A Case Study of Various Eagle Ford Shale Stabilizations for Pavement Subgrade

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A Case Study of Various EFS Stabilizations for Pavement Subgrade

- Introduction
- Eagle Ford Shale (EFS) Formation
- Goals of Treatment
- The Case Study Stabilization Program
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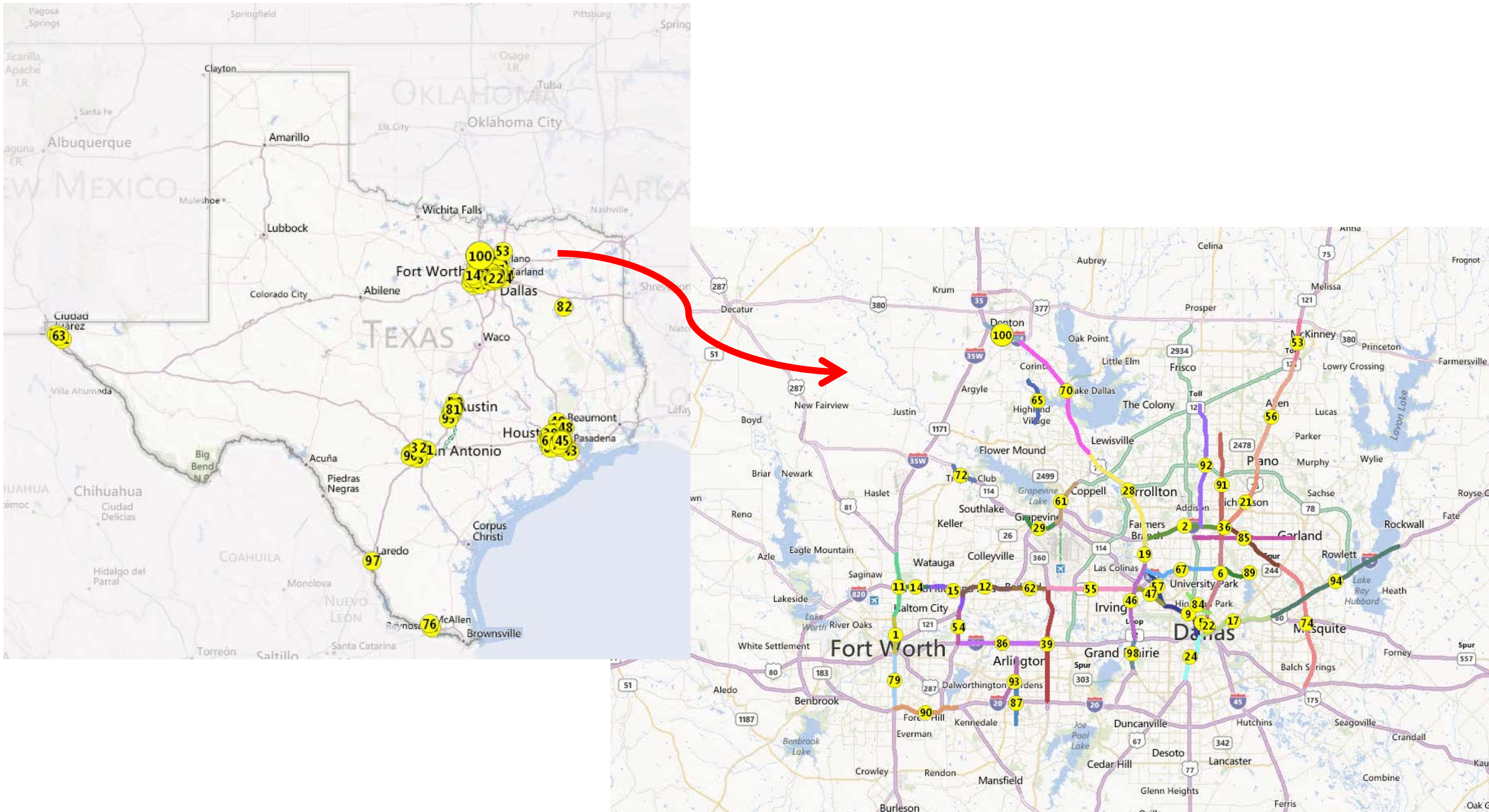
Introduction

