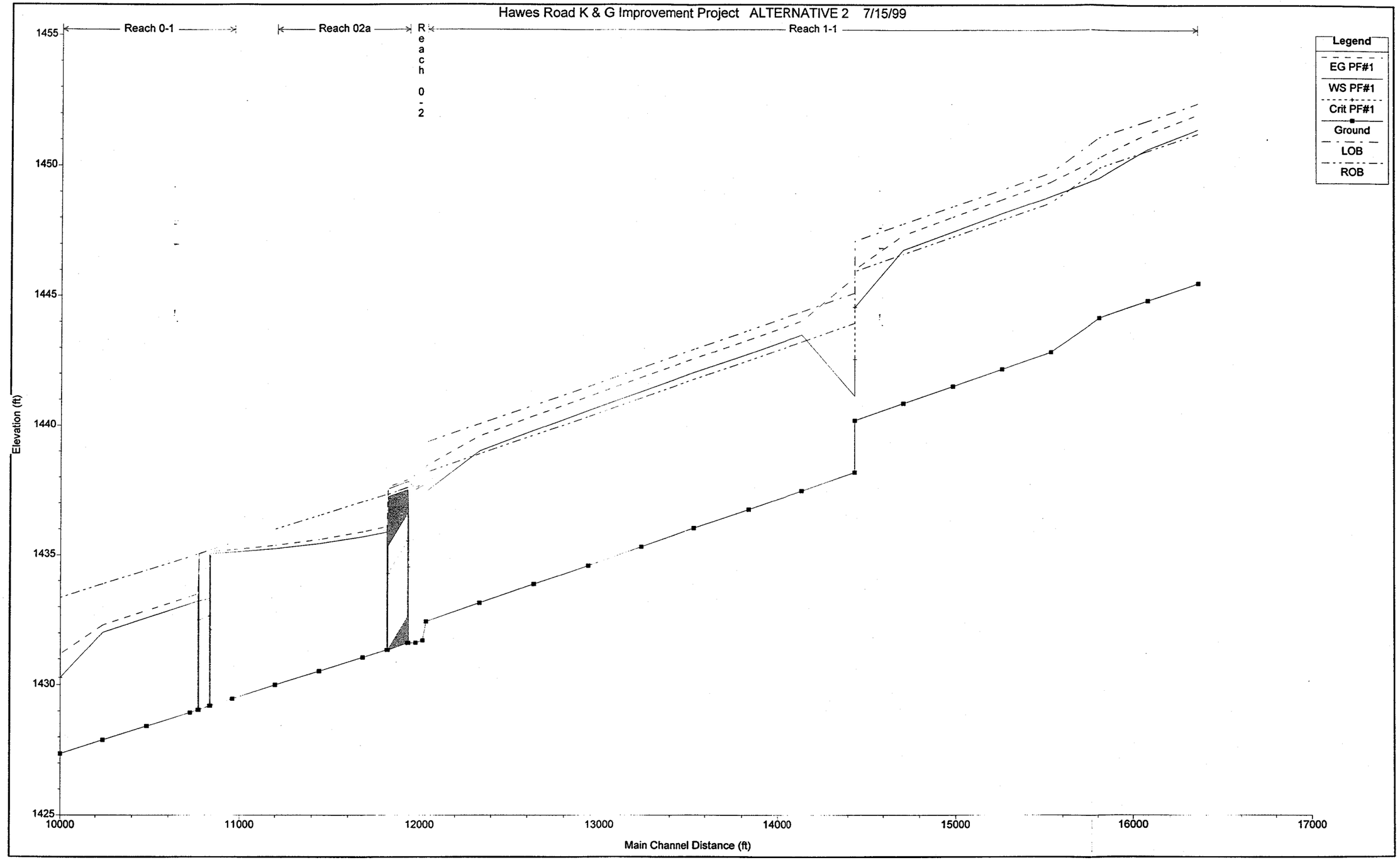
Appendix G

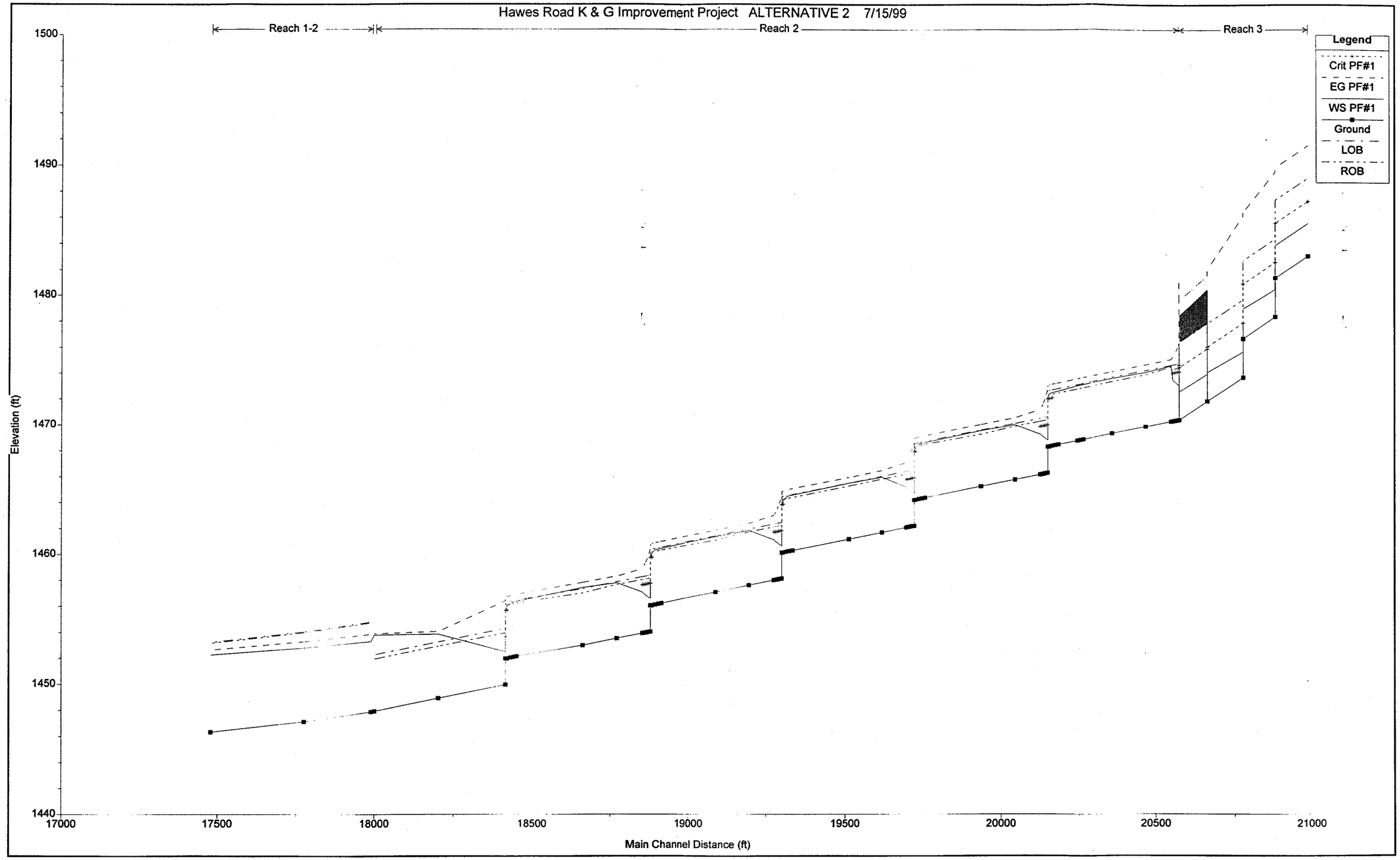
HEC-RAS Conceptual Hydraulic Analysis

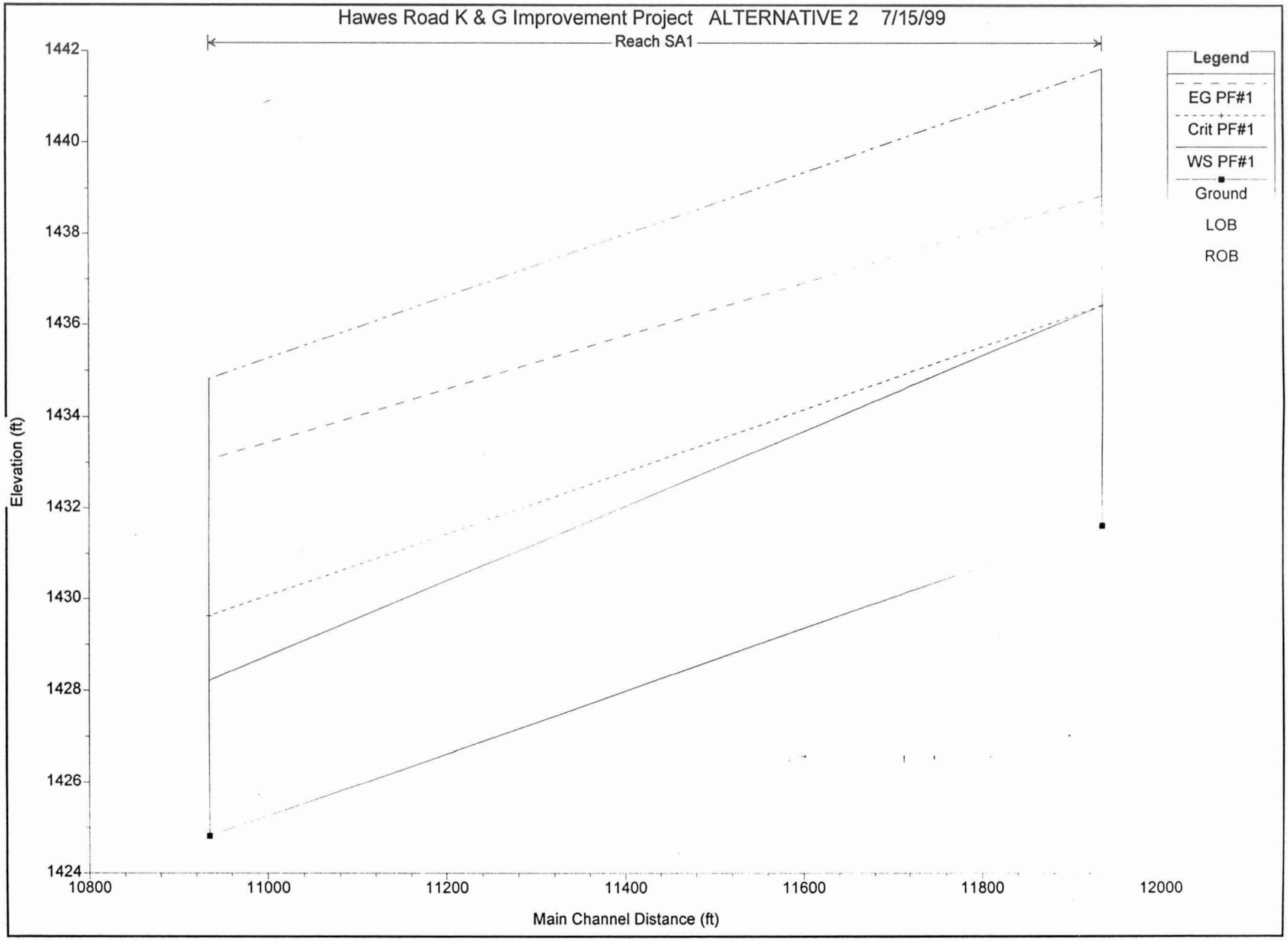
Alternative 2

Hawes Road K&G Improvement Project
Alternative 2
Geometry




Hawes Road K & G Improvement Project ALTERNATIVE 2 7/15/99
Reach 0-1
Reach 02a
Reach 0-2
Reach 1-1
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
LOB
ROB
Elevation (ft)
1455
1450
1445
1440
1435
1430
1425
10000
11000
12000
13000
14000
15000
16000
17000
Main Channel Distance (ft)


Hawes Road K & G Improvement Project ALTERNATIVE 2 7/15/99
Reach 1-2
Reach 2
Reach 3
Legend
Crit PF#1
EG PF#1
WS PF#1
Ground
LOB
ROB
Elevation (ft)
1500
1490
1480
1470
1460
1450
1440
17000
17500
18000
18500
19000
19500
20000
20500
21000
Main Channel Distance (ft)


Hawes Road K & G Improvement Project ALTERNATIVE 2 7/15/99
Reach SA1
Legend
EG PF#1
Crit PF#1
WS PF#1
Ground
LOB
ROB
Elevation (ft)
1442
1440
1438
1436
1434
1432
1430
1428
1426
1424
10800
11000
11200
11400
11600
11800
12000
Main Channel Distance (ft)

