Sinkholes in Irrigated Fields

soil-covered, debris-filled channels of former streams may be one cause of fall-outs during irrigation in certain areas

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Sinkholes—crater-like openings, sometimes as big as 10′ to 15′ across and 10′ to 12′ deep—that suddenly appear in fields during irrigation not only waste water and make farming difficult but—most serious—are a hazard to machinery and operators.

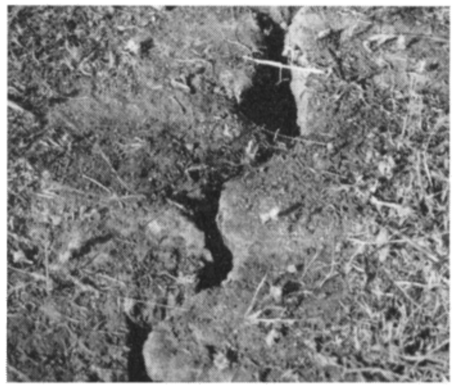
The sinkhole problem in California is confined—so far as is known—to several of the alluvial fans laid down by streams issuing from the east face of the coast range. Actually, the trouble is incipient at only a few places, but where sinkholes do occur they add materially to the cost of farming.

It is known that water has disappeared into one sinkhole—at a rate as high as three cubic feet per second—for a number of hours during a night irrigation.

Enough soil usually disappears into a hole to require replacement from off the field. Sometimes so much replacement soil is needed that the productivity of the land may be impaired if the replacement material is not carefully selected. One sinkhole will commonly require five cubic yards of backfill and occasionally 30 or more. A forty-acre field may need 100 cubic yards of backfill at one time, which may amount to 500 through repeated applications, until the erosion is halted.

Mechanical Analyses of Soils

Sample feet	% Clay (particle size .002 mm and less)	% Silt (particle size .002 to .05 mm)	% Sand (particle size .05 mm and over)
Field 1			
0–1	23.4	50.0	26.6
1–2	25.0	45.5	29.5
2–3	25.3	46.0	28.7
3–4	23.5	50.2	26.3
4–5	25.0	52.2	22.8
5–6	27.1	59.7	13.2
6–7	32.0	55.2	12.8
7–8	28.7	63.0	8.3
9–10	46.6	50.2	3.2
10–11	67.0	30.4	2.6
11–12	58.5	37.2	4.3
Field 2			
0–1	31.2	56.0	12.8
1–2	30.2	56.8	13.0
2–3	25.4	53.3	21.3
3–4	36.7	53.1	10.2
4–5	31.2	64.9	9.9
5–6	26.4	46.8	26.8
6–7	30.2	58.1	11.7
7–8	31.9	61.5	6.6
8–9	56.2	28.7	15.1
9–10	57.8	37.7	4.5
10–11	56.3	43.1	0.6
11–12	48.4	49.5	2.1



Soil shrinkage crack.

The maximum escape of water and the volume of soil that will erode away through a sinkhole are unknown, but the holes invariably become partially stopped up after the irrigation water is diverted.

Development of sinkholes in fields during irrigation usually starts with water running into a crevice, crack, or burrow; then, if not detected and stopped, they widen and deepen into crater-like depressions. They are a constant threat to the affected areas and possibly to adjoining land. They may never have shown up, then suddenly do so. They may reappear after several untroubled years. To guard as much as possible against a sinkhole's getting a good start, constant watch is essential wherever water is running—in ditches, in furrows, on checks. This means employing extra irrigators and stopping operations before nightfall.

In practice, it is impossible to detect all holes and divert the water before they enlarge to the danger point, because they are often hidden by the crop and collapse may occur without warning.

The greatest hazard is to farm machinery and operators. Not infrequently a tractor runs into a hole and is damaged and its operator thrown to the ground. Where sinkholes are possible, it is customary to search for holes and mark them before allowing machinery to go into a field. In extreme cases, farm laborers may be so fearful of these conditions that they refuse to continue on the job.

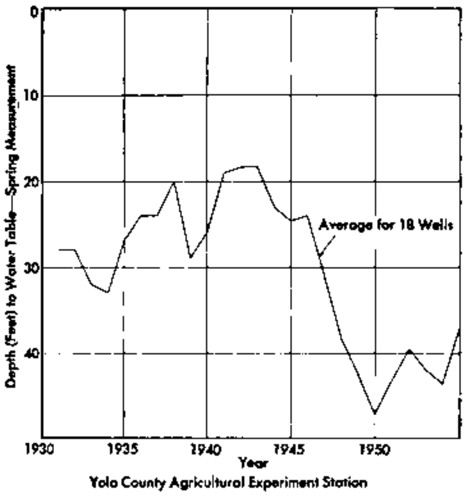
It is generally accepted that the crop planted has much to do with inducing sinkholes. An alfalfa seed crop is perhaps the greatest offender—especially when grown without irrigation—and alfalfa hay is reported to have a similar, though somewhat less, effect. These crops are said to contribute to the formation of sinkholes by drying out the soil to depths of 20′ or more, thereby causing cracks that extend from the surface to depths that allow the escape of water and soil into underlying voids or cavities. Sinkholes are not encountered in fields planted exclusively to any of the cultivated row crops.