- The stability of pavements subgrade vs long term performance.
- Most of Texas pavement on CL/CH/EFS
- Dry & wet cycles.
- DFW's highest numbers of congested highways.
- DFW's most expansive soils in the country

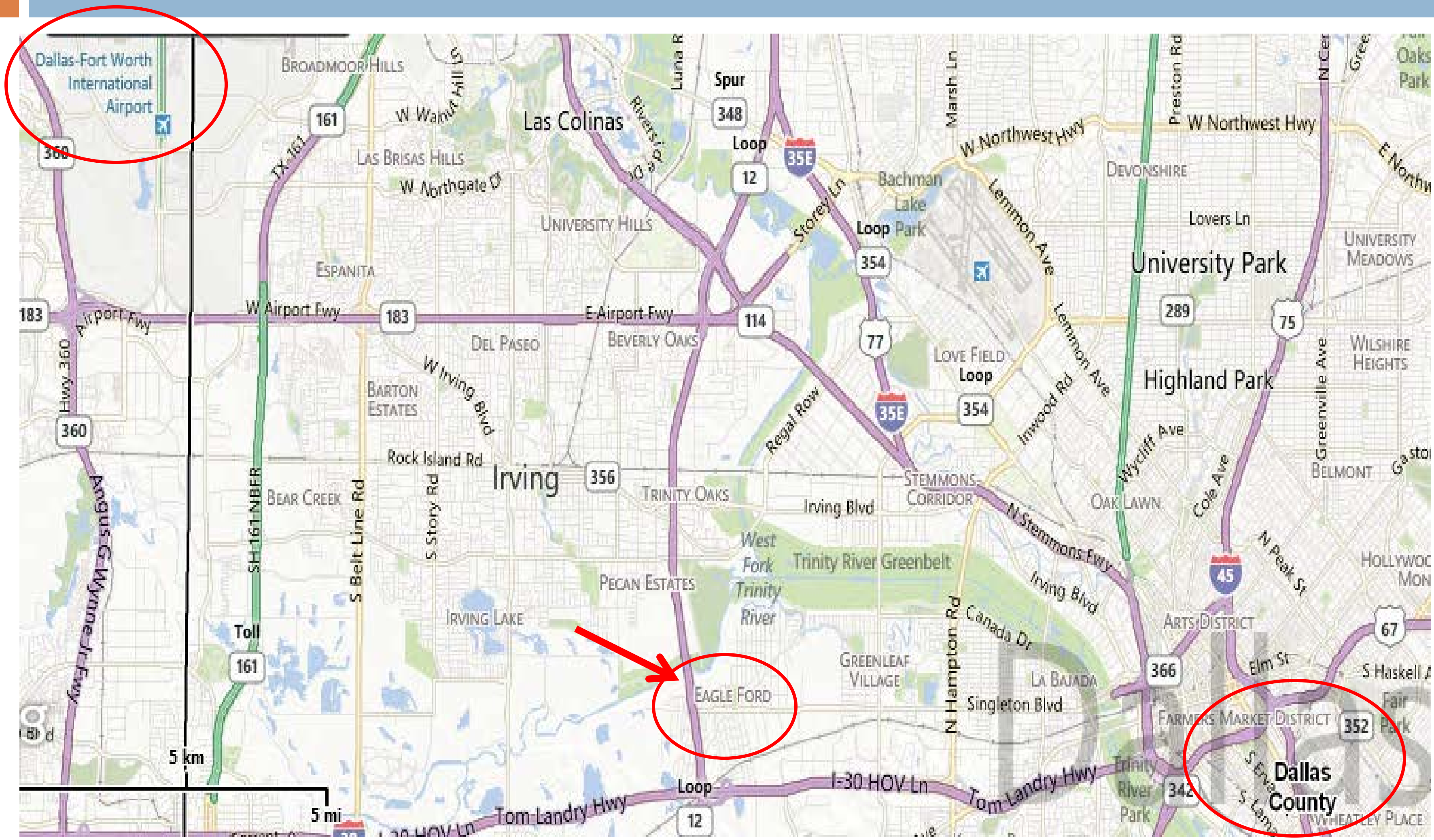
Top 100 Congested Segments of Roadways in DFW Metropolitan



