Maryvale Storm Drain Settlement Study Report

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February 7, 2003
File No.: 21517 (001)

Mr. Warren Rosebraugh, PE
Flood Control District of Maricopa
2801 West Durango
Phoenix, Arizona 85009

SUBJECT: Maryvale Storm Drain Settlement Study Report
Maryvale, Arizona

Dear Mr. Rosebraugh,

Kleinfelder, Inc. (Kleinfelder) is pleased to present this letter summarizing the Maryvale Storm Drain Settlement study results. As part of continued study of settlement problems along a reach of the Maryvale Stadium West Inlet Storm Drain, Kleinfelder has assisted in further assessment of the original construction of the pipeline. The results of our field study, opinions, and recommendations for the Maryvale Storm Drain settlement study are presented as follows. Included, as attachments to this letter, are the test pit boring logs, laboratory test data, site photographs, and an as-built backfill configuration.

FIELD STUDY

The field study consisted of observing the inside of the pipe between Station 20+04 and approximately Station 28+00 on December 23, 2002, followed by the excavation of four test pits, on December 30, 2002 and January 2, 2003 to evaluate the character of the backfill material and as-built construction. Kleinfelder representatives observed the operation, photographed, performed field density testing, classified the encountered soils, prepared boring logs, and collected representative soil samples for laboratory examination and testing. The excavation, backfill, and compaction of the four test pits was performed by FCDMC crews. The test pits were located at approximate Stations 19+25, 22+00, 24+50 and Station 27+00.

TEST PIT EXCAVATION OBSERVATION

The surface and subsurface soils encountered within the four test pits performed within the site generally consist of low plasticity sandy silt to clayey silt. Field test pit observations are as following:

- Station 19+25 - Fine-grained, dry to slightly moist, native soils (sandy silt to clayey silt) present from the surface to the springline of the pipe. Density of the fine-grained soils approximately 100 pounds per cubic foot (pcf). Clean gravel present from springline and below. No apparent contamination of the gravel.
- Station 22+00 - Fine-grained, dry to slightly moist, native soils (sandy silt to clayey silt) present from the surface to the springline of the pipe. Density of the fine-grained soils

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approximately 100 pcf. Clean gravel present from springline and below. No apparent contamination of the gravel.

- Station 24+50 - Fine-grained, dry to slightly moist, native soils (sandy silt to clayey silt) present from the surface to a point approximately one foot above the top of pipe where clean, fine sand was encountered. The fine sand was present from the point encountered to springline of the pipe. Density of the fine-grained soils approximately 93 pcf. Clean gravel present from springline and below. No apparent contamination of the gravel.
- Station 27+00 - Fine-grained, moist to very moist, native soils (sandy silt to clayey silt) present from the surface to the springline of the pipe. Density of the fine-grained soils approximately 93 to 103 pcf. Gravel contaminated by fine-grained soils was present from springline and below. The gravel was excavated by hand to a point approximately one foot below the invert of the pipe.

INTERNAL PIPE ASSESSMENT

On December 23, 2002, a Kleinfelder representative was accompanied by Carlos Rivera of FCDMC on an internal traverse of the 60-inch diameter pipe between the above noted stations to assess the condition of gasket seals at each pipe joint and to attempt to determine if leaks may be present where fine grained soils may be washed into the pipe from the overlying backfill during irrigation events. It was found that most joints were grouted and of sound quality without apparent deterioration. Selected open joints were checked with a feeler gauge to determine if the pipe gasket at each joint was properly seated. All gaskets that could be checked appeared properly seated. Some build up of sediment was noted in the pipe invert, comprised mostly of fine to medium grained silty sand (SP) with some clay. Most of the invert accumulations were limited to two sag areas in the pipe invert where the invert elevation dipped approximately five to six inches along station, allowing for the accumulation of sediments during periods of low flow.

LABORATORY TESTING

Grain size analyses (both sieve and hydrometer), Atterberg limits tests, and moisture-density relationship of compacted soil were performed on representative samples collected from the four test pits. The laboratory results are presented in appendix section of this letter report.

OPINIONS

It appears that the settlements experienced to date along the above noted reach of the storm drain may be related to the specifications, as-built construction, type of backfill placed and subsequent irrigation activities.

It is difficult to know what the condition at the time of construction or quality of the native soils place above the top of pipe. It is believed that the MAG specifications for placement may have required 85% of the maximum dry density. This alone would result is a certain amount of settlement upon wetting by irrigation activities. This is suspected because settlement of the pipe trench has only been noted on the Borman School property where the backfill is subjected to repeated wettings.

The second contributing factor to settlement may be the use of the gravel used for backfill up to springline of the pipe. The gravel, as placed, contains a significant amount of void space, allowing for fines to wash in from the overlying fine-grained soils. This loss of fines into the gravel may result in settlement of the overlying fine-grained soils. This is best evidenced in the

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test pit at Station 27+00, where the gravel is significantly contaminated by fine-grained soils. The sand blanket present at Station 24+50 may have helped filter some of the fines.

RECOMMENDATIONS

Based on the information collected from the field study and laboratory tests results, a minimum of five alternatives are possible for mitigation of future settlement of the pipe trench at Borman School. The alternatives ranging from the most expensive to the most cost effective are:

1. Removal of all backfill and replacement of backfill, in accordance with the original project plans requiring low strength slurry backfill, and improving compaction above the pipe to a minimum 90 to 95 percent of the maximum dry density;
2. Pressure grout the existing gravel surrounding the pipe;
3. Remove fine grained native backfill and install synthetic filter fabric or sand filter to minimize migration of fines and recompact as noted above;
4. Thoroughly wet the native soil backfill and attempt to densify soils using a vibratory compactor, grading densified areas to match the surrounding grades; or,
5. Leave site as is and fill settlement areas with soil as they develop.

It is our opinion that the vast majority of settlement has taken place along the pipeline located on the Borman School property. Repeated wettings and repairs completed to date have most likely allowed the backfill to attain an equilibrium condition. Therefore, alternative #5 is the most desirable, and we recommend that any future settlement, as it arises, be treated as a maintenance item whereby soil is placed and compacted in areas where minor settlement occurs. We do not recommend any further deep excavation and replacement and compaction of the trench backfill. Additionally, we do not believe it is cost effective to address the potential washing of fines into the gravel bedding and backfill.

