



IRRIGATION

FOR THE WILLAMETTE VALLEY

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Irrigation for the Willamette Valley

By M. L. UPCHURCH and E. L. POTTER*

IRRIGATION in the Willamette Valley has expanded sufficiently within the past fifteen years to attract widespread attention. In 1930, only about 12,000 acres were irrigated, but in 1946 between 50,000 and 60,000 acres were under irrigation.

The major part of this development has been on an individual farm basis, each farmer building his own irrigation system independently of his neighbors. About 9,000 acres, however, are included in 5 organized irrigation projects in which water is brought to the farm by means of large ditches owned and operated by some form of cooperative or corporate organization.

The amount of land that can be irrigated by individual farm systems is quite limited; and if irrigation is to cover any large percentage of the farm land of the valley, water storage and distribution systems larger than can be built or financed by individual farmers will be necessary. Many proposals have been made for the development of projects that would cover from 300,000 to 700,000 acres. The latter figure would include practically all land now under cultivation that is level enough for irrigation. Reservoirs for the storage of water are of significance not only for irrigation, but for control of floods, development of power, regulation of channels for navigation, abatement of pollution, and for their relation to fish and wild life. Whether it is practical or desirable to develop large-scale irrigation projects in connection with construction of multiple-purpose reservoirs and other installations is a crucial question at the present time.

The purpose of this bulletin is to show some of the history and the present status of irrigation development, to summarize the essential facts that have been demonstrated by experience and research, and to point out the more significant questions relating to irrigation development that are as yet unanswered.

THE VALLEY

Climate

Irrigation may seem out of place in a region that averages about 40 inches of precipitation a year, but the growing season from May through October averages only about 9 inches of rainfall and from

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June 10 to September 20 only 3 inches. For three summer months the Willamette Valley is as dry as or drier than much of the arid regions where irrigation is an unquestioned necessity (Table 1). The growing season is long and includes the spring months when rainfall is usually adequate for crop production, although sometimes too wet or too dry for satisfactory yields.

Table 1. NORMAL PRECIPITATION BY MONTHS FOR SELECTED WILLAMETTE VALLEY STATIONS.*

Month	Albany	Corvallis	Eugene	McMinnville	Salem	Average
	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>
January	6.06	6.53	5.42	6.91	5.33	6.05
February	5.05	5.31	4.65	5.28	4.57	4.97
March	4.01	4.18	3.90	4.29	3.65	4.00
April	2.51	2.43	2.61	2.51	2.35	2.43
May	2.02	1.70	2.33	1.78	1.81	1.93
June	1.28	1.15	1.48	1.17	1.21	1.26
July .....	.44	.33	.38	.39	.41	.39
August .....	.57	.45	.47	.53	.44	.49
September	1.82	1.72	1.99	2.00	1.73	1.86
October	2.90	2.90	2.73	2.92	2.90	2.87
November	6.72	6.91	5.89	7.40	5.89	6.56
December	6.06	6.62	5.72	6.84	5.84	6.22
Total	39.44	40.23	37.57	42.02	36.13	39.08

* Source: *Climatological Data, Oregon Section*; U. S. Weather Bureau.

Topography and soils

Topography and soils are primary factors determining the physical limit within which irrigation must develop. Geologically, the Willamette Basin is a structural valley filled in, within fairly recent times, by volcanic action and by stream deposition. As a result of volcanic action, ridges and hills extrude from the valley floor and a basalt dam crosses the river forming Willamette Falls at Oregon City. Behind this dam, stream deposition has filled the valley to a practically level plain.

Stream deposition of different sizes and kinds of soil particles and subsequent maturing of soil profiles have resulted in a wide variety of soil types in the valley floor. For convenience, these types have been grouped into classes, each differing in its adaptability for agricultural use (Table 2).

Class I soils are made up of recent alluvial deposits along river and stream bottoms and are suitable for intensive vegetable crops as well as for a wide variety of others. Fairly abundant and shallow groundwater is usually available under these soils, and much of the present irrigation is on Class I land. Most of this land is subject to occasional overflow resulting in rough or wavy surface topography. Such land is difficult or impossible to level for flood irrigation; consequently, sprinkler irrigation predominates.

Table 2. ACREAGES OF SELECTED LAND CLASSES BY COUNTIES IN THE WILLAMETTE VALLEY.*

County	Class I	Class II	Class III	Class IV
	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>
Benton	31,733	16,047	37,863	12,080
Clackamas	6,190	66,448	99,763	.....
Lane	57,245	53,417	69,642	65,632
Linn	68,330	35,456	73,084	131,624
Marion	34,594	97,459	126,287	12,647
Multnomah	29,127	66,179	23,336	3,099
Polk	17,885	33,926	66,561	4,610
Washington	17,530	100,769	34,617	.....
Yamhill	10,539	58,147	56,694	.....
Total	273,273	527,848	587,847	279,692

* Data from *Willamette Valley Land Adaptability*, Oregon Agricultural Experiment Station Circular 120, March 1937.