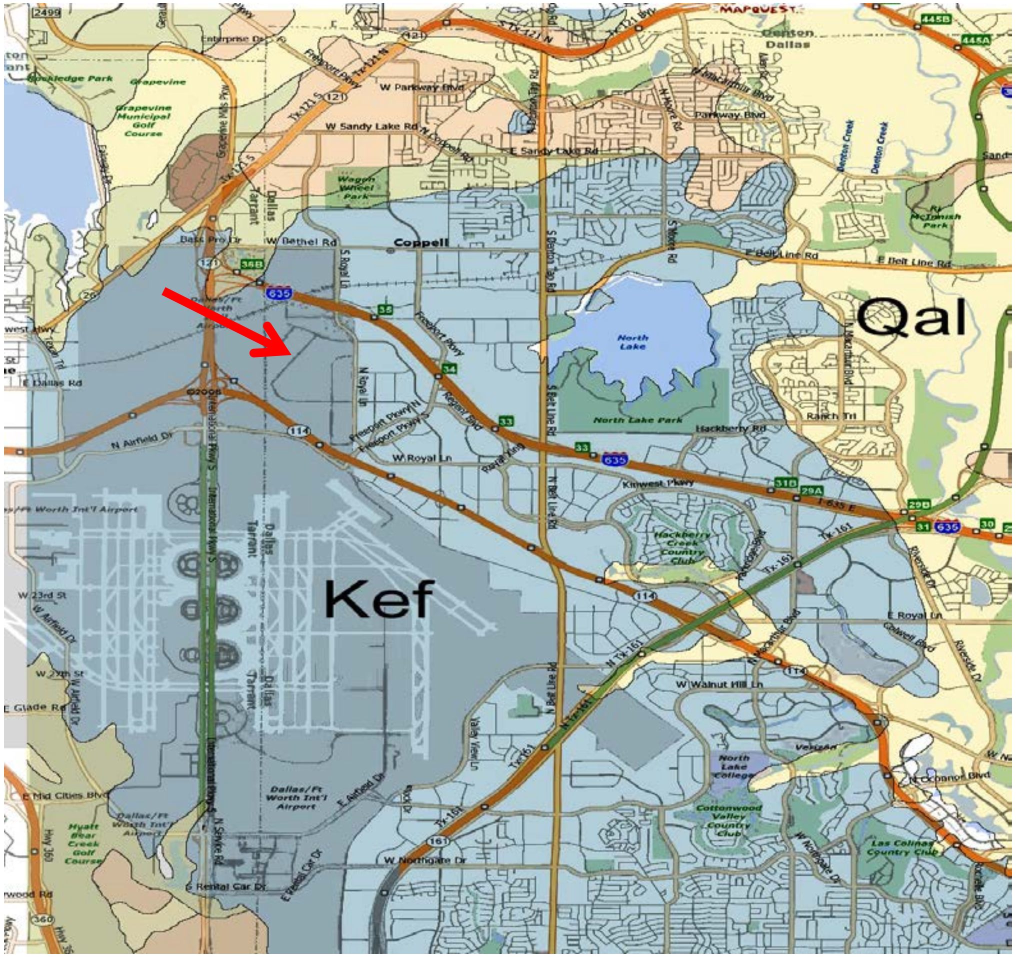
Eagle Ford Shale Formation

- EF Formation ~ EF Shale
- EFS is a sedimentary rock formation of Cretaceous age (66 to 155 million years ago).
- EFS derives its name from the old community of Eagle Ford, where outcrops of the Eagle Ford Shale were first observed.