We appreciate the opportunity to be of service on this project. If you have questions, comments or require additional information, please do not hesitate to contact our office.

Respectfully submitted,

KLEINFELDER, INC.

Charles E. Reynolds
Geotechnical Department Manager

Steven A. Haire, PE
Senior Geotechnical Engineer

Attachments: Test Pit Boring Logs
Laboratory Results
Site Photographs
As-Built Pipe Configuration

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TEST PIT BORING LOGS

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			USCS SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS (More than half of material is larger than the #200 sieve)	GRAVELS (More than half of coarse fraction is larger than the #4 sieve)	CLEAN GRAVELS WITH LESS THAN 5% PASSING NO. 200 SIEVE	GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES
			GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES
		GRAVELS WITH OVER 12% PASSING NO. 200 SIEVE	GM	SILTY GRAVELS, GRAVEL-SILT-SAND MIXTURES
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SANDS (More than half of coarse fraction is smaller than the #4 sieve)	CLEAN SANDS WITH LESS THAN 5% PASSING NO. 200 SIEVE	SW	WELL-GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE OR NO FINES
			SP	POORLY-GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE OR NO FINES
		SANDS WITH OVER 12% PASSING NO. 200 SIEVE	SM	SILTY SANDS, SAND-GRAVEL-SILT MIXTURES
			SC	CLAYEY SANDS, SAND-GRAVEL-CLAY MIXTURES
FINE GRAINED SOILS (More than half of material is smaller than the #200 sieve)	SILTS AND CLAYS (Liquid limit less than 50)		ML	INORGANIC SILTS & VERY FINE SANDS, SILTY OR CLAYEY FINE SANDS, CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC SILTS & ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS (Liquid limit greater than 50)		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILT
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH	ORGANIC CLAYS & ORGANIC SILTS OF MEDIUM-TO-HIGH PLASTICITY

Note: Fine grained soils that plot within the hatched area on the Plasticity Chart, and coarse grained soils with between 5% and 12% passing No. 200 sieve require dual USCS symbols. (See KEY A-3 if provided)

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Drafted By: TS
Date: January, 2003

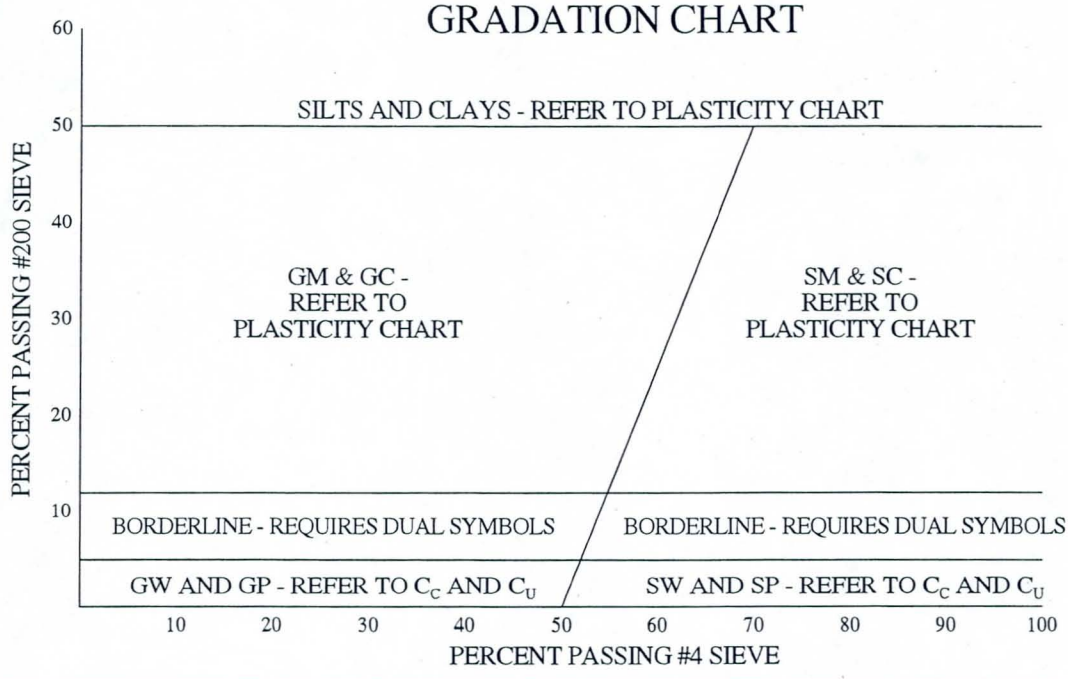
Project Number: 21517

UNIFIED SOIL CLASSIFICATION SYSTEM
Maryvale Storm Drain Testing - Phasell
Flood Control District of Maricopa County
Grand Canal at approximately 55th Drive
Maryvale, Arizona

