Evaluation of Erosion and Sediment Control Practices for Land Disturbance Activities Using RUSLE2

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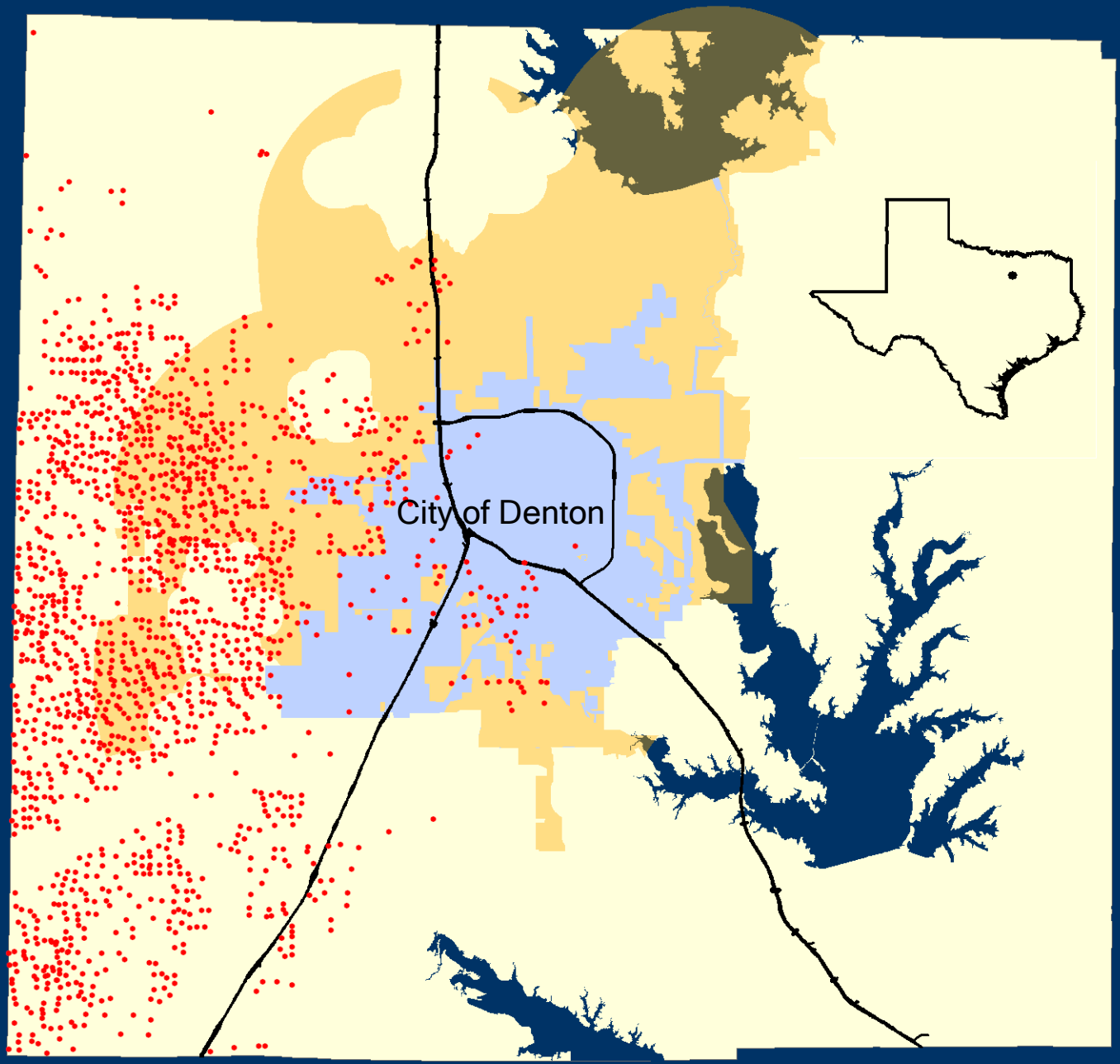
Erosion from Land Disturbance

- Sediments are the single most widespread pollutant affecting the water quality in rivers and streams (USEPA, 2000)
- Physical, chemical, and biological damage from erosion and sedimentation in North America may exceed $16 billion annually (Osterkamp et al., 1998)
- In developing urban areas, construction activities are responsible for 50 to 90% of sediment entering surface waters (Burton and Pitt, 2002; Canning, 1998)
- Sediment yields from construction activities range from a few tons to over 500 tons per acre per year (USEPA, 2002a)