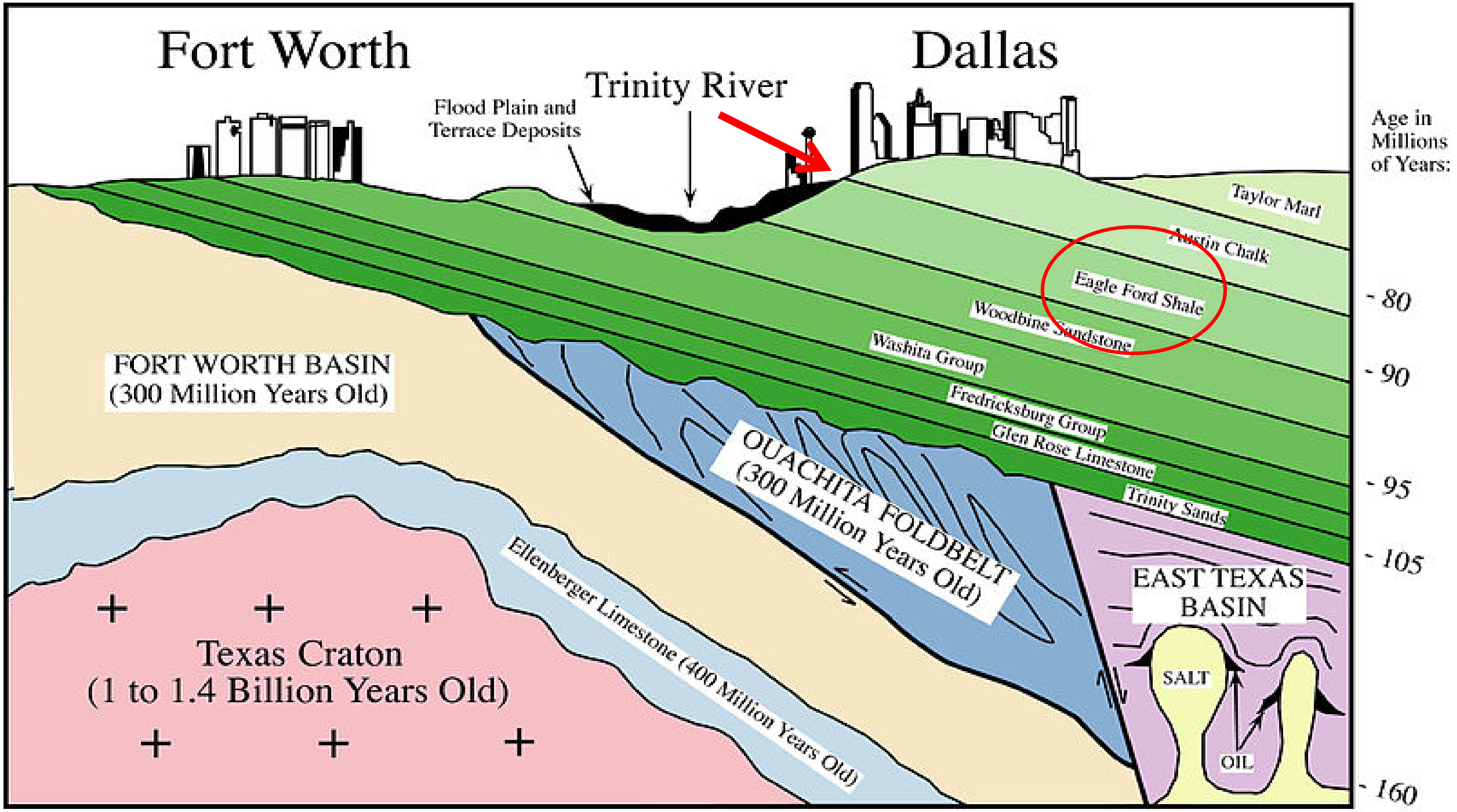
Eagle Ford Location



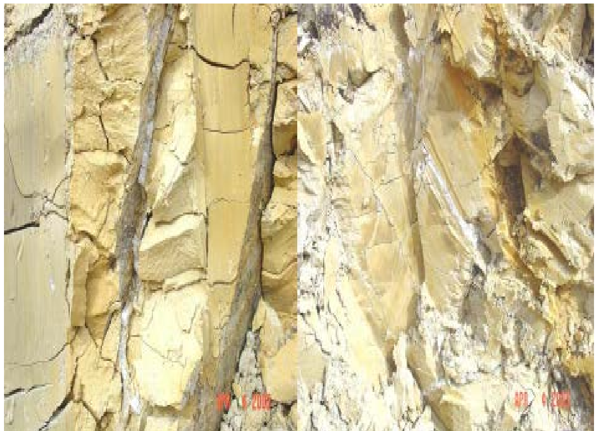
Eagle Ford Shale Formation (Near Test Site-Plan View)



Eagle Ford Shale Formation (Near Test Site-Elevation View)



Eagle Ford Shale Formation



Goals of Treatment

- Reduce shrink/swell.
- Increase strength to provide long-term support
- Reduce pavement thickness.
- Reduce moisture susceptibility and migration.
- Utilize local materials/LEED requirements.
- Resistance to frost.
- Provide a working Platform.

