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MODERN EOLIAN PROCESSES
ON THE SOUTHERN HIGH PLAINS

by

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CAUTION

This report describes research carried out by staff members of the Bureau of Economic Geology that addresses the feasibility of the Palo Duro Basin for isolation of high-level nuclear wastes. The report describes the progress and current status of research and tentative conclusions reached. Interpretations and conclusions are based on available data and state-of-the-art concepts, and hence, may be modified by more information and further application of the involved sciences.

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Eolian processes have substantially modified the landscape on the Southern High Plains within historic time. The maximum inferred rate of deflation was 18.9 mm/yr at a site in Bailey County, Texas, a region of loose, sandy soils and frequent, seasonal dust storms. At least locally, agricultural practices have accelerated natural rates of erosion and deposition by winds.

An extensive cover of windblown sand and silt mantles the gently sloping surface of the Southern High Plains. Eolian deflation and deposition were among the dominant geomorphic processes affecting this region throughout most of Plio/Pleistocene and Holocene time. Historically, human activities have heightened the importance of wind action by disrupting the natural vegetative cover, thereby exposing the unconsolidated sediments.

Agriculture, particularly dry-land cultivation, has been the principal form of land use in the area since the early 1900's or before (Webb, 1931). The effects of tilling practices on deflation are shown in figure 1. The cultivated field on the right (east) is approximately 0.8 m lower than the range site on the left (west). This long, narrow field was cleared and probably brought into cultivation in the 1920's (C. D. Tunnell, personal communication, 1983). Its furrows run from north to south, along the field's long axis. The orientation of these furrows tends to maximize local deflation, as the furrows are parallel to the dominant winds. During the winter and early spring, some of the strongest winds are from the north, whereas the prevailing wind direction is southerly at other times of the year (Bomar, 1983). Other factors that enhance the erosional impact of the wind include antecedent dry conditions and frost heaving. Both are seasonal effects that increase the soils' susceptibility to removal during the frequent spring dust storms. After becoming entrained, soil aggregates from this field and others like it are transported from their source and redeposited as a broad sheet of eolian sediment.

In Bailey County, sandy soils and periods of extended drought combine to create conditions highly favorable to deflation. This region and adjacent eastern New Mexico have been identified as major sources of sediment entrained by dust storms during the spring (Kessler and others, 1978; McCauley and others, 1981) (fig. 2). Rates of enhanced deflation over historic time were inferred from examination of exposed concrete foundations of abandoned buildings in the area (fig. 3). The ages of five structures showing evidence of deflation around their bases were determined from unpublished records, and average annual rates of deflation were calculated (table 1). The highest rate was 18.9 mm/yr. McCauley and others (1981) reported that in February 1977, plowed fields in eastern New Mexico were locally eroded to depths of more than 1 m during a single dust storm. However, an extreme event of this kind is probably offset by seasonal deposition, perhaps within a short time. In contrast, the mean rates shown in table 1 represent relatively long-term, net losses.

In order to evaluate the relative significance of deflation observed in the Bailey County area, rates there were compared to measurements of erosion at heavily denuded sites elsewhere. As few representative rates of prolonged deflation at other sites have been reported, data regarding denudation caused by both fluvial and eolian erosion were compared to the maximum deflation measured during the current study. Extrapolation of this rate, to 18.9 m/1000 yr, helps put this figure in perspective. The millenial rate is almost 50 percent greater than the maximum rate of erosion recorded in a small drainage basin in the Loess Hills of Iowa (Federal Interagency River Basin Committee, 1953). The rate at Loess Hills, 12.8 m/1000 yr, is one of the highest previously recorded (Schumm, 1977). The maximum deflation in Bailey County is also 19 times the average maximum rate of denudation expected in large drainage basins (Schumm, 1977). Direct comparison of these figures is somewhat artificial, but it does illustrate the relative intensity of local deflation around structures in the Bailey County study area. Most of the structures are located south of Muleshoe along the edge of the Blackwater Draw sand dune belt, which trends east-west (fig. 4). The soils are sandy loams subject to severe wind erosion (Girdner and others, 1963). Without irrigation these soils are poorly to only moderately well-suited to cultivation, yet early farmers attempted dry-land farming. Abandonment of numerous homesteads during the "Dust Bowl" days in the mid-1930's and the extended drought of the mid-1950's attests to the severity of this problem.