Bordering the immediate river bottoms are the older alluvial soils made up largely of the Willamette series. These have been grouped as Class II and are suitable for almost all crops grown in the area except some of the intensive vegetables. Surface topography is usually fairly level making these soils suited to gravity flood irrigation. Underground water is neither as plentiful nor as shallow as it is with Class I land, and the opportunities for developing irrigation from wells are limited. Extensive irrigation of these lands would require large-scale canal projects to divert water from streams and transport it over wide areas.

Soils of classes III and IV are the tighter, less fertile, less well drained, and the more acid soils of the valley floor. They are adapted only to the more extensive agricultural uses such as hay, grain, seed crops, and pastures. Their topography is generally favorable for flood irrigation, but they frequently need drainage—especially with irrigation. With the exception of pasture, the crops that respond well to irrigation are not suited to these soil types.

In addition to the four classes of soils discussed, some of the lower, more gently sloping hill lands bordering the valley floor and on the hills extruding from the main valley floor may be irrigable. Tree fruits, small fruits, and pastures adaptable to these soils may respond sufficiently to make irrigation feasible under favorable circumstances.

On the basis of these classifications, estimates have been made of the acreage adaptable to irrigation (Table 3).

Although more than 1 million acres in total may be considered either of good or fair irrigability, the practical limits are probably only a fraction of this amount. Economic and physical factors would place a large part of the land served by the canals in uses other than for irrigated crops even under the most favorable circumstances. The

Table 3. ADAPTABILITY OF LAND FOR IRRIGATION IN THE WILLAMETTE VALLEY.*

Generalized soil type	Good irrigability	Fair irrigability	Total
	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>
Old valley fill	434,000	309,000	743,000
Recent alluvial	261,000	253,000	514,000
Residual .....	.....	116,000	116,000
Total	695,000	678,000	1,373,000

* Data from House Document No. 544, 75th Congress, compiled by the U. S. Army Engineers and submitted March 12, 1938.

greatest limiting factors will be the relatively small number of crops that respond to irrigation and the price and volume of these crops that can be marketed.

PRESENT STATUS OF IRRIGATION

Pioneers in the Willamette Valley did a little irrigating of gardens and lawns where water was easily obtainable, but the practice on field crops was not very successful. A wide variety of crops has been grown successfully in the valley for a century without irrigation. The small grains and vetch sown in the fall did well with the normal precipitation. Most temperate zone fruits also produced well without irrigation. On the basis of these crops a stable and highly diversified agriculture has been established. Farm land has become valuable and relatively high priced without irrigation. The lack of summer rain, nevertheless, was and is a distinct handicap to some crops, particularly pastures, vegetables, clover, and alfalfa.

The Oregon Agricultural Experiment Station has conducted systematic studies of irrigation under valley conditions since 1907. Several bulletins based on these studies have been issued. Although the College has been experimenting on this subject for nearly forty years, irrigation was not tried very widely on farms until about 1925. For many years the Oregon Agricultural Extension Service has advocated the use of irrigation on farms where systems could be installed and used economically. Hay crops were the first to be irrigated to any extent, but the production of vegetable crops and ladino clover for pasture proved more profitable and became more common.

Irrigation methods

Irrigation in the valley is of two main types, gravity and sprinkler, but variations and combinations of these types may be found on many farms. Probably three-fourths of the irrigating done in the valley is by sprinkler and most of the present new development is of the sprinkler method. In general, sprinklers are used on river bot-

tom soils that are either difficult or impossible to level for efficient flooding, in localities having insufficient head of water to handle well under flood methods, or in places where gravity diversion is impracticable. If water must be obtained by pumping, sprinklers are frequently used as a means of easy distribution, although pumped water may be spread by gravity on land suitable for that method. Modified gravity systems, in which water is spread over a field by means of canvas or perforated pipe, are sometimes used.

The best methods and amounts of water that should be applied vary a great deal, depending on a wide range of conditions (7).^{*} The purpose of irrigation is to maintain soil moisture above the wilting point for plants, but below the point at which water is lost by gravity. Water in amounts large enough to run off leaches plant nutrients and may cause actual erosion. Somewhere between these two points is the most economical amount of water.

The method, rate, and frequency of irrigation are just as important as the total amount of water. Light shallow soils require frequent, light applications of water rapidly applied; whereas heavy deep soils require less frequent applications, will absorb more water per application, and must be irrigated more slowly to prevent run-off. Shallow-rooted crops require more frequent irrigations than deep-rooted crops, and heavy yields require more water than light yields. When water is applied too lightly, root systems develop near the surface of the ground, necessitating more frequent irrigations later. Proper irrigation wets the soil to field capacity the full depth of the root zone.

Irrigated crops

Roughly, one-third of the present irrigation is on ladino clover used mainly for dairy pasture. About another one-third is on vegetable crops for processing; sweet corn, beans, beets, and carrots account for most of this acreage in about the order named. The remaining one-third of the irrigation is on a wide variety of miscellaneous crops including other vegetables, hops, mint, and berries as well as hay and field corn for silage. A few of these crops, like ladino and some of the vegetables, have been irrigated extensively enough to have developed fairly standard cultural practices. With the others, irrigation practice is still largely experimental.