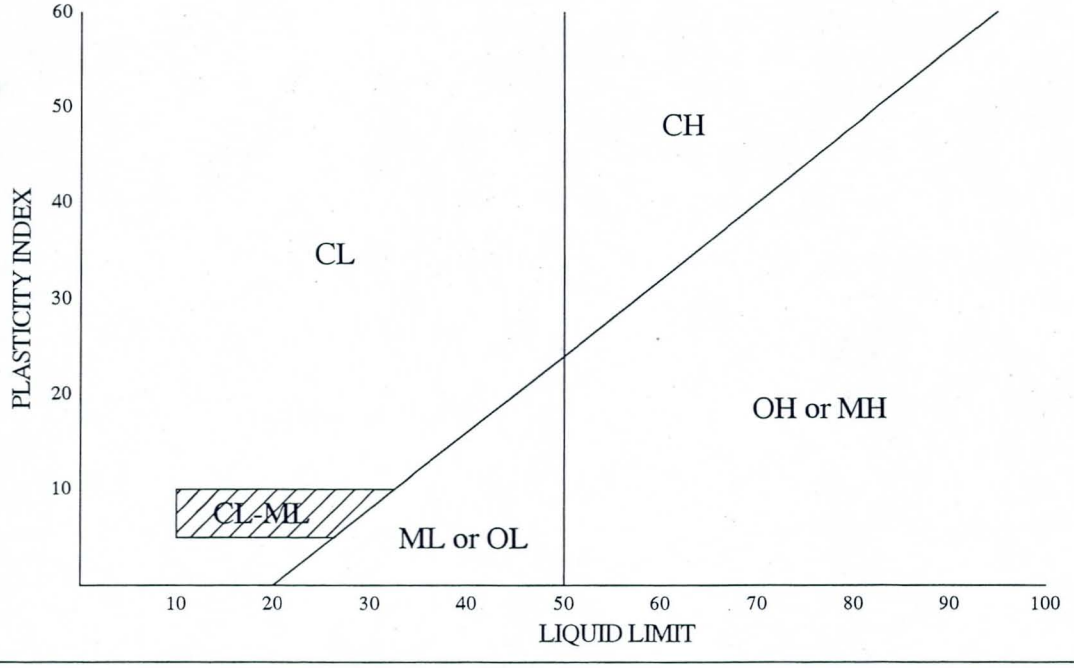
KEY
A-1

GEO-KEY_A1_SOIL 21517.GPJ cnewman@kleinfelder.com 01/30/2003

GRADATION CHART



PLASTICITY CHART



DEFINITIONS OF SOIL FRACTIONS

SOIL FRACTION	PARTICLE SIZE RANGE
Boulders	Greater than 300mm (12in.)
Cobbles	300mm to 75mm (12in. to 3in.)
Coarse Gravel	75mm to 19mm (3in. to 3/4in.)
Fine Gravel	19mm (3/4in.) to No. 4 sieve
Coarse Sand	No. 4 sieve to No. 10 sieve
Medium Sand	No. 10 sieve to No. 40 sieve
Fine Sand	No. 40 sieve to No. 200 sieve
Fines	less than No. 200 sieve

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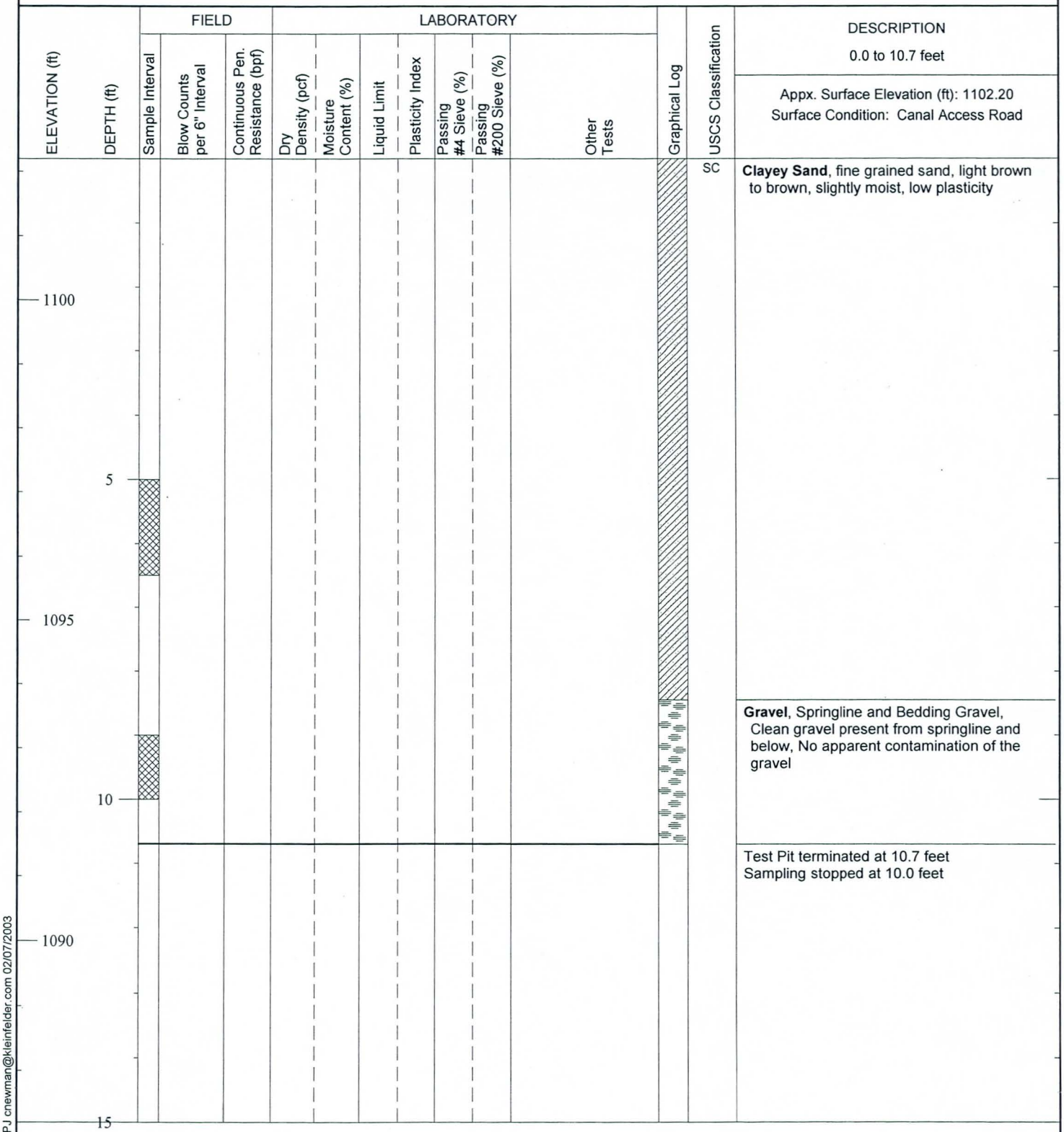
CHARTS & DEFINITIONS
Maryvale Storm Drain Testing - Phasell
Flood Control District of Maricopa County
Grand Canal at approximately 55th Drive
Maryvale, Arizona

KEY

A-3

GEO-KEY_A3_CHART 21517.GPJ cnewman@kleinfelder.com 01/30/2003

Station and Offset:				Date Started:	1/2/2003
Groundwater (ft):	No Free Groundwater Encountered			Date Completed:	1/2/2003
Drilling Company:	FCDMC	Equipment:	Backhoe	Logged By:	Tomas Sanchez
Hole Diameter (in):	N/A	Drilling Method:	N/A		
Hammer Type:	N/A			Total Depth (ft):	10.7



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Date: February, 2003	21517

LOG OF BORING STA 19+25
Maryvale Storm Drain Testing - Phase II
Flood Control District of Maricopa County
Grand Canal at approximately 55th Drive
Maryvale, Arizona

