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Irrigation and Drainage Practices in the Colorado River Basin of California

By

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History and Description of Area

The Colorado River basin in California consists of the Bard, Imperial, Coachella and Palo Verde valleys, and is located in the extreme southeast portion of California.

About 90 years ago this region was a desert wasteland -- hot, dry, sandy -- and about the opposite of what would be considered a desireable farming area. Water from the lower Colorado River, south of Parker Dam, transformed this area into one that is highly productive.

The Palo Verde and Bard valleys both started irrigating land about 1880. The Imperial Valley did not start irrigating until the turn of the century. The Coachella Valley started irrigating from wells about 1900. It was not until 1947 that they received water from the Colorado River through the All-American Canal.

Most of these lands are within a broad structural trough which lies north of the delta of the Colorado River in Mexico.

All the land in this trough is nearly level or gently sloping, except where it has been modified by wind, or where it has been dissected by the New and Alamo rivers (in the Imperial Valley during the flood of 1905 to 1907). Elevations within this area range from about 300 feet above sea level north of Blythe to 234 feet below sea level at the Salton Sea.

In 1962, approximately 620,000 acres were being served by the Colorado River. These can be broken down into the following: Bard, 24,000 acres; Imperial, 470,000 acres; Coachella, 53,000 acres; and Palo Verde, 80,000 acres. In the Coachella Valley there are a few farms still being served by wells.

Climate

The climate of the area is what is known as desert subtropical. It is one of the most arid regions of our country, with an annual rainfall of only three inches -- some years it has less than one inch, nearly all of which occurs as high intensity summer thunderstorms. These storms produce very high runoff, and contribute only enough moisture to support desert flora.

The summers are extremely hot, with maximum temperatures exceeding 100 degrees for more than 110 days of the year. The winters are short and mild, with a

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1/ Agricultural Engineer, U.S. Soil Conservation Service, U.S.D.A., El Centro, California. Paper prepared for California Irrigation Institute, Fresno, California, January 27-28, 1964.

large percentage of sunny days. Killing frost in the fall seldom occurs before the middle of November and the last frost occurs seldom after the middle of March. The annual frost-free growing season is about 300 days long.

The relative humidity is low during the greater part of the year, a circumstance which makes the summer temperatures bearable even though they are unusually high. This has been greatly helped with the advent of the air conditioner. With the exception of a few short periods of relatively high humidity in late summer, the humidity is ordinarily higher during the winter and spring months than the rest of the year.

Soils

The soils of the Imperial, Bard, and Palo Verde valleys are composed of recent alluvial and lacustrine deposits of the Colorado River. Sediments were brought in from several states and deposited in varying locations, sequences, and thickness that depended upon the vagaries of the river and fluctuation of the old lake which once existed in part of the area.

The newly exposed sediments developed sun cracks each time the land receded. Wind action may have filled these cracks with sand and may, in many instances, have built dunes upon them before the next inundation occurred. Thus, the formational elements were present for a highly complex body of stratified soil material, as well as for structural conditions that confuse the picture of soil-moisture relations. But some strata do exist that are consistent in thickness and continuous over an area of many acres.

The soils of the Coachella Valley are composed of recent alluvium of the Whitewater River and other local streams.

Land Use

The native vegetation consists mostly of creosote bush, salt bush, Yucca, arrowweed, salt cedar, cacti, mesquite, etc. The rainfall is insufficient to produce any vegetation for a suitable program of grazing.

All agricultural crops are grown under irrigation. The Imperial and Palo Verde valleys are known to many as producers of lettuce and melons. The acreage devoted to those crops is much less than that in alfalfa, barley, cotton and sugar beets. Many other crops are grown in the area (see attached list for Imperial Valley).

The Coachella Valley is known for its early table grapes, lemons, grapefruit, and other citrus fruits. Dates are also an important crop in the Coachella Valley. Other crops, such as those grown in Imperial Valley are grown also, but they comprise a much smaller acreage.