HEC-RAS Plan: Alternative2

River	Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
SA	Reach SA1	11935	1200.00	1431.62	1436.42	1436.42	1438.85	0.004045	12.49	96.09	20.00	1.00
SA	Reach SA1	10935	1200.00	1424.82	1428.22	1429.62	1433.06	0.010362	17.66	67.94	20.00	1.69
HRR&G	Reach 3	20655	922.00	1483.03	1485.54	1487.24	1491.51	0.016021	19.61	47.02	22.52	2.39
HRR&G	Reach 3	20550.1	922.00	1481.35	1483.86	1485.56	1489.83	0.016032	19.62	47.00	22.52	2.39
HRR&G	Reach 3	20550	922.00	1478.35	1480.45	1482.56	1489.49	0.029412	24.12	38.22	21.31	3.17
HRR&G	Reach 3	20445.1	922.00	1476.67	1478.96	1480.88	1486.35	0.021877	21.81	42.27	21.88	2.77
HRR&G	Reach 3	20445	922.00	1473.67	1475.65	1477.88	1486.10	0.036489	25.95	35.53	20.93	3.51
HRR&G	Reach 3	20330.1	922.00	1471.83	1474.06	1476.04	1481.97	0.024181	22.57	40.85	21.68	2.90
HRR&G	Reach 3	20330	Culvert									
HRR&G	Reach 3	20240	922.00	1470.39	1472.55	1474.60	1481.02	0.026725	23.35	39.48	21.49	2.90
HRR&G	Reach 2	20240	922.00	1470.39	1473.06	1474.10	1476.30	0.048935	14.44	63.84	41.78	2.06
HRR&G	Reach 2	20235	922.00	1470.36	1473.14	1474.06	1475.97	0.040845	13.50	68.29	43.18	1.89
HRR&G	Reach 2	20230	922.00	1470.34	1473.24	1474.04	1475.68	0.033489	12.54	73.55	44.78	1.72
HRR&G	Reach 2	20225	922.00	1470.32	1473.35	1474.02	1475.43	0.026948	11.56	79.77	46.61	1.56
HRR&G	Reach 2	20220	922.00	1470.29	1473.48	1473.99	1475.22	0.021338	10.59	87.04	48.65	1.40
HRR&G	Reach 2	20215	922.00	1470.27	1474.55		1475.05	0.005203	5.78	165.84	117.66	0.71
HRR&G	Reach 2	20135	922.00	1469.87	1474.05		1474.63	0.005143	6.22	154.60	111.07	0.72
HRR&G	Reach 2	20027.5	922.00	1469.35	1473.59		1474.10	0.004412	5.83	166.21	119.47	0.67
HRR&G	Reach 2	19930	922.00	1468.87	1473.12		1473.65	0.004618	5.98	162.48	117.48	0.68
HRR&G	Reach 2	19920	922.00	1468.82	1473.07		1473.61	0.004585	5.96	162.96	117.51	0.68
HRR&G	Reach 2	19910	922.00	1468.77	1473.03		1473.56	0.004549	5.94	163.48	117.54	0.68
HRR&G	Reach 2	19850	922.00	1468.48	1472.61		1473.24	0.005687	6.46	148.14	107.41	0.75
HRR&G	Reach 2	19840	922.00	1468.43	1472.55		1473.19	0.005760	6.49	147.33	106.59	0.76
HRR&G	Reach 2	19830	922.00	1468.38	1472.49	1472.09	1473.14	0.005841	6.52	146.43	105.68	0.76
HRR&G	Reach 2	19820	922.00	1468.33	1472.42	1472.03	1473.09	0.006079	6.62	143.89	103.06	0.77
HRR&G	Reach 2	19815.1	922.00	1468.31	1472.01	1472.01	1473.03	0.010396	8.10	113.88	55.55	1.00
HRR&G	Reach 2	19815	922.00	1466.31	1468.84	1470.01	1472.76	0.063170	15.89	58.04	39.88	2.32
HRR&G	Reach 2	19810	922.00	1466.28	1468.91	1469.98	1472.34	0.052989	14.88	61.97	41.18	2.14
HRR&G	Reach 2	19805	922.00	1466.26	1468.99	1469.96	1471.98	0.043979	13.88	66.43	42.60	1.96
HRR&G	Reach 2	19800	922.00	1466.23	1469.07	1469.93	1471.68	0.036596	12.96	71.15	44.06	1.80
HRR&G	Reach 2	19795	922.00	1466.21	1469.18	1469.91	1471.41	0.029748	11.99	76.88	45.77	1.63
HRR&G	Reach 2	19790	922.00	1466.18	1469.29	1469.88	1471.19	0.023988	11.07	83.31	47.61	1.47
HRR&G	Reach 2	19710	922.00	1465.79	1470.03		1470.56	0.005608	5.95	161.09	117.41	0.73
HRR&G	Reach 2	19602.5	922.00	1465.27	1469.55		1470.03	0.004105	5.67	171.09	119.71	0.64
HRR&G	Reach 2	19425	922.00	1464.40	1468.64		1469.17	0.005685	5.97	160.37	117.32	0.74
HRR&G	Reach 2	19415	922.00	1464.35	1468.58		1469.12	0.005772	6.01	159.46	117.26	0.74
HRR&G	Reach 2	19405	922.00	1464.30	1468.52		1469.07	0.005871	6.04	158.44	117.20	0.75
HRR&G	Reach 2	19395	922.00	1464.25	1468.24	1467.95	1468.99	0.007099	7.00	134.31	87.25	0.83
HRR&G	Reach 2	19390.1	922.00	1464.22	1467.92	1467.92	1468.94	0.010364	8.09	114.02	55.58	1.00