Irrigated pasture

The value of ladino clover pasture for dairy cows has long been recognized in Oregon. It furnishes a nutritious succulent feed during the entire grazing season. It is a fairly long-lived perennial,

^{*} Italicized numbers in parentheses refer to BIBLIOGRAPHY on page 28.

and although it does not like wet soils, it cannot stand drought. It does not grow without irrigation. When properly irrigated and fertilized, it can be grown on any of the irrigable soils, with heavier yields on the better land. Normally, good ladino pasture will carry 2 cows to the acre for a 6-month grazing season, although heavier grazing has been reported. Bloat is an ever-present danger and considerable care must be taken to avoid losses.

Ladino grows much like any other clover except that the root system is fairly shallow. Heavy yields and the shallow roots require frequent irrigations and a great deal of water, more than for any other crop commonly irrigated in the valley. An application of 3 to 4 inches of water 5 to 9 times during the season is common practice. This means a total of 20 to 30 acre-inches of water a year. Many growers fail to water ladino early enough in the season. They permit soil moisture to become depleted before the first irrigation, thus requiring heavier watering than should be necessary at a later date. Once the plant is permitted to wilt, strong vigorous growth is hard to regain for that season (8).

Vegetable crops for processing

Beans, sweet corn, beets, and carrots are the most important vegetable crops grown in the valley for processing, although many others are produced to a lesser extent. Almost all of these crops are produced on alluvial bottom soils under sprinkler irrigation, except for beans grown on Salem gravelly loams under gravity irrigation in the West Stayton area. Water requirements for these crops are somewhat less than for pasture and hay, averaging about 12 acre-inches a year. Beans normally are irrigated every 5 to 7 days during their peak production period with a total application of 7 to 10 inches of water (6). Sweet corn is usually irrigated once or twice during the season with 6 to 10 inches of water. Two irrigations are generally considered to be better than one in that a little better yield is obtained with more even ripeness and quality. Carrots require the least amount of irrigation because much of their growth is made during periods of ample natural precipitation. Beets also require relatively little water even though some are grown and harvested before fall rains start.

Vegetable crops for processing are almost all irrigated. The advantages in yield and quality are so significant that processors seldom will contract with producers unless irrigation facilities are available. Since these crops are grown almost entirely on river bottom soils, water usually is available for irrigation from streams, sloughs, or shallow wells that tap the gravelly substratum near the streams.

Under such circumstances individual producers can and do develop their own water supplies without needing major irrigation works such as reservoirs and long canal systems.

Hops and mint

Irrigation practice on crops other than clover pastures and processing vegetables is much less common and methods are much less well established. Irrigation of hops is increasing and in some sections almost all growers are using water; in other sections none of them are. Yields on irrigated yards are one-fourth to one-third greater, but so many factors affect yield that not all of this increase can be attributed to water alone. Proper fertilization along with water doubtless gives good results. Hops, like vegetables, are grown on bottom lands where water is usually available for individual development. Increasingly keen competition from other regions may force hop producers in the valley to fertilize more carefully and to irrigate more extensively.

Most of the mint produced in the Willamette Valley is irrigated. Although total acreage is small, the per-acre value has been high during the war years, making it one of the important specialty crops. Even under the most favorable circumstances, production of mint by irrigation is likely to remain a relatively minor enterprise measured in terms of acres involved. Not only is total production for the country fairly limited, but competition from nonirrigated areas is likely to be keen in normal times.

Hay

Throughout the irrigated areas of the West, hay is the most common crop. While hay was the first crop to be irrigated in the Willamette Valley to any extent, its production under irrigation has not yet become widespread even on farms that have water available. Oats and vetch hay are almost never irrigated, and experience does not indicate that any advantage is gained in doing so. Irrigation of clover and alfalfa is a little more common. While the first crop is rarely irrigated, irrigation may produce a heavy second crop where little or nothing would otherwise be obtained. On the Muddy Creek and McKenzie projects, between one-third and one-half of the clover and alfalfa was irrigated with a result of increased yields of one or two tons per acre.

A major difficulty in the valley is that of getting the first crop off the ground in time to irrigate for the second. First cuttings, particularly of alfalfa, come before the weather is sufficiently dry to assure good curing. Making silage of first cuttings overcomes this

difficulty and more widespread use of silage may stimulate more irrigation of clover and alfalfa. Artificial hay drying has not been tried to any extent in the valley, and it is not known whether such a method would be practical. If successful, it would permit the harvesting of the first cuttings in time to irrigate for a second crop.

Fruits

Results of the irrigation of fruits throughout the valley have been quite spotted. All small fruits, tree fruits, and nuts are grown extensively without irrigation under a wide variety of conditions and methods, but damage from drought frequently is significant. The State College has been experimenting with irrigation of major berry crops for many years and, in general, higher yields and better quality have been obtained (9). In the Lacombe Irrigation District, berries have been irrigated on a commercial basis with apparent success. Most of the berries throughout the valley, however, are not irrigated.