In recent years, the fatting of beef cattle in feed lots in the area has become a major income producing enterprise. In the Imperial Valley alone,

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in 1962, approximately 540,000 head of cattle were finished and shipped to the coast for slaughter. Each year this figure has increased as more feed lots are being built.

Every year, in the fall, a large number of lambs and ewes are shipped into the area. The lambs are fattened and shipped to market. The ewes are lambed out and these lambs are shipped to market in the spring as milk fat lambs.

In 1962, the approximate gross agricultural value for each area was as follows: Imperial and Bard valleys (both are in Imperial County), $214,700,000; Coachella Valley, $44,000,000; Palo Verde Valley, $32,000,000.

Conservation Problems

Drainage

Drainage problems have always followed the introduction of irrigation to the arid and semiarid valleys of western United States. With the liberal use of water for irrigation on stratified soils, water tables and salinity or alkalinity (or a combination of both) soon occur. Thus, the maintenance of a favorable salinity or alkalinity (or a combination) status in the root zone is a major problem.

This problem can be solved by the use of tile drainage and leaching. In this particular area, we are concerned only with high water tables and salinity. Drainage in this area has been one of the most vexatious problems of this region; the reason being that the soils are extremely complex, with a marked difference in textural stratification throughout the profile, together with an abundance of slightly saline water. These conditions soon brought about a widespread need for drainage.

In the Imperial Valley, as early as 1902 and in 1908, soil scientists and irrigation engineers of the United States Department of Agriculture pointed out the need for drainage investigations. By 1919, about one-fourth of the irrigable land in the Valley was affected in some degree by high water table and salt accumulation.

About 1921, the Imperial Irrigation District constructed an open drainage system, that intersected the area every half mile. This system was only partially successful in draining the land owing to the lack of understanding of the soil stratifications and their effects on the movement of water through them. Subsequent surveys showed that, in spite of the open drains, water-soluble salts were steadily accumulating in the Valley as a result of excessive salt intake in the irrigation water and poor internal drainage of the soil.

In 1919, the Federal Land Bank of Berkeley suspended making of loans in many sections of the Valley, primarily because of the hazard of high water table. The agricultural credit of the Valley was at stake. In the early 30's the Imperial Irrigation District started a program of tile drainage, but with a limited amount of success.

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In 1941, a research program was initiated to study the drainage problem. In 1944, it was felt that enough research had been accomplished so that actual application could be made on selected farms. As a result of all this work, a very effective program of drainage has been accomplished since the year 1946.

The open drains which were constructed in the 20's, along with the two rivers which flow into Salton Sea, serve as a master outfall system. This system conveys both surface waste and tile effluent. The Imperial Irrigation District provides a satisfactory tile outlet for each 160 acres. This is by means of either a gravity or sump type outlet. The District maintains about 1,375 miles of open drains and 220 sumps.

At the end of 1963, approximately 10,400 miles of tile on 318,000 acres had been installed; it has effectively lowered the water table and helps maintain a favorable salt balance. How long will this program last? Well, it is anyone's guess.

Today, the Imperial Valley is looked upon as a leader in agricultural reclamation. There are still scattered pieces of ground that have not been reclaimed and they stand out like a sore thumb.

For about the last five years, several hundred soil scientists, engineers, and other specialists, as well as important officials of foreign countries, have visited this area to look at the tremendous job of reclamation. Most of these people come from the Middle East, where their climate, soils and problems are very similar; however, many come from other countries. I believe that we have had visitors from almost every country in the free world.

In the Coachella Valley, drainage problems were first recognized in about 1927 around the lower part of the valley near the Salton Sea. After the introduction of Colorado River water, a large portion of the remainder of the area became affected by high water tables. This can be attributed to the shutting down of wells and allowing the ground water to rise by the abundant use of irrigation water. Along with this, a salinity problem developed.

A means had to be provided to drain the land. The Coachella Valley County Water District called upon the University of California, the Bureau of Reclamation, and Agricultural Research Service to make a drainage investigation. From the investigations, it was recommended that five lines of tile be installed on each 40 acres. In some cases it was found that five lines were inadequate, and additional tile had to be added to the existing system.