The Case Study

- Lime Stabilization
- Hydraulic Cement-Fly Ash
- Lime-Hydraulic Cement
- Chemical Products
  - Mix of clay-based and calcareous/limestone materials
  - Organic chemical (biocatalyst formulation)

Stabilization Program

- Hydraulic Cement (3%) -Fly Ash (3%)
- Lime (3%) -Hydraulic Cement (3%)
- Lime Stabilization (6%)
- Lime Stabilization (8%)
- Chemical Product No.1 (200 ml)
- Chemical Product No.1 (300 ml)
- Chemical Product No.1 (400 ml)
- Chemical Product No.1 (200 ml) -Lime (3%)
- Chemical Product No.1 (150 ml) -Lime (4%)
- Chemical Product No.2

Field Bulk Sample Program

- Two phases; preliminary and detailed
  - The preliminary program included sampling one bulk sample
  - The detailed and specific treatment program included sampling four bulk samples along the EFS Formation.

Field and Laboratory Bulk Sample Program

Laboratory Bulk Sample Program

Alternative	LL	PI	Ɣ pcf	MC	UC psi	Swell @0 day %	Swell @2 days %	Swell @4 days %	Swell @7 days %	Swell @17 days %
EFS Raw Soils	87	57	95.7	25.2	18.8	N/A	N/A	N/A	7.05	N/A
3% Cement & 3% Fly Ash	82	51	96	23.8	99.8	5.84	6.52	8.19	4.91	N/A
3% Lime & 3% Cement	60	16	89.7	28.2	186.8	1.73	0.71	0.62	1.75	1.75
6% Lime	59	16	89.5	29.6	170.0	1.36	1.08	0.97	N/A	0.27
8% Lime	58	14	89.2	30.6	176.0	0.98	1.00	0.86	N/A	0.44
Chemical Product No.1-200ml	83	55	98.3	24.2	7.8	13.76	14.76	16.47	N/A	7.96
Chemical Product No.1-300ml	85	57	97.8	23.8	6.4	12.85	13.66	14.58	N/A	7.67
Chemical Product No.1-400ml	84	56	97.3	23.8	8.1	12.91	14.73	15.56	N/A	6.87
3% Lime & Chemical Product No.1-200ml	68	33	91.6	28.7	94.3	1.45	1.21	1.11	N/A	0.25
4% Lime & Chemical Product No.1-150ml	63	24	90.4	29.7	102.7	1.07	0.91	1.02	N/A	0.47
Chemical Product No.2	85	57	98.1	22.5	6.3	N/A	N/A	8.10	7.86	N/A

Laboratory Bulk Sample Program

Alternative	LL	PI	γ* pcf	MC*	UC* psi	-200 Sieve	Sulfates ppm	Swell @0 days %	Swell @7 days %	Swell @17 days %
Sample 2A	72	56	86.4	32.5	153.9	95	147	0.52	0.34	0.10
Sample 2B	59	44	95.8	24.3	159.9	86	120	0.22	0.20	0.24
Sample 3	63	49	86.1	30.4	204.8	85	133	0.38	0.26	0.20
Sample 4	81	43	92.5	25.8	64.1	94	1753	1.78	0.42	1.13