Not enough is known yet about the irrigation of tree fruits and nuts to draw any definite conclusions. Prunes do not respond much to water and very few growers have tried their irrigation. Cherries seem to respond best although increased yields come the year following the irrigation, as increased water helps to develop fruiting branches for the following year. Peaches and filberts that have been planted too close together on poor soils respond well to irrigation, but the response is less significant on properly spaced and fertilized plantings on good land. This also seems to be the experience with other tree fruits. The effect of irrigation on winter hardiness of trees such as walnuts is yet to be determined.

Field crops

Irrigation has been used less on the extensive field crops than on any others in the valley. Winter oats and barley show no increase in yield with irrigation and may even show a decrease. Spring oats and barley sometimes are irrigated and in abnormally dry years significant increases in yield may be obtained. Whether such increase is worthwhile in most years is doubtful. Field corn for silage is more frequently irrigated, and increased yields of 1 to 3 tons are reported. Whether it pays to irrigate field corn depends entirely on how cheaply and easily water can be applied. Grass seed crops are not often irrigated because most of their growth is made before dry weather sets in. Experience with alfalfa and clover seed is about the same as with the hay crops, while ladino seed can be produced successfully only with supplemental water.

Summary

Experience and research have demonstrated that irrigation as now practiced is necessary and valuable in the production of ladino clover pastures and vegetables. Without irrigation these crops could not be grown successfully. Important as these crops are, however, they cover less than five per cent of the farm land of the valley. The value of irrigation on the majority of crops now grown and on the majority of land farmed has not yet been demonstrated clearly.

PRESSURE FOR EXPANDED IRRIGATION

Increased population

Throughout the development of the West there has been a demand for larger populations. More people mean additional producers and consumers and, as a result, increased business. Oregon is no exception in this demand.

For a long time the number of farms has been increasing and the average size of farms decreasing in the Willamette Valley. Some variations in this trend have occurred, but taken as a whole the trend has been definitely toward more of the smaller farms. An estimate is that about 125 Oregon farm boys come of age each year for every 100 farmers who reach retirement age. Not all of these boys want to farm, but many of them do. Along with them are people in non-farm jobs in the area who want to farm and people from outside who migrate to the area seeking farm opportunities. Many are attracted to the Willamette Valley by the climate and other resources, and population is likely to continue steadily to expand.

According to the 1940 census the 8 valley agricultural counties contained 28,454 farms having 2,651,482 acres—roughly 90 acres per farm. But these farms had only 1,027,886 acres of crop land, averaging 36 acres per farm.

Already about one-half of the farms are considered too small to provide the operator with full employment or to provide an adequate income for the family if the farm is the only source of livelihood. Subdivision of farms is continuing at a rather rapid rate, especially around the larger towns. So long as nonfarm employment is high and small farms are not expected to provide all the income for the family, little hardship may result from this trend. But if these are expected to be full-time farms, methods for increasing their productivity are needed. Irrigation is suggested as one of the methods.

Irrigation makes a farm bigger. It requires more work, more capital, more cash expenditure, and more intensive management than

does nonirrigation farming. By increasing the intensity of land use through irrigation, a greater number of farms providing full employment for the farmer and his family may be obtained in a given area. The State Planning Board estimated at one time that full development of irrigation in the valley would permit the establishment of 10,000 more farms (2). This would mean an increased farm population of probably 30 to 50 thousand people. This larger number of people on the land would greatly increase the total volume of business in the area regardless of the profitability of irrigation for the individual farmer.

Increased gross revenue

Gross return from land can nearly always be increased through irrigation. An acre of irrigated ladino pasture, for example, will produce 342 animal-unit days of grazing a year as compared to 50 for native grass, 96 for tame mixed grasses, and 164 for red and alsike clover (4). Production of vegetables, made possible only through irrigation, gives a gross return of several hundred and sometimes over a thousand dollars an acre. Irrigation of hops in some sections has increased gross returns from one-fourth to one-third. The increased product obtainable through irrigation nearly always increases *gross* returns, but whether or not *net* returns can be increased depends on the ratio between costs and the price and volume of the products grown.

Pressure for increased irrigation

The possibility of supporting more people on farms in the Willamette Valley and of increasing gross returns has stimulated a great deal of interest in irrigation. Chambers of commerce, civic organizations, and other groups want more people and more business opportunities developed in the region. They want more people in the country rather than in the cities. They want more customers and not more business competitors. They see irrigation as one method of reaching this objective. Public agencies charged with the development of water resources also are interested in expanded irrigation along with flood control, power development, and other phases of a coordinated development plan for the river basin.