Along with this, a master outfall system was planned. Since there were no open drains, almost the entire system was installed under ground. The system consists of 26 miles of open drains, 127 miles of pipe drains, and 2-1/2 miles of concrete-lined drains, serving about 53,000 acres. This system provides an outlet within a reasonable distance of each 40-acre parcel. By the end of June 1962, the farmers have installed 1,124 miles of tile drains which are serving 25,812 acres.

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In the Palo Verde Valley, the district drainage system is composed of about 153 miles of open drainage channels intercepting underground water, carrying canal spill and some surface tail water from fields. A charge of $1.00 per acre is levied against those farms that waste water into the drains.

In some instances, pumps are necessary on some of the drains so that they will be deep enough to provide necessary drainage. Several thousand acres of land are served by such drains.

According to district records, the overall ground water and drainage conditions and "salt-balance" continue to show improvement. It was reported that the average ground water elevation below the lowest field, adjacent to ground water observation wells, showed a drop in water table from 6.2 feet in 1961 to 6.5 feet in 1962. This is an average reflected by 217 observation wells.

These average figures do not mean that all land has a 6-foot water table, but they do show a lowering of the water table even with the increase in irrigated area and more water being applied. The lowering can be attributed to improvement of the open drains by the district. There is also a great deal of fluctuation in the wells during the year -- in some instances as much as two feet -- which varies with the type of crops being irrigated and when they are grown.

The salt condition has improved a great deal in the area. In 1962, approximately 913,600 tons of salt were brought in by the water and approximately 1,098,100 tons of salt removed, for a net gain of 184,500 tons.

Last year, for the first time since 1954, 11.3 miles of tile drains were installed. This brought the total to 55.4 miles of tile drains.

I believe that because of the soil conditions, vertical well drains may prove to be more practical in the area.

In Bard, partial drainage is provided by approximately 18 miles of open drain ditches. One of the main drains passes under a railroad track with a culvert which is too high. This does not permit the drains to be deep enough to provide for adequate removal of ground water in the lower portion of the area.

There are several poorly drained areas occurring in pockets or saucer-like shapes which have no constructed lateral drains to the present drainage system.

If the one main drain could be lowered and additional lateral drains constructed, most of the drainage problems could be solved.

In the Imperial Valley, tile is being installed at an average depth of 6 feet. The drawdown between the tile is maintained somewhere between 4 and 4.5 feet; that is, if the tile is properly spaced. (Spacing of tile ranges from about 50 feet for the fine-textured soils to about 250 feet for the coarse-textured soils.

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In the Coachella Valley, tile is being installed at an average depth of 7 feet with the drawdown being maintained at 4.5 to 5.5 feet. Tile spacing has varied from about 65 feet to about 265 feet. This seems to provide for a root zone area that gives satisfactory crop production.

The tile in the area varies in type. It is a matter of farmer preference; some prefer concrete, others clay, and still others the bitumin fiber pipe. The laterals range from 4 to 6 inches in diameter. Base lines will range from 5 to 12 inches in diameter. A gravel envelope is placed around the tile, consisting of approximately 2 inches of gravel on the bottom and about 1-1/2 inches on top. Generally, this will amount to 2-1/2 cubic yards to 100 feet for 4-inch diameter tile, and as the size of tile increases the quantity of gravel used goes up.

A few years ago another type of tile and filter media was tried in the Imperial Valley. It consisted of bitumen fiber pipe, and a fiber glass mat used in place of gravel. The use of these is not new; the bitumen fiber pipe was first used in drainage on the east coast, and a fiber glass mat has been used in the mid-west for some time. The fiber pipe is perforated and comes in eight-foot sections with tapered collar joints.

