Subgrade: It's Just Dirt. Isn't it?

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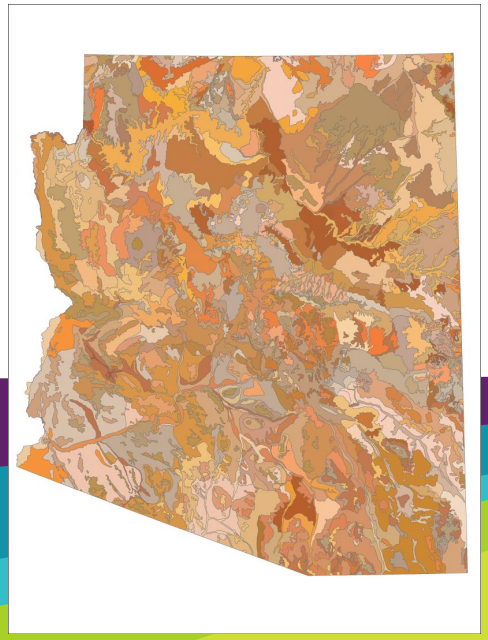


Outline of Presentation

- Introduction
- Pavement Components
- Specifications
- Factors that Influence Subgrade Performance
- Mitigation Strategies for Poor Subgrade
- Case Study – I-17 Widening Project
- Summary

Introduction

- **What is Subgrade?**
  - MAG –

    Subgrade: The supporting structures on which the pavement and its special undercourses rest.

  - ADOT –

    Subgrade:

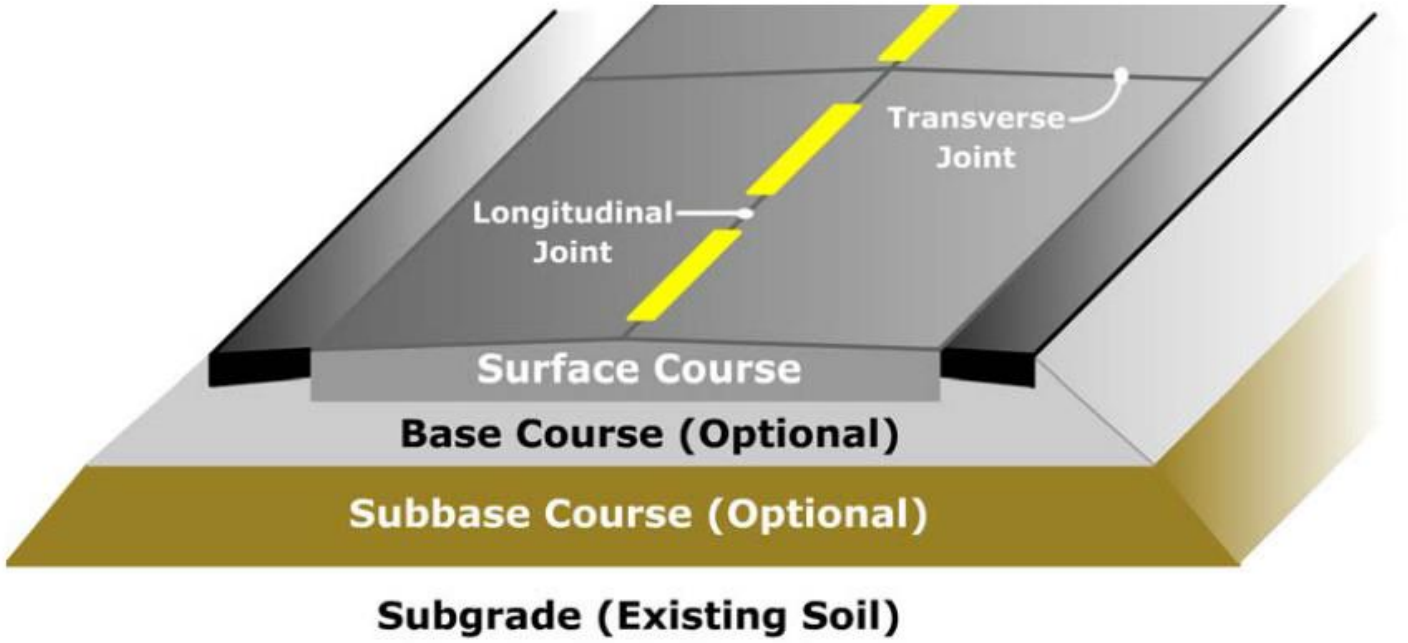
    The roadbed materials beneath the pavement structure.

  - FHWA –

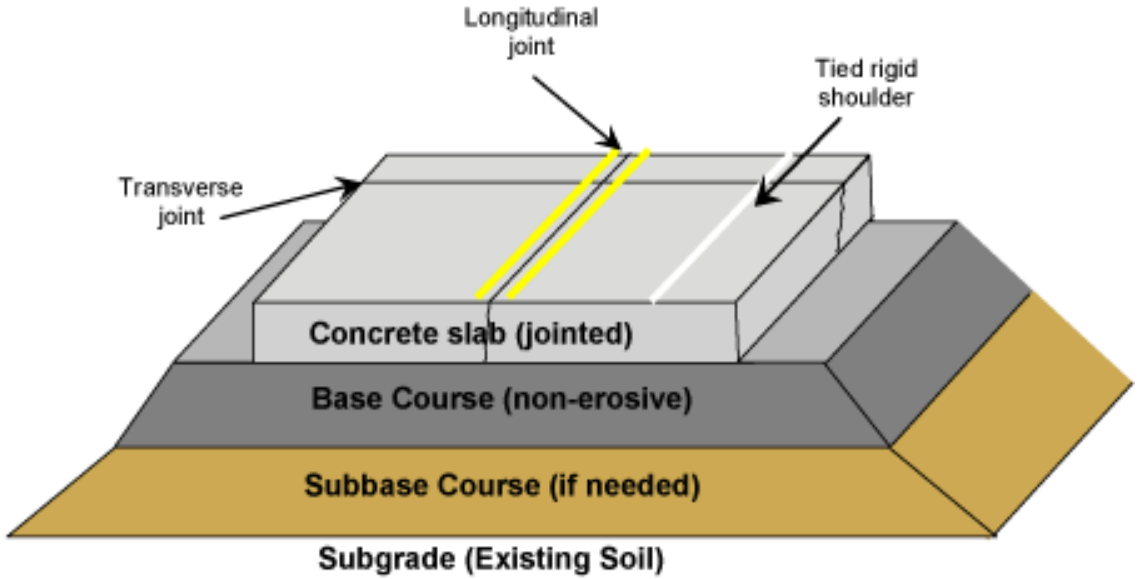
    Subgrade — The top surface of a roadbed upon which the pavement structure, shoulders, and curbs are constructed.

  - DNF – ?