BORING
STA 19+25
Page 1 of 1

GEO_ADOT_EW/EL 21517.GPJ cnewman@kleinfelder.com 02/07/2003

Station and Offset:				Date Started:	12/30/2003
Groundwater (ft):	No Free Groundwater Encountered			Date Completed:	12/31/2003
Drilling Company:	FCDMC	Equipment:	Backhoe	Logged By:	Tomas Sanchez
Hole Diameter (in):	N/A	Drilling Method:	N/A		
Hammer Type:	N/A			Total Depth (ft):	11.7

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION
														0.0 to 11.7 feet
														Appx. Surface Elevation (ft): 1102.20 Surface Condition: Grass Area
													SC	**Clayey Sand**, fine grained sand, light brown to brown, dry to slightly moist, low plasticity
1100					107	14.9								
	5													
1095									17	13				
	10													**Gravel**, Springline and Bedding Gravel, Clean gravel present from springline and below, No apparent contamination of the gravel
1090														Test Pit terminated at 11.7 feet Sampling stopped at 10.2 feet
	15													

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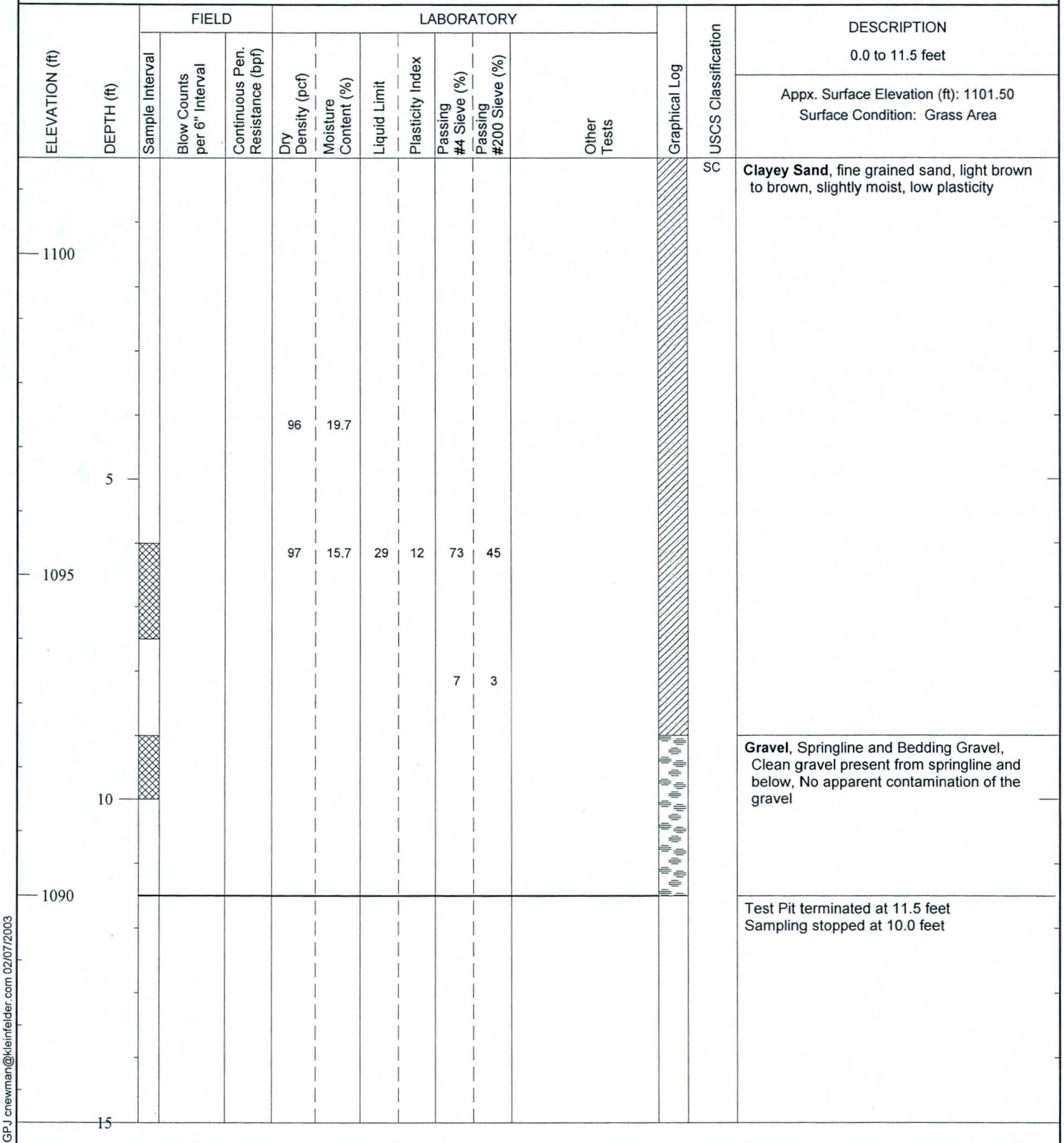
LOG OF BORING STA 22+00
Maryvale Storm Drain Testing - Phase II
Flood Control District of Maricopa County
Grand Canal at approximately 55th Drive
Maryvale, Arizona

BORING
STA 22+00
Page 1 of 1

Station and Offset:				Date Started:	12/30/2003
Groundwater (ft):	No Free Groundwater Encountered			Date Completed:	12/31/2003
Drilling Company:	FCDMC	Equipment:	Backhoe	Logged By:	Tomas Sanchez
Hole Diameter (in):	N/A	Drilling Method:	N/A		
Hammer Type:	N/A			Total Depth (ft):	11.5



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LOG OF BORING STA 24+50
Maryvale Storm Drain Testing - Phase II
Flood Control District of Maricopa County
Grand Canal at approximately 55th Drive
Maryvale, Arizona

BORING
STA 24+50
Page 1 of 1

GEO_ADOT_EW/EL 21517.GPJ cnewman@kleinfelder.com 02/07/2003

Station and Offset:				Date Started:	12/30/2003
Groundwater (ft):	No Free Groundwater Encountered			Date Completed:	12/31/2003
Drilling Company:	FCDMC	Equipment:	Backhoe	Logged By:	Tomas Sanchez
Hole Diameter (in):	N/A	Drilling Method:	N/A		
Hammer Type:	N/A			Total Depth (ft):	12.0