The fiber glass mat used in the Valley is one inch in thickness and much stronger than that used originally in the mid-west. With the aid of Agricultural Research Service and Owens-Corning Glass Company, a set of specifications was developed so that it could take the place of the gravel media. There is no real advantage in using it where there is a good gravel source. It would be advantageous in areas where good gravel is lacking or where the gravel would have to be hauled for a great distance.

Leaching

The leaching program being carried out in connection with maintaining a satisfactory salt balance, is done by one of two means: (1) intermittent leaching, and (2) irrigation in excess of plant requirements.

The first method has been used extensively in the Imperial and Coachella valleys, and to some degree in the Palo Verde Valley. Few people consciously use the second, and no quantitative control is maintained. The second method is probably met through over-irrigation on the part of the farmer, and is controlling salinity in a great many of the cases where the salinity level has not reached a detrimental stage. Where the salinity level has reached a point where crops cannot be grown satisfactorily, a program of tiling, leveling, deep plowing and leaching will be necessary.

The first method consists of putting up levees, similar to those used in rice fields, which will pond water at a depth of not more than 1-1/2 feet. The water is ponded on the soil up to 90 days. The general practice is to pond about 6 inches of water on the soil for 30-day intervals. Each 30 days is followed by a drying period during which time soil samples are taken for a

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salinity check. If the salinity is too high, the field is leached for another 30 days. This may continue for some time.

X On coarse-textured soils the problem is fairly simple. These soils may be reclaimed in 30 days or less of leaching, or even by applying excessive amounts of irrigation water.

X On fine-textured soils it may take as long as 4 to 5 years of leaching and careful land management to restore the soils to a suitable level of production. In some cases, it has taken as long as 10 years, with splitting of tile lines, leaching, and other cultural practices to bring the land to top production. Once the land is reclaimed, the salinity level can be maintained at a satisfactory level by proper crop rotation, irrigation, and other agronomic practices.

In Palo Verde and Imperial valleys, there are some fine-textured soils that are not economical to tile and leach. These soils are relatively impermeable. The best land use for these soils is the growing of bermuda grass, which has a relatively high tolerance to salinity and a root that penetrates these soils.

Irrigation

Generally, irrigation of crops under the desert climate follows the same principles which apply to irrigation in other areas. However, lack of effective rainfall, high temperatures, low humidity and salt content of soils and water make it necessary to vary irrigation practices.

The lack of effective rainfall requires irrigation during the entire growing period. In this area it is a year-round proposition.

Low humidity and high temperatures result in high rates of water use. For instance, in the summer alfalfa will use up to about a half acre-inch of water per acre per day. To prevent wilting, it may be necessary to irrigate alfalfa every 5 to 8 days during the summer months. In the winter, irrigation intervals may be lengthened to 3 or 4 weeks.

On saline soils, more frequent irrigations are required. The salt content of the soil has an important bearing on the amount of water available to the plant. Salt gives the plant a lot of competition for water. For example, if a saline soil has an electrical conductivity of about 7.5 millimhos (ECx103) or 4800 ppm, a reduction of about 25% in available moisture can be expected. 7.5 x 640

The farmer has to apply approximately 13% more water in order to maintain a proper salt balance. This may be applied all at once in the pre-irrigation or during the irrigation season. No one has said just when it has to be applied.

It is recommended that on fine-textured soils, the farmers apply light, frequent irrigations during the summer months, to avoid scalding. In the winter months, slow, heavy applications are recommended, to provide excess water for the removal of excess salts.

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Irrigation water being used in the area has an electrical conductivity of about 1.1 millimhos ($ECx10^3$), which is equivalent to about 700 ppm dissolved salts or a little over one ton of salts per acre-foot of water. Of this, approximately half is gypsum. This is the reason there is no alkaline problem. The remainder of the salts includes other calcium, magnesium and sodium.

In Imperial Valley the Imperial Irrigation District operates and maintains about 1,656 miles of canals and laterals. These are set up so they will deliver water to the corner of each 160 acres.

