applications of pesticides allowing us to go to an IPM spraying program, eliminates trash for rodents to live and breed in, cuts our cost for rodenticides, lessens competition for available water, lessens the pressure of irrigation, and last—but first—a non-competitive environment for our plants to grow and flourish in and maybe make the market one year earlier and possibly increasing our profit.

In the spring of 1988 we are going to test a small area of our container operation for this type of program.

RALPH SHUGERT: In Western Michigan Dual has not knocked out yellow nutsedge as you have reported.

SOLVING DRAINAGE PROBLEMS ASSOCIATED WITH AUTOMATIC IRRIGATION SYSTEMS

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The modern nursery has faced cost controls in many ways. One of these has been to install automatic irrigation systems in areas used for container production. Whether the automatic system is drip, or overhead spray there is, in varying degrees, waste in the form of run-off. Without a doubt the worst offenders are the various overhead spray systems. They put as much water on the area between the containers as they put in the containers. No great amount of time need be spent around a nursery to see that serious drainage problems quickly build up near irrigation systems.

There are, it turns out, two related problems with this waste water. The first problem is most readily apparent in the form of the surplus water running across the surface of the ground or puddling in the low spots. Through proper grading of the surface the puddling can be eliminated, and the flow can be channeled into areas where its presence can be more easily accepted. The second problem is much more difficult to solve. As the waste water lands on the ground from the sprinklers, or emerges from a pot, it proceeds to run off, following the natural grading of the bed surface. During the process a fair amount is absorbed by the soil itself, or whatever material is being used as the growing surface. Absorption occurs to even a greater degree in the areas where the water has been channeled after it leaves the bed area. The very obvious and, unfortunately all too real, problem rears itself in the form of the bed surface or the water channel areas turning into bogs.

Through the years we have used many different methods to deal with both of these problems, either together or independently. Difficulty and drawbacks were encountered in many of the various attempts and many methods discarded. The temptation when you encounter a spongy bed surface is to elevate the beds. This unfortunately shifts the water to the intermediate aisles or roads, which in turn become mushy. Elevating the beds does not solve the water absorption problem by the bed surface. They still are difficult to get equipment on when you need to drive on the bed surface. Simply putting stone or plastic down on the surface seems only to mask the problem temporarily, only to have it reappear later.

We are a medium-sized nursery with little land to spare. We need to have a maximum use of our available production area. This requires us to keep our growing beds constantly in use. We use the areas between the beds as our roadways and paths to move plants in and out. In our retail areas these paths between the beds are where customers walk. Therefore the conventional wisdom of grading the beds to drain into the intermediate paths became unacceptable to our application.

Large amounts of mental concentration were not necessary to arrive at the next logical step in drainage water handling. This was to install perforated pipe underground to leach this surplus water away from the surface and carry it to a distant discharge point. After installing several of these systems in various trial beds we quickly discovered that their design is not as simple as it would seem to be. Our first discovery was that by installing a drainage pipe through the bed area, this did not necessarily mean that you therefore dried up the bed surface (we used exclusively, corregated, perforated, black plastic drainage pipe). It turned out that the water was held within the soil by capillary action between the soil particles. This force acting on the water is actually stronger than the force of gravity. How strong the capillary action is, is a direct relation to how small the soil particles are. The smaller the soil particles, the more water is held in the soil. There is a tremendous difference in particle size and numbers in the common soil types.

We found that what was happening to our new underground drainage system was that so much water was being held in the soil by the capillary action that the system failed. We had drained the area immediately over and close to either side of the pipe, but as we went further away from the pipe it remained wet. Figure 1 shows what happened to the water level on our system.

Our soils change greatly from area to area in the nursery. We found that in coarse material, such as coarse sand or fine gravel, the water line projected outward from the level of the drainage pipe somewhat flatly. Where we were in a heavy silty clay or loam, how-

