PAVEMENT DESIGN REPORT

March 24, 2025

Attention: Greg Vega, P.E.

Dibble
177 N. Church Ave
Tucson, Arizona 85701
Greg.Vega@dibblecorp.com
(520) 495-4065

Subject: Pavement Design
Butterfield Elementary Fire Lane Improvements
3400 W. Massingale Rd.
Marana, Arizona
SAECO Project No. 29.25.2601, Revision 0

Smith & Annala Engineering Co. (SAECO) is providing this memorandum at the request of Mr. Greg Vega, P.E., in accordance with our proposal dated August 27, 2024 (SAECO Proposal Number PG29.24.122, Rev. 0). We understand a new hammerhead turnaround and ADA improvements are to be constructed to improve the existing fire lane to the east of Butterfield Elementary School.

SCOPE OF WORK

Our field investigation was performed on February 26, 2025, after notifying Arizona 811. Soil borings were extended using a Central Mine Equipment, Model CME-55 truck mounted drill-rig utilizing a 8-inch (OD) diameter hollow-stem auger operated by Southlands Engineering. The borings extended approximately to 5 feet below the current pavement surface. Driven samples were collected at 5 feet below ground surface in each boring, and bulk samples were collected from auger cuttings. Upon completion, the borings were backfilled with cuttings derived from auger advancement, and asphalt surfaces were repaired using cold-patch asphalt mix.

During the field investigation a representative from SAECO:

- Noted the current site conditions from cursory observations
- Sited the explorations in the field by estimating bearings and distances from site features shown on aerial photographs
- Directed the exploration subcontractor with respect to total depth of exploration and the type and depth of the sampling performed
- Visually classified the subsurface materials exposed during the advancement of the explorations in general accordance with ASTM D2487 (Visual Manual Procedure) with some modifications from SAECO

- Created a log of the explorations, including subsurface materials encountered, results of field testing performed, and a record of any samples collected
- Appropriately labeled and packaged the samples collected for transport to the SAECO laboratory

After completion of the field investigation, SAECO representatives:

- Performed laboratory testing on selected samples obtained from the exploratory borings. The details of the laboratory testing and the results are attached to this letter.
- Performed an analysis of the subgrade soils and prepared pavement section recommendations
- Provided geotechnical construction recommendations for the project

FINDINGS

- **Site Conditions**

  The project site is an asphalt surfaced fire lane located immediately to the east and south of the Butterfield Elementary School building. East of the fire lane is a fenced area containing grass fields and play equipment for the school. The fire lane is accessed through a gate to the south of the school building. The roadway is generally flat and sits slightly above the fields to the east. Site elevation is approximately 2,280 feet above mean sea level based on publicly available topographic data.

- **Pavement Condition**

  The pavement surface at the site appears to be in fair condition. It shows signs of aging including minor block cracking and some weathering/raveling.

  Based on boring observations, the pavement section is composed of approximately 2 inches of asphalt supported on native soils.

- **Subgrade Soils**

  Subgrade soils encountered below the pavement generally consist of silty sand with trace amounts of gravel. The material is generally moist, brown to dark brown in color, is loose in relative density, and is non-plastic.

PAVEMENT RECOMMENDATIONS

Pavement was designed with reference to the following standards and documents:

- Arizona Department of Transportation (ADOT) *Pavement Design Manual* (2017)
- Pima County *Roadway Design Manual* (2014 with 2016 Update)
- AASHTO *Design of Pavement Structures* (1993)

A summary of the design parameters and recommended flexible pavement section are included in Appendix D of the report.

- **Traffic Loading**

To account for the existing use as a fire lane and proposed occasional use of the turnaround by heavy trucks and equipment, we have assumed for conservatism that design traffic loading will not exceed 100,000 ESALs.

- **Reliability, Variability, and Serviceability**

The level of reliability and standard error for the project were 75% and 0.674 respectively.

The change in serviceability was 3.0, and the maximum allowable rutting for unbound pavement design was 2.0 inches.

- **Subgrade Support**

SAECO collected soil samples from three locations at the site and used sieve and plasticity index testing to determine the correlated R-value. The design R-Value determined is 53.

The design R-Value was then used to determine the subgrade resilient modulus using the ADOT methodology and included a seasonal variation factor (SVF) to account for local climate conditions for Tucson, per ADOT the SVF of Tucson is 1.7. The design resilient modulus for the site is 24,828 psi.

- **Pavement Section Alternatives**

The design structural number (SN) was calculated from the governing equation provided in the ADOT Preliminary Design Manual.

Unbound pavement was designed using the graphical methodology described in AASHTO Design of Pavement Structures.

Using a layered analysis with the following material layer coefficients (as prescribed in the Pima County Roadway Design Manual) we determined the Flexible pavement section below:

Material	Layer Coefficient	Drainage Coefficient	USC
Asphalt Concrete (AC)	0.44	--	--
Aggregate Base Course (ABC)	0.12	0.92	--

Alternative	Asphalt Concrete (inches)	Aggregate Base Course (inches)	Cement Treated Subgrade (inches)	Section SN	Total Section (inches)
A	2.0	4.0	--	1.29	6.0
B	--	10.0	--	--	10.0

The asphalt materials and mix design should conform to PAG 406. It is recommended that asphalt mix designation No. 2 or No. 3 be used for pavements. While the No. 2 mix has a somewhat rougher texture, it offers more stability. Pavement construction and lift thicknesses should be performed in accordance with applicable portions of PAG Section 406.

