

Sinkhole Collapse Due to Groundwater Pumpage for  
Freeze Protection Irrigation near Dover, Florida, January, 1977

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Introduction

During the period of January 17 to 22, 1977, central Florida experienced freezing weather with lows to  $-3.9^{\circ}$  C. To prevent freeze damage, the strawberry growers in the Dover area of eastern Hillsborough County irrigated their crops with warm groundwater withdrawn from the Floridan aquifer. The stress placed on the aquifer resulted in a large decline in water levels and in numerous small collapses or sinkholes.

Location and Land Use

The seven square mile study area, shown in Figure 1, is centered around the rural community of Dover, Florida, where land use is predominantly agricultural. Products and crops include citrus, strawberries, vegetables, chickens, tropical fish, and cattle.

Geology and Hydrology

The study area is a part of the Gulf Coastal Plain, and is underlain by Tertiary and Quaternary deposits which dip to the south and southwest. These sedimentary rocks are largely limestones and are covered with sand of Pleistocene age. Economic deposits of phosphate occur in the area.

The stratigraphy is described in detail by Carr and Alverson (1959), and Applin and Applin (1944). In general terms, the geologic section consists of 3-6m of surficial sands; 7-15m of clay, phosphate, clayey sand, and clayey limestones underlain by more than a thousand meters of various limestones and dolomites. The upper 300m of the carbonate section contains the Floridan aquifer, which is a very productive artesian aquifer that supplies the water needs of the area.

Carr and Alverson (1959) reported very deep sand-filled sinkholes in the study area. One of their test holes, drilled to a depth of 150m, penetrated through sand to about 30m below the expected top of limestone. Cathcart (1963) noted the presence of a karst topography and stated that the age of sinkhole formation ranges from late Miocene to the present.

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A consultant's report prepared for the City of Tampa (Watson and Company, 1973) states that there are several sinkholes within the proposed wellfield and that two new sinkholes formed during aquifer test pumping. One test well had to be abandoned when it penetrated a sand column to a depth of 94m, about 79m below the expected top of limestone.

Menke, et.al. (1961) also noted the presence of sand filled sinkholes in the study area. The authors of this paper have observed possible cavity fill during the construction of a well at the Dover-Turkey Creek fire station. The well penetrated an interval of chert with loose sand and black sand size phosphate at a depth of 57 to 62m. This sandy unit is overlain by 31m of limestone and the underlying limestone is continuous to the total depth of 91m.

#### Effects of Freeze Protection Irrigation

Strawberry farming is a very important element in the economy of the study area. The plants are set out in the fall and berries are harvested during the following spring. Although the Florida winters are mild, there are a few nights when frost or freezing conditions may exist. In order to protect the crop, the farmers spray irrigate their fields with warm (23<sup>o</sup> C) groundwater withdrawn from the Floridan aquifer. Ice forms during certain wind and temperature conditions and coats the plants. However, by constantly applying groundwater, the temperature of the continually forming ice stays at 0<sup>o</sup>C and the plants do not freeze.

New record low temperatures were established for the Tampa area on January 18, 19, and 20, 1977, when minimum temperatures averaged -1.7<sup>o</sup>C, -2.8<sup>o</sup>C, and -3.3<sup>o</sup>C respectively. The strawberry farmers began to pump groundwater with the onset of the record cold weather. Figure 2 shows the hydrograph of Tampa Well 15 in the proposed Thonotosassa wellfield and the thermograph from the weather station located at Riverview, 16km south of the study area. It can be easily seen that the drawdown portion of each pumping cycle occurred when the temperature dropped below 4<sup>o</sup>C and continued until the temperature rose above 4<sup>o</sup>C. The pumpage stress placed on the Floridan aquifer resulted in a total drawdown of 2.9m as shown by the hydrograph in Figure 2. Other drawdowns of 3.7, 12.2, and about 18, were also reported (Figure 1).

Residents affected by large drawdowns were forced to modify or repair pumping equipment in order to obtain water for domestic use. Several

residents reported that during the cold weather their private wells would not pump water; however, as the weather warmed the wells returned to service as water levels recovered.

### Sinkhole Occurrence

Newspapers and Hillsborough County officials received numerous complaints about the sudden appearance of sinkholes during the period of cold weather. Sinkholes caused major structural damage to one house, the loss of the citrus trees, and two cases of road damage. Sinkholes occurred near a fish farm pond, at a chicken farm, and in a drainage canal. Three sinkholes collapsed when vehicles were driven over them; two strawberry farms' reported sinkholes (see Figure 1).

The authors made field inspections and interviewed many of the property owners. A total of 22 sinkholes were catalogued. The actual number of sinkholes was probably somewhat higher; others may have occurred undetected in idle fields and remote areas.

