Preparing Land for Efficient Irrigation

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On many farms three-fourths of the irrigation water is wasted. A good way to prevent such waste is to prepare fields properly before they are irrigated.

The preparation of land for irrigation—or land leveling, as it is commonly called—is the reshaping of the land surface to facilitate or improve the uniformity of application of the water. It includes grading or shaping the surface to any desired slope as well as the formation of an actual horizontal plane.

Generally the reshaping is done to provide uniform grades or to reduce grade in the direction of irrigation or at right angles to it. Sometimes the grade of a field is increased or grading was done so the direction of planting could be changed. Land preparation in humid areas is needed to provide surface drainage and to achieve more even penetration of irrigation water and rain.

Because of differences in soils, slopes, or the farmer's wishes, not all fields are given smooth surfaces. Land preparation may consist only of removing a part of the high spots and filling a part of the low places. It may bring only a minor improvement in the land surface and slight improvement in irrigation efficiency. Or it may be possible to reshape a field to the extent that beneficial use can be made of all the irrigation water and much of the rainfall.

Many irrigation workers in the Southwestern States have used a classification of types of land preparation. It is based on the effectiveness of different forms of land surfaces in improving the uniform application of water.

Six types are classified, starting with rough grading (type 1), then variable grades in all directions (type 2), up through uniform irrigation grade with side slope (type 3), level transversely with a variable irrigation grade (type 4), and with a uniform grade (type 5), and finally to exactly level in all directions (type 6). The first three types permit side slope. The others require that the land be exactly level at right angles to the direction of irrigation. The classification has proved to be useful, and something like it would be of value in all irrigated areas.

If we acknowledge that there are different types or degrees of efficiency in land preparation, we recognize that the farmer or land operator must make a choice of type when he undertakes land leveling. We say generally that the highest type of land leveling suitable to a field should be adopted, but there are situations in which something less will be satisfactory and more practical.

THE LAND SLOPES, kind and depth of the soils, climate, crops to be grown, water supply for each field, economic considerations, and the farmer's preferences all have to be evaluated in designing any job of land preparation.

If the land is very rolling, steep, and irregular and the soils are shallow, it may not be possible to shape the surface to uniform slopes on good irrigation grades. Successful irrigation farming can be practiced on land of steep and nonuniform slopes, but that land should be kept in pasture as much of the time as possible in order to prevent severe soil erosion.

The development of a uniform grade only in the direction of irrigation often may be the highest practical type of land leveling. That is especially true of fields that have little cross slope, where the crops will always be irrigated by the furrows or corrugations. In orchards especially, this type of leveling is satisfactory.

Some extremely irregular fields or irregular fields with shallow soils will not permit use of a higher order of land preparation. Only a study of the cuts that will be required for better leveling can determine this, but often they will be so great that too much earth will have to be moved or the fertile soil will not be deep enough to allow the cuts to be made without exposing too much infertile subsoil. On the other hand, a high type of leveling often can be done on fields with rather shallow soil if the slope is gentle and the surface already nearly smooth.

Grading the land to a uniform slope in the direction of irrigation and removing all slope at right angles to it should be the result of most leveling jobs, particularly when irrigation is to be by flooding. A good irrigation grade, designed in accord with the infiltration rates of the soil, the size of irrigation streams available, the crops to be grown, and the erosion hazard from rainfall, permits uniform distribution of water and is particularly important in this type of leveling.

Land graded to an exact level—no slope in any direction—permits the most efficient irrigation. Only the actual amount of water needed can be put on the land so there is no waste through runoff, but it is not practical for all fields. Its cost is high and its use is limited to sites where the available streams of water are large enough to force the water the entire length of the irrigation run before much moisture soaks in at the inlet end. Nor is it suitable for humid areas, where at times excessive rainfall must be drained off the fields.