CONSTRUCTION RECOMMENDATIONS

The area covered by these recommendations should include a construction envelope that extends over the entire limits of the area to be paved.

1. We believe the existing section to be suitable for re-use, although no aggregate base was observed under the existing asphalt, as existing observed distresses can be attributed to exposure. Any cracks should be sealed and pavement surface sealcoated as a part of the reconditioning to ensure continued performance.

2. Any new areas of asphalt pavement should be constructed according to Alternative A above.

3. Areas where new pavement is to be constructed should be completely cleared of vegetation (including roots). Any debris and other deleterious materials should be excavated and disposed of off-site at a legal dumpsite. If any new fills are required, all areas should be observed by a representative of the geotechnical engineer for evidence of any remaining undesirable materials prior to placing new fills.

4. If unbound pavement is to be used for the construction of the new turnaround, raised on at-grade curbs should be constructed to constrain the pavement section.

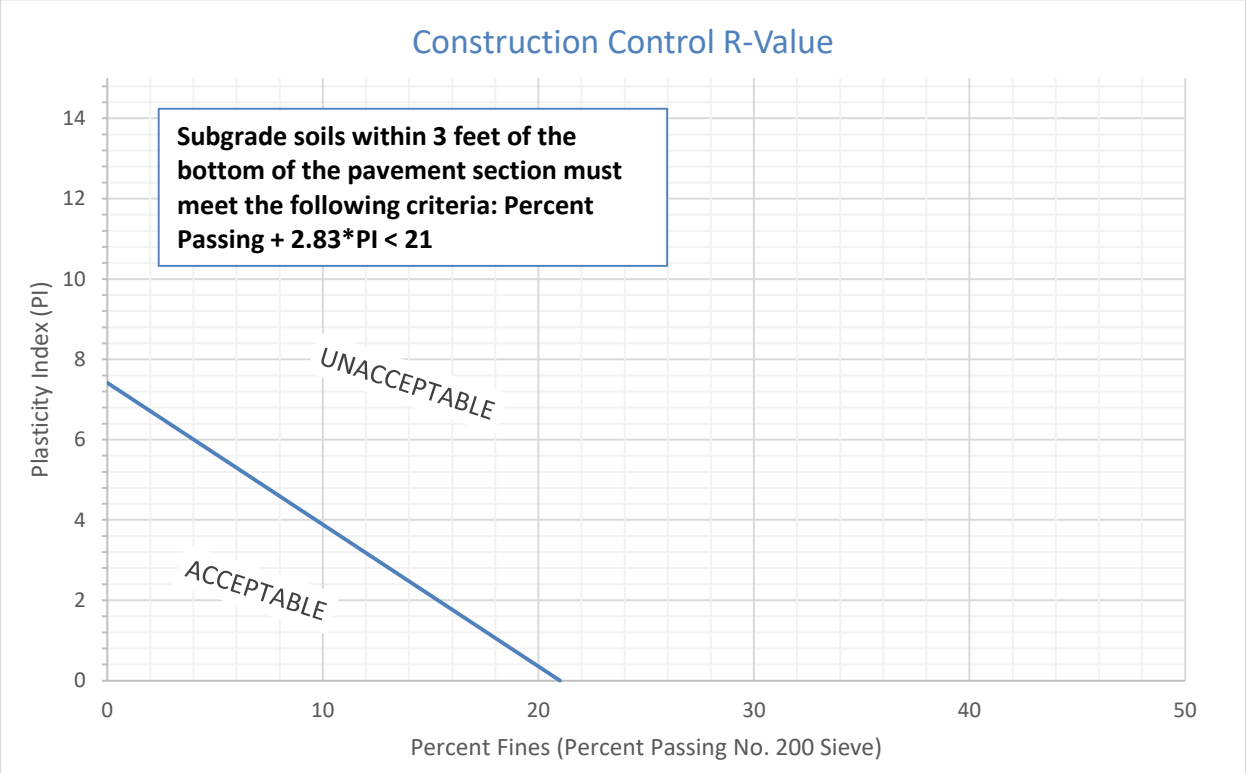
5. Prepare the ground surface in pavement areas by scarifying the subgrade soils to a depth of 10 inches, moisture-conditioning, and compacting.

6. Subgrade soils should be compacted to 95% of standard Proctor MDD, and aggregate base should be compacted to 100% of standard Proctor MDD. Recommended moisture content range is OMC -3% to OMC +3%

7. We recommend site grading be constructed to provide positive drainage off the pavement surface and prevent water from ponding.

MATERIALS

- **Subgrade Soils:**
  If needed, imported soils within 3 feet of the pavement surface should conform to the requirements of the following chart:



- **Aggregate Base Course**
  Aggregate base course should conform to PAG 303.

- **Asphalt Concrete**
  The asphalt concrete materials and mix design should conform to PAG 406. It is recommended that asphalt mix designation No. 2 or No. 3 be used for pavements. While the No. 2 mix has a somewhat rougher texture, it offers more stability. Pavement construction and lift thicknesses should be performed in accordance with applicable portions of PAG Section 406.