### Conclusion

The sudden withdrawal of large quantities of groundwater for freeze protection created at least 22 sinkholes, some of which resulted in property damage. The large drawdown of the Floridan aquifer also caused inconvenience and minor property damage to nearby residents. Because short term test pumping of a proposed wellfield in the study area also created two small sinkholes, it is not surprising that a larger regional drawdown produced a greater number of sinkholes. Considering the growth of the strawberry farming industry and the proposed development of large scale wellfields in the area by the City of Tampa and Hillsborough County, the generation of sinkholes by groundwater withdrawals in this area merits further study.

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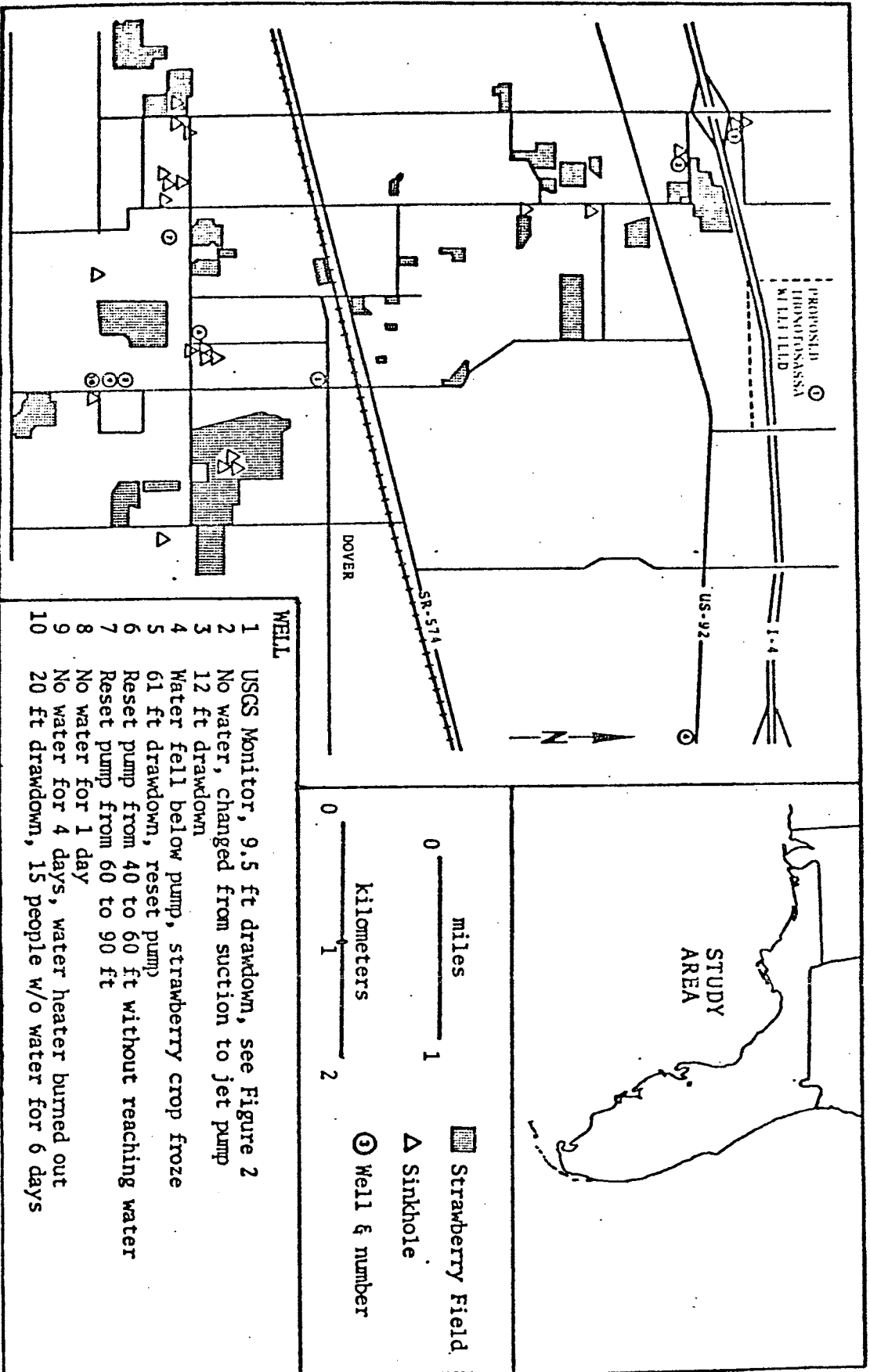


FIGURE 1: Location Map of Strawberry Fields, Sinkholes, and Wells Inventoried January, 1977, near Dover, Florida.

