Memo

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From	**Brett A. Howey, P.E.**	cc	
Tel	**480-940-2320 ext. 116**		
Fax			
Date	**February 19, 2008**		

Subject **Preliminary Fissure Mitigation**
Supplemental Technical Memorandum
Siphon Draw Drainage Improvement Project
Maricopa County, Arizona

1.0 INTRODUCTION

This supplemental technical memorandum is submitted by AMEC Earth & Environmental, Inc. (AMEC) pursuant to the refinement of an additional channel alternative for the Siphon Draw Drainage Improvement Project. The discussion included herein is being provided as supplemental information to the AMEC technical memorandum entitled, Earth Fissure Investigation and Preliminary Fissure Mitigation Technical Memorandum, dated January 30, 2008. AMEC understands the information presented in this supplement will be provided to the Value Engineering (VE) Team for use during an upcoming VE workshop.

As a result of the Failure Modes and Effects Analysis (FMEA) workshop completed on February 6 and 7, 2008, additional mitigation alternatives were identified that may be applied to an unlined earth channel alternative. Complete results of the FMEA will be documented in a future AMEC report currently scheduled for completion in early March 2008. This supplement has been prepared for use by Stanley Consultants, Inc. (Stanley), the Flood Control District of Maricopa County (District) and its project partners, for the development and evaluation of design alternatives for the Siphon Draw Drainage Improvement Project, Contract No. FCD 2007C012.

2.0 PRELIMINARY FMEA RESULTS – UNLINED CHANNEL

During the FMEA two failure modes were identified that could fail an unlined channel should the channel be impacted by an earth fissure. FMEA participants discussed each of the two unlined channel failure modes in detail to evaluate the likelihood of occurrence and the factors affecting the likelihood. Following the discussion and team analysis, each failure mode was categorized into one of four failure mode categories.

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Discussed below are the two failure modes, the mechanisms of failure, the likelihood of failure and the assigned failure mode category.

(EF-ULC-1) UNLINED CHANNEL: WATER FLOW FROM INSIDE THE CHANNEL ERODES AN UNDERLYING EARTH FISSURE RESULTING IN A LOSS OF CAPACITY AND CONTAINMENT FAILURE WHICH CAUSES DAMAGE OUTSIDE THE PROJECT LIMITS.

Earth fissure erosion occurs from water introduced from within the channel. This results in loss of the unlined channel's capacity and containment causing damages outside the limits of the project. The earth fissure erosion is exacerbated by water fed from the channel conveyance.

Likely/Negative	Not Likely/Positive
○ Moderate fissure risk zone ○ No liner/no intrinsic defense ○ Erodible soils ○ Sufficient head ○ More difficult to monitor/detect	○ No known fissures are present, as supported by continuous seismic refraction profiling results
Category: II (*Considered but Not Highlighted* – less significant failure mode than Category I, but worthy of discussion and identification.)	

(EF-ULC-2) UNLINED CHANNEL: OVERLAND FLOW FROM OUTSIDE THE CHANNEL ERODES AN UNDERLYING EARTH FISSURE RESULTING IN A LOSS OF CAPACITY AND CONTAINMENT FAILURE WHICH CAUSES DAMAGE OUTSIDE THE PROJECT LIMITS.

Earth fissure erosion caused by overland flow outside the channel that erodes the fissure sufficiently enough to intercept the channel side slopes. This results in loss of the unlined channel's capacity and containment causing damages outside the limits of the project. The earth fissure erosion is exacerbated by overland flow and other runoff that has not yet entered the flood control system.

Likely/Negative	Not Likely/Positive
○ Moderate fissure risk zone ○ No liner/no intrinsic defense ○ Erodible soils ○ Sufficient head ○ More difficult to monitor/detect	○ No known fissures are present, as supported by continuous seismic refraction profiling results
Category: II (*Considered but Not Highlighted* – less significant failure mode than Category I, but worthy of discussion and identification.)	

After the failure mode category was identified for each of the two failure modes the failure modes were assessed through a binning process to determine their relative "likelihood" and "consequence" of occurrence. The result was the same for failure mode EF-ULC-1 and EF-ULC-2. Each had a moderate "likelihood" of occurrence and moderate "consequence". This relative comparison established the qualitative risk associated with each failure mode.

3.0 DEFENSE MITIGATION FOR EARTH FISSURES – UNLINED CHANNEL

Once the relative risk was established the team identified potential fissure defense mitigation options. Each mitigation option was discussed by the team to assess the degree (if any) that the mitigation would lower the risk (whether by a reduction in the "likelihood" or "consequence") associated with each potential failure mode.

3.1 Unlined Channel Fissure Defense Mitigation Options

For the unlined channel alternative the following mitigation measures were discussed and evaluated through the binning process with respect to amount of relative risk reduction realized.

OPTION 1 – Line channel with reinforced structural concrete

- May not achieve all project goals (aesthetics, multi-use, etc.)
- Does have benefit of lessening likelihood
- Structural concrete tends to be expensive

Reduction in risk realized? **YES (reduces likelihood)**

OPTION 2 – Monitoring only

- Allows for response and emergency actions
- District not comfortable with this option alone
- Monitoring efforts may not be sustained for the 50 year design life of the project

Reduction in risk realized? **MAYBE (reduces likelihood)**

OPTION 3 – Permeable cut-off on the west side of channel

- Channel still unprotected
- Erosion from the channel-side could cause the cut-off to fall into the channel
- Could use gabion baskets as an alternative component
- Could use channel scour protection

Reduction in risk realized? **YES (reduces consequence)**

OPTION 4 – Line west side of channel with HDPE liner or similar material

- Will contain channel flow
- Does not defend against earth fissures advancing toward channel
- Could lose east side of channel

Reduction in risk realized? **NO**

OPTION 5 – Line entire channel with HDPE liner or similar material and provide permeable cut-off on the east side of channel

- Will contain channel flow
- Does not defend against earth fissures advancing toward channel on west side
- Damage to liner could occur if channel scour occurs

Reduction in risk realized? **YES (reduces consequences)**

3.2 Recommended Unlined Channel Fissure Defense Mitigation

To provide a reduction in the risk, consideration has been given to incorporate engineering defense mechanisms into the unlined channel project design. The intent of the solutions is to maintain full operation of the flood control channel during a single design storm event without initiating any of the identified failure modes. Damage to the channel may occur during the design storm event that would require maintenance and possible repair, but the integrity of the system would be relatively maintained.