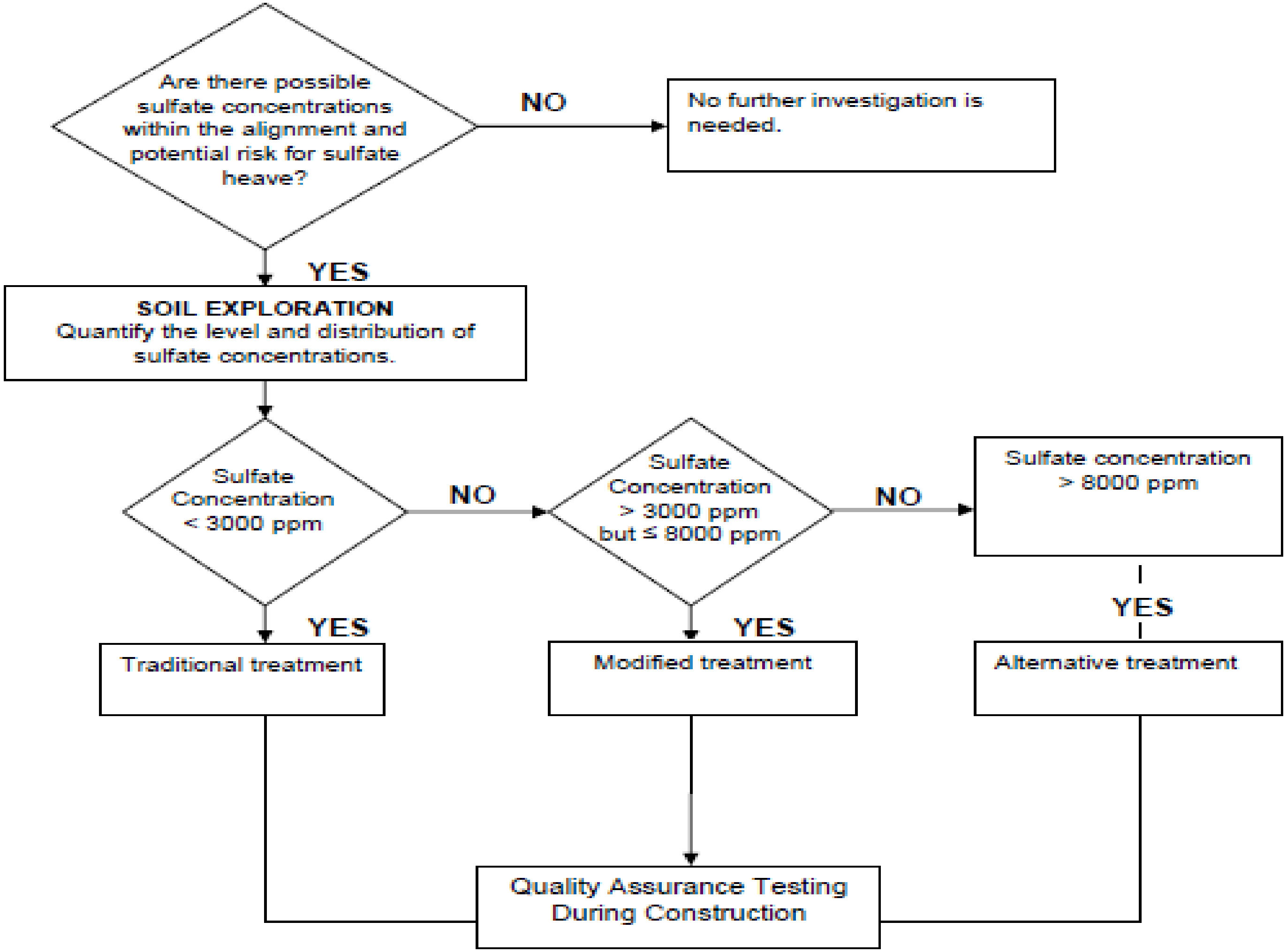
Project Requirements

- Limit the swell potential to a maximum of 2%
- Achieve a minimum of 100 psi for the unconfined compressive strength
- Other typical reasons for stabilization include:
  - Increased strength to provide long-term support.
  - Reduction in pavement thickness.
  - Reduction in moisture susceptibility/migration.
  - Working platform.