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION
														0.0 to 12.0 feet Appx. Surface Elevation (ft): 1101.75 Surface Condition: Grass Area
					110	20.3							CL	**Sandy Clay**, fine grained sand, light brown to brown, slightly moist to moist, low plasticity
1100														
	5				101	20.3	28	9	97	82				
1095														
									16	12				
	10													**Gravel**, Springline and Bedding Gravel, Gravel contaminated by fine-grained soils was present from springline and below
1090														Test Pit terminated at 12.0 feet Sampling stopped at 10.4 feet
	15													

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Date: February, 2003	21517

LOG OF BORING STA 27+00
Maryvale Storm Drain Testing - Phase II
Flood Control District of Maricopa County
Grand Canal at approximately 55th Drive
Maryvale, Arizona

BORING
STA 27+00
Page 1 of 1

GEO_ADOT_EW/EL 21517.GPJ cnewman@kleinfelder.com 02/07/2003

LABORATORY RESULTS

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PROJECT: MARICOPA FLOOD CONTROL
LOCATION: 55TH AVENUE & OSBORN AVE., PHOENIX, AZ
REVIEWED BY: M. CONNOLLY

PROJECT NO: 21517
WORK ORDER NO: 03003
DATE SAMPLED: 12/30/02

MECHANICAL SIEVE ANALYSIS
GROUP SYMBOL, USCS (ASTM D-2487)

SIEVE SIZES

					COBBLES		GRAVEL								SAND								Silt or Clay	
							Coarse				Fine				Coarse		Medium			Fine				
Location & Depth	USCS	LL	PL	PI	6"	4"	3"	2"	1 1/2"	1"	3/4"	1/2"	3/8"	1/4"	#4	#8	#10	#16	#30	#40	#50	#100	#200	Lab #

PERCENT PASSING BY WEIGHT

TEST PIT B, BACKFILL 6'	SC	29	17	12	100	100	100	100	100	100	99	96	91	80	73	71	70	67	63	60	56	50	45	3
TEST PIT A, BACKFILL 5'	CL	28	19	9	100	100	100	100	100	100	100	98	97	97	97	97	96	96	96	95	94	90	82	5
TEST PIT B, SPRINGLINE GRAVEL	N/A	NT*	NT*	NT*	100	100	100	100	100	100	98	35	11	7	7	6	6	6	5	4	4	3	3	6
TEST PIT A, SPRINGLINE BEDDING GRAVEL	N/A	NT*	NT*	NT*	100	100	100	100	100	100	99	23	19	16	16	15	14	14	14	14	14	13	12	7
TEST PIT C, SPRINGLINE BEDDING GRAVEL	N/A	NT*	NT*	NT*	100	100	100	100	100	100	99	23	20	18	17	17	16	16	16	16	15	14	13	8

*NT = NOT TESTED

1335 WEST AUTO DRIVE, TEMPE, ARIZONA PHONE: (480) 763-1200 FAX: (480) 763-1212
ISSUED: 01/30/03

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PROJECT:	MARICOPA FLOOD CONTROL	**PROJECT NO:**	21517.00
LOCATION:	55TH AVENUE & OSBORN AVENUE, PHOENIX, AZ	**WORK ORDER NO:**	03003
MATERIAL:	CL	**LAB NO:**	5
SAMPLE SOURCE:	TEST PIT A, BACKFILL 5'	**DATE SAMPLED:**	12/30/02
		REVIEWED BY:	M. CONNOLLY

PARTICLE-SIZE ANALYSIS OF SOILS (ASTM D422)

WEIGHT OF SAMPLE DISPERSED	49.81	SPECIFIC GRAVITY OF SOILS	2.74
PERCENT PASSING #10 SIEVE	96.44		

HYDROMETER RESULTS (% PASSING)

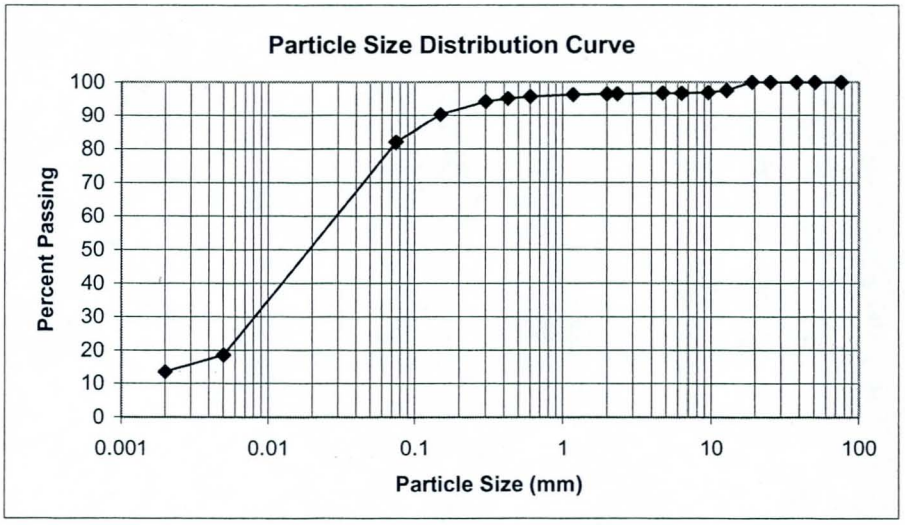
PARTICLE SIZE (DIA. mm)	0.0700	0.0503	0.0335	0.0203	0.0147	0.0105	0.0022	0.0016
PERCENT SAMPLE TESTED	70.3	66.4	52.6	38.8	32.9	27.9	15.0	12.2
PERCENT TOTAL SAMPLE	67.8	64.0	50.7	37.4	31.7	26.9	14.4	11.7

FULL SIEVE ANALYSIS
MECHANICAL SIEVE & HYDROMETER
(% PASSING)

3 IN	100
2 IN	100
1 1/2 IN	100
1 IN	100
3/4 IN	100
1/2 IN	98
3/8 IN	97
1/4 IN	97
# 4	97
# 8	97
# 10	96
# 16	96
# 30	96
# 40	95
# 50	94
# 100	90
# 200	82
0.005 mm	19
0.002 mm	13

MECHANICAL SIEVE ANALYSIS AFTER HYDROMETER (% PASSING)