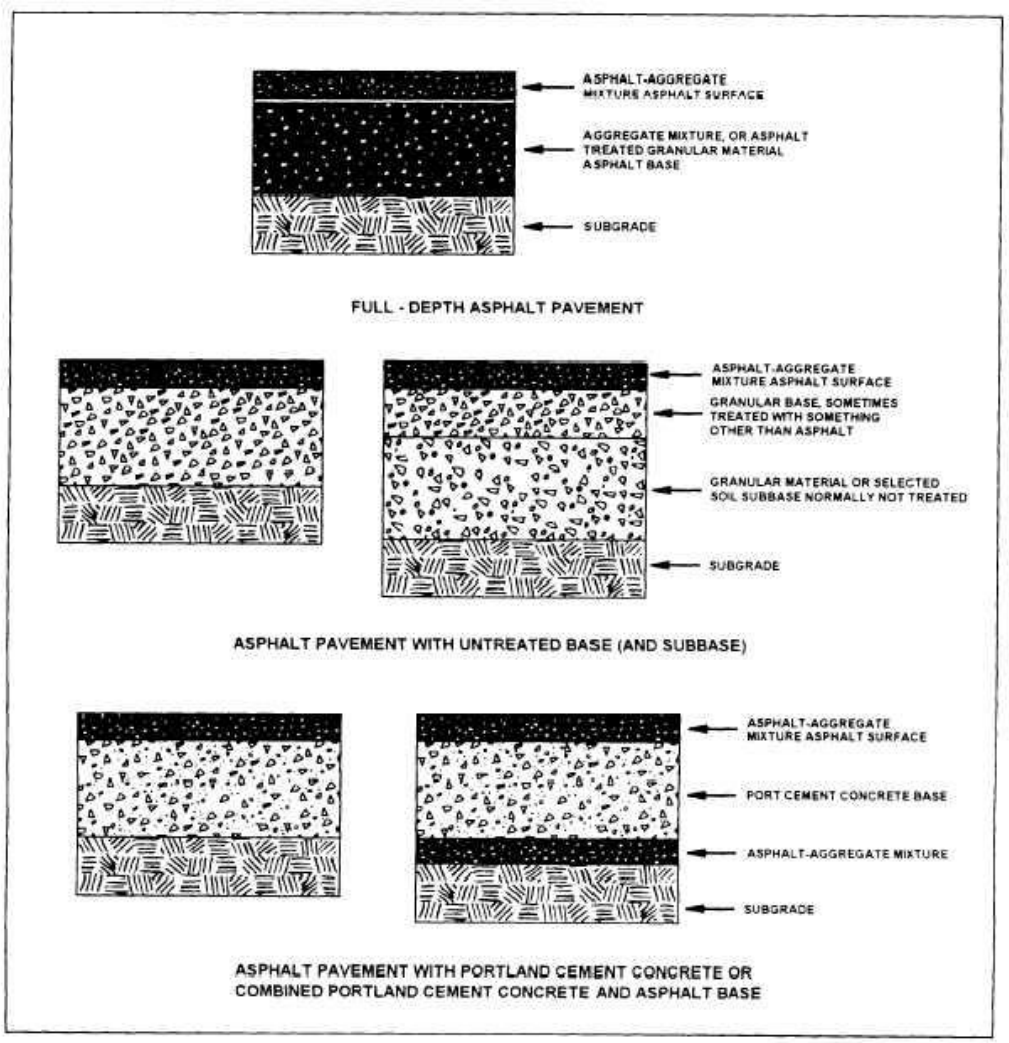
Pavement Components



Pavement Components



Pavement Components



Summary of Pavement Components

- **Manufactured/Produced Components**
  - Portland Cement Concrete
  - Asphaltic Concrete
  - Base Course

- **Naturally Occurring**
  - Subgrade

Construction Specifications – Portland Cement Concrete

SECTION 725

PORTLAND CEMENT CONCRETE

725.1 GENERAL:

Portland cement concrete shall be composed of cementitious materials, fine and coarse aggregates, water, and, if specified or allowed, certain chemical admixtures and additives.

TABLE 725-1

CONCRETE CLASSES - MINIMUM REQUIREMENTS

Class of Concrete	Minimum Cementitious Materials Content (lbs. per cubic yard)	Minimum Compressive Strength (1) at 28 Days (psi)
AA	600	4000
A	520	3000
B	470	2500
C	420	2000

Construction Specifications – Asphaltic Concrete

SECTION 710

TABLE 710-2
COARSE/FINE AGGREGATE REQUIREMENTS

Characteristics	Test Method	Low Traffic	High Traffic
Fractured Faces, % (Coarse Aggregate Only)	Arizona 212	75, 1 or more	85, 1 or more 80, 2 or more
Uncompacted Voids, % Min.	AASHTO T-304, Method A	42	
Flat & Elongated Pieces, % 5:1 Ratio	ASTM D4791	10.0 Max.	10.0
Sand Equivalent, %	AASHTO T-176	50 Min.	50
Plasticity Index	AASHTO T-90	Non-plastic	Non-
L.A. Abrasion, %Loss	AASHTO T-96	9 max. @ 100 Rev. 40 max. @ 500 Rev.	9 max. @ 40 max. @
Combined Bulk Specific Gravity	AI MS-2/SP-2	2.35 – 2.85	2.35
Combined Water Absorption	AI MS-2/SP-2	0 – 2.5%	0 –

SECTION 710

TABLE 710-3
MARSHALL MIX DESIGN CRITERIA

Criteria	Requirements				Designated Test Method
	3/8" Mix	1/2" Mix	3/4" Mix	Base Mix	
1. Voids in Mineral Aggregate: %, min	15.0	14.0	13.0	12.0	AI MS-2
2. Effective Voids: %, Range	4.0±0.2	4.0 ±0.2	4.0 ±0.2	4.0 ±0.2	AI MS-2
3. Absorbed asphalt: %, Range*	0-1.0	0-1.0	0-1.0	0-1.0	AI MS-2
4. Dust to Eff. Asphalt Ratio, Range **	0.6-1.4	0.6-1.4	0.6-1.4	0.6-1.4	AI MS-2
5. Tensile Strength Ratio: % Min.	65	65	65	65	ASTM D 4867
6. Dry Tensile Strength: psi, Min.	100	100	100	100	ASTM D 4867
7. Stability: pounds, Minimum	2,000	2,500	2,500	3,000	AASHTO T-245
8. Flow: 0.01-inch, Range	8-16	8-16	8-16	8-16	AASHTO T-245
9. Mineral Aggregate Grading Limits					AASHTO T-27
	Percent Passing with Admix				
Sieve Size	3/8 inch Mix	1/2 inch Mix	3/4 inch Mix	Base Mix	
1-1/4 inch				100	
1 inch			100	90-100	
3/4 inch		100	90 – 100	85-95	
1/2 inch	100	85 – 100	---	---	
3/8 inch	90-100	62 – 85	62 – 77	57-72	
No. 8	45-60	40 – 50	35 – 47	33-43	
No. 40	10-22	10 – 20	10 – 20	9-18	
No. 200	2.0 – 10.0	2.0 – 10.0	2.0 – 8.0	1.0 – 7.0	

Construction Specifications – Aggregate Base

SECTION 702

Table 702-1 Sieve Analysis Test Methods AASHTO T-27, T-11			
Sieve Size	Accumulative Percentage Passing Sieve, by Weight		
	Select Material		Aggregate Base Course
	Type A	Type B	
3 in.	100	--	--
1-1/2 in.	--	100	100
1 in.	--	--	90 – 100
No. 4	30 - 75	30 - 70	38 - 65
No. 8	20 - 60	20 - 60	25 – 60
No. 30	10 - 40	10 - 40	10 – 40
No. 200	0 - 12	0 - 12	3 – 12
Plasticity Index Test Methods AASHTO T-89 Method A, T-90, T146 Method A			
Maximum allowable value	5	5	5
Fractured Face, One Face Test Method ARIZ 212, Percent by Weight of the Material Retained on a #4 Sieve			
Minimum required value	50	50	50
Resistance to Degradation and Abrasion by the Los Angeles Abrasion Machine Test Method AASHTO T-96, Percent Loss by Weight			
Maximum allowable value at 100 revolutions	10	10	10
Maximum allowable value at 500 revolutions	40	40	40

702.2.2: When tested for acceptance, Base material that does not meet Table 702-1 properties for gradation or PI may be approved at the Engineer's discretion if the R-Value is at least 70, when determined by test method AASHTO T-190 (see Table 310-1).