Several years ago the Imperial Irrigation District set up a program to start lining some of the smaller laterals, and last year they started lining some of their larger canals. This is done on a cost-share basis -- the District furnishing 50% of the cost of lining and the farmer the other half. In addition, the District does the engineering and builds the ditch pad, which can be a costly item in some instances. To date, the District has lined about 60 miles of canals and laterals.

The farmers, to date, have lined approximately 1,175 miles of field ditches. This is at a rate of about 110 miles per year. At this rate, it will take nearly 20 years to get all the field ditches lined. All the lined ditches are being constructed by a slip-form method.

Field ditches are constructed with a 2-foot bottom, 1:1 side slope, and vary in depth according to needs. The wall thickness is constructed at a minimum of 1-1/2 inches. Laterals and canals are constructed with a 2- or 4-foot bottom, 1:1 or $1\frac{1}{4}$:1 side slope, and will vary according to needs. Wall thickness for these will be a minimum of 2 inches.

Farmers use syphons or turnouts to apply water to their fields. Syphons vary from 4 to 10 inches, and they use a battery of them. The 6-inch size is the most popular. Two types of slide turnouts are used, and both operate on the same principle. These vary in size from 12 to 18 inches and the size used depends on the amount of water to be delivered to each panel.

The types of structures used in diverting and checking water are varied. They include jack gates, redwood board slide gates, border gates and tapoons. For earth ditches, farmers use a special type of slide gate, sometimes known as the Imperial Valley Border Gate. They range in size from 4 to 36 inches, but for irrigation on the panels the farmer uses the 12- to 16-inch size. The larger ones are used for water diversion or for checking water.

The net average application of water is about 4.5 inches. The farmer orders 4 to 10 acre-feet and applies between 2 and 6 cfs per panel.

Irrigation runs will vary between 1300 and 2600 feet for most of the field crops. For vegetable crops, irrigation runs will vary from 600 to 2600 feet depending on the crop grown. Panel widths vary from 40 to 66 feet. In a few instances they are wider.

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In the Coachella Valley you will find the entire irrigation distribution system underground. The Coachella Valley County Water District operates and maintains approximately 485 miles of pipe lines; of this, one-third of the pipe is reinforced concrete, the remainder being un-reinforced concrete. The system is set up to serve each arable 40 acre tract.

The district will deliver approximately 3 cfs to each 40 acre tract. Most of the farmers in the area irrigate only during the daylight hours, and at night the water is run into an overnight storage reservoir. This gives the farmer more efficient irrigation, permits him to irrigate a greater area in a given period, and provides sufficient water during the peak growing season, because there are times when the water district cannot furnish water just when the farmer wants it.

Where there is excessive seepage, impervious linings are installed. Two types are used. The most popular is a 6 mil, black plastic. It is cheaper, but does not last as long. The other, less common, is a soil-cement lining and is considered to be more permanent.

Between 4 and 7 inches of water is applied each irrigation. This will vary as to soil type, crops, and time of year.

The farmers' irrigation systems consist of underground pipe lines with distribution hydrants. Several different types are used in the area. One consists of a riser pipe extending to about ground level. Over this is a larger concrete pipe. It has openings in the sides through which water can be discharged into furrows. A second type is similar to the first except it has no openings in the sides and only one on the top, and is used to irrigate panels or basins. This one extends about a foot above ground level. A third type of hydrant used is similar to the first one except the flow through holes can be regulated with small slides.

With these distribution hydrants, an orchard valve is used to regulate total flow. Generally a 5-inch diameter valve is used. Flows between 100 to 480 gpm are delivered through each hydrant.

A portable hydrant, which fits over the other types of hydrants, is used with a gated metal pipe to irrigate furrow-type crops.

There are a few cases where sprinkler irrigation is used to irrigate some of the very sandy soils.

Irrigation runs will vary from 330 to 1320 feet, and in a few cases up to 2600 feet. For border type irrigation, panel widths will run about 30 feet. This will depend on slope and soil textures.