Research Objective

- The objective of this research was to evaluate the relative effectiveness of BMP alternatives for natural gas well sites
  - Modeling approach using the Revised Universal Soil Loss Equation (RUSLE, Version 2)
  - Three slope profiles
  - Three soil erodibility factors
- Short-term goal - understand how slope and soil might effect various BMP efficiencies
- Long-term goal – use quantitative results to improve storm water component of existing ordinance

Study Area



Gas Well
City Limits
ETJ

Site Characteristics

- Construction activities from natural gas well sites disturb a substantial amount of the ground surface (2-5 acres)
- Completed sites may have moderate to steep cut and fill slopes that are unprotected from erosion
- Pad sites are semi-permeable
- Construction activities and field operations for oil and gas exploration and production are exempt from NPDES permitting

Site Grading

Bird's Eye View of Site Development

Drilling in Process

Natural Gas Well Site

Methodology

- Average annual sediment yields were modeled using RUSLE2
- For each slope and soil combination sediment yields were modeled with and without BMPs
- BMP Efficiencies were calculated accordingly:

$$ER = (SY_{without\ BMP} - SY_{withBMP}) \ / \ SY_{without\ BMP}$$

ER = (50 tons - 10 tons) / 50 tons = 80% efficiency

Modeled BMPs

- Seeding
- Mulching
- Erosion Blanket

} Erosion Control

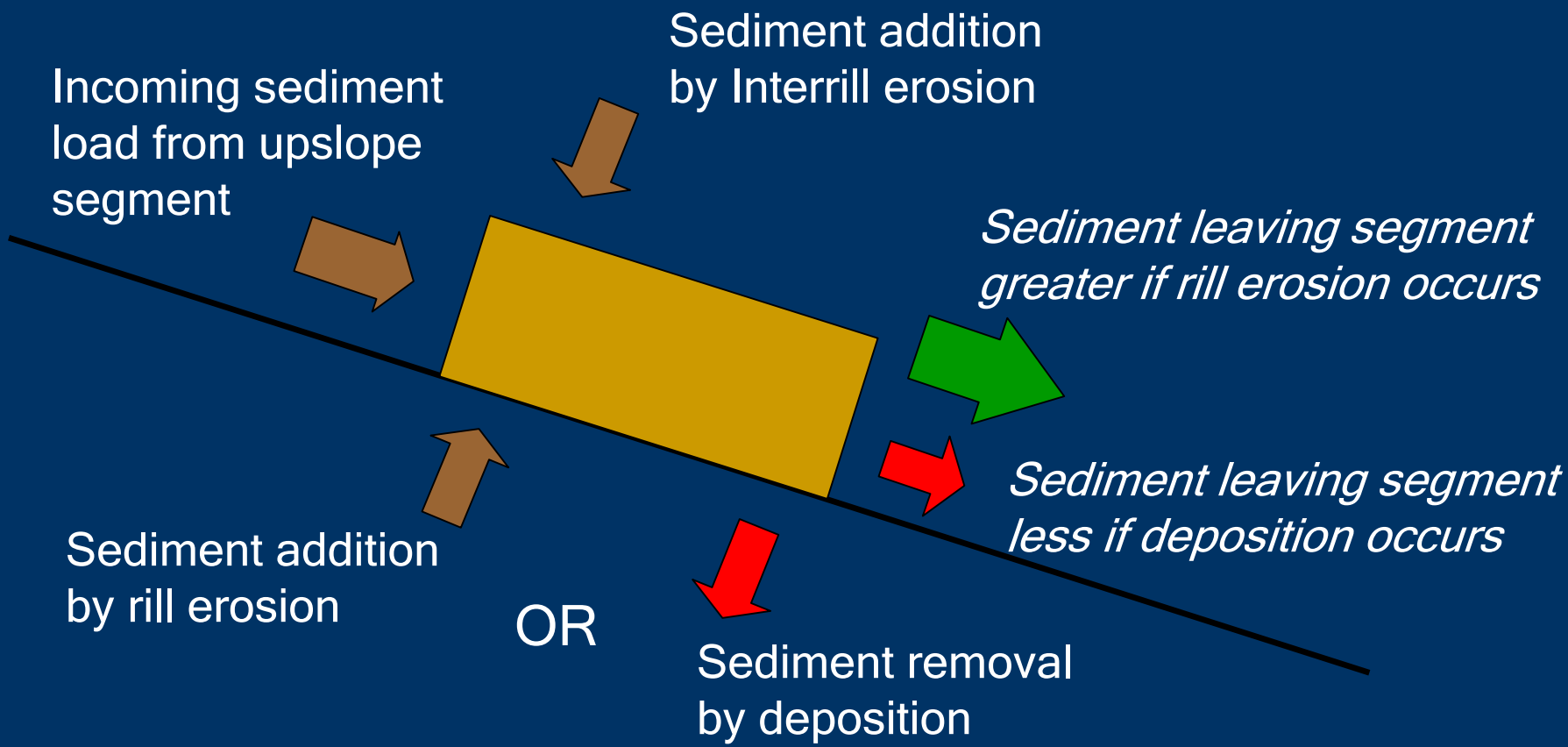
- Silt Fence
- Filter Strip
- Sediment basin