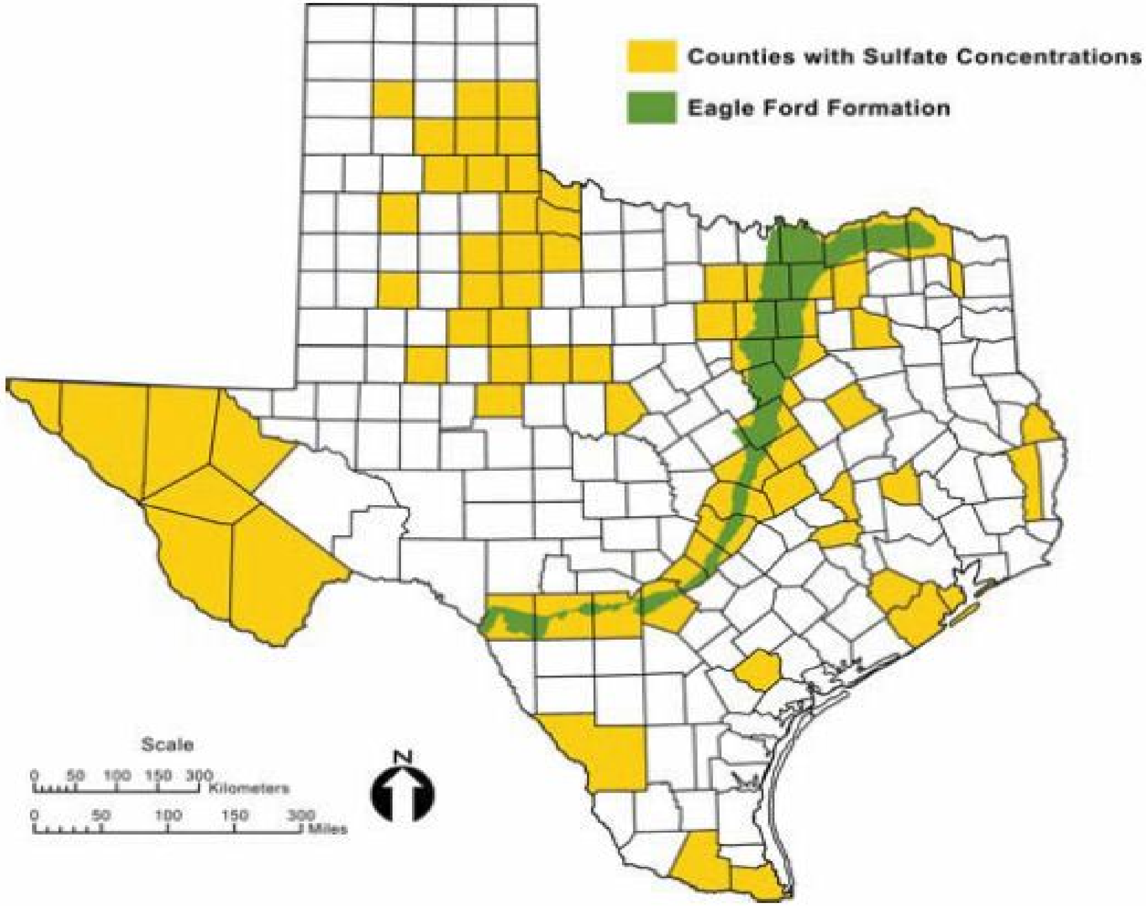
Discussion

- Lime either alone or as a combined agent meets the project requirements.
- Fly ash/chemical products did not achieve the project requirements; swell potential (2 %) or compressive strength (100 psi).
- Lime or lime/cement reduced
  - The Plasticity Indices from 57 to less than 16
  - The maximum dry density from 95.7 pcf to less than 89.7 pcf