PAVEMENT DESIGN LIFE & MAINTENANCE CONSIDERATIONS

A 20-year design life was used for this pavement design, but the owner should recognize that routine maintenance, such as periodic crack sealing and surface treatments, will be required during this design

period. Even with regular maintenance major rehabilitation of the pavement surface will likely be required before 20 years due to climatic effects and normal deterioration from use. It is typical that most pavements will require substantial maintenance before reaching half of the analysis design life. The pavements will require periodic maintenance where proper drainage is provided and maintained, and seal coats, overlays, or patching are regularly applied. Should moisture penetrate to the subgrade soils or ponding occur on or adjacent to the pavement section, a significant reduction in pavement life could occur along with the need for increased maintenance; therefore, good surface drainage is essential to achieving the desired pavement life.

We recommend an initial fog seal be performed between 1 and 2 years after the completion of paving. The coating seals surface-voids and reduces the infiltration of air and water. Fog sealing should not be performed on asphalt less than 1 year after construction.

We also recommend the following maintenance activities be undertaken regularly to prolong the service life of the new pavement:

Maintenance Activity	Frequency	Comments
Fog Sealing	Every 3-5 Years	After initial fog seal
Crack Sealing	Every 2-3 Years	--
Pavement Condition Assessment	Every 2-3 Years	To be performed by a qualified professional.

LIMITATIONS

Some variations in the soil and existing asphalt conditions are anticipated between the points explored. The nature and extent of variations may not be evident until construction occurs. If any conditions are encountered at this site that are different from those described in this report, our firm should be immediately notified so that we may make any necessary revisions to the recommendations contained in this report. In addition, if the scope of the proposed construction changes from that described in this report, our firm should also be notified.

The exploration, laboratory testing, and geotechnical analyses presented in this geotechnical report have been conducted in general accordance with current practice and the standard of care exercised by geotechnical consultants performing similar tasks in the project area. No warranty, expressed or implied, is made regarding the conclusions, recommendations, and opinions presented in this report.

This report may be used only by the client and only for the purposes stated within a reasonable time from its issuance, but in no event later than one year from the date of the report. Land or facility use, on and off-site conditions, regulations, or other factors may change over time, and additional work may be required with the passage of time. Similarly, future irrigation, broken water or sewer pipelines, or other

factors may adversely influence the project. Any party other than the client who wishes to use this report shall notify SAECO of such intended use. SAECO may require that additional work be performed and that an updated report be issued. Non-compliance with any of these requirements by the client or anyone else will release SAECO from any liability resulting from the use of this report by any unauthorized party and client agrees to defend, indemnify, and hold harmless SAECO from any claim or liability associated with such unauthorized use or non-compliance.

We appreciate the opportunity to be of service to you during this phase of the project.

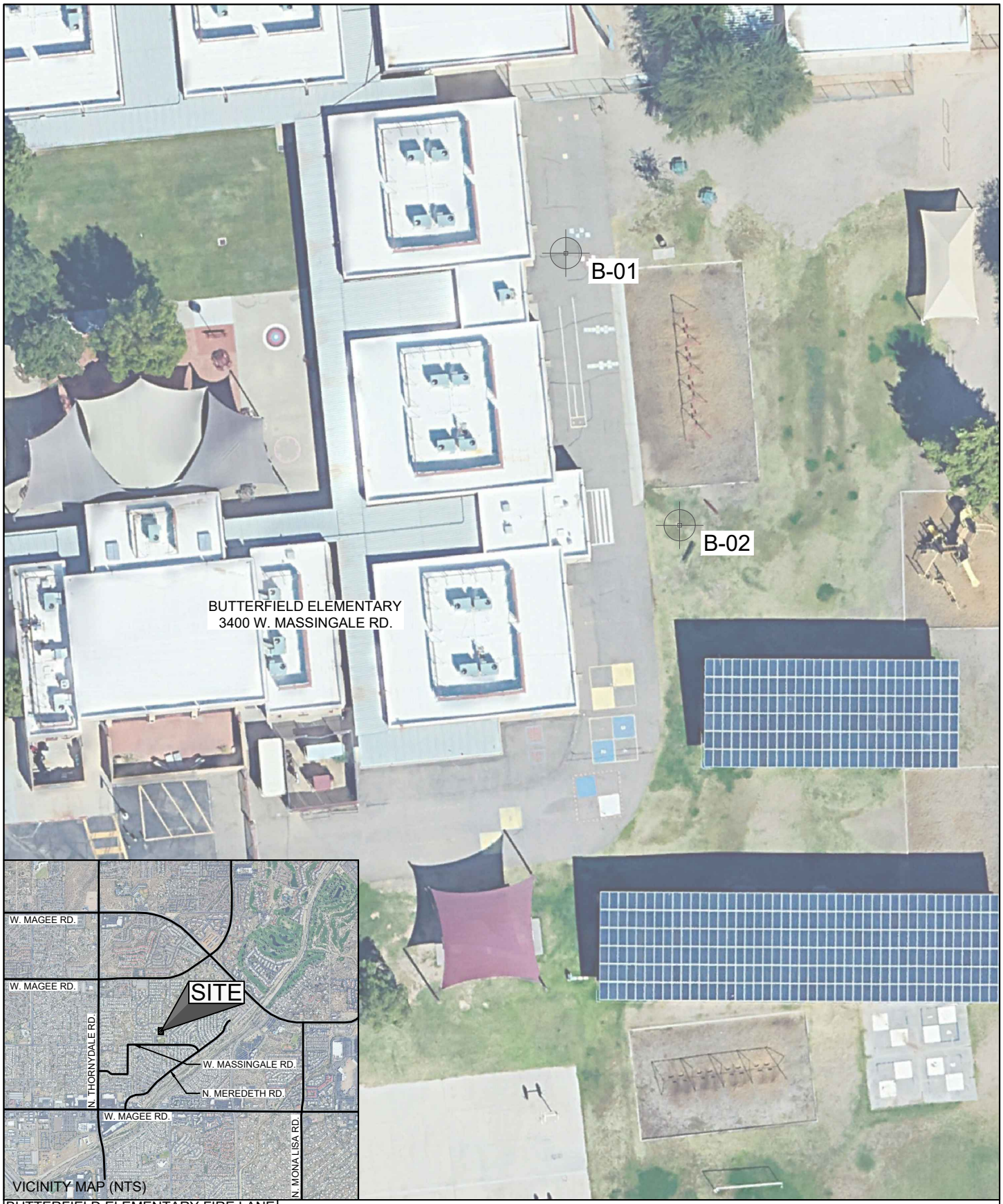
Sincerely,
SMITH & ANNALA ENGINEERING CO.