But farmers, by and large, are not exerting any pressure for expanded irrigation, particularly those who have well organized and profitable farms. Although many of them are interested in developing their own water supplies where they can with relatively little cost, they have shown very little interest in extensive reclamation projects. Even on the present projects where costs are relatively low, farmers

are rarely irrigating all their crop land or even all the acreage for which they have water rights. The total acreage irrigated in any of the projects has not approached the original expectations. For example, the promoters of the McKenzie Project planned to irrigate 16,000 acres, but stock in the company has been sold for only 1,449 acres, and only 1,030 acres were actually watered in 1944, the last year for which data are available (5). On the Muddy Creek, only 43 of the 96 holders of stock were irrigating and these held stock for only about 10 per cent of their crop land. From the experience of these projects and others, it seems clear that Willamette Valley farmers generally are interested only in getting water to grow dairy pasture and vegetable crops and are not interested in developing a full system of irrigated farming such as is found in the arid sections of the West.

WILLAMETTE VALLEY PROJECT

Proposals have been made by various federal and state agencies for the development of flood control, navigation, irrigation, power, and other uses of the waters of the Willamette Valley (10). The Army Engineers have been working in the valley for many years and have developed plans for the major flood control, navigation, drainage, and power projects. The Oregon State Planning Board published a comprehensive report in 1936 outlining a coordinated plan for the valley that was based largely on surveys made by the Army Engineers and other agencies. This combined or coordinated plan covered most of the various proposals and has been known as the "Willamette Valley Project."

The most significant part of the project is the storage of flood waters in suitable reservoirs to reduce flood peaks. Water so stored will be used to develop power, to maintain river stages needed for navigation, and to reduce stream pollution. Water not required for these uses will be available for irrigation.

The part of the project designated as the "Initial Development Plan" provides for the construction of flood control reservoirs having a storage capacity of about 1,300,000 acre-feet of water. It also provides for certain channel improvements in the river and for improvement of the Oregon City Locks. Construction of these reservoirs by the Army Engineers has been authorized by Congress and two have been completed. Appropriations recently have been made for additional survey work, and the entire flood control plan will be completed as funds are appropriated.

To aid in promoting the Willamette Valley Project, the Governor of Oregon appointed a committee known as the Willamette Valley Project Committee having wide representation from various interests in the state. Later, in 1939, the legislature established a commission having legal powers to represent the State in all matters pertaining to the development of the project. The committee has been particularly active in directing local interest in the flood control and irrigation aspects of the project.

Although flood control is the major objective of the Initial Plan, the development of flood control dams would make water available for irrigation. The Bureau of Reclamation suggests the irrigation of about 230,000 acres from the flood control reservoirs. This acreage would be organized into 11 irrigation projects, each being a complete canal system in itself served by a single source of water. In addition, the construction of these reservoirs would maintain enough water in the river to permit direct pumping on about 96,000 acres. The Bureau of Reclamation proposes that an additional 7 reservoirs be built primarily for irrigation to provide water for 187,300 acres organized into 10 projects. (This includes 2 proposed projects that would use direct diversions rather than stored water.) Grand total of the proposed development is 514,000 acres. This acreage includes all the better irrigable land so located that water could be put on it without unusual engineering problems. It is not based on economic feasibility.

WATER RIGHTS

Surface water

Surface waters of the state belong to the State subject to appropriation for beneficial use (except for certain streams withdrawn from appropriation). Under the basic water code, enacted in 1909, prospective users must file with the State Engineer an application for a permit to appropriate water. On receiving a permit, necessary equipment may be installed and water diverted for use. When proof is submitted to the State Engineer that water has actually been used beneficially, a certificate of appropriation is issued. This certificate constitutes a water right and bears the date of the original permit request which determines the priority of the right. It entitles the holder to the specified flow of water, if that flow exists in the source and is not claimed by prior appropriators. Certificates now issued for water rights in the Willamette Valley contain a rotation clause which provides that the right to use water is subject to rotation use by other appropriators.

In Oregon, one who uses water belonging to a prior appropriator is subject to damages through civil action. If water rights have been determined, adjudicated by a court, and the supply administered by a water master, the use of water belonging to another is a misdemeanor.

Claims for water made before 1909 are not considered as actual rights under present law unless they have been adjudicated by court action. Even so, such claims are good, if beneficial use has been and is being made of the water. If these claims made before 1909 are contested, the courts have accepted for priority purposes the date of the original filing on publication or of initiation of the works. Such claims, therefore, supersede the later appropriations acquired through present procedures. Roughly 50 per cent of the claims in the Willamette Basin are of this sort.

The first claim on the waters of the Willamette River, as on all other navigable rivers, is for navigation. Navigation frequently does not conflict with other uses of the stream, however, and maintenance of flow for navigation alone has not been subject to contest on the Willamette.

Early in the development of the valley, the normal summer flow of the river was appropriated and used for power, most of which was located at Willamette Falls. Any use of the water above the falls that reduces this flow may encroach on the rights of the power users. Nevertheless, considerable water has since been appropriated and used out of the river and its tributaries above that point. No recourse has yet been sought by the power users, and it may be that with the development of the Willamette Valley Project and the maintenance of navigable channels in the river, sufficient water will pass the falls to fulfill their needs.