#200	#100	#50	#40	#30	#16	#10
83	91	95	95	96	96	96



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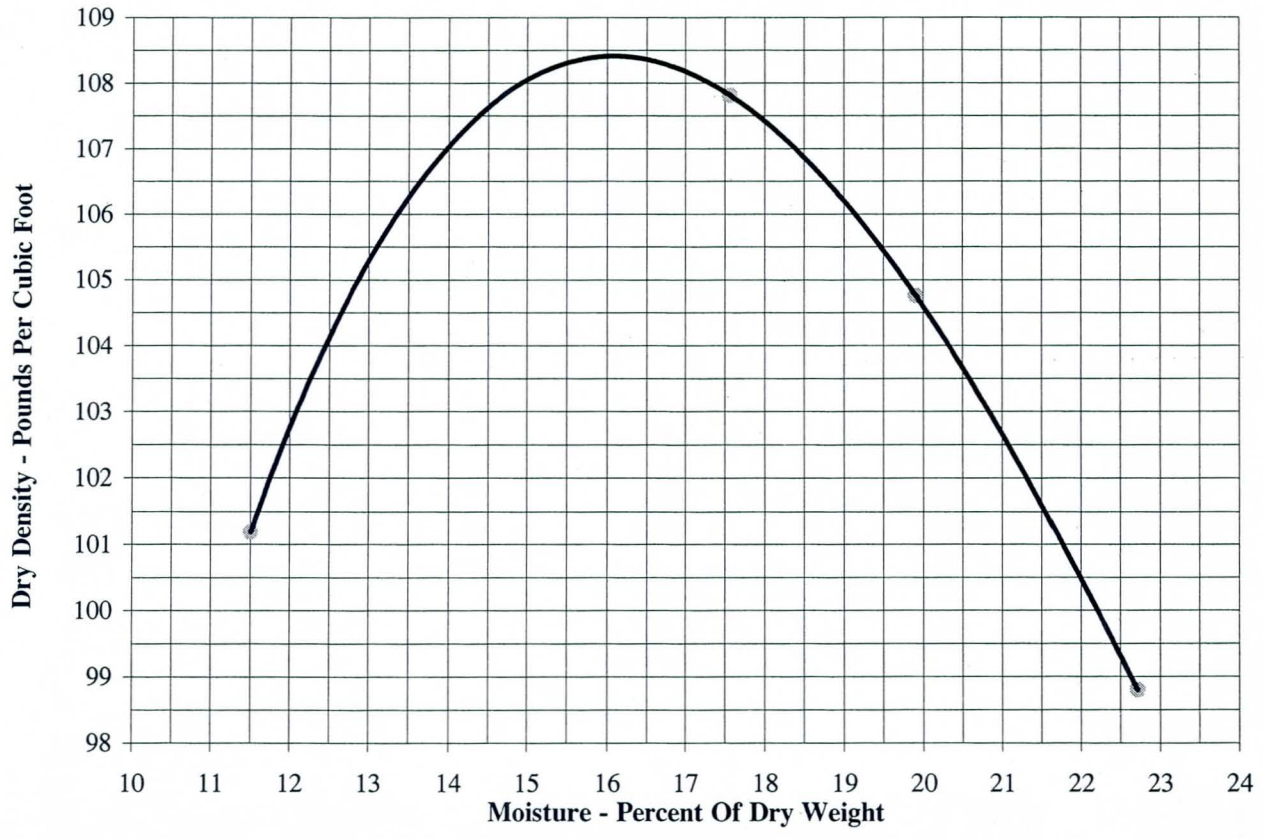
COMPACTION CURVE

CLIENT:	MARICOPA COUNTY	KLEINFELDER JOB #:	21517
PROJECT:	MARICOPA FLOOD CONTROL	KLEINFELDER LAB#:	03003-3
LOCATION:	55TH AVENUE & OSBORN	DATE RECEIVED:	12/30/02
MATERIAL:	SC		
SAMPLE SOURCE:	TEST PIT B, BACKFILL 6'		
SAMPLED BY:	T. SANCHEZ	TEST DATE:	01/22/03
SAMPLE DATE:	12/30/02	TESTED BY:	W. ASKEW
SUBMITTED BY:	C. REYNOLDS	CHECKED BY:	M. CONNOLLY

Method: ASTM D698 A

Weight of mold + soil	6105.6	6088.5	6022.3	5895.2		
Weight of mold	4189.3	4189.3	4189.3	4189.3		
Factor	0.06614	0.06614	0.06614	0.06614		
Wet Density pcf	126.7	125.6	121.2	112.8		
Water added (ml)						
Wet soil + tare	574.5	604.8	375.0	567.1		
Dry soil + tare	488.7	504.4	305.6	508.6		
Tare	0.0	0.0	0.0	0.0		
Moisture content %	17.6	19.9	22.7	11.5		
Dry Density	107.8	104.8	98.8	101.2		

Maximum Dry Density (pcf): 108.4 (kg/m^3): 1736.4
Optimum Moist. Cont. (%): 16.1



SITE PHOTOGRAPHS

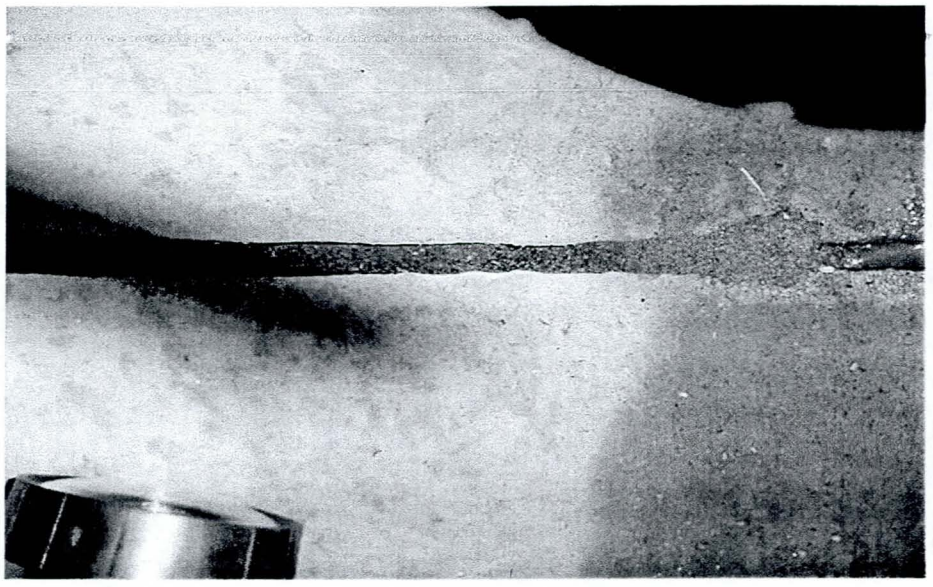


Photo 1. Typical sediment at ungrouted pipe joint.