Aaron J. Spreiser, E.I.T.
Staff Professional

Jonathan K. Alexander, P.E.
Principal

Attachments: Exploration Map
Log of Borings
Lab Test Reports
Pavement Design Worksheets

Distribution: (1) Addressee (via e-mail)



BUTTERFIELD ELEMENTARY FIRE LANE
& ADA IMPROVEMENTS
3400 W. MASSINGALE RD.
MARANA, ARIZONA

DRAWN BY:	CHECKED BY:	PROJECT NUMBER:
AJS	JKA	29.25.2601

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GEOTECHNICAL ENGINEERING • CONSTRUCTION QA/QC • ENVIRONMENTAL SERVICES

MAP KEY
APPROXIMATE BORING LOCATION

0 INCHES 1
0 FEET 50

N

CLIENT:	DATE:	SCALE:	FIGURE TITLE:	FIGURE NO.:
CLIENT	3/20/2025	1" = 50'	EXPLORATION MAP	A-1

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KEY TO SYMBOLS

Client: Dibble

Project Name: Butterfield Elementary Fire Lane and ADA

Project Number: 29.25.2601

Project Location: Marana, Arizona

LITHOLOGIC SYMBOLS
(Unified Soil Classification System)

ASPHALT: Asphalt

SM: USCS Silty Sand

SAMPLER SYMBOLS

Bulk Sample

Split-barrel ring-lined sampler, 2.4-inch I.D.

WELL CONSTRUCTION SYMBOLS

ABBREVIATIONS

LL - LIQUID LIMIT (%)
PI - PLASTIC INDEX (%)
W - MOISTURE CONTENT (%)
DD - DRY DENSITY (PCF)
NP - NON PLASTIC
-200 - PERCENT PASSING NO. 200 SIEVE
PP - POCKET PENETROMETER (TSF)
TV - TORVANE
PID - PHOTOIONIZATION DETECTOR
UC - UNCONFINED COMPRESSION
ppm - PARTS PER MILLION
Water Level at Time Drilling, or as Shown
Water Level at End of Drilling, or as Shown
Water Level After 24 Hours, or as Shown

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KEY TO SOIL SYMBOLS AND TERMS

Client: Dibble

Project Name: Butterfield Elementary Fire Lane and ADA

Project Number: 29.25.2601

Project Location: Marana, Arizona

UNIFIED SOIL CLASSIFICATION (ASTM D-2487)

MATERIAL TYPES	CRITERIA FOR ASSIGNING SOIL GROUP NAMES			GROUP SYMBOL	SOIL GROUP NAMES & LEGEND
COARSE-GRAINED SOILS >50% RETAINED ON NO. 200 SIEVE	GRAVELS >50% OF COARSE FRACTION RETAINED ON NO 4. SIEVE	CLEAN GRAVELS <5% FINES	C_u >= 4 AND 1 <= C_c <= 3	GW	WELL-GRADED GRAVEL
			C_u < 4 AND/OR 1 > C_c > 3	GP	POORLY-GRADED GRAVEL
		GRAVELS WITH FINES >12% FINES	FINES CLASSIFY AS ML OR CL	GM	SILTY GRAVEL
			FINES CLASSIFY AS CL OR CH	GC	CLAYEY GRAVEL
	SANDS >50% OF COARSE FRACTION PASSES ON NO 4. SIEVE	CLEAN SANDS <5% FINES	C_u >= 6 AND 1 <= C_c <= 3	SW	WELL-GRADED SAND
			C_u < 6 AND/OR 1 > C_c > 3	SP	POORLY-GRADED SAND
		SANDS AND FINES >12% FINES	FINES CLASSIFY AS ML OR MH	SM	SILTY SAND
			FINES CLASSIFY AS CL OR CH	SC	CLAYEY SAND
FINE-GRAINED SOILS >50% PASSES NO. 200 SIEVE	SILTS AND CLAYS LIQUID LIMIT<50	INORGANIC	PI>7 AND PLOTS>"A" LINE	CL	LEAN CLAY
			PI>4 AND PLOTS<"A" LINE	ML	SILT
		ORGANIC	LL (oven dried)/LL (not dried)<0.75	OL	ORGANIC CLAY OR SILT
	SILTS AND CLAYS LIQUID LIMIT>50	INORGANIC	PI PLOTS >"A" LINE	CH	FAT CLAY
			PI PLOTS <"A" LINE	MH	ELASTIC SILT
		ORGANIC	LL (oven dried)/LL (not dried)<0.75	OH	ORGANIC CLAY OR SILT
HIGHLY ORGANIC SOILS		PRIMARILY ORGANIC MATTER, DARK IN COLOR, AND ORGANIC ODOR		PT	PEAT