Considerable variation exists in the use made of water for irrigation in the tributary streams. On some, particularly the western tributaries, almost the complete normal flow is now being used and the stream practically disappears during dry periods. On such streams the State Engineer discourages, but does not necessarily prohibit, further applications for permits to appropriate water. To avoid costly litigation, prospective irrigators should always check carefully the water rights situation on their particular stream.

In 1936, it was estimated that about 50,000 acres could be irrigated in the valley without substantial damage to rights then established and without storage of winter flows. Since more than that amount is now being irrigated, it seems that opportunities for further expansion by surface diversion of natural flow are limited.

Ground water

Much of the irrigation water in the Willamette Valley is pumped from wells (11). Most of these wells are located in the river bottoms and draw water from the underflow of the streams. Deposits of ground water also exist throughout the central valley plain and in deposits of weathered gravel that cap benches and terraces around the margins of the valley floor, but the yield of water away from the stream bottoms is much less certain and its depth likely to be greater. For this reason most irrigation from wells has been in the river bottoms, and even there wells should be tested thoroughly by the driller before investment is made in pump and equipment.

Economical use of ground water for irrigation depends on maintenance of dependable supplies at levels high enough to permit profitable pumping. Although underground water supplies in the valley have not yet been drained excessively, lowered water tables in some areas indicate a danger of depletion if irrigation expands materially. This danger will be minimized in the stream bottoms by construction of the proposed reservoirs in that strong flows can be maintained during the summer months. In other areas, however, replenishment of the underground supplies is less rapid and excessive pumping in relation to the supply much more likely.

Oregon statutes provide for the appropriation of underground water in a manner similar to that of surface water, but this law applies only to the eastern part of the state. As a result of lowered water tables in some areas and the probable expansion of irrigation by wells, the application of this law to western Oregon might forestall some of the underground water problems experienced in other regions.

IRRIGATION ORGANIZATIONS

Most of the irrigation in the Willamette Valley up to the present has been developed by individuals for use on individual farms. Private enterprise has exploited favorable diversion or pumping sites from supplies near at hand. The individual farmer has or can get sufficient capital to install irrigation works under such circumstances, but the opportunities for developing such favorable sites are definitely limited.

Pump irrigation is limited almost entirely to the river bottom soils, and probably not over 50 per cent of those soils have sufficient ground water for irrigation purposes. Irrigation from gravity ditches is generally limited to small streams, many of which are now almost completely used. Larger streams of the valley cannot, as a rule, be

tapped by gravity ditches after they reach the main valley floor. Channels are too deep and variations in water levels too great. If these streams are to be diverted into canals, the diversion must be made where the streams emerge from the foothills. Plans for all the larger proposed projects call for tapping the streams at strategic points; for example, the McKenzie River at Coburg Bridge, the South Santiam at Lebanon, the North Santiam at Stayton, the Molalla at Mulino, and the Yamhill at Willamina. Such projects involve long canals and relatively expensive construction. Installations of this sort are clearly beyond the means of the individual and must be made by group or public action.

Since any major expansion of irrigation in the valley necessitates extensive projects, the methods of organization, operation, and financing of these projects are of vital importance. At present, one irrigation district, one commercial company, and several cooperative companies are supplying water to organized projects. Although in general the experience of these enterprises has been favorable, they do not give much information upon which to base larger and more extensive projects in the future. Each of these projects is favorably located. Each has used previously defunct facilities or facilities built originally for other purposes, or has been aided by Works Progress Administration grants. As a result, their costs are relatively low, and the success that they have made under such conditions may not carry over to larger and more costly projects.

Bureau of Reclamation

Much of the irrigation throughout the West has been developed by the Bureau of Reclamation. This is an agency of the Federal Government created for the purpose of surveying and constructing irrigation works. To date this bureau has not built any projects in western Oregon, but it has made and is making studies to determine the feasibility of some of the suggested projects in the Willamette Valley.

Each reclamation project undertaken by the Bureau must be authorized by Congress and have money appropriated. Usually several appropriations are made for studies and surveys before any funds are made available for construction. In all Bureau of Reclamation projects, Congress has adhered to the policy that the costs of construction without interest should be repaid by the water users. In the case of a multiple purpose project a proportion of the costs is attributed to irrigation, and landowners within the project must contract with the Bureau of Reclamation to repay that proportion.

Such contracts are made through irrigation districts having the power to levy assessments against all land within the project thereby making all landowners parties to the contract.

Although many prosperous communities have been developed on Bureau of Reclamation projects, rarely have the water users been able to repay the costs of reclamation under the terms of the original contracts. As a result, Congress has passed many acts amending the methods and rates of repayment. Originally repayment was to be made in 10 years; the period was extended to 20 years; still later payments were based on percentage of gross crop; in 1926 Congress provided that repayment should be made in 40 years without interest, a policy maintained to the present time. In spite of the changes and extensions, the repayment principle has remained paramount in federal reclamation policy. Theoretically, this places all the risks of reclamation on the water users. Actually, water users can pay only that portion of their income that is left after more immediate costs of production and living expenses have been met, so the risks of reclamation fall back on the Federal Government. The belief is being generally accepted now that all who benefit from reclamation, including urban commercial, industrial, and professional interests, as well as farmers, should help bear the costs.