} Sediment Control

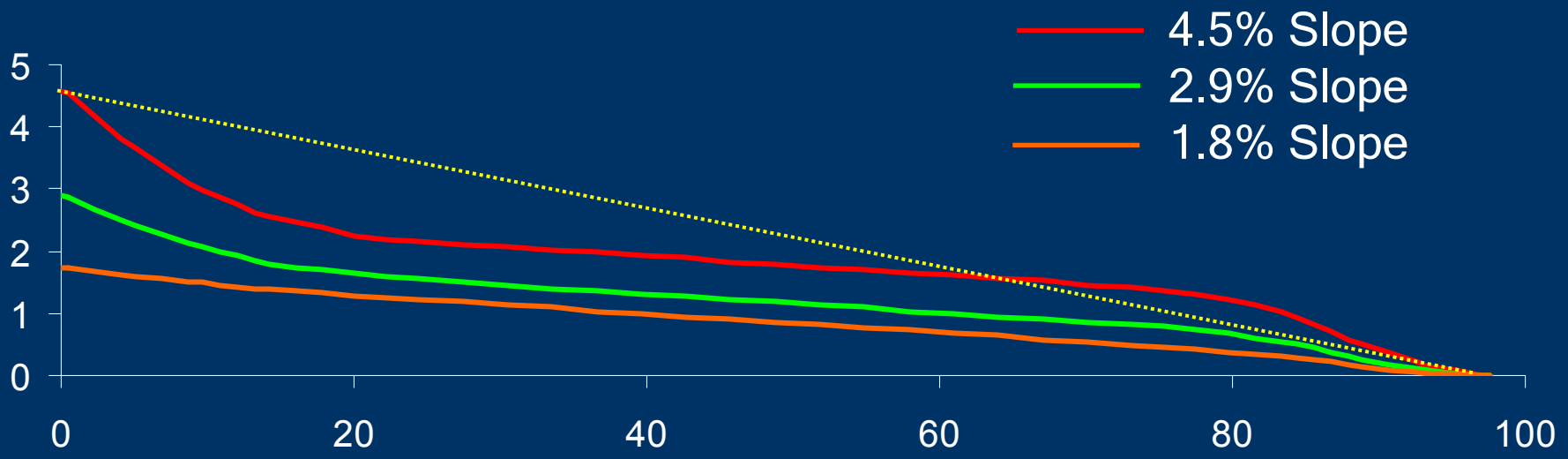
About the RUSLE2

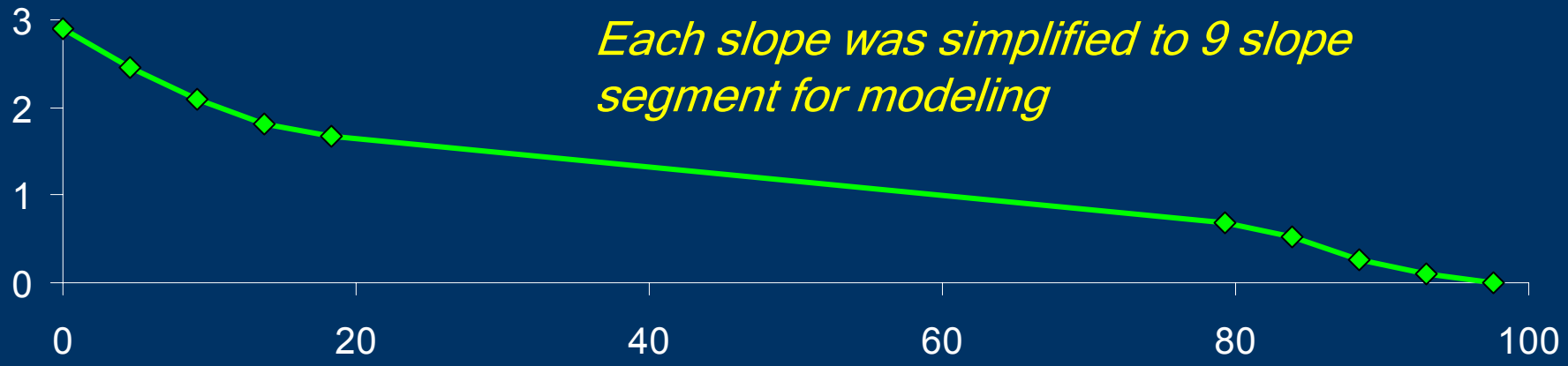
- Public domain model – developed and maintained by USDA – Agricultural Research Service - *Model Documentation (Foster, 2003)*
- Specifically designed as a conservation management tool for a variety of different land uses
- Intended to be used uncalibrated
- Estimates average annual sediment yields
- Easily customizable to specific site characteristics and geographical regions