HEC-RAS Plan: Alternative2 (Continued)

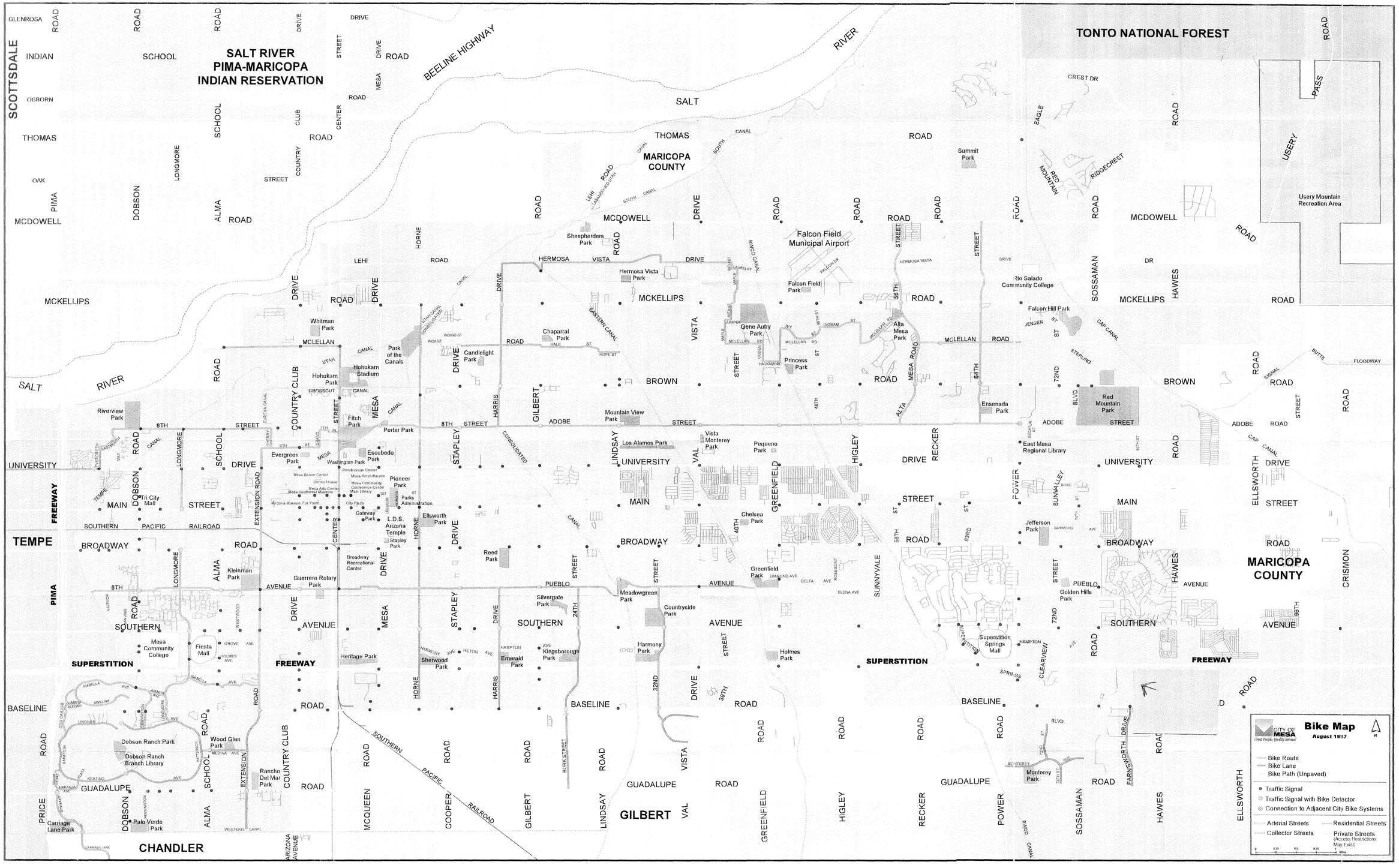
River	Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
HRR&G	Reach 2	19390	922.00	1462.22	1464.75	1465.92	1468.67	0.063200	15.89	58.03	39.87	2.32
HRR&G	Reach 2	19385	922.00	1462.20	1464.83	1465.90	1468.25	0.052703	14.85	62.09	41.22	2.13
HRR&G	Reach 2	19380	922.00	1462.18	1464.92	1465.88	1467.89	0.043703	13.85	66.59	42.65	1.95
HRR&G	Reach 2	19375	922.00	1462.15	1465.00	1465.85	1467.59	0.036345	12.92	71.34	44.12	1.79
HRR&G	Reach 2	19370	922.00	1462.13	1465.10	1465.83	1467.33	0.029517	11.96	77.10	45.83	1.62
HRR&G	Reach 2	19365	922.00	1462.10	1465.21	1465.80	1467.10	0.023775	11.03	83.59	47.69	1.47
HRR&G	Reach 2	19285	922.00	1461.71	1465.98		1466.49	0.005298	5.82	164.51	117.60	0.71
HRR&G	Reach 2	19177.5	922.00	1461.18	1465.51		1465.95	0.004417	5.42	176.67	126.51	0.65
HRR&G	Reach 2	19000	922.00	1460.31	1464.60		1465.10	0.005131	5.75	166.59	117.90	0.70
HRR&G	Reach 2	18990	922.00	1460.26	1464.55		1465.05	0.005146	5.76	166.41	117.70	0.70
HRR&G	Reach 2	18980	922.00	1460.22	1464.44		1464.99	0.005881	6.05	158.33	117.19	0.75
HRR&G	Reach 2	18970	922.00	1460.17	1464.16	1463.87	1464.91	0.007121	7.01	134.12	87.02	0.83
HRR&G	Reach 2	18965.1	922.00	1460.14	1463.85	1463.85	1464.86	0.010314	8.07	114.22	55.63	0.99
HRR&G	Reach 2	18965	922.00	1458.14	1460.67	1461.85	1464.59	0.063227	15.89	58.02	39.87	2.32
HRR&G	Reach 2	18960	922.00	1458.12	1460.75	1461.82	1464.17	0.052714	14.85	62.09	41.22	2.13
HRR&G	Reach 2	18955	922.00	1458.09	1460.82	1461.79	1463.82	0.044072	13.89	66.38	42.59	1.96
HRR&G	Reach 2	18950	922.00	1458.07	1460.92	1461.77	1463.51	0.036316	12.92	71.36	44.12	1.79
HRR&G	Reach 2	18945	922.00	1458.04	1461.01	1461.74	1463.25	0.029898	12.02	76.73	45.73	1.63
HRR&G	Reach 2	18940	922.00	1458.02	1461.14	1461.72	1463.02	0.023655	11.01	83.75	47.74	1.46