Irrigation districts

Various institutions have been provided for the purpose of concentrating capital and authority necessary to construct large irrigation works or to contract with the Bureau of Reclamation for such construction. The most common of these institutions is the irrigation district. The policy of the Bureau of Reclamation has been to construct irrigation works only on contract with irrigation districts. These districts are municipal corporations, or quasi-governmental bodies, having certain powers granted to them by the State. In Oregon, they may be created by a favorable vote of 60 per cent of the landowners in the proposed area. The most distinguishing characteristics of irrigation district organization are the power to include within its operation all land within its boundaries regardless of the wish of the minority of owners, and the power to use the taxing machinery of the state for collecting funds from the landowners. Once established, the directors of such districts may issue bonds, on approval of half the landowners, that become first liens against all land within the district. Assessments for operating costs and for retirement of indebtedness are extended on the county tax rolls and are collectible in the same manner as taxes. Such assessments take priority over mortgages and other debts.

There is some doubt as to whether such organizations would be suitable to Willamette Valley irrigation. Under present conditions it seems likely that only a small part of the land in any of the proposed projects would be irrigated. To make assessments on all land in a project when only a small part of it would benefit from the water would not be equitable. Some lending agencies, among them the Federal Land Banks, have refused or have been reluctant to make loans on farms within irrigation districts because of the debt against the land. The policy that lending agencies would follow, if irrigation districts were organized in the Willamette Valley to include farms on which they now have loans, is not known. In any case, farmers are reluctant to commit land, already valuable without irrigation, as security against the costs of irrigation district development.

Cooperative associations

Several cooperative associations organized to divert and distribute irrigation water are now operating in the valley. These are non-profit corporations financed by the members on the basis of their use of the facilities. Normally, a member buys one share of stock for each acre he intends to irrigate, then must pay the assessments levied by the association on the stock he holds. Failure to pay the assessment denies him the right to receive water through the facilities of the company, but the charges are not liens against his land. A cooperative can encumber only the assets that it actually owns; it cannot issue bonds against the land of its members.

Obviously such an organization has important limitations. The fact that farmers may or may not use its facilities and keep up their payments makes such a project difficult to plan from an engineering standpoint and difficult to operate from a financial standpoint. Drainage problems concomitant with irrigation also are hard to handle with such an organization because all landowners within a drainage area might benefit from the drainage, but might not participate in the cost of the facilities involved.

A cooperative probably would have serious difficulty raising enough capital for expensive storage facilities. If, however, the more expensive storage and other structures could be built and financed by other means, cooperatives might be used to advantage for the construction and operation of water distribution systems.

Corporations

One noncooperative corporation is now supplying water for irrigation in the Willamette Valley. This company was developed and operates under unusually favorable circumstances, and its experience cannot be used as a guide for other concerns. An irrigation com-

pany, to be successful, must be able to distribute water at a price the user can afford to pay and leave a profit for its owners. In view of the history of private irrigation companies throughout the West, it is extremely likely that few if any companies will be organized in the valley for that purpose. In any case, it would seem undesirable to divorce the ownership of the irrigation facilities from the ownership of the land and water.

Conservancy districts

A universal criticism of irrigation districts is that the entire cost of the development is charged to the water user. Even though prosperous communities having profitable businesses of all sorts may result from the development of irrigation, the farmer alone is charged with the bill under an irrigation district. Of course, this cost, in some cases, may be diffused in the land values or the price of the products from the land, but it is the landowner who bears the burden irrespective of other cost-price relationships. In an attempt to get wider distribution of the costs of such developments, some states have passed legislation permitting the organization of conservancy districts. Oregon does not have such an act.

Although the details of organization and the powers granted to conservancy districts depend entirely on the legislatures that create them, several principles are common among those now organized. They usually cover fairly extensive areas with the power to tax, within limits, all property both urban and rural. They are created to plan and construct multiple-purpose improvements such as irrigation, flood control, navigation, power, recreation, and others, and may enter into contracts with the United States Government or with others for the performance of these authorized functions. They usually are authorized to sell services and facilities developed under their control as one method of helping to defray the costs involved. Revenue thus obtained has helped to finance flood control, drainage, recreation development, and other non-revenue-producing services. A conservancy district may be used in conjunction with an irrigation district to finance the same project. When so used, it would finance that part of the costs adjudged chargeable to the entire community, while the irrigation district would contract to pay that part of the costs adjudged chargeable to the irrigators.

PROBLEMS OF EXPANSION

Expansion of irrigation on the scale proposed for the Willamette Valley raises many fundamental questions from the standpoint of the nation, the region, and the individual farmer. Although the

regional and individual problems will be of most concern to local planning groups and civic organizations interested in the development, cognizance of the national issues is vital.