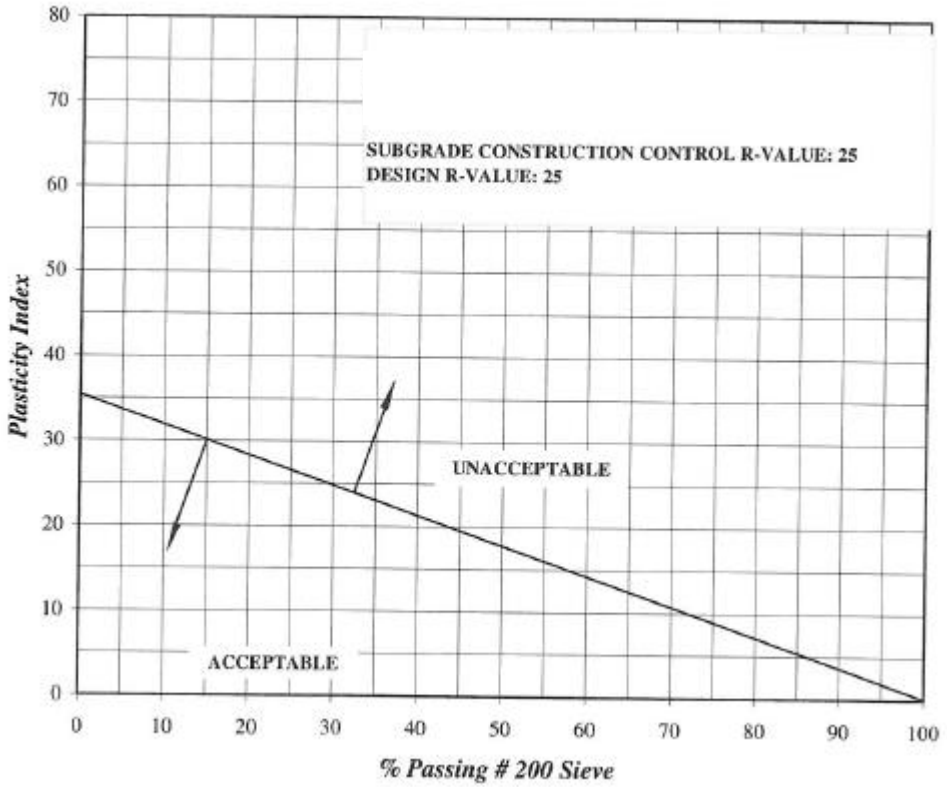
- End of Section -

Construction Specifications – Subgrade

The material from this stockpile may be suitable for embankment. Any portion of the stockpile material that is placed within three feet of the finished subgrade shall meet the following requirements:

The Plasticity Index (PI) (AASHTO T90) and the percent passing the No. 200 Sieve (Minus 200) (Arizona Test Method 201) when used in the equation below, shall give a value of X that does not exceed 100.

$$X = (\text{Minus } 200) + [2.83\ (PI)]$$



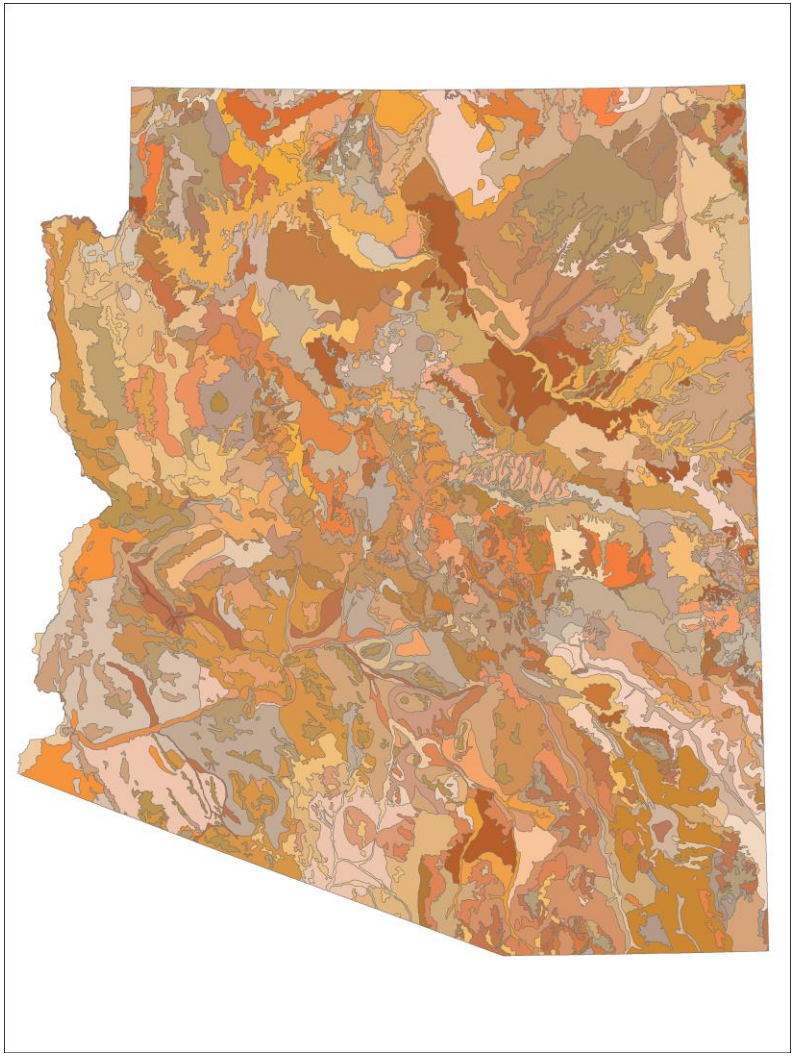
Factors Influencing Subgrade Performance

- **Soil Type**
  - Plasticity
  - Percent fines (% < No. 200)
  - Swell potential
  - Collapse potential
- **Environmental Effects/ Climatic Conditions**
  - Elevation
  - Temperature
  - Precipitation/Moisture
- **Drainage**