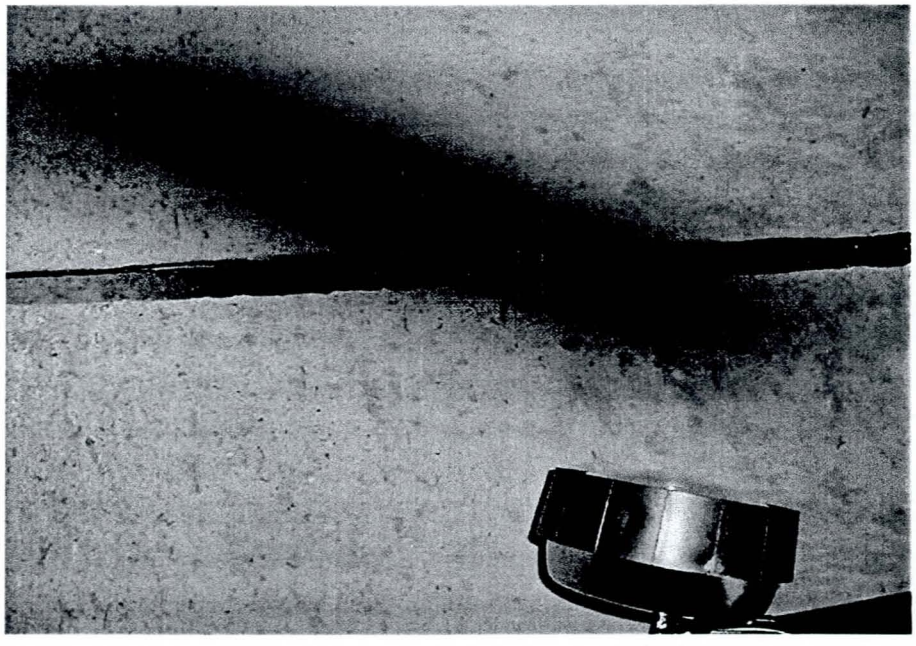


Photo 2. Minor sediment in ungrouted pipe joint.

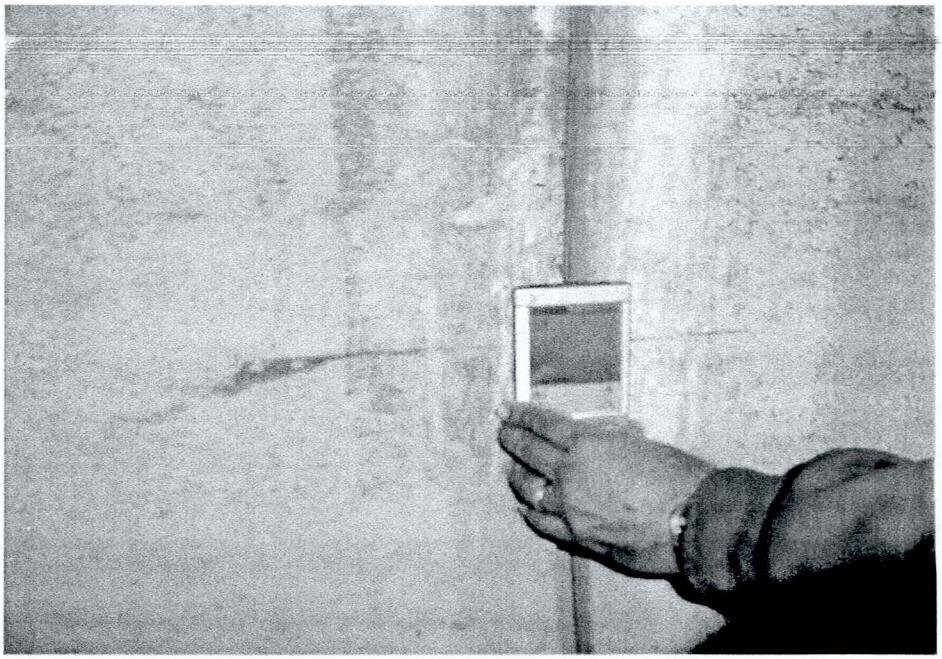


Photo 3. Ungrouted pipe point open to maximum width.

Photo 4. Gravel bedding beneath pipe at approximate Sta. 27+00

Photo 5. Gravel at springline contaminated by fine-grained soil.

Photo 6. Gravel at springline with overlying sand at Sta. 24+50.

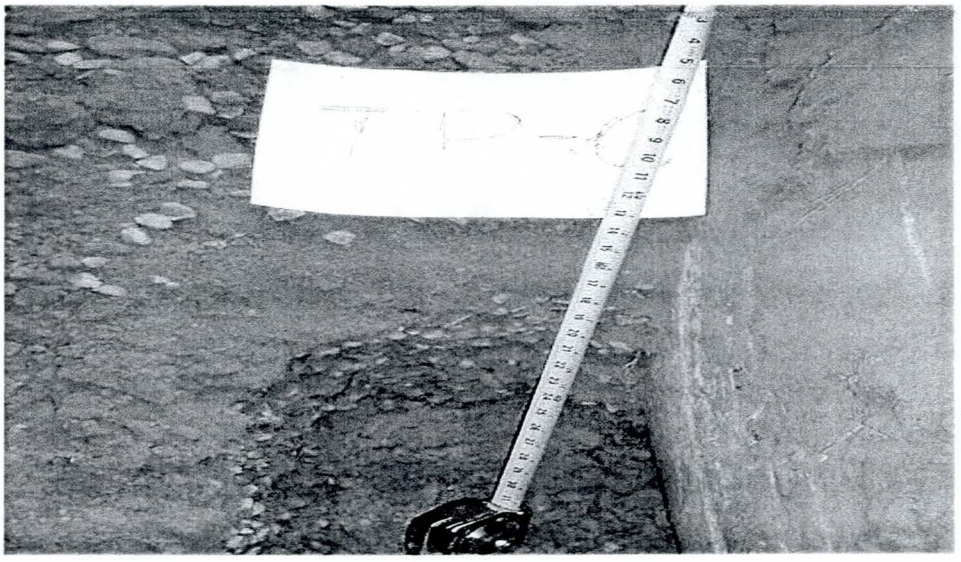


Photo 7. Gravel at springline near Sta. 22+00.