PARTICLE SIZE DEFINITION FOR SANDS AND GRAVELS

SOIL FRACTION	GRAIN SIZE
Boulders	12 inches +
Cobbles	12 inches to 3 inches
Gravel	
Coarse	3 inches to 3/4 inches
Fine	3/4 inches to #4 Sieve
Sand	
Coarse	#4 to #10 Sieve
Medium	#10 to #40 Sieve
Fine	#40 to #200 Sieve

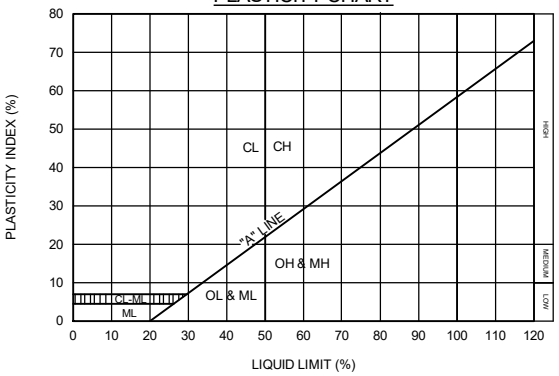
SAMPLE TYPES

- SPT - Standard Penetration Test
- RING - Ring-lined Sampler
- BULK - Bulk Sample
- UD - Undisturbed Sample
- RC - Rock Core, HQ3 Core Barrel
- DCP - Dynamic Cone Penetrometer (Blows/1.75")

OTHER TESTS OR COMMENTS

- (NR) - NO RECOVERY
- CN - CONSOLIDATION
- DS - DIRECT SHEAR
- SW - SWELL
- UC - UNCONFINED COMPRESSION
- RV - R-VALUE
- CBR - CALIFORNIA BEARING RATIO
- EI - EXPANSION INDEX
- PP - POCKET PENETROMETER (TSF)
- pH - pH OF SOIL
- RES - MINIMUM ELECTRICAL RESISTIVITY
- CHLOR - CHORIDE CONTENT
- SULF - SULFATE CONTENT
- THRM - THERMAL RESISTIVITY
- HSA - HOLLOW STEM AUGER
- REC - SAMPLE RECOVERY (%)
- RQD - ROCK QUALITY DESIGNATION

PLASTICITY CHART



CONSISTENCY / RELATIVE DENSITY DEFINITIONS

PENETRATION RESISTANCE (RECORDED AS BLOWS / FT)				
SAND & GRAVEL		COHESIVE SOILS		
RELATIVE DENSITY	N-VALUE BLOWS/FOOT*	CONSISTENCY	N-VALUE BLOWS/FOOT*	UNCONFINED COMPRESSIVE STRENGTH (TSF) **
VERY LOOSE	0 - 4	VERY SOFT	0 - 2	0 - 0.25
LOOSE	4 - 10	SOFT	2 - 4	0.25 - 0.50
MEDIUM DENSE	10 - 30	FIRM	4 - 8	0.50 - 1.0
DENSE	30 - 50	STIFF	8 - 15	1.0 - 2.0
VERY DENSE	OVER 50	VERY STIFF	15 - 30	2.0 - 4.0
		HARD	OVER 30	OVER 4.0

* NUMBER OF BLOWS OF 140 LB HAMMER FALLING 30 INCHES TO DRIVE A 2 INCH O.D. (1-3/8 INCH I.D.) SPLIT-BARREL SAMPLER THE LAST 12 INCHES OF AN 18-INCH DRIVE (ASTM-1586 STANDARD PENETRATION TEST).

** VERY APPROXIMATE

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BORING NUMBER B-01

Client: Dibble
Project Name: Butterfield Elementary Fire Lane and ADA
Project Number: 29.25.2601
Project Location: Marana, Arizona
Date Started: 2/26/25 Completed: 2/26/25
Ground Elevation: Not Determined Hole Size: 8 inches
Drilling Contractor: Southlands
Ground Water Levels:
Drilling Method: CME-55/Hollow Stem Auger
At time of Drilling: Not Encountered
Logged By: AJS Checked By: JKA
At end of Drilling: Not Encountered
Notes:
After Drilling: Not Encountered

Elevation (ft)	Depth (ft)	Bullnose Pen. (blows / ft)	Sample type/Interval	Blows per 6 in.	N-value (blows / ft)	Dry Unit Wt. (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing No. 4 Sieve (%)	Passing No. 200 Sieve (%)	Other Tests or Comments	Graphic Log	USCS Classification	MATERIAL DESCRIPTION
														SM	2" Asphalt Concrete, poor to fair condition
															SILTY SAND, brown, moist, loose, non plastic
								NP	NP	94	24				
	5			3 4	(7)	97	4								

Bottom of borehole at 6.0 feet.