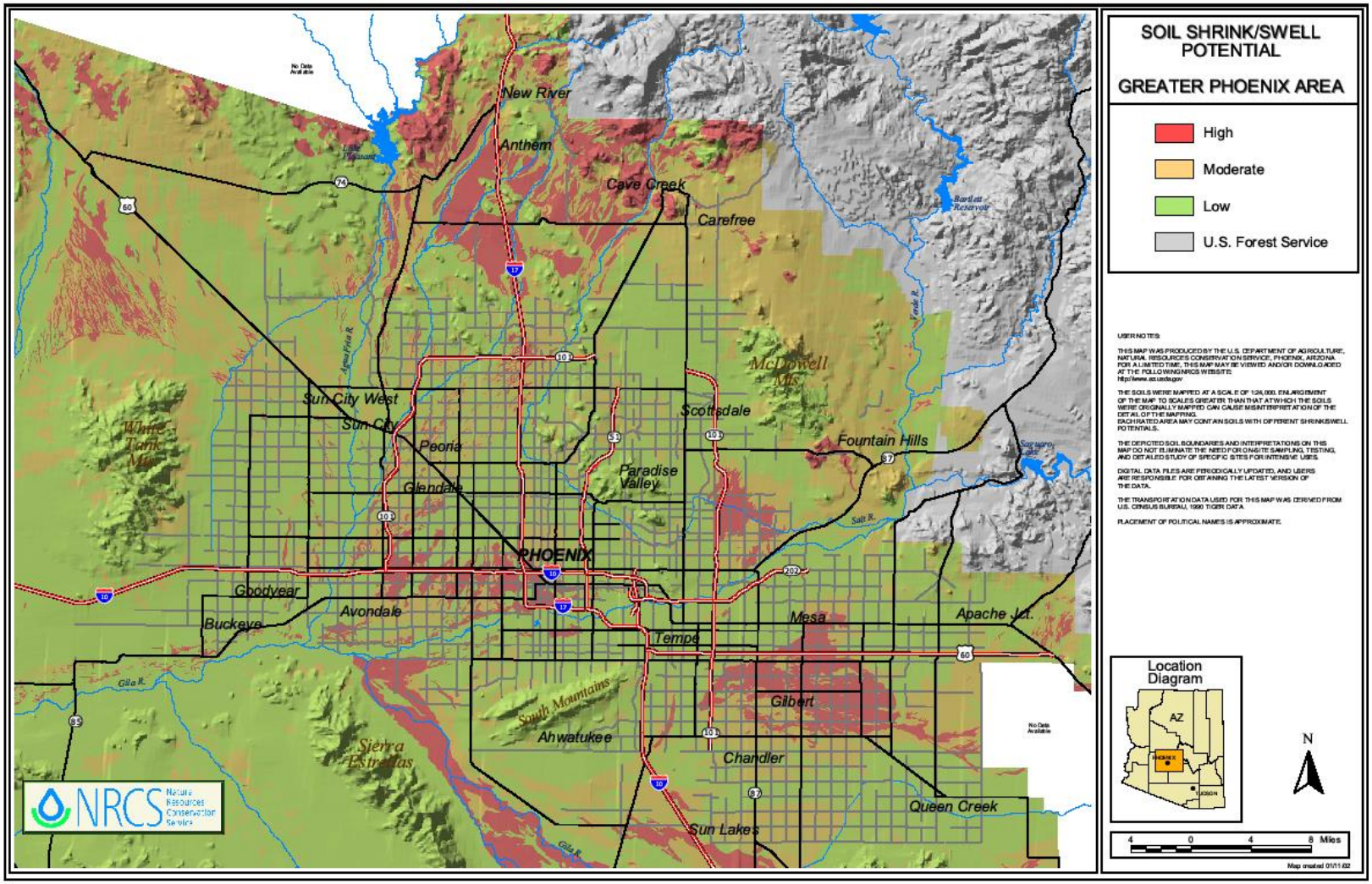
Soil Type

- **Soils Map of Arizona**

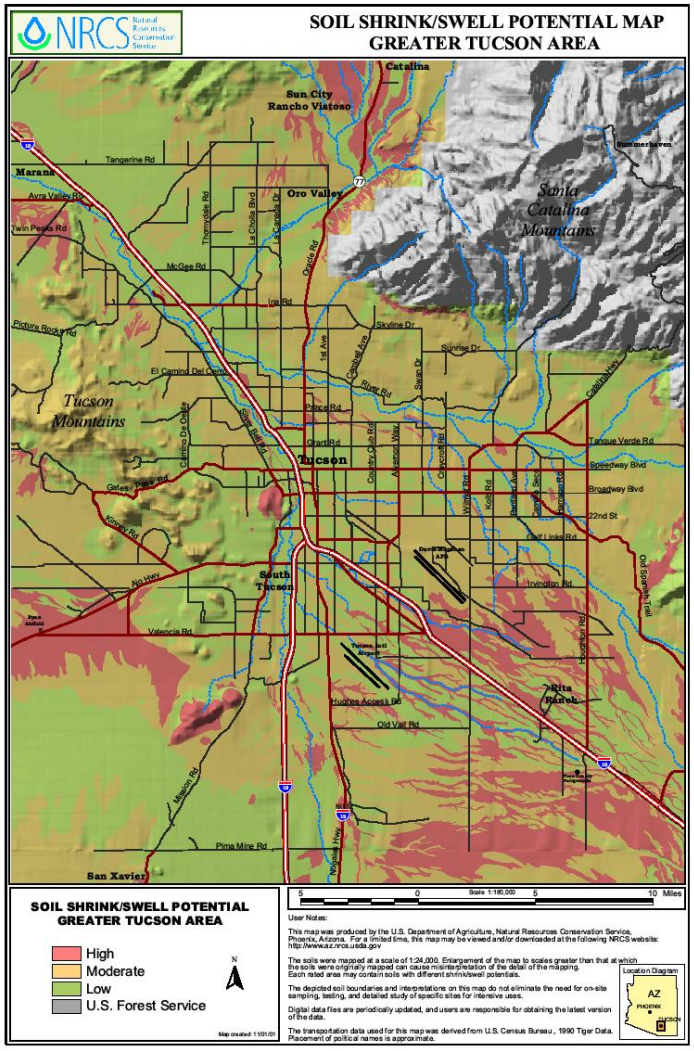
  (USDA-NRCS)