HRR&G	Reach 2	18860	922.00	1457.63	1461.86		1462.40	0.005734	5.99	159.75	117.33	0.74
HRR&G	Reach 2	18752.5	922.00	1457.10	1461.38		1461.86	0.004122	5.68	170.82	119.70	0.64
HRR&G	Reach 2	18575	922.00	1456.23	1460.47		1461.00	0.005648	5.96	160.77	117.34	0.73
HRR&G	Reach 2	18565	922.00	1456.18	1460.41		1460.95	0.005729	5.99	159.92	117.29	0.74
HRR&G	Reach 2	18555	922.00	1456.13	1460.36		1460.90	0.005821	6.02	158.95	117.23	0.75
HRR&G	Reach 2	18545	922.00	1456.08	1460.12	1459.78	1460.83	0.007141	6.79	139.29	97.40	0.83
HRR&G	Reach 2	18540.1	922.00	1456.06	1459.76	1459.76	1460.78	0.010363	8.09	114.02	55.58	0.99
HRR&G	Reach 2	18540	922.00	1454.06	1456.61	1457.76	1460.44	0.061452	15.72	58.64	40.08	2.29
HRR&G	Reach 2	18535	922.00	1454.03	1456.67	1457.73	1460.04	0.051528	14.72	62.62	41.39	2.11
HRR&G	Reach 2	18530	922.00	1454.01	1456.76	1457.71	1459.69	0.042692	13.73	67.17	42.84	1.93
HRR&G	Reach 2	18525	922.00	1453.99	1456.86	1457.69	1459.39	0.035114	12.76	72.26	44.40	1.76
HRR&G	Reach 2	18520	922.00	1453.96	1456.95	1457.66	1459.13	0.028839	11.86	77.77	46.03	1.61
HRR&G	Reach 2	18515	922.00	1453.94	1457.09	1457.64	1458.91	0.022655	10.83	85.11	48.12	1.44
HRR&G	Reach 2	18435	922.00	1453.54	1457.79		1458.31	0.005484	5.90	162.44	117.48	0.72
HRR&G	Reach 2	18327.5	922.00	1453.02	1457.43		1457.83	0.003232	5.20	187.53	129.97	0.58
HRR&G	Reach 2	18150	922.00	1452.15	1456.39		1456.92	0.005661	5.96	160.63	117.34	0.74
HRR&G	Reach 2	18140	922.00	1452.10	1456.33		1456.87	0.005743	6.00	159.77	117.28	0.74
HRR&G	Reach 2	18130	922.00	1452.05	1456.27		1456.82	0.005838	6.03	158.79	117.22	0.75
HRR&G	Reach 2	18120	922.00	1452.00	1456.03	1455.70	1456.75	0.007094	6.85	137.78	94.14	0.83
HRR&G	Reach 2	18115.1	922.00	1451.98	1455.68	1455.68	1456.70	0.010364	8.09	114.02	55.58	1.00