The exceptional amount of deflation around these foundations must be considered a "worst-case" condition owing to the increased disturbance of soils associated with construction and habitation of the structures. Not surprisingly, most of the buildings exhibit maximum deflation on their north and northwest sides, the directions from which storm winds originate in the spring (Sidwell, 1938; Johnson, 1965). On those sections of land converted to range, cattle seeking shade further disturbed the vegetation and substrate, particularly on the north and west sides, thus increasing the potential deflation of soils.

The rates of deflation shown in table 1 were calculated relative to the dates of construction of these buildings. At some sites most of the deflation may have resulted from individual severe wind storms such as those that affected the region on March 25-26, 1935, March 2-3, 1956, and February 23-24, 1977 (McCauley and others, 1981; Bomar, 1983). If this is the case, the average annual rates as calculated are minima. Yet even these rates are greater than would be expected under natural conditions and almost certainly are not representative of soil-loss regionally. They are, however, indicative of conditions at severely disturbed sites from which all groundcover has been removed. Thus, the effects of eolian processes, enhanced by land-use at the repository site and vicinity, should be considered when siting and designing a facility for isolating long-lived nuclear waste. Mounds of mined salt and large, heavily trafficked areas at the construction site would be particularly vulnerable to redistribution of sediment.

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Figure Captions

Figure 1. Effects of deflation resulting from agricultural practices. The field on the right (east) is approximately 0.8 m lower than the vegetated rangeland on the left (west). The rangeland is in the southeastern corner of Caprock Canyons State Park immediately north of Farm-to-Market Road 1065, approximately 6.8 km north of Quitaque, Briscoe County, Texas. Photograph by R. W. Baumgardner, Jr.

Figure 2. Infrared satellite image at 1800 GMT (12:00 noon CST) of a dust storm over the Texas Panhandle, April 2, 1982. The source of dust is the region of dry, sandy soils along the Texas-New Mexico border.