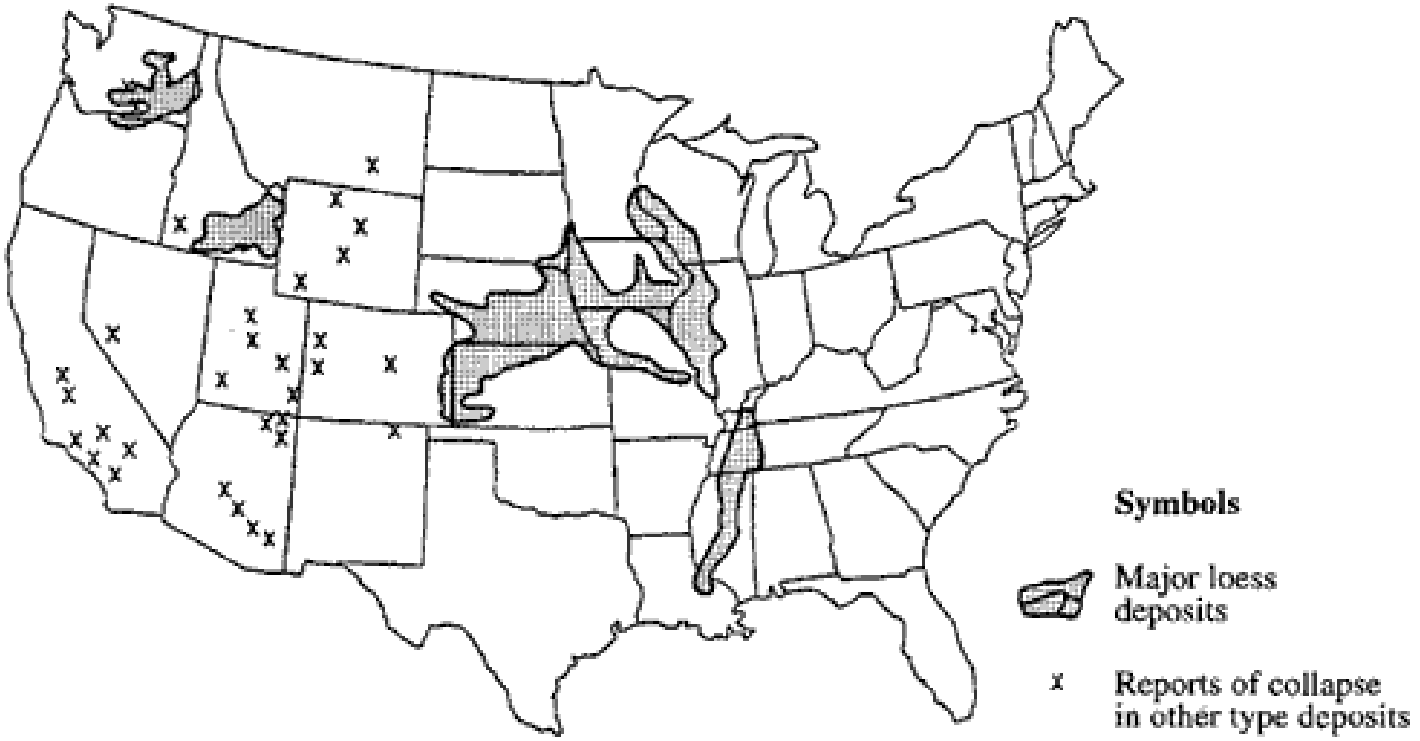
Swell Potential Map – Phoenix Area



Swell Potential Map – Tucson Area



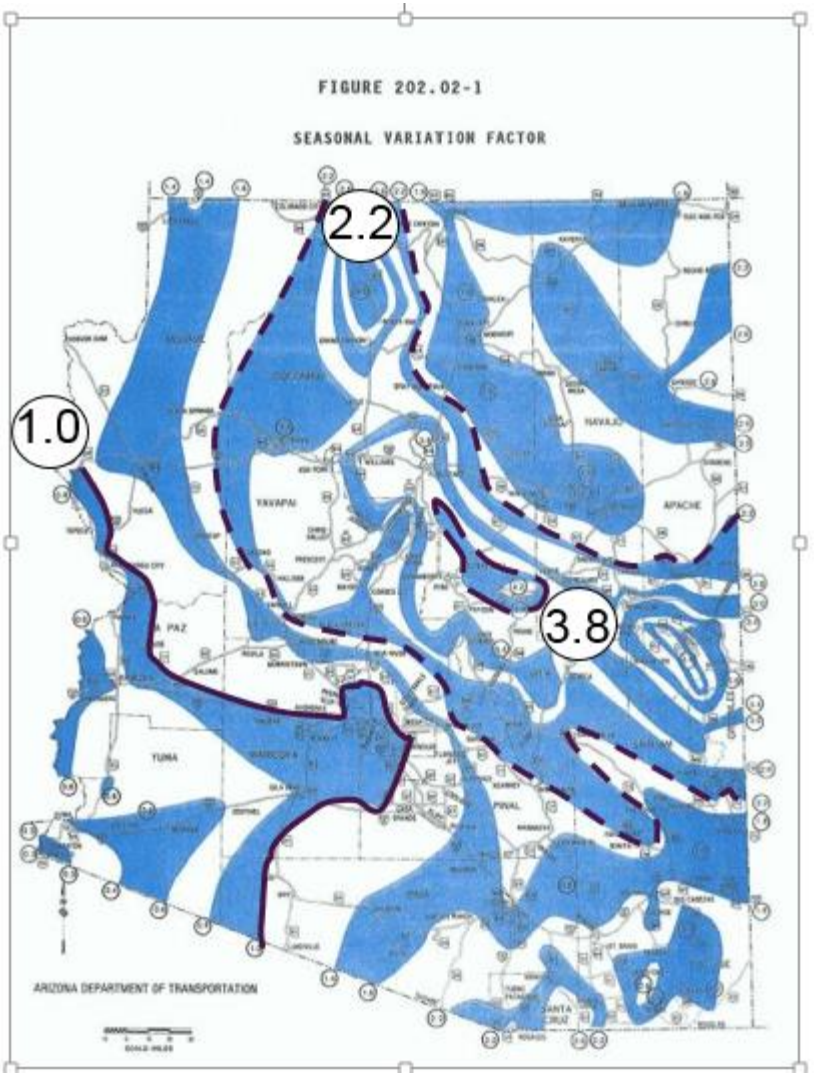
Collapsible Soils



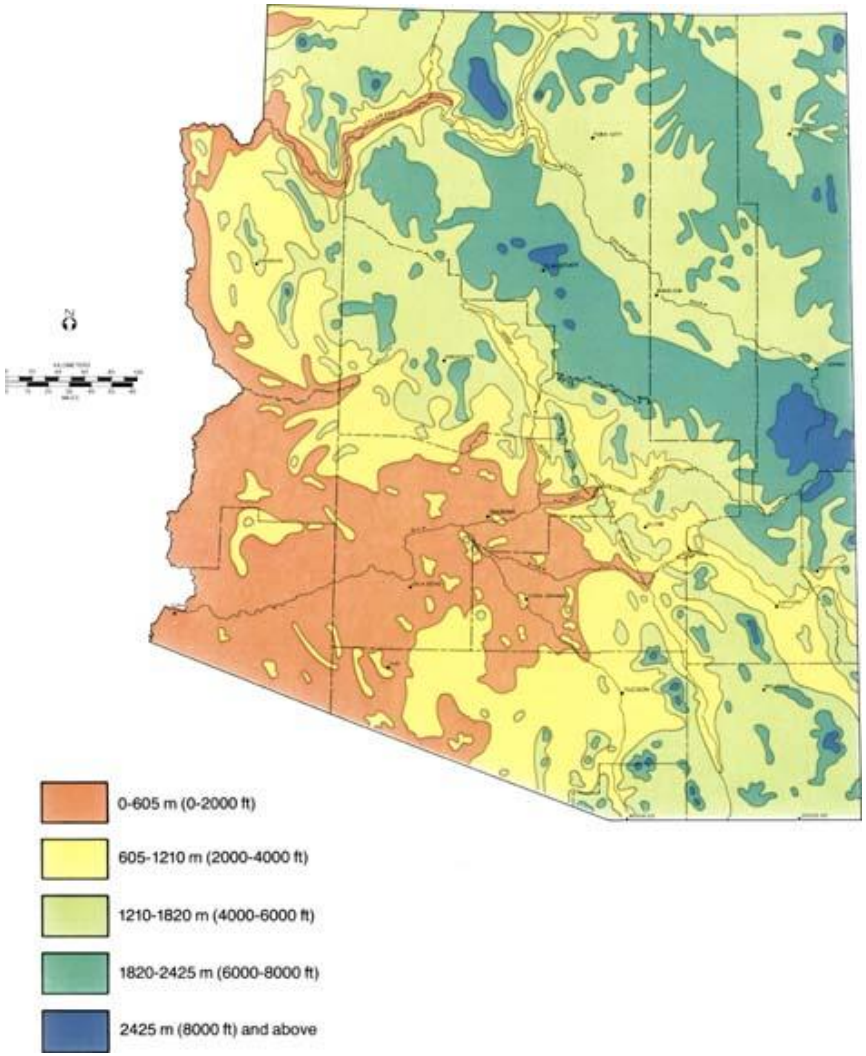
Collapsing Soils consist of loose, dry, low-density material – i.e., undercompacted – that shrinks in volume when wetted (hydrocompaction), and/or when loaded with a great weight, such as a building or street. These types of soils are particularly common in the semi-arid southwestern U.S. where wind and ephemeral streams deposit loose, unconsolidated, and undersaturated (re.: dry) sediments that are prone to sudden collapse.

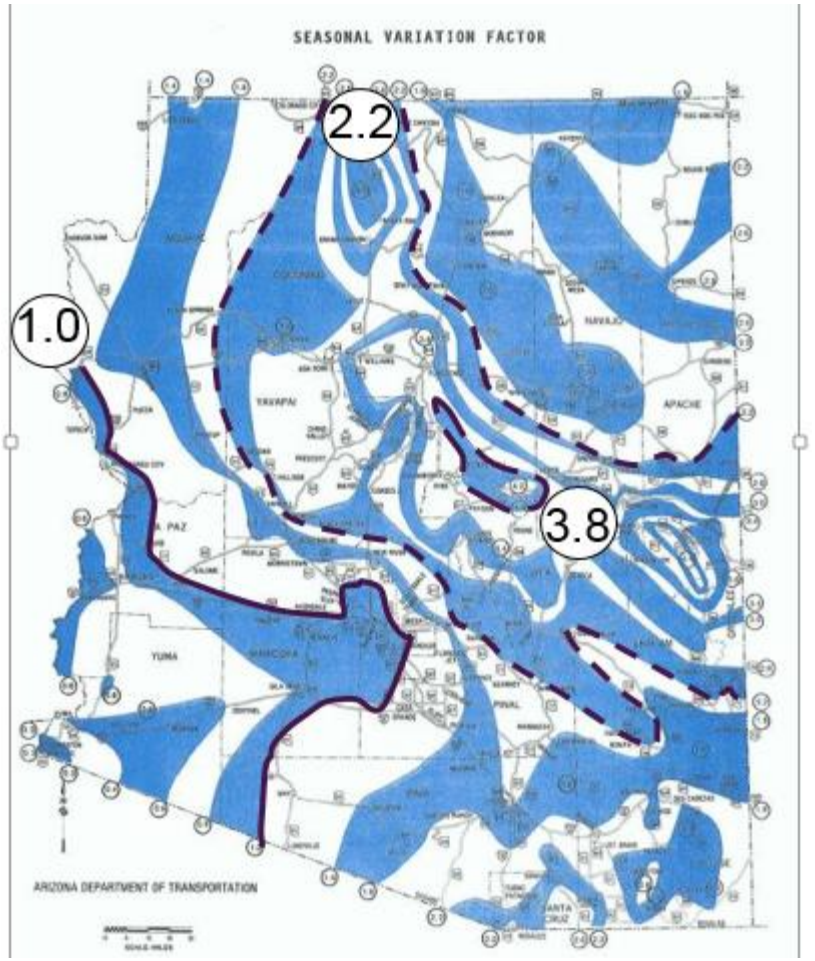
Environmental Effects/ Climatic Conditions

- **Elevation**
- **Temperature**
- **Precipitation**
- **Seasonal Variation Factor**