A combination of defense mitigations was selected from the Options discussed in Section 3.1. Depicted on the attached sheet is the recommended solution which has been assembled from Option 3 and from parts of Option 5. The defense mitigation for an unlined channel includes three principal components. The first two components include a permeable backfill cut-off that parallels the east and west sides of the channel to intercept the formation of an earth fissure gully. A 4-foot wide trench excavated into underlying cemented soils (±16 to 18 feet deep) is positioned parallel and adjacent to the channel. The trench is backfilled with a permeable backfill material wrapped on all sides, top and bottom, with a 16 oz. non-woven geotextile. A minimum of 3 feet of compacted earthfill is provided on top of the trench backfill. Should an earth fissure develop within the channel bottom, the permeable cut-offs have been designed in such a manner that they are founded within the more erosion resistant cemented soils.

The third component is channel scour protection which has been shown as a riprap option on the attached sheet. Scour protection is required to maintain the integrity of the channel to protect the stability of the paralleling permeable backfill cut-offs.

4.0 PRELIMINARY COST ESTIMATES

Preliminary cost estimates for the potential engineering defense solutions are provided in Appendix A. The preliminary cost estimates were developed by accounting for major construction activities and materials and should be used for planning purposes only. AMEC will participate with the consultant team in developing a more refined construction cost estimate for the final alternative.

Please do not hesitate to contact us if you have any questions concerning this report.
Respectfully submitted,

AMEC Earth & Environmental, Inc.

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Reviewed by:

Lawrence A. Hansen, Ph.D., P.E.
Principal Geotechnical Engineer

c: Addressee (6)

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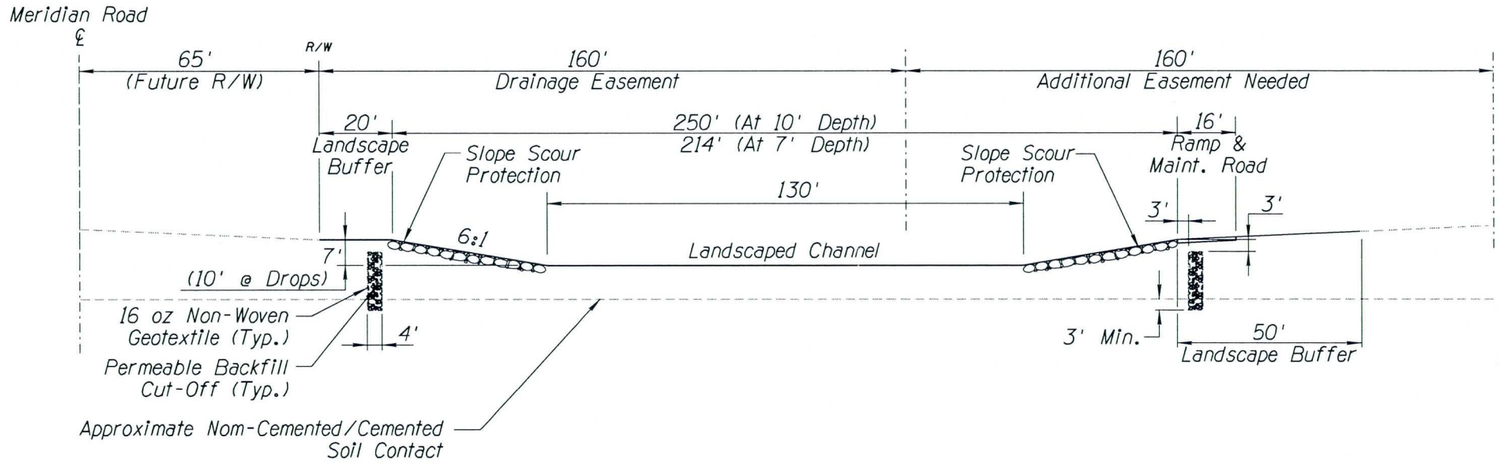
FIGURES



SECTION B-B (UNLINED CHANNEL)

0 10 20
Scale

Plotted By: ${getvar,loginname} Date: ${edtime,${getvar,date},D-MON-YY-+HH:MM}
File: ${getvar,dwgprefix}${getvar,dwgname}

REVISIONS:

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PROJECT: SIPHON DRAW DRAINAGE IMPROVEMENT PROJECT
MARICOPA & PINAL COUNTIES, ARIZONA
CONTRACT FCD 2007C012

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OR
RECORDING

PROJECT NO.
7-117-001080

SHEET NO.
4

APPENDIX A

Preliminary Cost Estimates for Earth Fissure Mitigation

Description	Unit	Quantity	Unit Price	Cost
Unlined Channel Mitigation				
Permeable cut-off excavation	CY	9,380	$5.00	$46,900
Permeable cut-off geotextile	SY	18,780	$4.25	$79,815
Permeable cut-off granular fill	CY	9,380	$42.00	$393,960
Channel Protection	CY	8,330	$85.00	$708,050
Subtotal				**$1,228,725**
Contingency (20%)				**$245,745**
Total				**$1,474,470**