How RUSLE2 Works



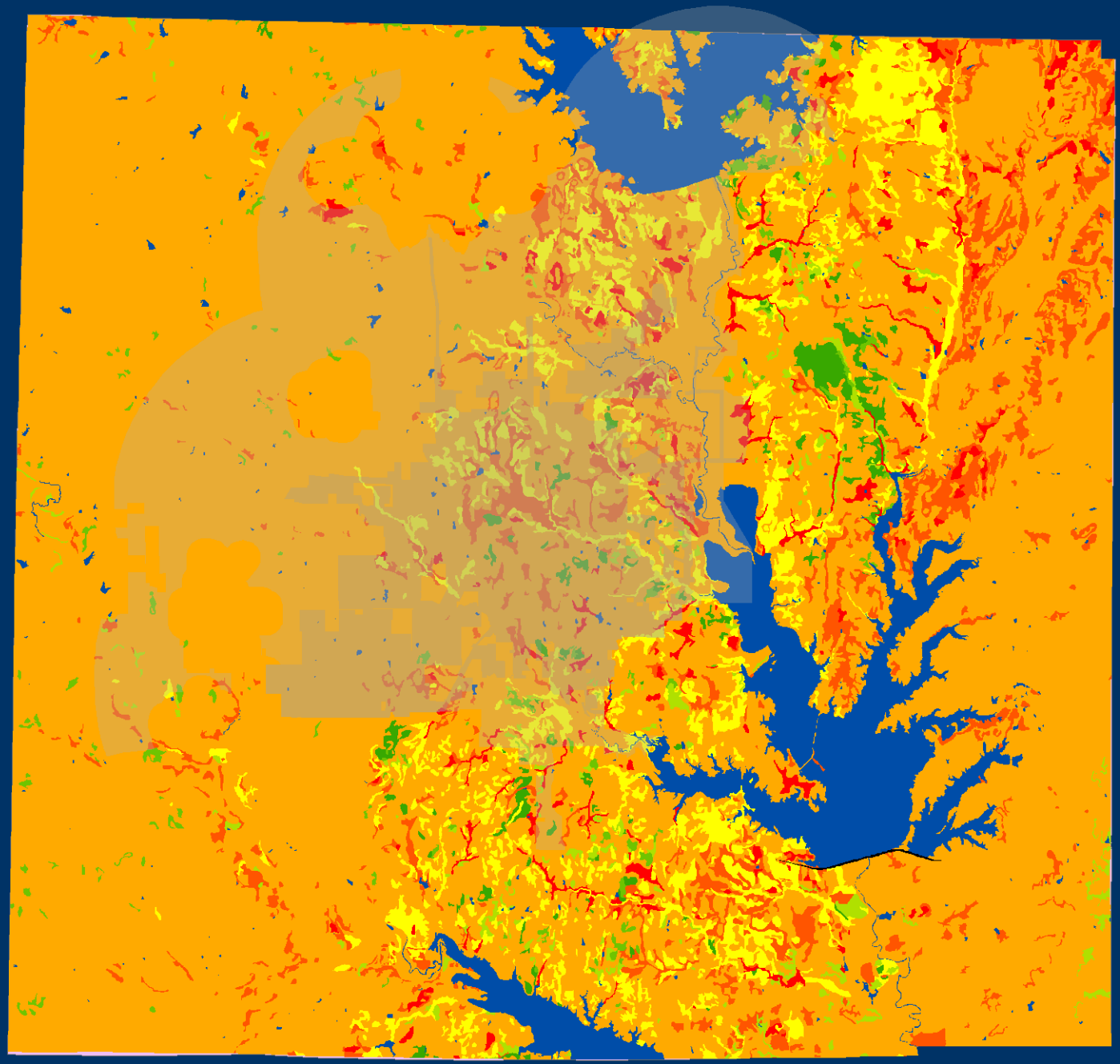
Modeled Site Slopes





Each slope was simplified to 9 slope segment for modeling

Area Soils



NRCS Soils

K-factor

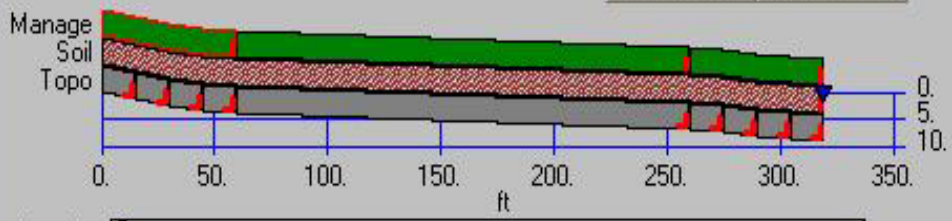
- .17
- .20
- .24
- .28
- .32
- .37
- .43
- Dam
- Water

(NRCS, 2006)

RUSLE2 ARS Version Aug 9 2006 - [Profile: Highly disturbed land\2.9% Gas Well Slope Profile]

File Database Edit View Options Window Help

Auto update | Calc



Location: USA\Texas\Denton County

Detachment on slope, t/ac/yr	27
Soil loss erod. portion, t/ac/yr	67
Soil loss for cons. plan, t/ac/yr	20
Sediment delivery, t/ac/yr	17
Enrichment, fraction	1.3
Crit. slope length, ft	

Horiz. overland flow path length, ft	320
Avg. slope steepness, %	2.9

Adjust res. burial level: Normal res. burial
Surf. res. cov. values: Surf. cover
Adjust ext. res. additions: Residue inputs
Adjust rock cover: Adjust rock cover

General yield level: Base yield
Adjust yield: Yields

Graphic | Rock cover, % 0

How get soil erodibility: set by user
Erodibility, US 0.32