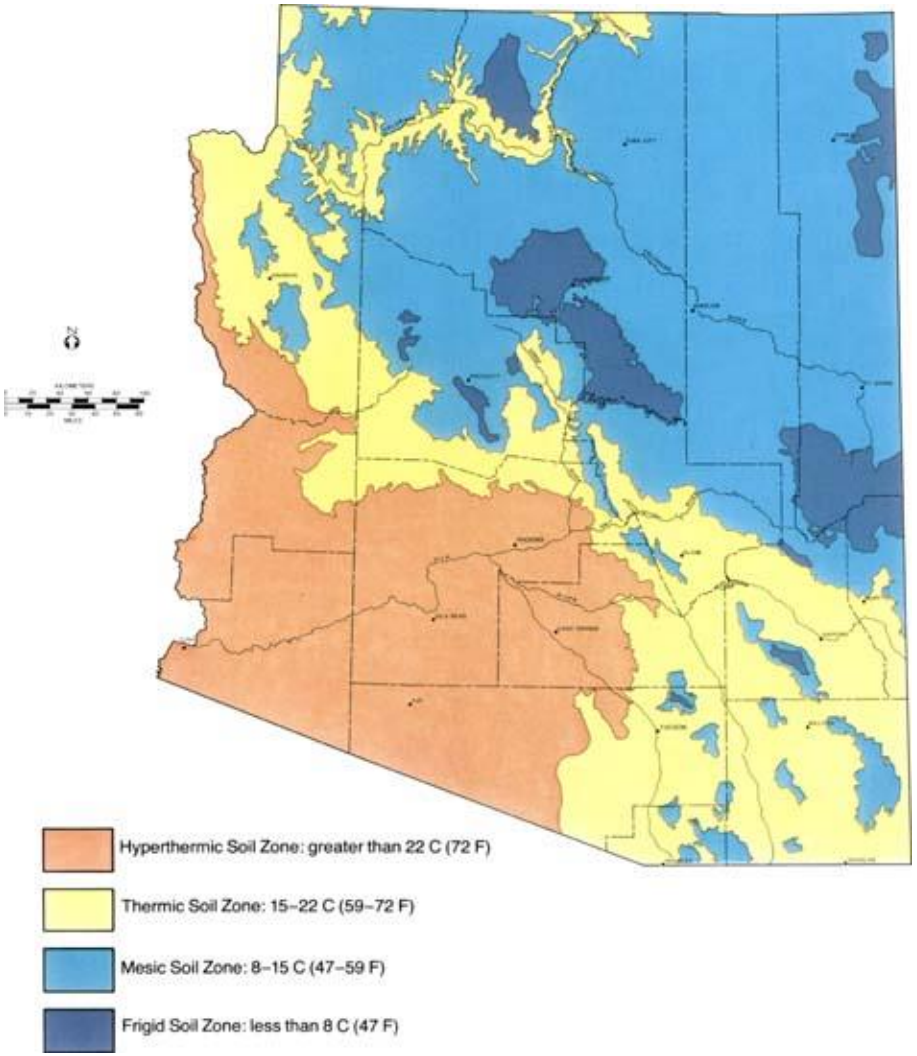


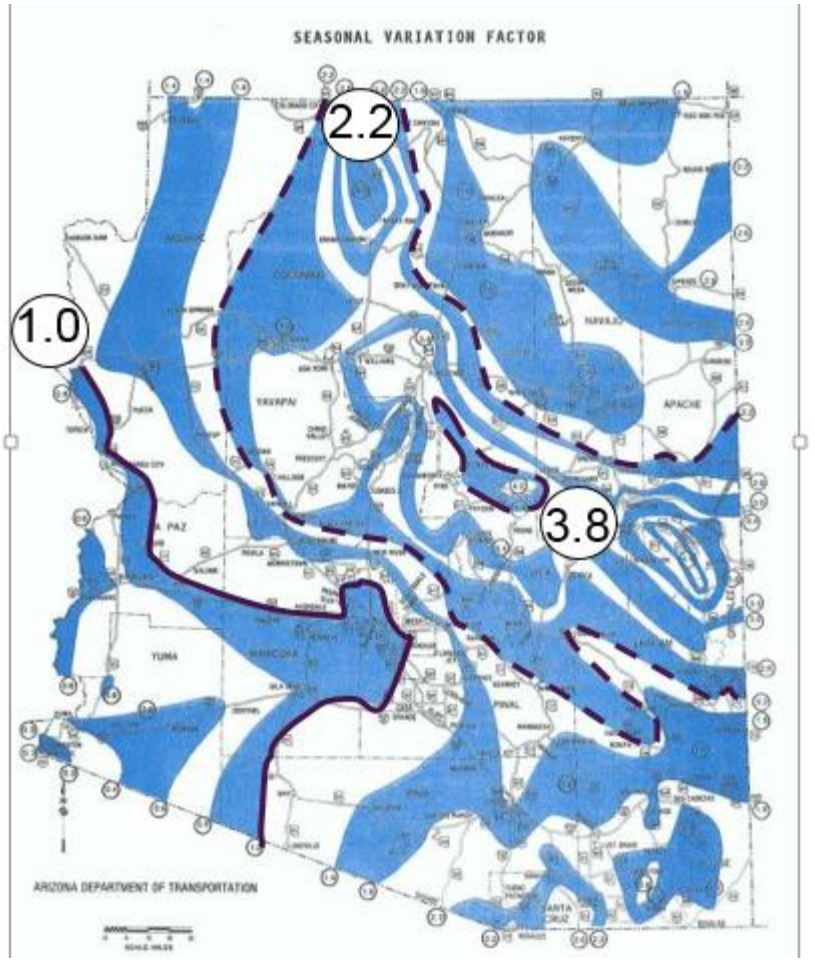
Seasonal Variation Factor vs Elevation



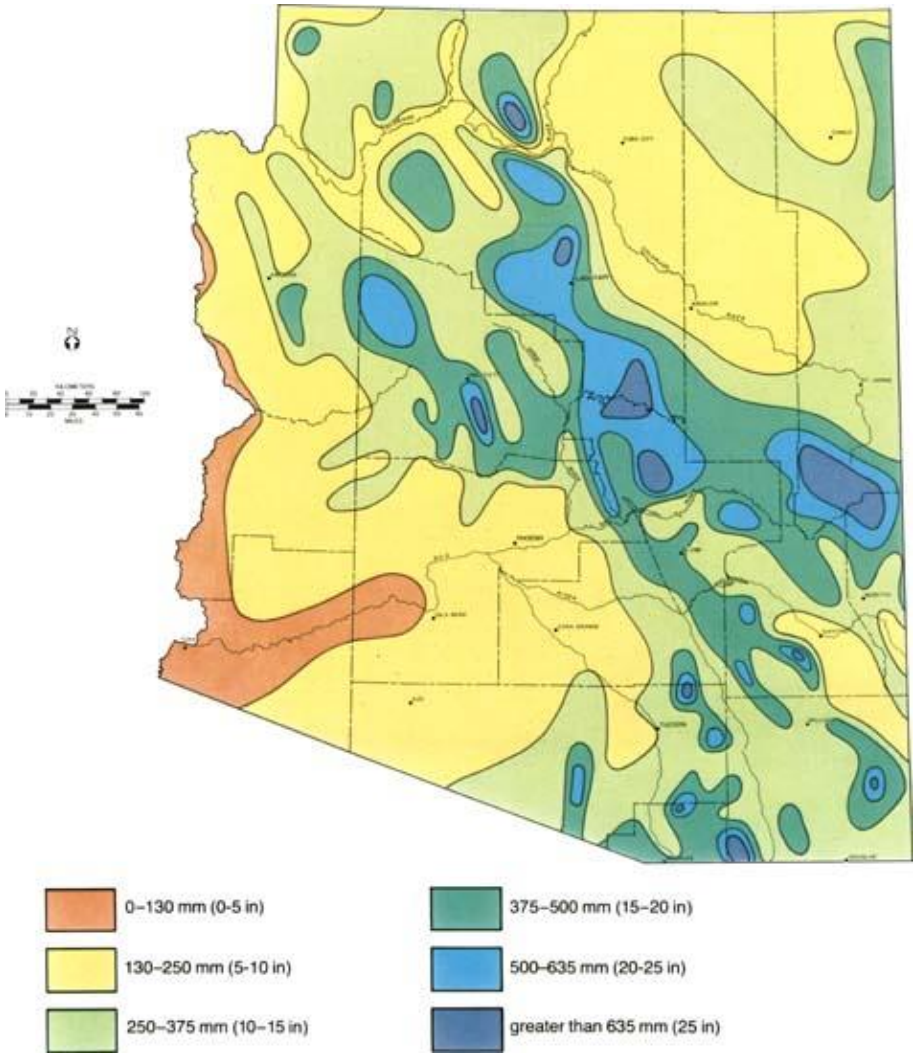


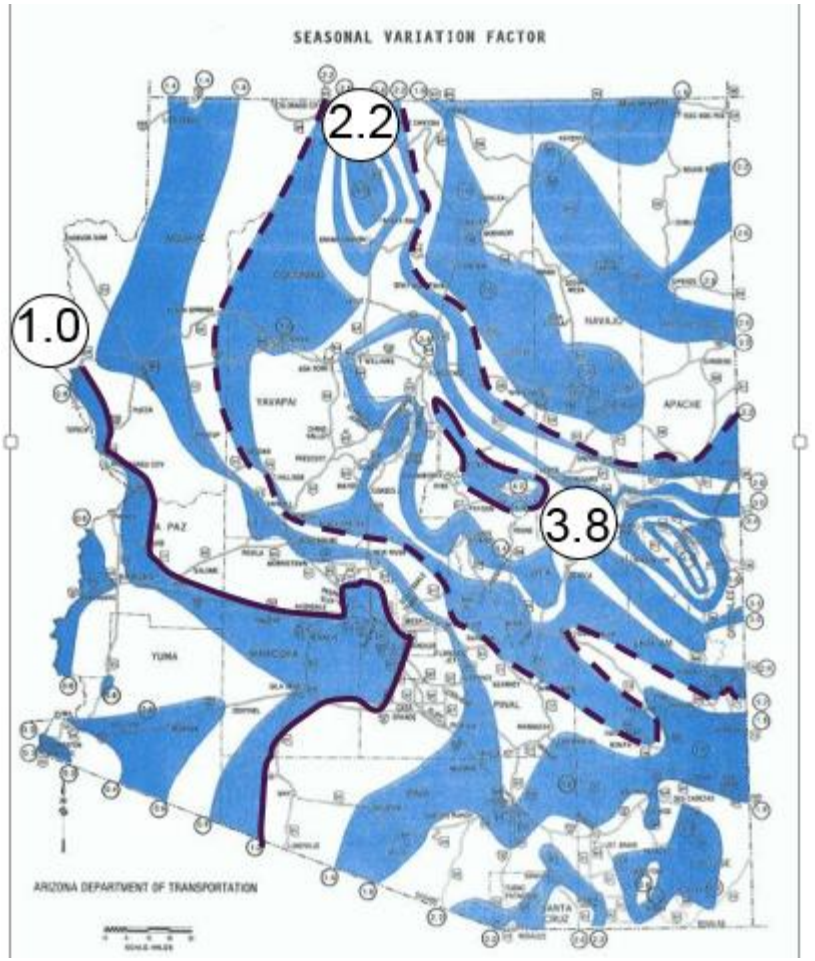
Seasonal Variation Factor vs Temperature





Seasonal Variation Factor vs Precipitation





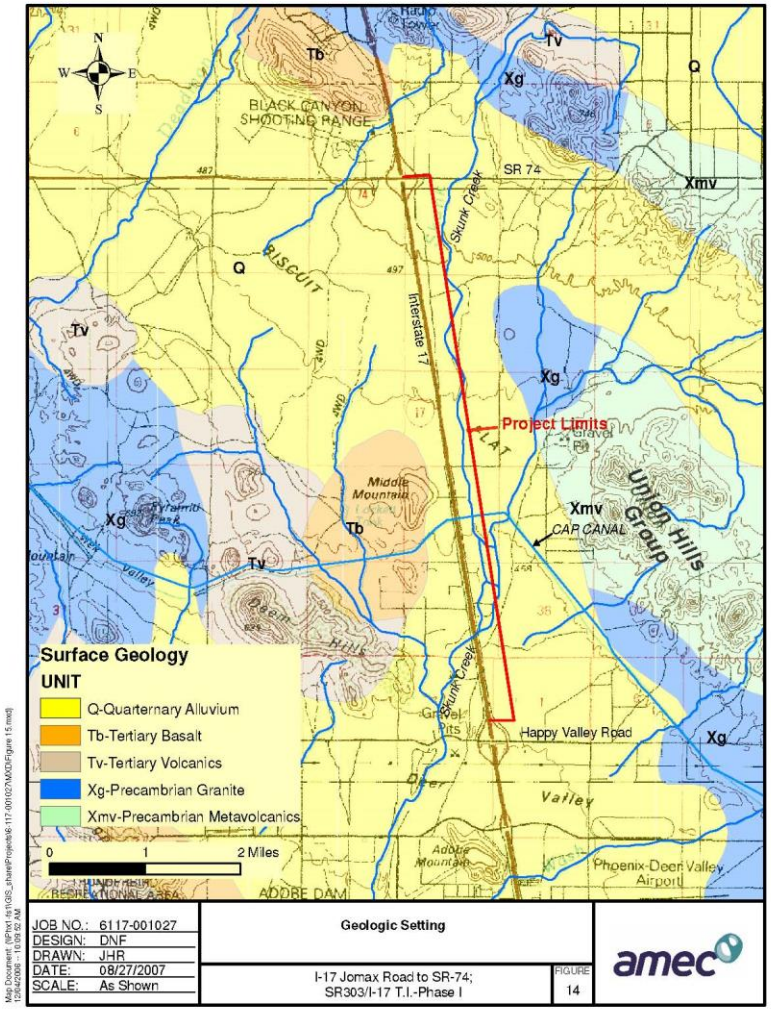
Mitigation Strategies for Poor Subgrade