In the Palo Verde Valley, the Palo Verde Irrigation District operates and maintains about 295 miles of mains and laterals with capacities from 30 to 2100 cfs. These canals are so located that they will deliver water to each 80 acres.

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At present none of the canals are lined. Recently, there has been an increasing demand by some of the farmers for lining of some of the canals. Canal seepage is not considered a major problem, although there is some evidence of seepage in some areas. At present, there is no contemplation of lining any canals, but is being considered in the future.

The farmers, to date, have concrete lined approximately 200 miles of farm ditches, with an ever increasing demand for more lining.

The farm ditches are constructed and operate in the same manner as those in Imperial Valley except they have much flatter slopes and are deeper because of the flatter slopes. The turnouts are larger because of the flatter ditches and flatter fields.

Irrigation runs, in the valley, will vary from 660 to 1320 feet and panel widths vary from 50 to 100 feet.

The net average application is about 3 inches. The farmer orders between $7\frac{1}{2}$ to 15 acre-feet for 24 hours and applies from 2 to 6 cfs per panel.

On the Palo Verde mesa soils, which are coarse sands and gravelly coarse sands, a continuous water supply of 13 gpm per acre is required for peak use before any development is started. Water for the mesa area is either pumped from wells or lifted by pumps from the valley, a height of about 130 feet. At peak use, a 3 to 5 day irrigation frequency is used. Irrigation runs for these soils will run between 330 to 440 feet.

There is also some sprinkler irrigation in this area.

Irrigation in Bard is very similar to that of the Palo Verde Valley. Water use, lengths of run, border widths and delivery rates are about the same. There is no sprinkler irrigation in the Bard Valley.

Land Leveling

Land Leveling in this area probably differs very little from anywhere else. It is necessary to have uniform grades on the field. Where fields are out of level, salt accumulations are found on the high spots, and in the low spots, where water stands for some time, crops will drown. In the summer, alfalfa will scald where water stands for some time.

The grades vary considerably in area.

In Imperial Valley, main fall grades range from 1 to 4 feet per 1000 feet, and side fall will vary from flat to 2 feet per 1000 feet, depending on soil type.

In the Bard and Palo Verde valleys, grades are much flatter, with the main fall ranging from 0.2 to 0.5 feet per 1000 feet on fine-textured soils, and on fine sandy soils up to 1 foot per 1000 feet. Side falls range from flat

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to 1 foot per 1000 feet, depending on soil texture. On the Palo Verde mesa soils, which are coarse textured (coarse sands and gravelly sands), main fall grades are about 2 feet per 1000 feet and side slopes run about 10 feet per 1000 feet.

In the Coachella Valley, main fall grades range from 0.5 to 1.5 feet per 1000 feet and side falls ranging from 1 to 3 feet per 1000 feet. Some of the land is steeper than it is when leveled, and the end result is two or three benches per 40 acres. Recently, there has been a trend to flatter grades such as those in the Palo Verde Valley.

Special Tillage Practices

There are certain special tillage practices which complement the aforementioned practices in maintaining a favorable salt balance.

First, chiseling or subsoiling, which is usually carried on every year, helps to relieve soil compaction and permits better water penetration. This practice which is carried out generally to depths of 12 to 36 inches -- and in a few cases to 48 inches -- is felt to be temporary since after several irrigations the soils tend to run together and return to nearly their normal state.

Plowing is another practice used to relieve soil compaction. It is carried out to depths of 12 to 18 inches.

A third practice which is increasing in popularity, is deep plowing to a depth of 50 inches. This improves water penetration by relieving soil compaction and breaks up strata of different textured soils. These strata are on a horizontal plane prior to plowing. Following plowing, the strata end in a near vertical plane, fractured, with some mixing taking place.

This not only provides for better water penetration, but also helps to aerate the soils.

Many times salts are turned up, and it may be necessary to leach after plowing. It is felt that this practice will last for at least 10 years, if not longer. The operation costs from $40 to $50 an acre. The cost will vary depending on whether 2 or 3 tractors are used. Two tractors are needed for the coarse- and medium-textured soils. For the fine-textured soils, three tractors are required. The tractors referred to are Caterpillar D-7 or D-8 Crawlers or their equivalent. This allows for a coverage of about 9 acres per day.