Calc. consolidation from precip? Yes
Nominal consolidation time, yr

T value, t/ac/yr 3.0

Texture: Clay loam

Clay (<0.002 mm), %	34
Silt (0.002-0.05 mm), %	33
Sand (0.05-2 mm), %	33

Hydrologic class: D - highest runoff
Hydrologic class with subsurface drainage: D - highest runoff

Align of oper on segments | Segment output | Erosion by day | Ero
USLE/RUSLE1 factor values | Sediment distribution | S
Soil | Topography | Management | Contouring

Topography along overland flow path

Segment	Steepness, %	Horiz. distance from origin of flow to bottom of segment, ft	Erosion rate, t/ac/yr	Sed. load per unit width, lb/ft/yr
3	6.0	45.0	36	101
4	3.0	60.0	-43	71.4
5	1.5	260	-5.3	22.3
6	3.0	275	57	61.5
7	6.0	290	150	164
8	4.0	305	89	226
9	2.0	320	33	249

Info | Detached particles

Spec. surf. area, ft2/oz 3400

Detached Particle Info

Type	Portion, %	Diameter, in.	Fall velocity, mph	Specific gravity
clay	8.8	0.000079	0.0000069	2.6
silt	2.3	0.00039	0.00018	2.7
sand	4.1	0.0079	0.052	2.7
small agg.	31	0.0019	0.0022	1.8
large agg.	54	0.027	0.11	1.6