Types of land preparation that permit a cross slope at right angles to the direction of irrigation are more adaptable to an entire field than are the types in which all cross slope must be removed. Usually excessive cuts are necessary to eliminate the cross slope. That may be too costly or require cuts that expose large areas of infertile subsoil. Therefore, if these more advanced types of reshaping, which eliminate the side slope, are desired on sloping ground, the field often is divided into parts and the leveling is done in strips—or "lands"—at different elevations, separated by low ridges or borders. It is commonly called bench leveling, especially if there is a considerable difference in elevation between adjacent strips. Such benches may be rectangular or they may have curved boundaries.

The width of the benches will be influenced by the farming equipment to be used, the available irrigation stream, and the amount of earth work involved. The amount of earth work, in turn, is governed by the original slope at right angles to the direction of irrigation. Depth and character of soil will naturally limit the depth of cut and consequently the width of the bench.

Leveling jobs cannot be changed easily once they have been completed, so every precaution should be taken to insure that irrigation grades, runs, and streams are so adjusted that the field can be uniformly irrigated. The only way to avoid guessing is to get the information from actual field tests. Measuring the rate of moisture penetration, soil movement, and uniformity of rate of water flow will furnish the information needed to select a proper grade and length of run for a particular soil. The importance of making those determinations in the field, as a basis for the design of the layout, cannot be overemphasized.

The selection of the type of leveling and the layout of various fields should always take into consideration the crops to be grown throughout the complete rotation. Widths of borders and benches should be adjusted for the use of standard farm implements. A bench on which grain is to be grown, for example, should be some multiple of the width of the grain drill. When possible, benches should be made uniform in width, as too much variation means uneven irrigation. Some farmers select the minimum acceptable width so that the difference in elevation between benches will be kept small and less earth will have to be moved. Many others prefer to make the benches as wide as possible, so as to interfere less with farming operations.

The relation of benefits to costs of

land preparation influences the selection of type. If at all possible, the most efficient type suitable to a particular field should be selected and planned at the start and built with as little delay as possible. That usually is less costly in the long run than doing the work in successive steps and taking several years to finish the job.

A direct relationship exists between the methods of irrigation and the increased efficiency in the use of irrigation water that land preparation can bring. Some methods of irrigation may be inefficient and because good land preparation can improve them only slightly, expensive land preparation cannot be justified. So, besides the restrictions imposed by physical limitations, the choice of a type of land preparation should be governed somewhat by the method of irrigation that will be used.

Basin irrigation floods a more or less square area rapidly with the desired amount of water. It can be effective in getting a uniform application if properly designed. Consequently a high, rather costly type of land preparation can be justified. Basins are usually exactly level, or at least level in one direction with a very little cross slope.

It is not, however, a satisfactory method in areas of high rainfall unless the excess can be drained off the fields to prevent damaging ponding of water.

Borders, which are long, narrow basins, also can be used effectively to accomplish uniform irrigation. Because the water has to flow the length of the border, some grade is usually provided in the direction of irrigation. The amount of slope that is provided depends mainly on the available irrigation stream, the soils, the climate, and the crops. The best type of land preparation for border irrigation is a uniform slope in the direction of irrigation with no cross slope. The highly efficient use of irrigation water possible with border irrigation justifies the cost of land preparation. Here again, excessive rainfall will be a problem in humid areas and enough slope must be provided to remove all excess water.

Furrows are used to distribute water over fields and can do so effectively in a well-designed and well-managed layout. Furrows should have a uniform grade throughout their length to be most effective or they may be level, but some cross slope in the field is not detrimental. If furrow irrigation alone is to be used, the highest types of land preparation seldom should be selected. Crop rotations used on most fields include both row crops and close-growing crops, however. So, since border irrigation is the best way for irrigating close-growing crops such as alfalfa, border irrigation criteria will usually govern the selection of a type of land preparation even though furrow irrigation would be the method under immediate consideration.