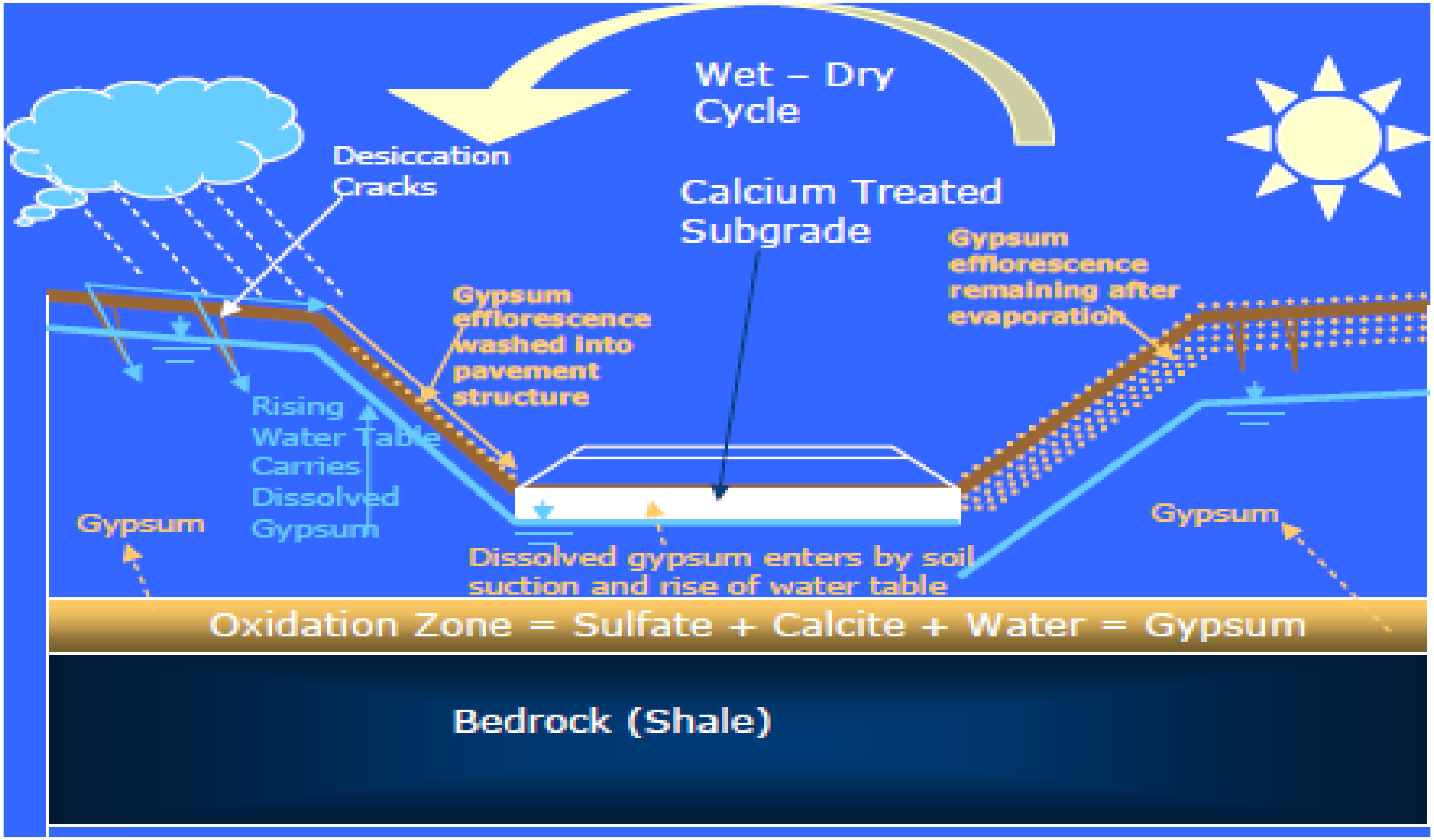
Sulfate Impact on EFS



Sulfate Concentration vs EFS



Sulfate Impact on EFS



Pavement Heave Due to Sulfate

Case Studies of Expansive Soils around the World

- Oman
- Canada
- Malaysia
- Algeria

CONCLUSION

- Understanding the stabilized agent, the project requirements, soil properties, geology formation, previous history and local practice.
- Lime either alone or as a combined agent was highly effective at the project location.
- Fly ash and chemical products did not achieve the project requirements.
- Lime or lime/cement reduced the Plasticity Indices and maximum dry density

CONCLUSION

- Curing time and percentage are major factors.
- Stabilization utilizing lime may be applied on a single or double application process.
- Sulfate concentration of the EFS Formation.
- Lime is the most common chemical agents.
- The treatment of expansive soils of some countries is very similar to what we obtained from the EFS due to the similarity of dominating Montmorillonite in the expansive clay soils.

QUESTIONS?