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BORING NUMBER B-02

Client: Dibble

Project Name: Butterfield Elementary Fire Lane and ADA

Project Number: 29.25.2601

Project Location: Marana, Arizona

Date Started: 2/26/25 Completed: 2/26/25

Ground Elevation: Not Determined Hole Size: 8 inches

Drilling Contractor: Southlands

Ground Water Levels:

Drilling Method: CME-55/Hollow Stem Auger

At time of Drilling: Not Encountered

Logged By: AJS Checked By: JKA

At end of Drilling: Not Encountered

Notes:

After Drilling: Not Encountered

Elevation (ft)	Depth (ft)	Bullnose Pen. (blows / ft)	Sample type/Interval	Blows per 6 in.	N-value (blows / ft)	Dry Unit Wt. (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing No. 4 Sieve (%)	Passing No. 200 Sieve (%)	Other Tests or Comments	Graphic Log	USCS Classification	MATERIAL DESCRIPTION
								NP	NP	96	19			SM	SILTY SAND, brown, moist, loose, non plastic, no cementation
	5			3 3	(6)	89	25								Dark brown

Bottom of borehole at 6.0 feet.

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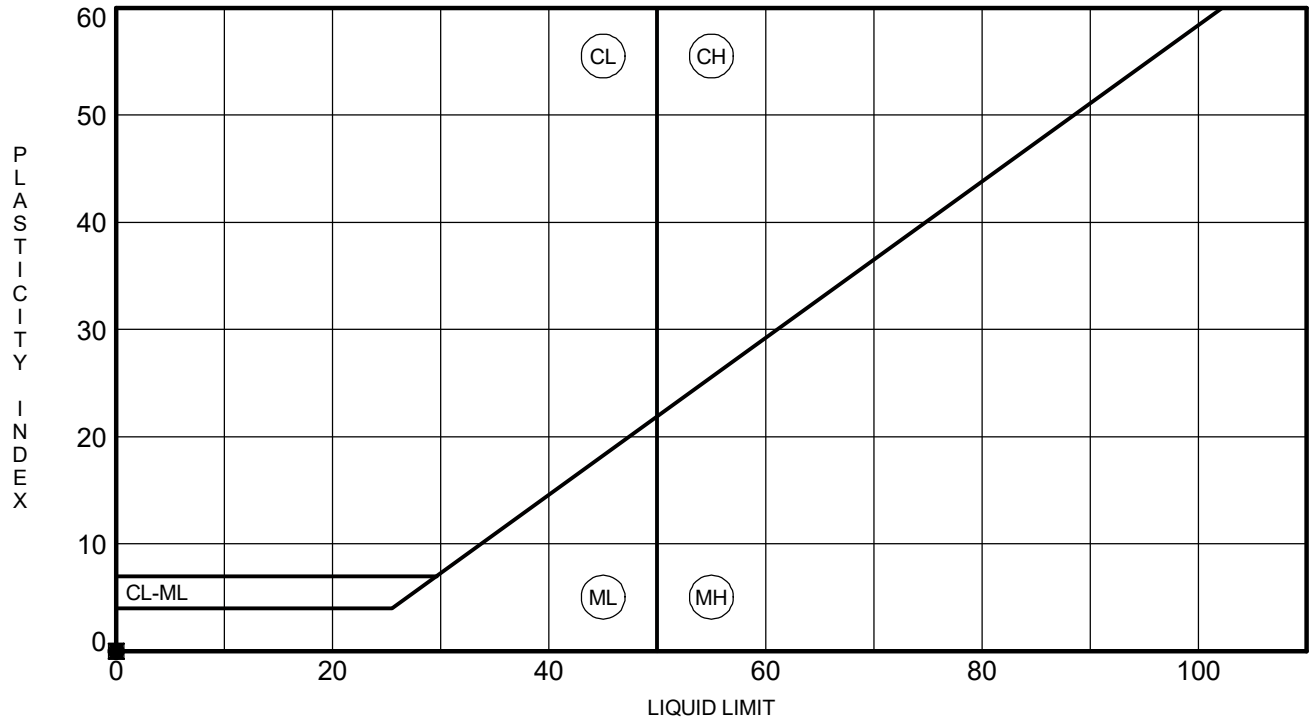
ATTERBERG LIMITS' RESULTS

Client: Dibble

Project Name: Butterfield Elementary Fire Lane and ADA

Project Number: 29.25.2601

Project Location: Marana, Arizona



	Borehole	Depth (ft)	LL	PL	PI	Fines (%)	Classification
●	**B-01**	**0.5-5.0**	**NP**	**NP**	**NP**	**24**	**SILTY SAND(SM)**
⧓	**B-02**	**0.0-5.0**	**NP**	**NP**	**NP**	**19**	**SILTY SAND(SM)**