Irrigation by corrugations, which are small and closely spaced furrows, is generally a good deal less efficient than furrow, border, basin, or sprinkler irrigation. That is largely because of the difficulty of equalizing the flow in many small channels and keeping the corrugations free of obstructions to prevent them from breaking over into adjacent corrugations. Also, corrugations are so shallow that there must be a minimum of slope at right angles to their direction. Thus the irrigation is directly down the steepest slope. Unless fields are practically uniform to start with, a land preparation layout of a high type, such as uniform grades with no cross slope, adapted to irrigating directly down slope, will result in cuts and fills of such size that the work will not be feasible. Furthermore, the possibility of improving the distribution of irrigation water to any great degree is not sufficiently promising to justify a high type of leveling if it involves a significant increase in cost. Grading to a fairly uniform slope is probably the best that should be undertaken if irrigation by corrugations is to be continued.

Wild flooding does not use dikes to guide the flow of irrigation water. The water is distributed over the field by the irrigator as best he can. It is an inefficient method, and land preparation will do little to help the irrigator to do a better job. Rough grading and smoothing is about all the leveling that can be justified until a better method replaces wild flooding.

SURVEYS, MAPS, AND ENGINEERING are needed to develop a good plan, and land preparation may not be of much value unless it is done according to a good plan. Many fields appear smooth to the eye but are too uneven to apply irrigation water uniformly.

A soil survey should be made before leveling is done. The map the soil surveyor prepares will show the nature of the soil, the subsoil, and the materials under the subsoil. It will show the depth to sand, gravel, caliche, rock, or other materials that might limit the depth of the cut, as well as the extent of such areas. Alkali spots will be outlined and the depth to water table shown. That information will help the engineer to plan the best layout for leveling. In some instances, cuts into the subsoil will not be harmful because organic matter and fertilizer can be added to build up its productivity quickly. In other instances, the engineer learns that if he removes the surface soil, he will expose inert material, which will not grow crops. Soil surveys also furnish information relative to infiltration rates and permeability. If the subsoil and substratum are sand or sandy loam, and the infiltration rates are high, the irrigation runs must be shorter than if there is clay loam or clay underlying the surface. For best results the engineer must team up with crop specialists and soil scientists. They must all see the problem the way a farmer does.

Land leveling is a technical procedure. Time and time again it has been proved that the eye alone is not good enough to do a first-class job of leveling. Accurate leveling can be done only through the use of surveying instruments in the hands of technicians.

A topographic survey and a map should usually form the basis for preparation of a plan and layout. Besides showing the shape and size of a field, the map should show surface topography, proposed surface elevations and irrigation layout, and, where they exist, the drainage facilities. How detailed the map should be will depend upon the regularity of the surface and the degree of refinement or type of work proposed. The better the type of land preparation to be undertaken, the more refined should be the studies and the work of layout and supervision.

The type of many leveling jobs can be selected as soon as the field or farm has been looked over and some preliminary observations made. But more detailed surveys and investigations often are necessary before final choice is made.

In planning a field to be leveled, it is helpful to square up the layout with permanent ditch locations, fence lines, or property boundaries as much as possible. Sometimes it is necessary to lay out borders and irrigation runs diagonally across a field. That complicates the location of field ditches, makes irrigation more difficult because of varying lengths of runs, often increases farming problems, and also results in some loss of land at the ends of borders or crop rows. By relocating ditches and field fences, however, it is often possible to have a better and more economical plan for land leveling and irrigation in which the field boundaries are square with the irrigation layout.

After the design is complete, estimates can be made of the earthwork and its costs. It is important that the farmer have a record of the estimates made by the engineer. Everyone concerned should know exactly what the plan of work is and how it is to be performed. On larger jobs and particularly on contract jobs, plans should be accompanied by written specifications, however brief. Contract jobs also should be covered by at least an informal but written agreement between the farmer and the contractor.

CONSTRUCTION can be carried out with various pieces of equipment. Leveling must be finished to the given grades. Obtaining an economical and workmanlike job depends not only on the right kind of equipment, but also on the skill of the operator.

Land leveling is done most effectively with tractor-drawn or motor-propelled equipment. The carryall is used widely. It is an efficient machine.

It cuts to grade, spreads the dirt evenly, and hauls economically for fairly long distances. Carryalls have capacities of 3 to 30 cubic yards. They almost always require more power than is available from farm tractors.