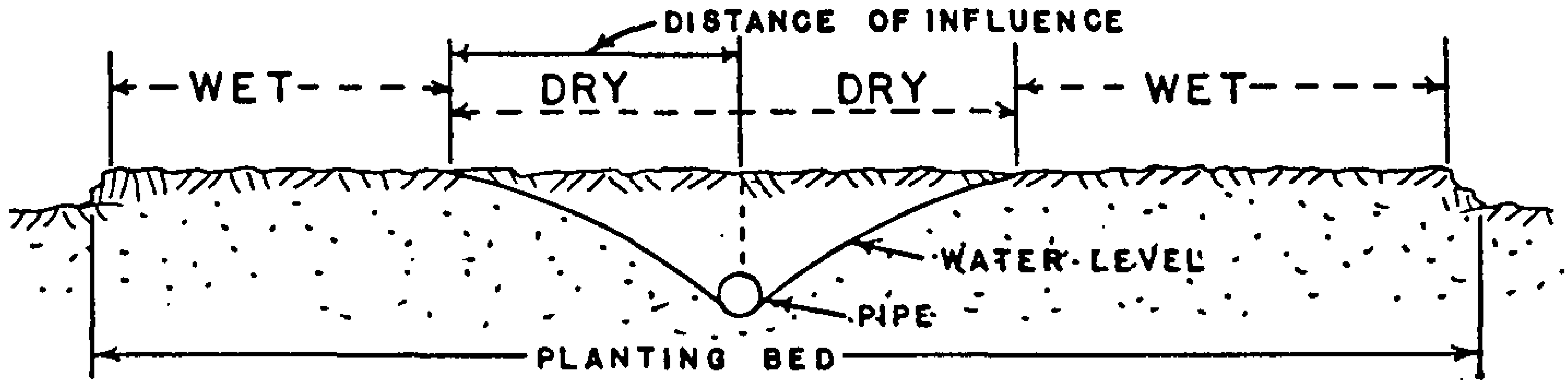

Figure 1. Water level characteristics after installation of a single drainage pipe.

ever, it rose very steeply and restricted the surface area that could effectively be drained by the pipe. By monitoring the soil water level at various distances from the drainage pipe; by placing the pipe at various depths; and by trying this in several types of soil, a chart was developed to give a guideline of the drawdown capability of the drainage pipe. Table 1 gives a guideline as to the distance from a given pipe, at a given depth, that the water line will reach back up to its original height. Beyond the stated distance on the chart the pipe will have no influence, the ground surface will remain wet. The chart is based on level ground conditions.

Table 1. Drainage pipe distance of influence[1].

Pipe depth (ft)	Soil types and distance of influence (ft) Silt/clay	Very fine sand	Fine sand	Medium sand	Coarse sand
1	2	4	8	15	28
2	4	8	15	30	
3	6	12	24		
4	8	16	32		
5	10	20	36		

[1] Meaning that distance either side of the drainage pipe that the water level is back at its original height.

EXAMPLE: If we wished to design a well-drained bed using the existing soil as the final surface, then:

GIVEN: Bed size needed—45 × 200 ft.
Soil type—very fine sand

DESIGN: From Table 2: for a pipe 2 ft deep in very fine sand we find that it will keep a dry surface for a distance of 8 ft on either side of the pipe (its distance of influence). Therefore a pipe will drain an area 16 ft wide. We will have to place three parallel pipes in our bed in order to come close enough to our desired 45 ft width. If this is done the water level configuration under the bed surface would appear something like Figure 2.

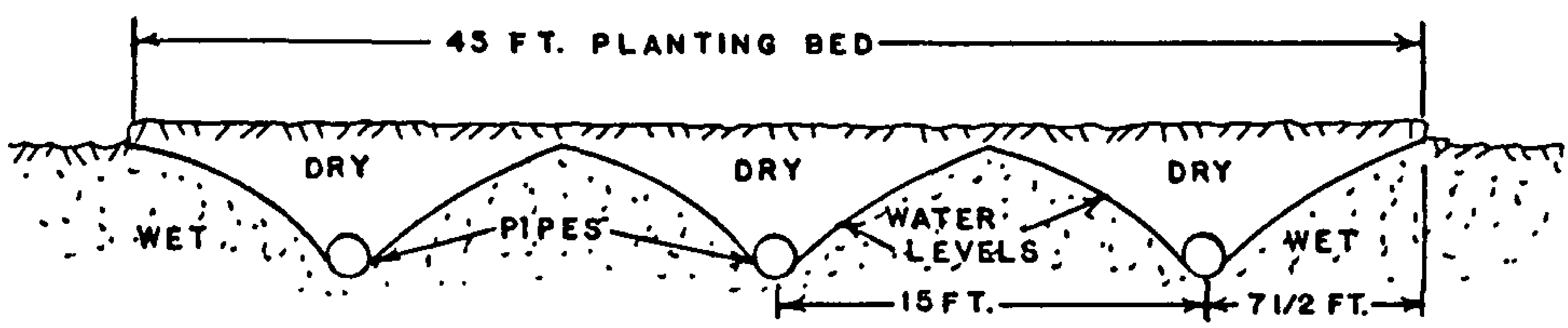

Figure 2. Water level configuration under the 45 × 200 ft. described in the text.