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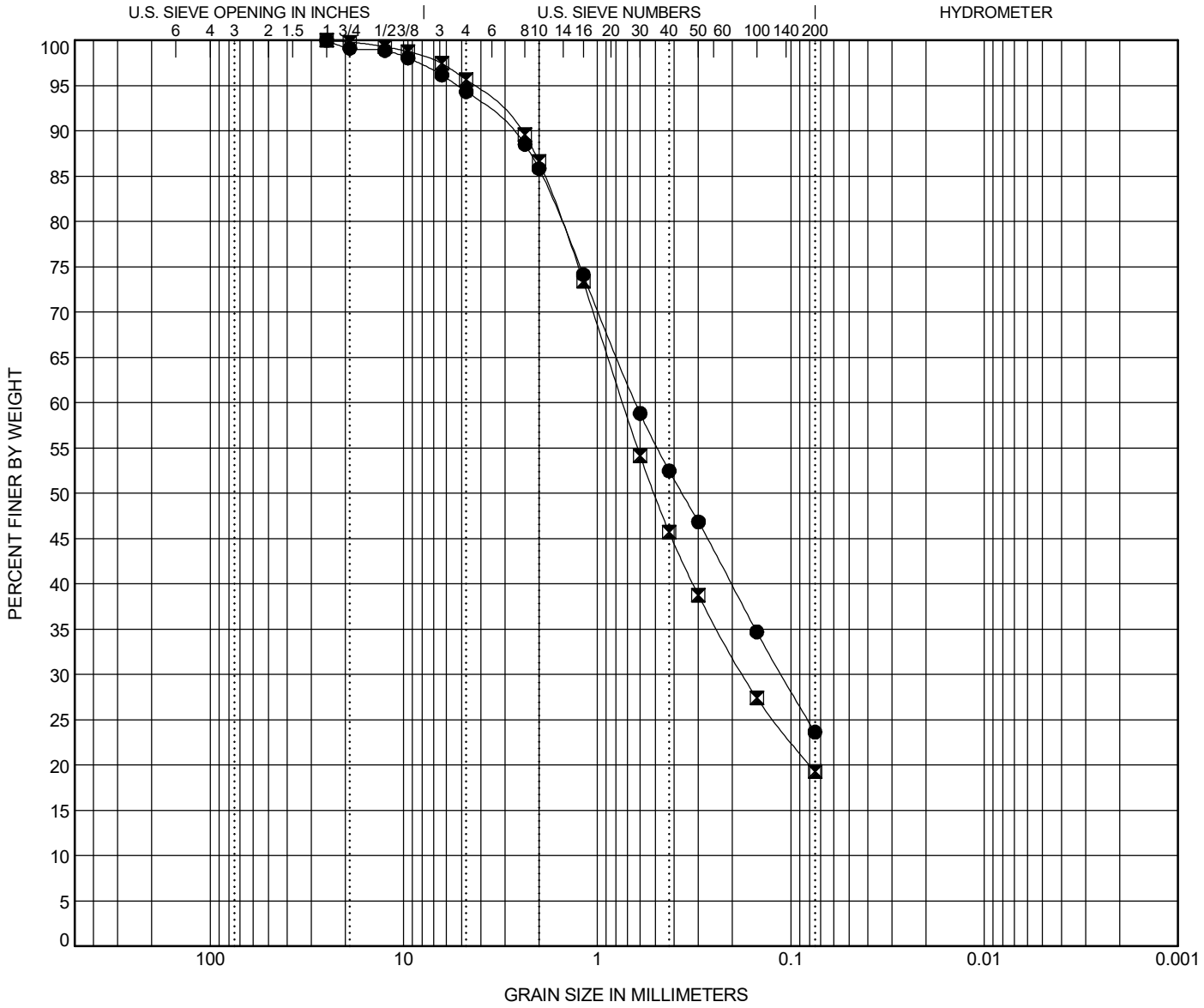
GRAIN SIZE DISTRIBUTION

Client: Dibble

Project Name: Butterfield Elementary Fire Lane and ADA

Project Number: 29.25.2601

Project Location: Marana, Arizona



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Borehole	Depth (ft)	Classification	LL	PL	PI	Cc	Cu
● B-01	0.5-5.0	SILTY SAND(SM)	NP	NP	NP		
⊠ B-02	0.0-5.0	SILTY SAND(SM)	NP	NP	NP		

Borehole	Depth (ft)	D100 (mm)	D60 (mm)	D30 (mm)	D10 (mm)	%Gravel	%Sand	%Silt	%Clay
● B-01	0.5-5.0	25	0.632	0.112		5.7	70.7	23.7	
⊠ B-02	0.0-5.0	25	0.737	0.176		4.3	76.4	19.3	

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SUMMARY OF LABORATORY RESULTS

Client: Dibble

Project Name: Butterfield Elementary Fire Lane and ADA

Project Number: 29.25.2601

Project Location: Marana, Arizona

Borehole	Depth (ft)	USCS Group Symbol	Liquid Limit	Plastic Limit	Plasticity Index	%>#4 Sieve	%<#200 Sieve	Water Content (%)	Dry Density (pcf)	Consol(-)/ Swell(+) (%)	pH	Minimum Resistivity (Ohm-cm)	Sulfate (ppm)	Chloride (ppm)
B-01	**0.5-5.0**	**SM**	**NP**	**NP**	**NP**	**6**	**24**							
B-01	**5.0-6.0**	**SM**						**4.1**	**96.8**					
B-02	**0.0-5.0**	**SM**	**NP**	**NP**	**NP**	**4**	**19**							
B-02	**5.0-6.0**	**SM**						**25.3**	**88.9**					