HEC-RAS Plan: Alternative2 (Continued)

River	Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
HRR&G	Reach 2	18115	922.00	1449.98	1452.51	1453.68	1456.43	0.063200	15.89	58.03	39.87	2.32
HRR&G	Reach 2	17902.5	922.00	1448.94	1453.86		1454.07	0.001329	3.76	253.92	131.00	0.38
HRR&G	Reach 2	17700	922.00	1447.94	1453.81		1453.91	0.000379	2.40	371.94	131.00	0.21
HRR&G	Reach 1-2	17690	1650.00	1447.89	1453.31		1453.85	0.002774	5.90	279.76	81.22	0.56
HRR&G	Reach 1-2	17475	1650.00	1447.14	1452.81		1453.29	0.002289	5.55	297.19	81.78	0.51
HRR&G	Reach 1-2	17180	1650.00	1446.32	1452.25		1452.66	0.001901	5.12	322.56	87.30	0.47
HRR&G	Reach 1-1	16880	1930.00	1445.48	1451.39		1451.97	0.002596	6.09	317.21	85.16	0.55
HRR&G	Reach 1-1	16605	1930.00	1444.82	1450.64		1451.23	0.002786	6.17	312.74	85.73	0.57
HRR&G	Reach 1-1	16330	1930.00	1444.16	1449.52		1450.30	0.003994	7.10	271.77	78.49	0.67
HRR&G	Reach 1-1	15780	1930.00	1442.84	1448.83		1449.38	0.002443	5.96	323.91	86.40	0.54
HRR&G	Reach 1-1	15505	1930.00	1442.18	1448.18		1448.71	0.002399	5.88	328.41	88.22	0.53
HRR&G	Reach 1-1	15230	1930.00	1441.52	1447.47		1448.03	0.002523	6.03	320.33	85.74	0.54
HRR&G	Reach 1-1	14955	1930.00	1440.86	1446.77		1447.33	0.002575	6.02	320.88	87.03	0.55
HRR&G	Reach 1-1	14680.1	1930.00	1440.20	1444.56	1444.56	1446.02	0.009360	9.70	198.93	68.20	1.00
HRR&G	Reach 1-1	14680	1930.00	1438.20	1441.14	1442.56	1445.71	0.045182	17.16	112.47	53.47	2.09
HRR&G	Reach 1-1	14380	1930.00	1437.48	1443.50		1444.03	0.002358	5.85	330.32	88.52	0.53
HRR&G	Reach 1-1	14080	1930.00	1436.76	1442.76		1443.31	0.002426	5.95	324.65	86.53	0.53
HRR&G	Reach 1-1	13780	1930.00	1436.04	1442.05		1442.59	0.002366	5.85	329.93	88.46	0.53
HRR&G	Reach 1-1	13480	1930.00	1435.32	1441.31		1441.86	0.002446	5.97	323.76	86.37	0.54
HRR&G	Reach 1-1	13180	1930.00	1434.60	1440.59		1441.13	0.002409	5.89	328.01	88.16	0.53
HRR&G	Reach 1-1	12880	1930.00	1433.88	1439.81		1440.38	0.002555	6.05	318.97	85.49	0.55
HRR&G	Reach 1-1	12580	1930.00	1433.16	1439.02		1439.60	0.002693	6.10	316.23	86.29	0.56
HRR&G	Reach 1-1	12280	1930.00	1432.44	1437.46		1438.44	0.005458	7.96	242.60	74.71	0.78
HRR&G	Reach 0-2	11980	1930.00	1431.72	1437.68		1438.23	0.003016	5.95	324.31	102.26	0.58
HRR&G	Reach 0-2	11940	1930.00	1431.63	1437.54		1438.10	0.003140	6.05	319.27	98.93	0.59
HRR&G	Reach 02a	11935	730.00	1431.62	1437.83	1434.54	1437.90	0.000338	2.08	352.30	120.47	0.20
HRR&G	Reach 02a	11930	Culvert									
HRR&G	Reach 02a	11815	730.00	1431.35	1435.89		1436.09	0.001520	3.65	199.76	76.07	0.40
HRR&G	Reach 02a	11680	730.00	1431.06	1435.70		1435.89	0.001364	3.51	207.97	77.58	0.38
HRR&G	Reach 02a	11440	730.00	1430.53	1435.44		1435.60	0.001053	3.18	229.22	81.45	0.33
HRR&G	Reach 02a	11200	730.00	1430.00	1435.25		1435.37	0.000785	2.83	257.69	87.57	0.29
HRR&G	Reach 0-1	10960	730.00	1429.47	1435.11		1435.20	0.000561	2.49	293.27	94.04	0.25
HRR&G	Reach 0-1	10835	730.00	1429.20	1435.05	1432.12	1435.14	0.000470	2.33	313.83	97.58	0.23
HRR&G	Reach 0-1	10830	Culvert									
HRR&G	Reach 0-1	10765	730.00	1429.04	1433.22		1433.50	0.002209	4.20	173.78	71.08	0.47
HRR&G	Reach 0-1	10720	730.00	1428.94	1433.12		1433.40	0.002207	4.20	173.83	71.09	0.47
HRR&G	Reach 0-1	10480	730.00	1428.42	1432.58		1432.86	0.002260	4.24	172.29	70.78	0.48
HRR&G	Reach 0-1	10240	730.00	1427.89	1432.02		1432.31	0.002334	4.29	170.23	70.37	0.49
HRR&G	Reach 0-1	10000	730.00	1427.36	1430.28	1430.28	1431.19	0.011101	7.65	95.37	53.27	1.01