Smaller wheeled scrapers, which can be used with farm tractors, are in common use for leveling land. They will move the earth just as cheaply as large equipment, but they take more time to get the job finished. Under most conditions, the carryalls and wheeled scrapers can be used to cut without first plowing the ground. But sometimes it is necessary to loosen tight or hard soil by ripping before using land-leveling machinery.

Bulldozers are used for rough grading but are not efficient for fine grading or for moving earth beyond 200 feet. Graders, terracers, or maintainers are frequently used to move earth short distances sideways, but the cost per yard is fairly high, even for short moves.

Leveling jobs are finished with levelers, floats, or land planes rather than with heavy earth-moving equipment. The land plane has four wheels and an adjustable blade located at about the center of the frame. It is at least 60 feet long, and this great length makes it possible to finish a field to a uniform smooth surface. Large tractors are needed to pull it.

The two-wheeled automatic-type leveler ordinarily is used for fine leveling. It has a movable blade placed at about the center and so constructed that it will drag a considerable volume of dirt. It is usually less than 35 feet long, and medium-sized farm tractors can power it. It is much less efficient than a carryall for moving large quantities of earth or for moving earth long distances. The commonly used wooden float or drag is found in many variations as to detail of design. It is usually shorter than the other two types of levelers and therefore does not do so good a job of finishing.

Regardless of the type of equipment used, the work should be checked during construction. A final check should always be made after the job appears to be finished—but before the equipment is moved off the field.

For farm ditches, border ridges, and various improvements associated with land preparation and irrigation layout, other equipment is needed. Several types of ditchers will do a good job of building head ditches cheaply. Borders are made with road graders, plow, V-ditchers, disk ridgers, slip scrapers, fresno scrapers, A-floats, and other farm implements. Most of them leave a furrow or gutter along the border ridge, which should be floated out or filled up before the field can be considered finished unless the furrow is required for drainage on flat areas.

Efficient equipment for constructing and maintaining the head ditches and border ridges should be available on an irrigated farm because it is good practice to plow up the ditches and border ridges each time a field is plowed in order to kill weeds. Temporary field ditches often must be replaced during the irrigation season.

THE COST OF LAND LEVELING varies through such a wide range that a general statement about it has little value. On some lands a price of 10 dollars an acre would be too much.

On other lands, which are steep but capable of producing high-valued crops, a cost of 300 dollars an acre might be justified. It all depends on the value of the increased crop yields that can be expected from the improved irrigation.

For any who must have an average figure, a cost of approximately 50 dollars an acre has been derived from records covering more than one-half million acres of land preparation in the Southwest. The records show that small, light equipment powered with farm tractors could do the leveling at no higher cost than big, heavy equipment but took a much longer time to complete the work. The cost of land preparation done by contract or the cost when it was done with the farmer's own equipment were nearly the same.

MAINTENANCE OF LEVELED LAND is required in order to keep it leveled. Perennial crops, such as alfalfa, should not be planted immediately after leveling. Since fills will settle and leave the ground surface uneven when water is applied, it is better to plant an annual crop the first year. When the crop has been removed, the low spots should be filled in by floating and the entire field put into final shape before a crop that will occupy the field for several years is planted.

If the leveling operations have exposed infertile subsoils, it is a good plan to plant a green manure crop the first year. This should be plowed under to add organic matter to the soil. As a rule, it will be necessary to add some commercial fertilizer since the areas from which the topsoil has been removed will be much less fertile than the original topsoil. A heavy application of barnyard manure may be used in place of a cover crop.

It is usually beneficial to plant a row crop after the green manure crop or during the first year. Cultivation tends to mix the disturbed soil, loosen the areas that have been compacted by leveling machinery, allow air to enter more readily, and make conditions more favorable for soil bacteria.

Back furrows and dead furrows should be eliminated in plowing. Plowing should not be done in a way that will continuously move the soil in one direction. Every time a field is plowed it will have to be refinished with a float or similar implement if high and low spots are to be avoided. In the lower types of leveling, regular tillage and maintenance operations provide an opportunity for a farmer to improve progressively the leveling work on his fields until he has reached the greatest practical refinement.