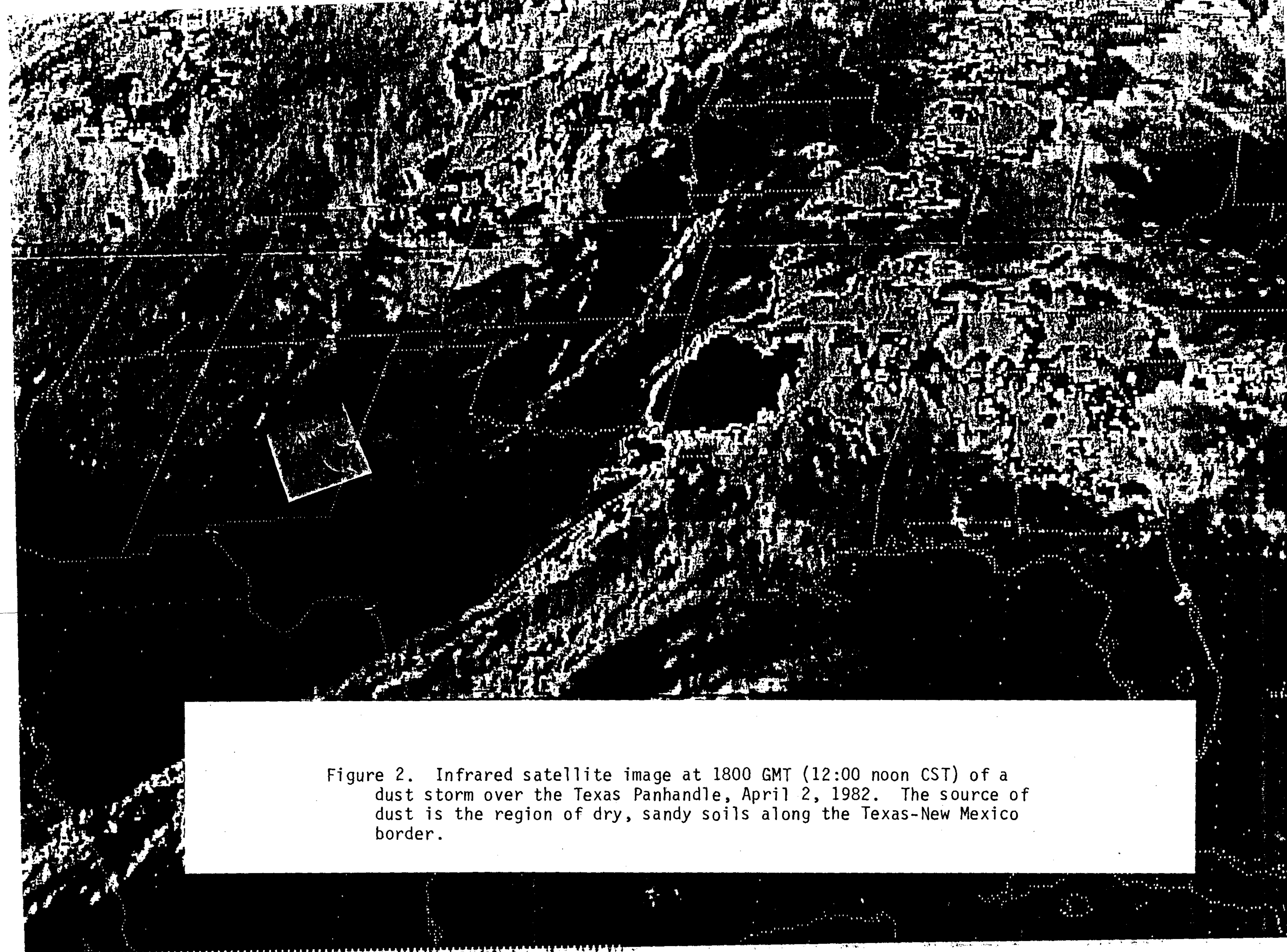
Figure 3. (A) Abandoned homestead, located 5.2 km north of Needmore, Texas, in Bailey County, Texas, along State Highway 214. The house was constructed in 1928, abandoned in 1940, and exhibits a maximum of 1.02 m of deflation around its concrete foundation. (B) Detail of exposed foundation, the lower half of which retains impressions of trowel marks and root traces. The concrete forming this part of the foundation was poured against the wall of a shallow excavation. The original ground level is indicated by the rim of concrete at the top of the 1-m scale bar.

Figure 4. General soil map of Bailey County, Texas, showing deflation-prone soils and sand dunes south of Muleshoe (modified from Girdner and others, 1963). Numbers refer to the locations of abandoned structures at which deflation was measured (table 1). The Tivoli-Brownfield Association corresponds to the sandhills along Blackwater Draw, a relict drainage feature.

Table 1. Mean annual rates of deflation from around the base of abandoned structures, Bailey County, Texas.

Building Reference Number	Construction Date	Age (yr)	Maximum Foundation Exposure (mm)	Mean Annual Deflation (mm/yr)
1	1929	53	260	4.9
2	1930	52	390	7.5
3	1930	52	320	6.2
4	1928	54	1,020	18.9
5	1951	31	280	9.0

Figure 1. Effects of deflation resulting from agricultural practices. The field on the right (east) is approximately 0.8 m lower than the vegetated rangeland on the left (west). The rangeland is in the southeastern corner of Caprock Canyons State Park, immediately north of Farm-to-Market Road 1065, approximately 6.8 km (4.2 mi) north of Quitaque, Briscoe County, Texas. Photograph by R.W. Baumgardner, Jr.