- **Over-Excavation and Replace**
- **Over-Excavation and Recompaction**
- **Geogrid with Geotextile**
- **Lime or Cement Treated**
- **Alternative Engineering Solutions**

Case Study – I-17 Widening

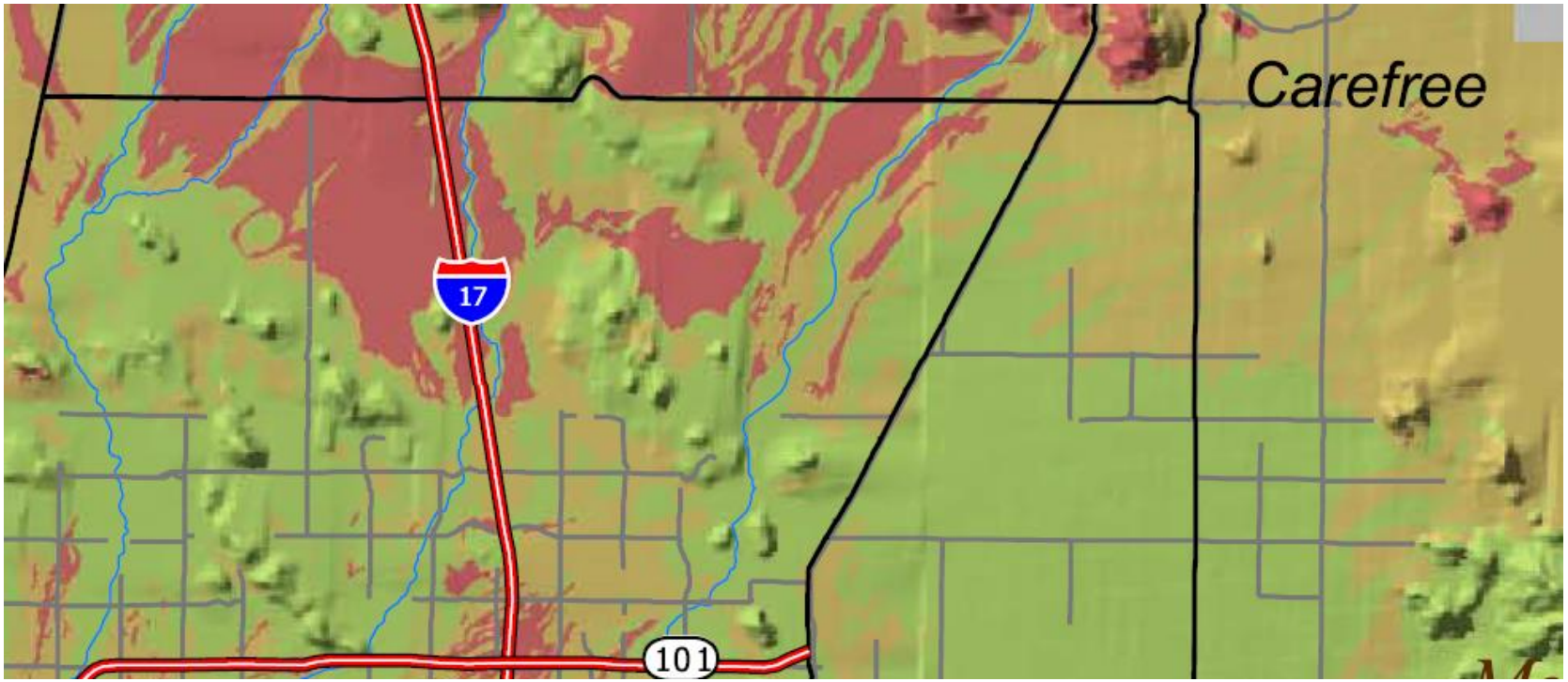
- **Project Location**
- **Project Soils**
- **Subgrade Characterization (R-Value Evaluation)**
- **Alternatives Evaluated**
- **Final Design**