In designing underground drainage one must consider the capacity of the pipes to use. One should take the maximum number of gallons per minute of water to pump through the irrigation system and increase this amount by no less than one-third, to arrive at a figure to base the pipe size upon. If the natural ground water table is very high, and the piping must handle this water as well as the irrigation water, then one must consider this too when arriving at a pipe capacity figure. With this calculated one may look up the capacity of various sized pipes in Table 2.

Table 2. Flow capacity for corregated plastic pipe[1,2].

Pipe diameter (in.)	Flow[2](GPM)[3]
4	75
6	215
8	450
10	1250
12	1900

[1] Chart courtesy of US Soil Conservation Service.
[2] For pipe installed on a 1% pitch.
[3] Flow is based on a totally free discharge—no obstructions.

EXAMPLE: If we were to use our previous example of the 45 × 200 ft bed, and added to our given information that we wanted to irrigate this bed at a rate of 150 GPM, we add our safety factor of one-third of the irrigation flow (150 + 50), giving us 200 GPM. From Table 3 we see that we would need to use 4 in. diameter pipe. This is due to the fact that we will be using three pipelines (see previous example workup). Therefore each pipe will carry only one-third of the total flow or about 66 GPM. If the pipes were to be combined at the end of the bed into a single pipe to carry the water to the discharge point then this single pipe would have to be 6 in. in order to have the capacity to carry the flow of 200 GPM.

Some other strategies can also be employed to deal with the waste water underground if it is desired to not utilize the drainage characteristics of the existing soil. Should the soil be a clay or silt with demoralizing drainage characteristics, one probably would be better off not trying to percolate the water through it. Grading the surface of the bed to slope to the center (assuming a level bed) from both edges with a pipe in a trench at the middle, and covering the entire surface with 3 to 4 in. of stone works well (see Figure 3A). A modification of this, if the bed is on a slight slope, would be to have the pipe trench along the low side of the graded bed and have the water flow through the stone and down into the trench and pipe (see Figure 3B). The pipe trenches must be totally backfilled with stone. The best stone we found for the bed surface, from a water carrying standpoint, is clean ¾ in. crushed stone. This is without a doubt also the best stone to surround the pipes in the trenches. Finishing the bed surfaces with stone is very desirable, but it must be remembered that this can be costly as well. One ton of ¾ in. clean crushed stone, placed 3 to 4 in. deep (the desirable depth) will only cover 60 sq ft of bed surface.

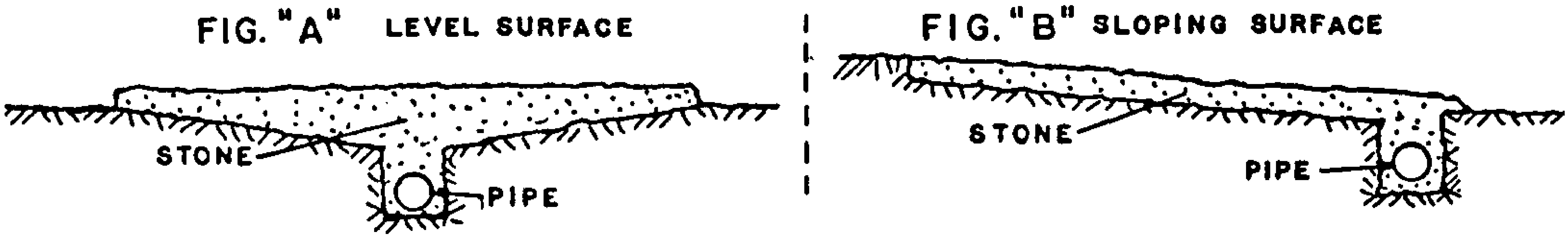

Figure 3. Grading configuration for level or sloping beds.

A very desirable thing to do if one is using the natural ground as the final surface, is to totally backfill the pipe trench with stone even though the stone may not be used for the bed surface. This will definitely increase the transmission of the ground water to the pipe. If, in the nature of the operation, there will tend to be a great deal of silt or organic matter traveling in the water, it is desirable to put a "filter" layer of 2 in. of ⅜ in. stone on top of the trench or bed surface. This filter layer, placed on top of the ¾ in. stone, will trap the foreign matter and keep it from clogging the water flow ability of the larger stone. In extreme cases the ⅜ in. stone may have to be replaced periodically. Choose the surface on its inherent ability to transmit water. One cannot get soil with poor water carrying ability to move water to the pipes.

These systems have worked well for us. Properly done, they have taken us from mud holes to good, dry clean working surfaces in our nursery.