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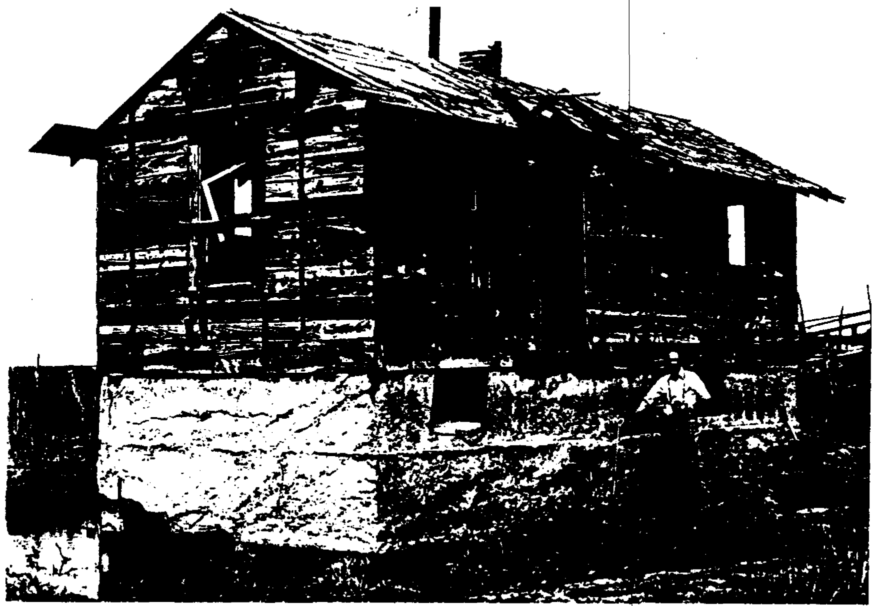
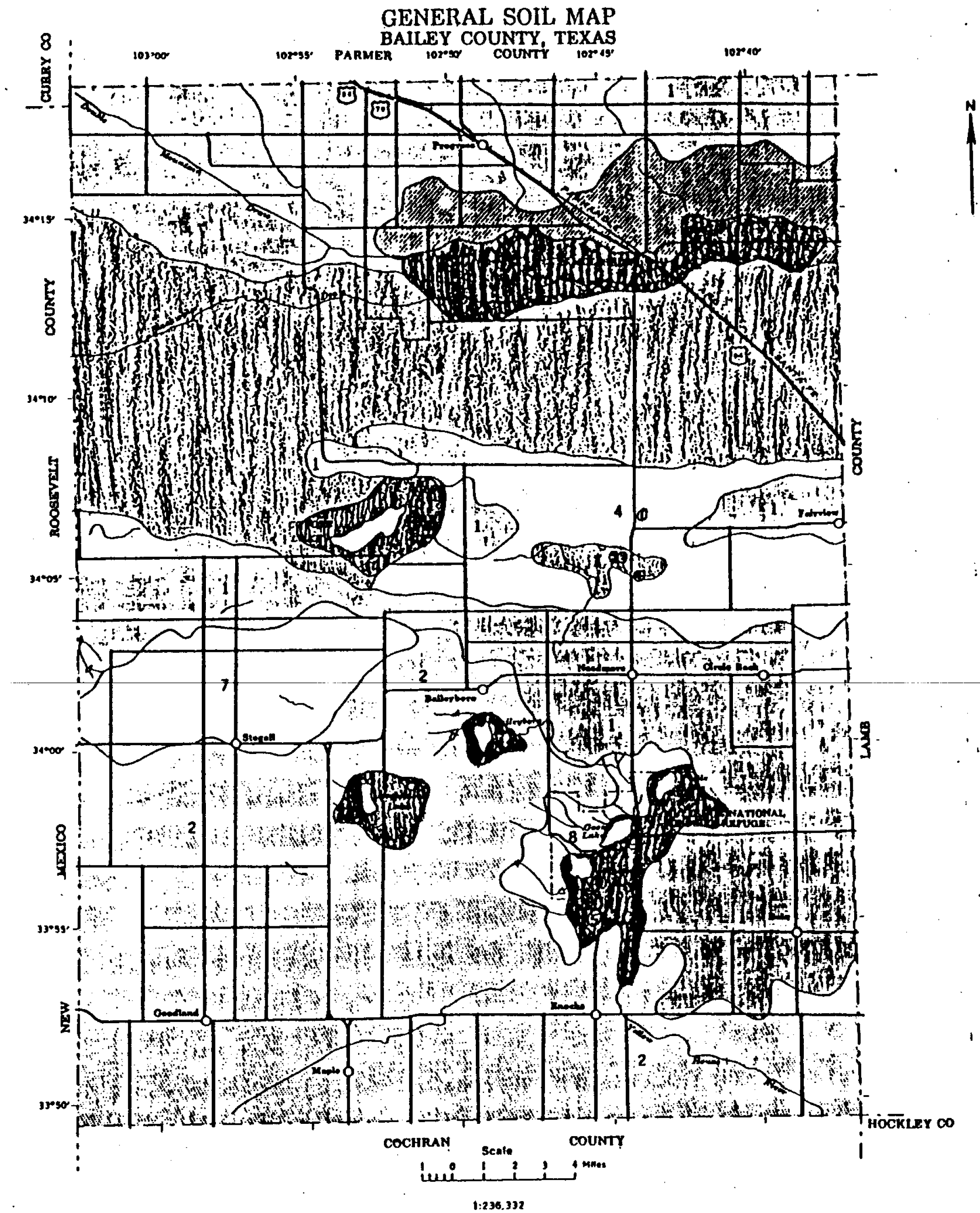