To date, approximately 30,000 acres have been plowed with satisfactory results.

Last year a new deep tillage practice was introduced into Imperial Valley. It is being called slip plowing. Actually, it is a modification of a subsoiler or chisel shank. The plow is mounted on a chisel frame, a center shank being used to hold the plow knife in alignment. A ten-foot sliding shoe bottoms the knife approximately 44 to 48 inches underground, while the depth angle is set by control of the center shank which connects to the bottom shoe in a triangle effect.

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According to one farmer, slip plowing may be done after any crop at one-third the cost of deep plowing. The cost for a 50-acre field is between $11 and $14 per acre. The primary purpose of this practice is to bring medium- or coarse-textured soil to the surface, mixing it with a fine-textured soil. Some farmers are now using it to break up strata and improve water penetration. The above-mentioned farmer is plowing his land at five-foot intervals. In this manner the ground is loosened and lifted, bringing loam to the surface while aerating the subsurface.

In another case where slip plowing was used, a farmer was able to get 120 gpm discharge from a tile system. This tile was installed in a fine-textured soil approximately 12 years ago, and had never run a drop of water in all this time.

Other cases can be cited where a great deal of improvement has been realized. I believe this method of deep tillage may prove to be a boon in farming problem soils.

Cost of Reclamation

Reclamation can be expensive. Whether a program of reclamation is successful depends on how much benefit can be realized from the expenditure of time and money. Various cost items must be considered in any reclamation program. These can be broken down as follows:

1. Cost of land leveling
2. Cost of subsurface drainage
3. Cost of surface drainage
4. Cost of leaching

Land leveling

Before leaching is attempted, land should be leveled and graded so that leach water can be applied evenly. A properly leveled field will have leach borders which are straight and evenly spaced. A field which has not been leveled will require contoured borders, and will have high and low places. An average level job will consist of approximately 250 cubic yards per acre, at a cost of about 16 cents per cubic yard, or about $40 per acre.

Subsurface drainage

Good subsurface drainage, either natural or tile, is necessary if land is to be reclaimed effectively by ponding or leaching. The average cost per foot of tile installed at an average depth of 6 feet in Imperial Valley, and 7 feet in Coachella Valley, is as follows:

	Imperial Valley	Coachella Valley
4-inch tile	$ .40	$ .56
5-inch tile	.45	.60
6-inch tile	.50	.66
8-inch tile	.60	.84
12-inch tile	1.50	

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The foregoing figures represent cost of complete installation, including material, labor and gravel envelope.

In Imperial Valley the average cost per acre will be about $90, based on a 200-foot spacing. In Coachella Valley the average cost will be about $125 per acre, based on a 260-foot spacing.

Leaching

Leaching involves a number of cost items which may be accounted for as follows: (Note - all cost items are on a per acre basis and are approximate)

	Imperial Valley	Coachella Valley
1. Engineering cost (dike location).	$ 3.00/ac	$ .90 (av.)
2. Construction of dikes.	8.00	16.00
3. Subsoiling (May not always be done, but recommended).	8.00	19.00
a. Deep plowing (may be done instead of subsoiling prior to construction of dikes).	45.00	---
4. Control devices between dikes. These may be wooden boxes or	2.00	
plastic sheets.	1.00	Not known
5. Water cost.	9.00	11.00
6. Labor for attendant.	1.50	25.00
7. Smoothing out dikes.	8.00	15.00
8. Land leveling (level touchup).	8.00	23.00
9. Replacing lost soil nutrients.	9.00	9.00

Leaching costs in Imperial Valley will vary between $56.50 and $101.50 per acre. In Coachella Valley, they will be about $119.00 per acre.

Certain cost items will vary in accordance with the length of leaching. These operations may have to be repeated over a period of years on the finer textured soils.

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