Case Study – I-17 Widening



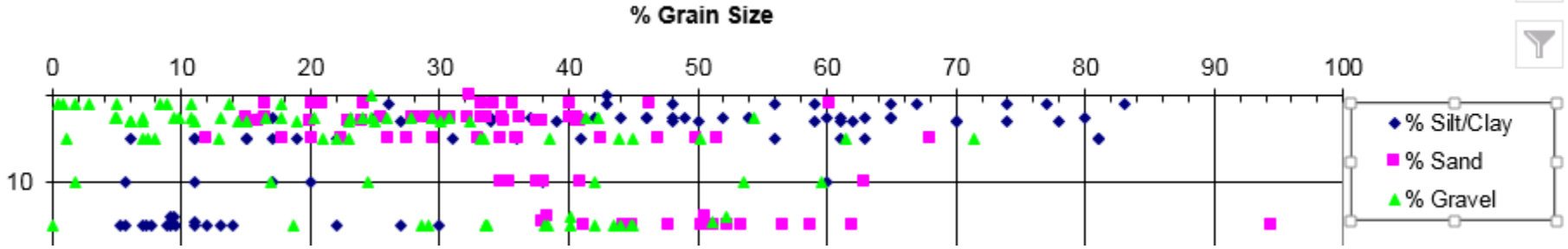
Case Study – I-17 Widening

- **Swell Potential Map – Phoenix Area**

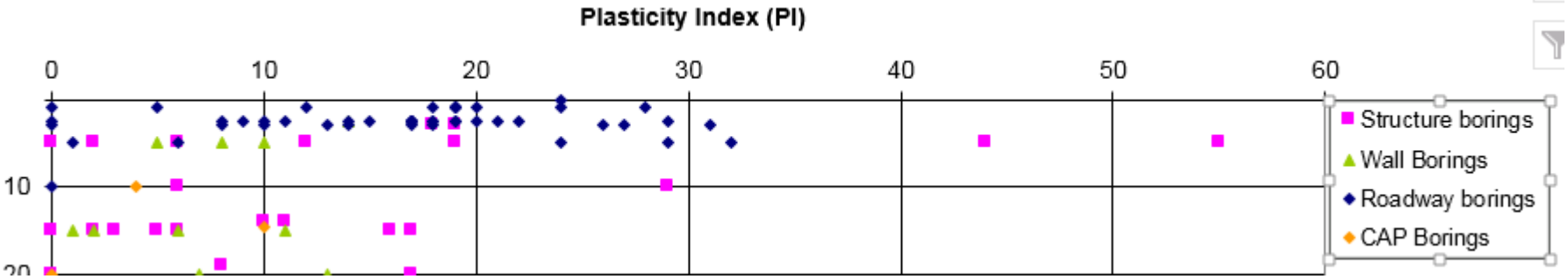


Case Study – I-17 Widening Project Soils

- **Subgrade Criteria**
  - Percent Passing No. 200 Sieve

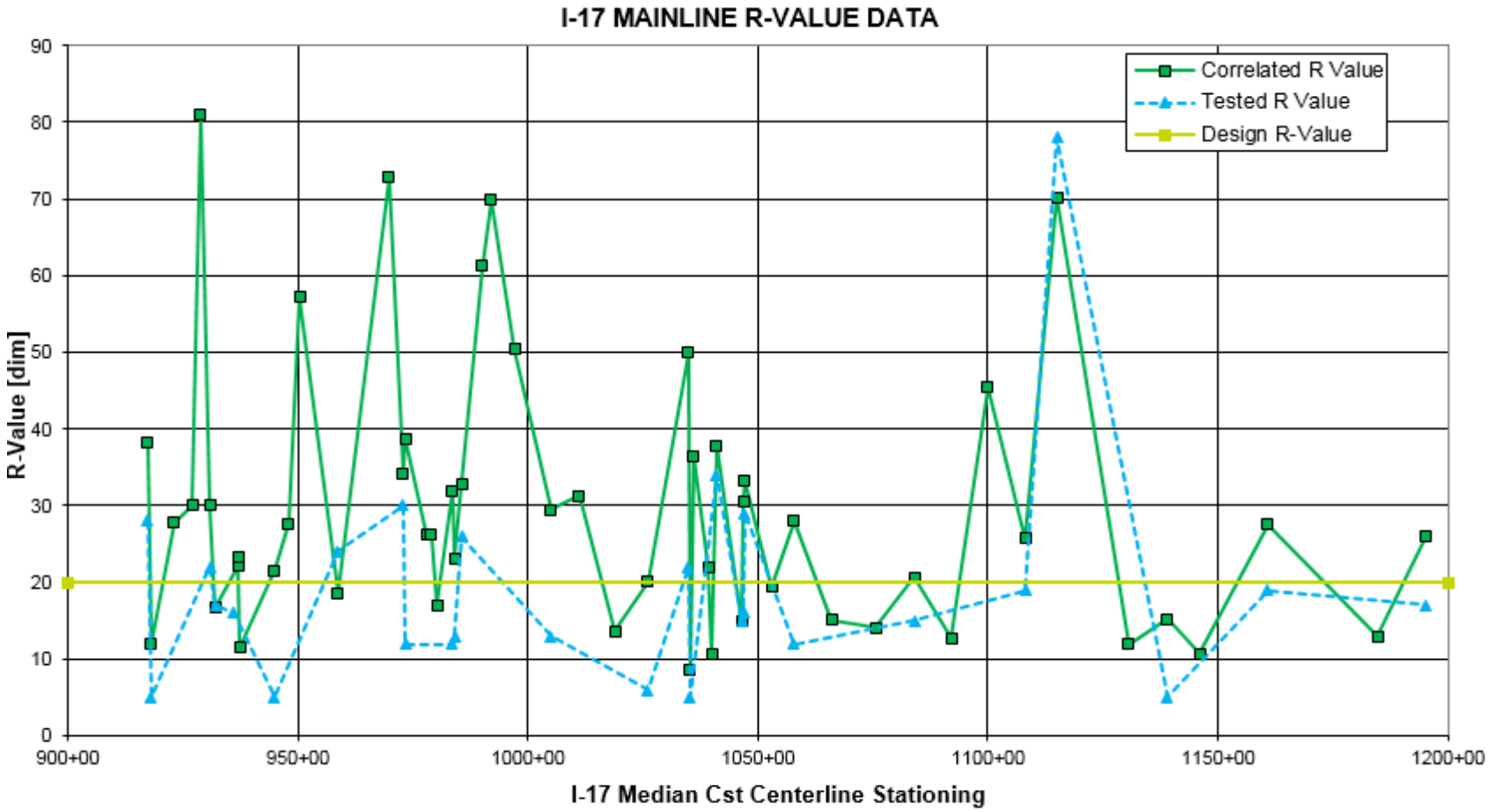


  - Plasticity Index (PI)



Case Study – I-17 Widening

- **R-Value Data**



Case Study – I-17 Widening
Alternatives Evaluated

amec foster wheeler

Alternatives Evaluated

- **Over-Excavation and Replace**
  - Viable alternative
- **Over-Excavation and Recompaction**
  - Not viable, soils not collapsible
- **Geogrid with Geotextile**
  - Strain compatibility concerns
- **Lime or Cement Treated**
  - ADOT did not want to pursue
- **Alternative Engineering Solutions**
  - Evaluate impact of lower R-value on pavement thickness

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    Subgrade — The top surface of a roadbed upon which the pavement structure, shoulders, and curbs are constructed.

  - DNF –
    - Subgrade: Foundation for the pavement
    - Largest variability, Know the least about


LANE ENDS
1/2 MILE
MERGE RIGHT
EXIT 223B
74 WEST
Carefree Hwy
Wickenburg
EXIT ONLY
EXIT 223A
Carefree Hwy
East
EXIT ONLY
QUESTIONS?