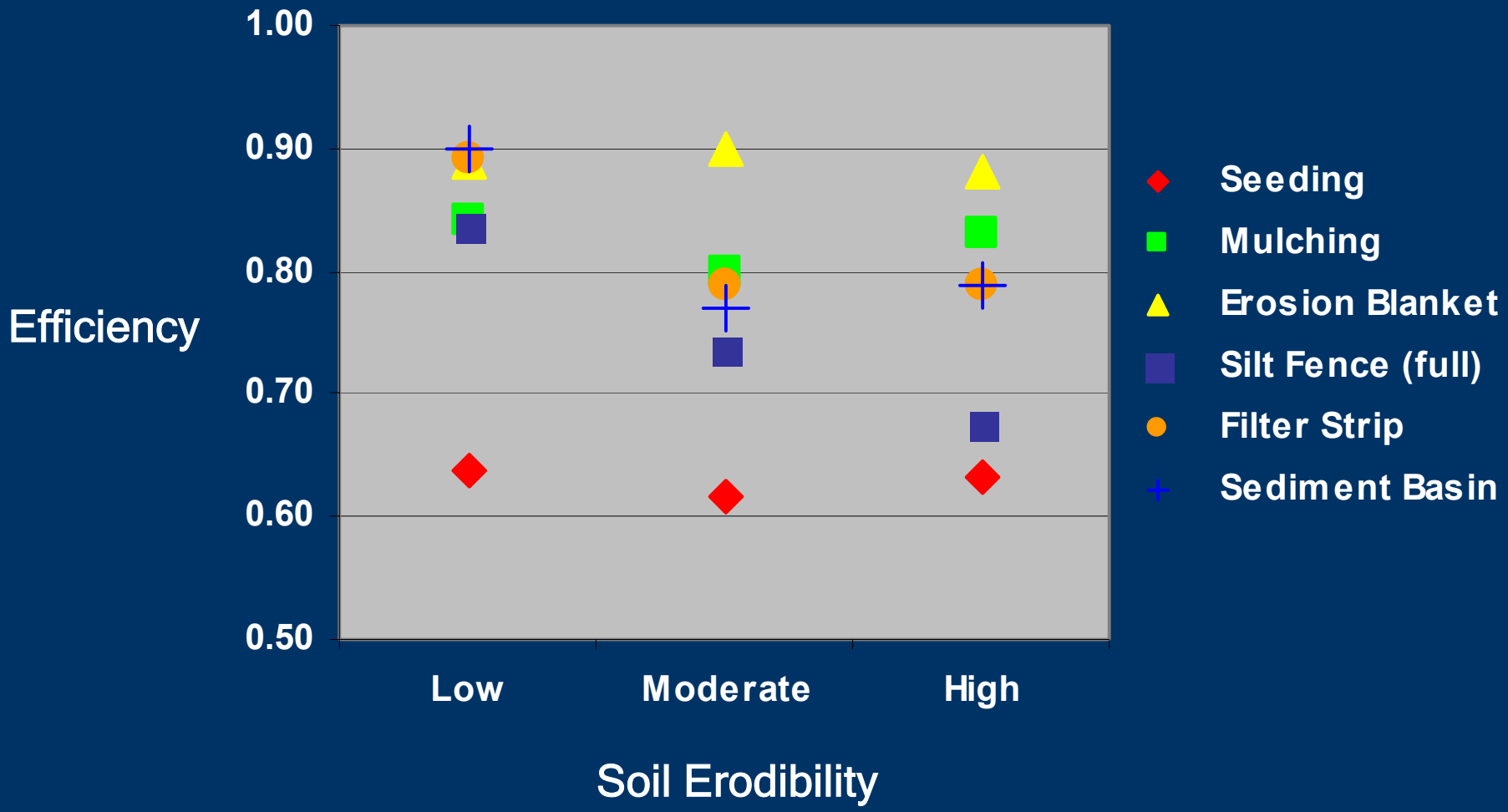
Results

Sediment Yield without BMPs (tons/acre/yr)