DESIGN R-VALUE CALCULATION

Laboratory Test Data

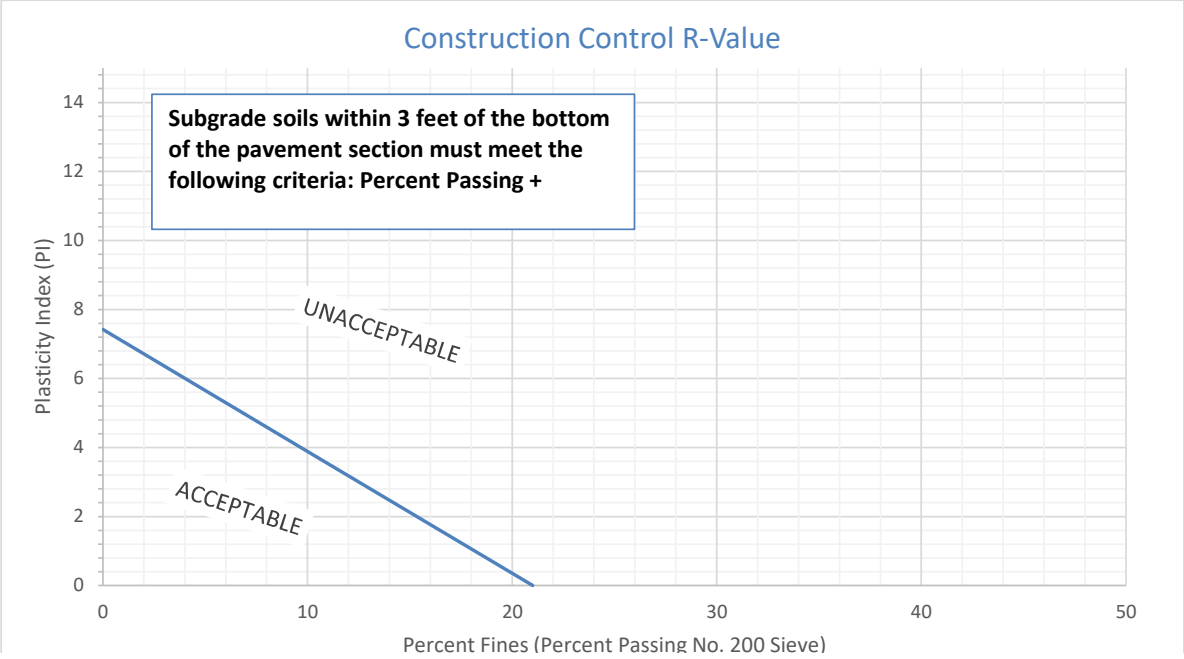
Boring	Depth	Notes	%pass#200	PI	R_t (Tested)	R_c (ADOT)	R_c (PCDOT)
B-01	0.5-5		24	0	65	72	51
B-02	0-5		19	0		77	55

Note: PI Value of 0 indicates Non Plastic

Test Data Analysis

	%pass#200	PI	R_t	R_c	R_c
Average	22	0	65	75	53
Count	2	2	1	2	2
Standard Dev	3.54	0.00	--	3.54	2.83
Maximum	24	0	65	77	55
Minimum	19	0	65	72	51
Adjusted Average (if Standard Dev>10)	--	--	--	--	--

Calc'ed PCDOT Design R-Value (with PCDOT power-curve correction)	53	$R_{m(PCDOT)}$
Calc'ed Construction Control R-Value	53	R_{CCMin}
Recommended Design R-Value	**53**	**$R_{m(SAECO)}$**
Recommended Construction Control R-Value	**53**	**R_{CCMin}**



FLEXIBLE PAVEMENT DESIGN

Pavement Loading

ESALs	100,000	W_{18}

Construction Variability

Level of Reliability	75%	
Standard Normal Deviate	-0.674	Z_R
Overall Standard Deviation	0.45	S_0
Initial Design Serviceability Index	4.5	P_0
Terminal Design Serviceability Index	1.5	P_t
Change in Serviceability Index	3.0	Δpsi

Site Conditions

Seasonal Variation Factor	1.7	SVF
Design R-Value	53	$R_{m(SAECO)}$
Resilient Modulus (psi)	24,828	M_r

Pavement Structure Strength

	Layer Coefficient	Drainage Coefficient	UCS (PSI)	Elastic Modulus
Rubberized Asphalt Concrete (RAC)	0.42	--	--	625,000
Asphalt Concrete (AC)	0.42	--	--	625,000
Aggregate Base Course (ABC)	0.12	0.93	--	34,000
Cement Treated Subgrade (CTSB)	0.18	1.00	300	300,000
Lime Treated Subgrade (LTSB)	0.17	1.00	160	480,000

Structural Number

Calculated Structural Number Subgrade	1.29	SN
Minimum Required Structural Number	--	SN
Design Structural Number	**1.12**	**$SN_{(design)}$**

Pavement Section Alternatives

Alt.	RAC (inches)	AC (inches)	ABC (inches)	CTSB (inches)	LTSB (inches)	Ratio Check	Total (inches)	Section SN
A		2.0	4			n/a	6.0	1.29
B		0.0	10			n/a	10.0	1.12