- WELL**
- 1 USGS Monitor, 9.5 ft drawdown, see Figure 2
  - 2 No water, changed from suction to jet pump
  - 3 12 ft drawdown
  - 4 Water fell below pump, strawberry crop froze
  - 5 61 ft drawdown, reset pump)
  - 6 Reset pump from 40 to 60 ft without reaching water
  - 7 Reset pump from 60 to 90 ft
  - 8 No water for 1 day
  - 9 No water for 4 days, water heater burned out
  - 10 20 ft drawdown, 15 people w/o water for 6 days

0 ————— 1  
 miles  
 0 ————— 2  
 kilometers  
 ▣ Strawberry Field  
 △ Sinkhole  
 ⊙ Well & number

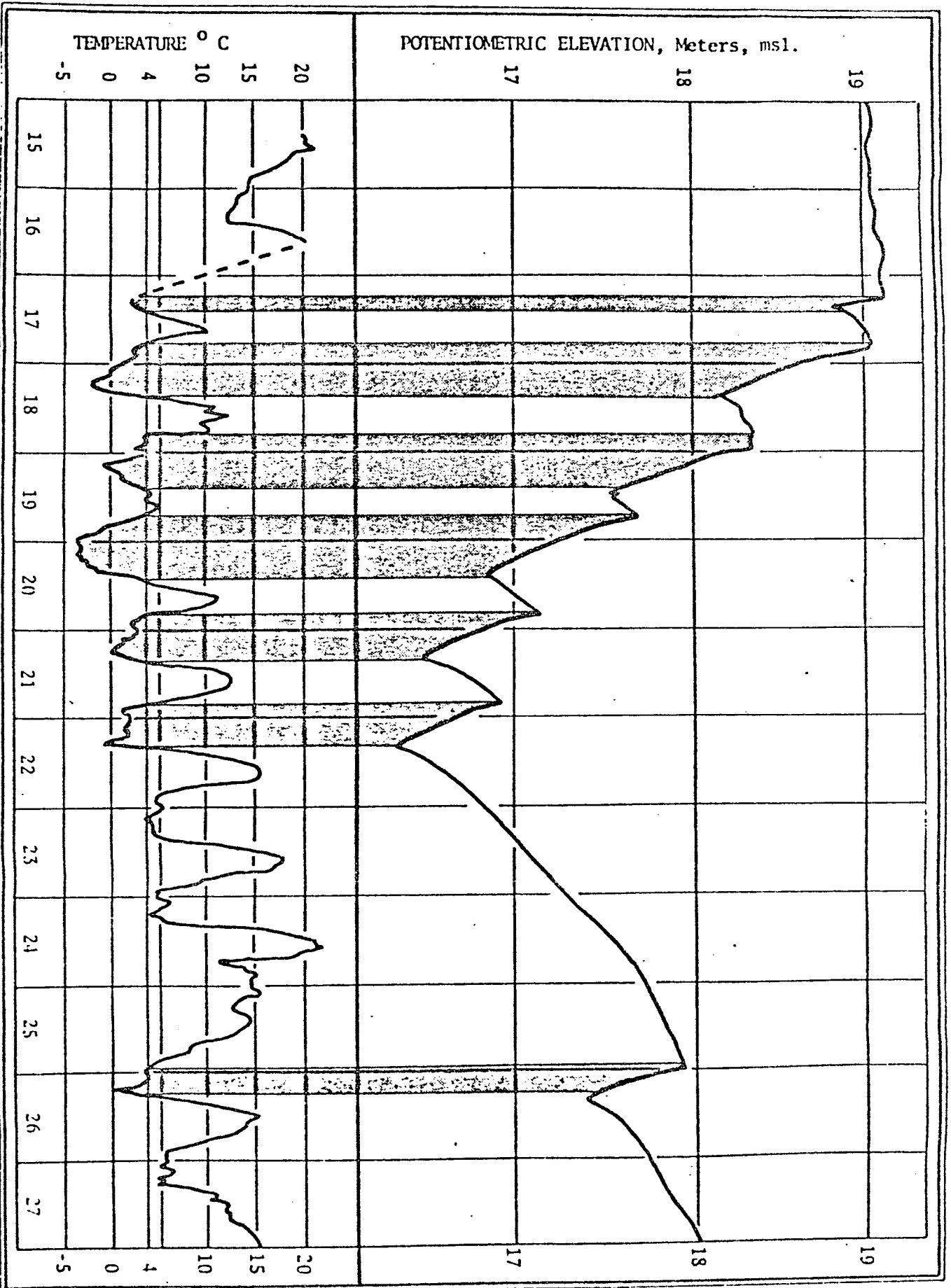


Figure 2. - Comparison of Hydrograph from Proposed Thonotosassa Wellfield and Thermograph from Riverview Weather Station, January, 1977.