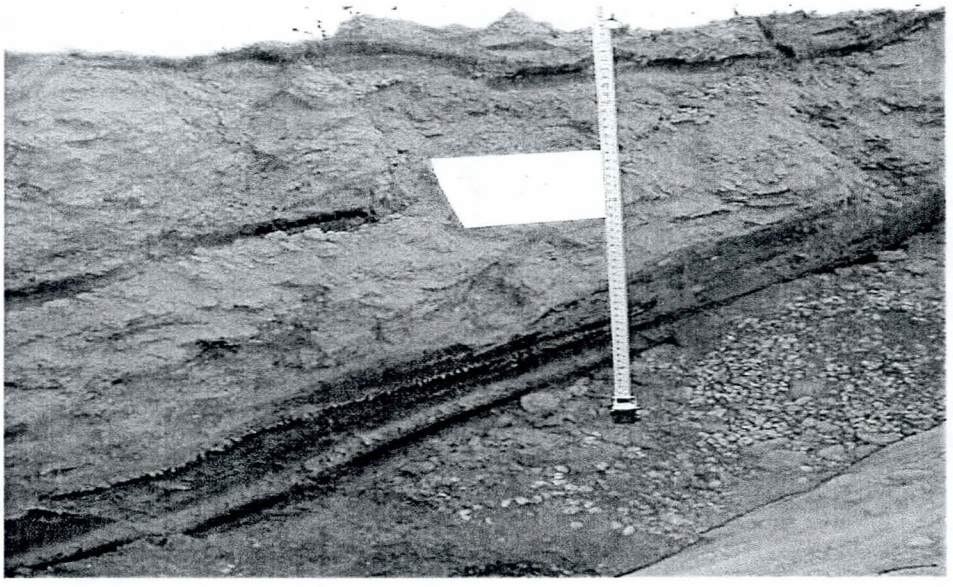
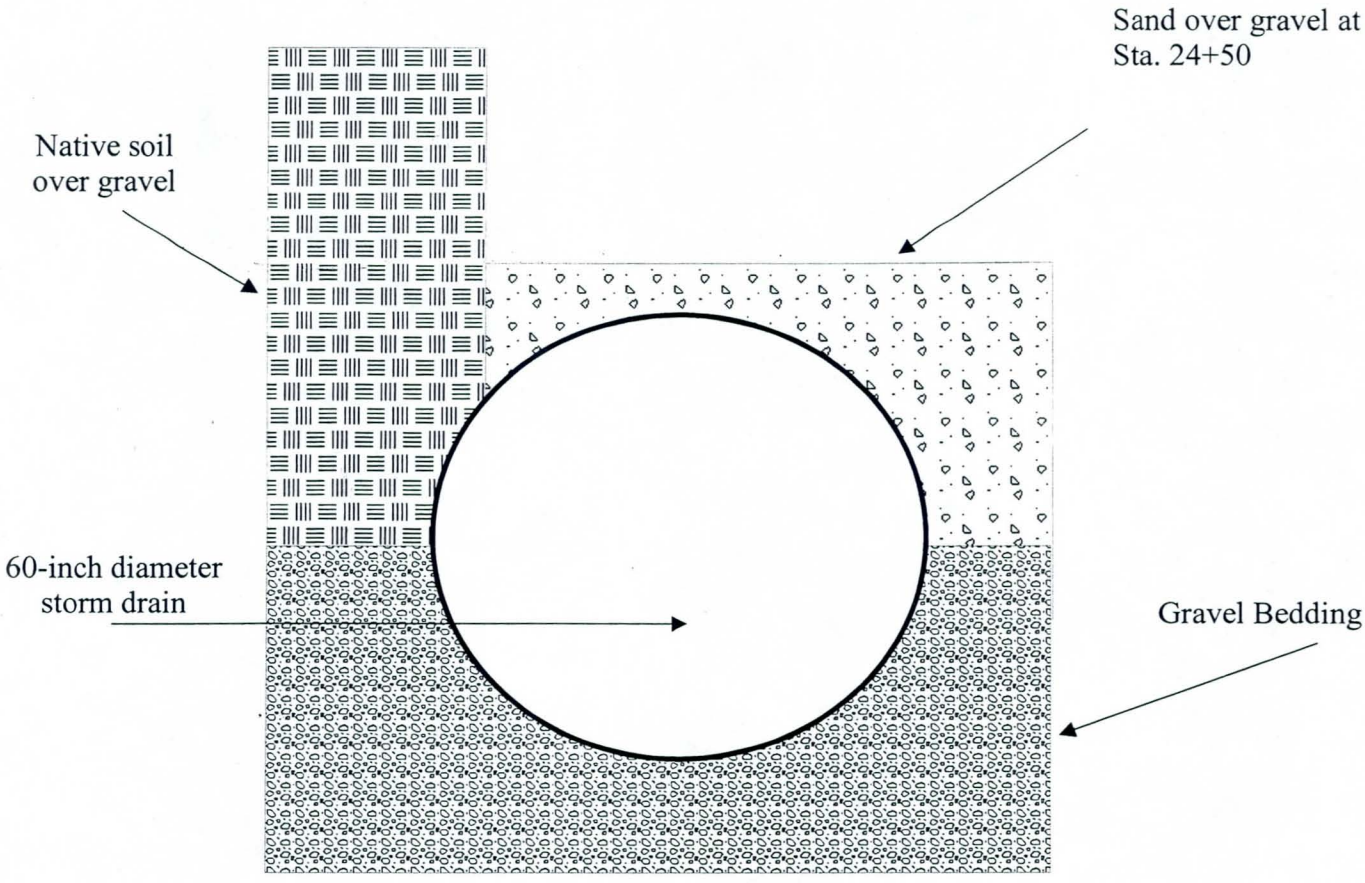


Photo 8. Typical condition of backfill above gravel.

AS-BUILT PIPE CONFIGURATION



Typical As-Built Backfill
Configuration
Sta. 19+25 to 28+00
Maryvale Storm Drain

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Project Number 21517 January 2003

Maryvale Storm Drain
Grand Canal at approximately 55th Drive
Maryvale, Arizona

As-Built Backfill **CONFIGURATION**

PLATE
B