	K-factor 0.17 *Sandy Loam*	K-factor 0.32 *Clay Loam*	K-factor 0.43 *Silty Clay Loam*
1.8% slope	5.4	8.7	13.0
2.9% slope	11.0	17.0	27.0
4.5% slope	25.0	38.0	60.0

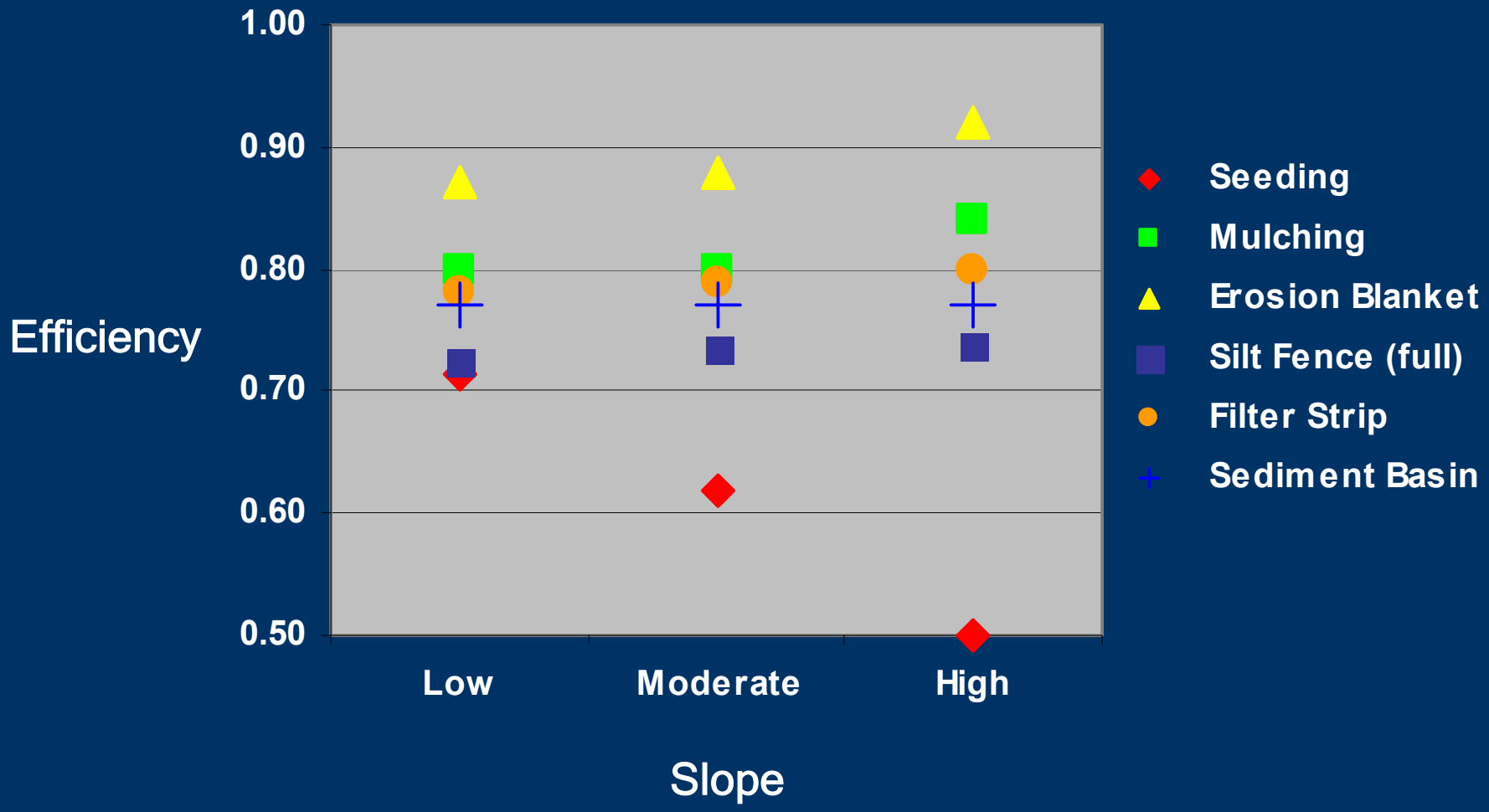
Results

BMP Efficiencies for 2.9% Slope



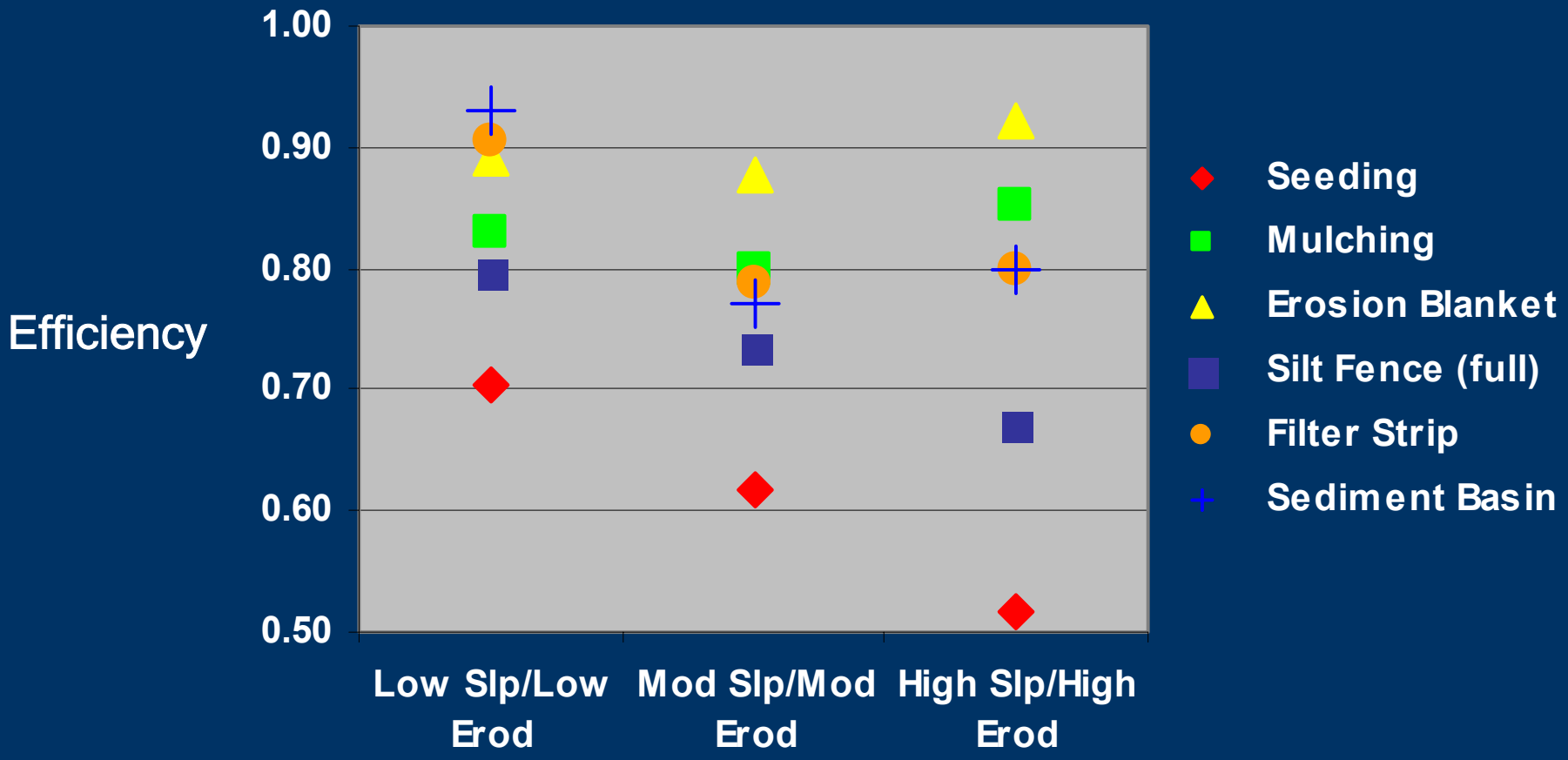
Results

BMP Efficiencies for 0.32 k-factor



Results

BMP Efficiencies for Combined Factors



Conclusion

- Without BMPs, modeled sediment yields ranged from 5 to 60 tons per acre per year
- With BMPs, sediment yields were reduced by 50 to over 90 percent
- Soils and slope can both influence BMP efficiency
- Methodology can be used to assist in the selection of BMPs according to various site factors

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Thank you

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