Figure 3. (A) Abandoned honestead, located 5.2 km (3.4 mi) north of Needmore, Texas, in Bailey County, Texas, along State Highway 214. The house was constructed in 1928, abandoned in 1940, and exhibits a maximum of 1.02 m of deflation around its concrete foundation.

(B) Detail of exposed foundation, the lower half of which retains impressions of trowel marks and root traces. The concrete forming this part of the foundation was poured against the wall of a shallow excavation. The original ground level is indicated by the rim of concrete at the top of the one-meter scale bar.



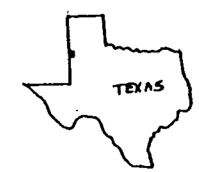


Figure 4. General soils map of Bailey County, Texas, showing deflation-prone soils and sand dunes south of Muleshoe (modified from Girdner and others, 1963). Numbers refer to the locations of abandoned structures at which deflation was measured (Table 1). The Tivoli-Brownfield Association corresponds to the sandhills along Blackwater Draw, a relict drainage feature.

SOIL ASSOCIATIONS	DEFLATION POTENTIAL
Amarillo fine sandy loam association: Level to gently sloping, deep, moderately coarse textured, moderately permeable soils.	Moderate
Amarillo-Arvana association: Level to gently sloping, moderately deep to deep, moderately coarse textured, moderately permeable soils.	Moderate
Tivoli-Brownfield association: Duned and undulating, deep, coarse-textured soils.	Very High
4 Amarillo loamy fine sand association: Gently undulating, deep, coarse-textured, moderately permeable soils with thin surfaces.	High
Arch-Drake association: Level to sloping, moderately deep, medium-textured, high-lime soils.	High
Portales association: Nearly level, deep, medium-textured, moderately to moderately rapidly permeable soils.	Low
Stegall association: Nearly level, moderately shallow to deep, medium-textured, slowly permeable soils.	Low
8 Berthoud-Mansker association: Sloping, shallow to deep, medium-textured, moderately rapidly permeable soils.	Low

② Location of abandoned structure exhibiting deflation.