Appendix H

City of Mesa Bike Map


TONTO NATIONAL FOREST
SALT RIVER PIMA-MARICOPA INDIAN RESERVATION
MARICOPA COUNTY
Usery Mountain Recreation Area
Falcon Field Municipal Airport
Sheepherders Park
Hermosa Vista Park
Falcon Field Park
Rio Salado Community College
Falcon Hill Park
Summit Park
Whitman Park
Park of the Canals
Hohokam Park
Hohokam Stadium
Candlelight Park
Chaparral Park
Gene Autry Park
Princess Park
Alta Mesa Park
Ensenada Park
Red Mountain Park
Riverview Park
Fitch Park
Porter Park
Mountain View Park
Los Alamos Park
Vista Monterey Park
Pequeno Park
East Mesa Regional Library
Evergreen Park
Escobedo Park
Washington Park
Pioneer Park
Parks Administration
Tri City Mall
Gateway Park
L.D.S. Arizona Temple
Ellsworth Park
Stapley Park
Chelsea Park
Jefferson Park
Reed Park
Broadway Recreational Center
Kleinman Park
Guerrero Rotary Park
Greenfield Park
Golden Hills Park
Silvergate Park
Meadowgreen Park
Countryside Park
Mesa Community College
Fiesta Mall
Heritage Park
Sherwood Park
Emerald Park
Kingsborough Park
Harmony Park
Holmes Park
Superstition Springs Mall
Dobson Ranch Park
Dobson Ranch Branch Library
Wood Glen Park
Rancho Del Mar Park
Carriage Lane Park
Palo Verde Park
SCOTTSDALE
TEMPE
CHANDLER
GILBERT
BEELINE HIGHWAY
SOUTHERN PACIFIC RAILROAD
SALT RIVER
SUPERSTITION FREEWAY
PIMA FREEWAY
GLENROSA ROAD
INDIAN SCHOOL ROAD
OSBORN ROAD
THOMAS ROAD
OAK STREET
MCDOWELL ROAD
LEHI ROAD
MCKELLIPS ROAD
MCLELLAN ROAD
HERMOSA VISTA DRIVE
BROWN ROAD
UNIVERSITY DRIVE
MAIN STREET
BROADWAY ROAD
SOUTHERN AVENUE
BASELINE ROAD
GUADALUPE ROAD
ADOBE ROAD
PUEBLO AVENUE
CREST DR
EAGLE
RED MOUNTAIN
RIDGECREST
USERY PASS
SOSSAMAN
HAWES
ELLSWORTH
CRISMON
DOBSON
ALMA
LONGMORE
COUNTRY CLUB
MESA
STAPLEY
HORNE
HARRIS
GILBERT
LINDSAY
VAL
GREENFIELD
HIGLEY
RECKER
POWER
SUNNYVALE
SUNMALLEY
PRICE
BURK STREET
EASTERN CANAL
RWCD CANAL
CAP CANAL
SOUTH CANAL
UTAH CANAL
EUREKA CANAL
WESTERN CANAL
BUTTE FLOODWAY
SIGNAL
CITY OF MESA
Great People. Quality Service.
Bike Map
August 1997
N
Bike Route
Bike Lane
Bike Path (Unpaved)
Traffic Signal
Traffic Signal with Bike Detector
Connection to Adjacent City Bike Systems
Arterial Streets
Collector Streets
Residential Streets
Private Streets (Access Restrictions May Exist)
0 0.25 0.5 0.75 1 Miles