Maintenance is also needed on fields that are irrigated with silty water. Silt accumulations tend in time to build up the upper ends of the borders or rows. The silt is never deposited evenly, and the ground surface must be properly releveled before it becomes so uneven as to interfere with efficient irrigation.

An overall plan covering ditch locations and capacities, water control structures, cropping practices, and a tentative irrigation schedule based on best available information on infiltration rates and water-holding capacity of the soil should be developed in addition to the land leveling plan. Land preparation is only one factor in the efficient use of irrigation water. Other factors must be considered and the land-leveling plan fitted into the plan for the others if the greatest effectiveness is to be attained.

BENEFITS from a well-planned, well-constructed, and well-operated land preparation job are many. Leveling makes possible a more even distribution of the irrigation water through its better control and management. The result is water saved, labor saved, more uniform stands, and increased crop yields of better quality.

A rough or uneven field will be watered too little on the high spots and too much in the low spots. When too little water is applied, a crop may ripen prematurely, if it survives at all. Too much water tends to make a crop ripen late. Also, low spots remain wet for a longer time than the rest of the field, so sometimes a farmer has to cultivate around them. Sometimes he may cultivate them when they are too wet, and then puddling results. Alkali and harmful salts usually accumulate in low areas. Such spots can sometimes be eliminated by land leveling. Irrigation year after year to depths below the root zone is certain to result in the loss of valuable soil elements and a drop in fertility. Too heavy irrigation on many types of land likewise hastens the day when the land has to be drained. In a properly leveled field, soil losses caused by application of irrigation water can be held to a minimum. And aside from the more tangible benefits of land leveling, the general appearance of a farm is enhanced if a good job of leveling has been followed up with other improvements in the layout of irrigation.

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Wells and Pumps for Irrigated Lands

Carl Rohwer

In much of the arid and semiarid regions of the United States, the water from streams is completely utilized for irrigation or, if surplus water is still available, the cost of bringing it to the land is too high. In those places, therefore, pumping from the great reservoir of water in the ground is the only source of additional water for irrigation.

Factors to be considered in developing successful irrigation enterprises by pumping from wells are the supply of ground water, the land, the well, the pump and accessories, the crops, and the markets.

First is the water supply. If it is inadequate or if the quality is unsatisfactory there is no need to consider the other factors.

Next in importance is the land. It must be fertile. The topography must be suitable for irrigation.

A supply of adequate and suitable ground water usually is harder to find than land that is suitable for farming. Water exists beneath the surface of the ground in most arid and semiarid regions, but conditions often are not favorable for utilizing it to irrigate crops. Sometimes it is so far down that the cost of pumping is too great. Or the formation in which the water occurs is so tight that it does not yield water readily or is so limited in extent that the supply would soon be exhausted. Or the rate of recharge of the ground water reservoir is too small to justify extensive development of the area. Or the supply may contain too much salt.

Alluvial deposits containing thick layers of water-bearing sand and gravel are most favorable for obtaining a good water supply. Broad alluvial valleys, traversed by rivers or irrigated by a network of canals, are ideal sites. The seepage from the rivers and canals and the deep percolation loss from irrigation nearly always assure adequate recharge of the ground-water reservoir. In such valleys the water table usually is quite close to the surface, an important aspect from the standpoint of pumping costs.

No hard-and-fast rules can be laid down as to the depth to water beyond which pumping is no longer feasible for irrigation. It depends primarily on the value of the crops produced. In California and Texas, where fruits, cotton, and winter vegetables are grown, lifts of 400 to 500 feet and more are common, but in other areas where general farm crops are grown, 100 feet is probably the maximum, except under special conditions. If sprinklers are used, the total pumping lifts can be higher because the amount of water required usually is less.

The water need not be potable, but it must not contain high concentrations of salts injurious to plants or soil. Water of doubtful quality should be tested to determine which alkalies are present and the percentage of each.