It is significant that the areas where sinkholes occur lie between delta-building streams. Hence, the land surface slopes away from the streams and during the process of formation is traversed by meandering overflow channels, or sloughs. In certain areas of Arizona, it has been found that soil-piping—rapid seepage—from irrigated fields to adjacent stream beds causes sinkholes. But in the California areas where the problem exists, the topography makes soil-piping unlikely. Furthermore, no evidence has been found of underground flow of soil and water into stream beds.

To a large extent the water used for irrigation is pumped from wells with the effect on the water table shown in the

Sinkhole Excavations

Depth feet	Material	Observations
Field 1 Old alfalfa seed crop		
0–8	Clay loam	Excavation made through sinkhole 18″ wide, 4′ long, and 6′ deep, following a soil-shrinkage crack.
8–20	Yellow clay	Pit excavated to 12′. Profuse root penetration to this depth. 4″ auger hole put down to 23′ level. Scattered root penetration to this depth.
20–23	Red clay	Soil shrinkage crack visible at both ends of pit.
Field 2 Young alfalfa seed crop		
0–11	Loam	Excavation made through sinkhole 10′ across and 7′ deep. Pit excavated to 12′. Profuse root penetration and many gopher holes to 6′ depth, soil shrinkage cracks beyond.
11–27	Clay	Visible soil shrinkage cracks. Scattered root penetration.
27–30	Red clay	Same as found under Field 1.



Water table fluctuations where sinkholes occur.

accompanying graph. It seems highly probable that this situation has a bearing on the problem. On the other hand, the depth of soil unwatered falls far short of that held responsible for land subsidence, notably in the San Jose and Delano areas of California.

The characteristics of the earth mantle in two fields where sinkholes occur were shown by mechanical analyses of the soil. Exactly comparable earth-mantle conditions exist in adjoining fields where no trouble has been experienced with sinkholes.

There are good reasons to believe that the eroded soil lodges in buried overflow channels. Such channels still functioning as surface water courses show evidence that the ancient channels were bordered and choked by heavy vegetation. It is reasonable to assume that they were buried in that condition, forming veins of unconsolidated organic material at various depths beneath the surface.

So long as such channels remained under water, the trash that must have filled them continued to be unconsolidated while clay strata formed over the trash. On becoming drained by the lowering of the water table, the loose fills may have settled and become bridged by the overlying clay formation, thus forming tunnels a few feet across and several miles in length.

Any one of these elongated underground channels could be expected to contain a large, silt-laden stream of water for a number of hours. It could also be expected to clog partly when the flow stopped. Being confined by the banks of the buried overflow channel and the water table at its downstream end, such an underground tunnel could not continue indefinitely to receive more eroded soil. Erosion could cease for an indefinite length of time and then be reactivated by a further lowering of the water table, which might expose additional deeply buried, debris-filled overflow channels.

Control Measures

The surest way to keep sinkholes from developing in irrigated fields is to avoid ponding or running the water over the soil surface by transporting it in pipe lines or concrete-lined ditches and applying it with an overhead irrigation system. No risk is involved in growing deep-rooted, uncultivated crops if the sprinkler system's water-application rate does not exceed the permeability of the soil. Early planning for sprinkler irrigation would make unnecessary the heavy expense for grading that might be required if the land were to be surface irrigated.

If the experience over a long period of years can be accepted as proof, the production of a deep-rooted, uncultivated crop is an essential link in the chain of circumstances that produces sinkholes in California irrigated fields. Total avoidance of such cropping might therefore mean freedom from the sinkhole trouble.

Collapse of a ditch section during irrigation.

A sinkhole that opened suddenly to a depth of 8'.

Preventive measures will never remove the potentiality of sinkholes. If there is a change of ownership or tenancy, and—through lack of knowledge or by preference—the new occupant should change the irrigation or planting practice, he would expose himself to the sinkhole trouble, and—perhaps—in a stored-up amount.

To elect to farm as usual and deal with the sinkholes as they show up presupposes that it will be feasible to irrigate satisfactorily and that the trouble will be rectified hole by hole until it stops.

The situation where holes are in irrigation ditches or furrows has been successfully dealt with by diverting the water around the hole, bridging it with light-weight pipe, or by partly filling it with earth and covering it with a large tarpaulin. In extreme cases the latter method has succeeded where the others have failed.

The worst-affected field can be completely irrigated by diverting the water around a sinkhole in a furrow, if there is sufficient extra water to take care of unavoidable waste of water and if enough manpower is available to see that the irrigating streams reach the lower ends of the runs.

Holes that show up in flooded checks have been successfully isolated during an irrigation by manually throwing up a dike around them.

To repair sinkhole damage that occurs during an irrigation season, it is sufficient to fill the holes with earth early enough in the fall to assure that the winter rains will settle the fills.

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