National

From the standpoint of the nation, two questions are paramount.

(1) Do we need the product of the more intensively used land that results from irrigation development? Although at the present time more intensive use of land and more food production are in great demand, experience of the 1920's and '30's throws a veil of caution on proposals for agricultural expansion. If the products of a more intensive agriculture are needed, the nation still may ask whether this or some other region should produce them.

(2) Do we need to make available opportunities to accommodate more people in the agricultural industry? Whether or not more people will need to be employed in agriculture in the future will depend largely on continued and expanded employment in nonfarm industries. Even if additional employment opportunities are needed in the future, the nation again may ask whether the Willamette Valley or some other region should provide them. The abnormal periods of war and reconversion offer little evidence on which to answer this question.

Regional

Historically, the nation has been built by a philosophy of expansion and intensification of land use. More farms, more people, more production, and more business has been the slogan of promoters and civic groups as the frontier moved from Virginia to Oregon. Pressure for expanded irrigation projects in the Willamette Valley reflects, in part, a continuation of this philosophy. Whether the proposed development is profitable for the individual farmers or desirable from the standpoint of national policy is of minor concern to the promoters as compared to obtaining maximum gross production and maximum volume of business for the region.

But there are many regional problems that will have to be met in the development of extensive irrigation projects. The interrelationships between irrigation and flood control, development of power, improvement of navigation, abatement of pollution, and preservation of fish and wild life are of major concern. Methods of financing irrigation developments and methods of organizing and operating the water distribution also present questions of regional importance.

Individual

In considering the development of major irrigation projects, the most important question for the individual farmer is whether or not it will be profitable. The relatively small acreages of intensive dairy pastures and processing vegetables grown under irrigation at the present time have been profitable generally. But if irrigation expands to become a major and dominant factor in the valley's agriculture, the same relationship between economic factors may not prevail at all. In the future, profitability to the individual farmer will depend on the kind and volume of crops that can be grown under irrigation, the costs of production including the costs of irrigation, and the volume and price of the products that can be sold.

Engineering and water supply problems

Compared to much of the irrigation throughout the West, the construction of the proposed Willamette Valley projects would be relatively easy. Although some pumping is contemplated on the proposed projects, the topography of the valley is such that diversions can be made from the main streams as they emerge from the foothills with sufficient elevation to spread the water by gravity over wide areas of the valley floor. The distribution canals would have to be lined in some soil types to prevent excessive seepage and loss of water, but this probably would be no greater problem than in irrigation projects elsewhere. Ditch and canal maintenance would be more difficult in the valley than in other regions because of the wet winters and the heavy growth of vegetation, but such maintenance would mean more trouble and expense rather than an insurmountable problem.

The construction of the storage reservoirs offers some difficult engineering problems that are by no means solved in the initial plans. One of the most difficult of these is the relocation of highways, railroads, and other public utilities that will be necessary in the case of some of the dams. To make such changes may involve considerable expense.

The Willamette Valley is much more fortunate than most regions where irrigation is proposed in that the total water supply is not a limiting factor. The average annual discharge of the Willamette River is about 23,000,000 acre-feet, so a relatively small proportion of the total flow would be enough to irrigate all land in the valley. The crucial problem of water supply, however, is proper distribution between seasons and between the various projects. Some of the tributary streams now have almost enough flow to serve the projects proposed under them without storage, but other streams are fully

utilized at the present time and virtually no additional acreage could be irrigated without storage. According to Bureau of Reclamation plans, the 7 flood control reservoirs would provide about 1.3 million acre-feet of usable stored water for 326,700 acres of irrigable land, and the additional 7 irrigation reservoirs would provide about 383,000 acre-feet of usable stored water for 187,300 acres of irrigable land. Although the amounts vary between projects, the average is about 3 acre-feet of water for every acre of irrigable land. Assuming normal delivery losses, this would appear to be adequate for Willamette Valley conditions.

Irrigation facilities

In the development of proposed irrigation projects in the valley, the methods of financing, organization, and operation of the facilities will be very important considerations. The present projects with their relatively favorable sites and low costs and with their relatively minor acreages of highly intensive crops offer little evidence on which to base larger and more expensive projects.

The only estimates of costs available at the present time are those made by the State Planning Board in connection with the Willamette Valley Project. Estimated construction costs on the 22 projects proposed totaled \$50,456,000 for 659,000 acres or an average of \$76.50 an acre. Considerable variation existed between projects, averaging from \$60.50 an acre for the proposed Coburg-Calapooya project to \$136 an acre for the proposed Salem-Woodburn project. These estimates were made on the basis of partial surveys during the depression years and do not include the costs of storage reservoirs. Various other estimates have been made on the costs of proposed irrigation projects by the Army Engineers and the Bureau of Reclamation, based on varying acreages and plans for storage facilities, but they are all substantially similar to those quoted above. No estimates based on postwar prices are available.

The evaluation of a proposed major public improvement, such as an irrigation development, cannot be based solely on whether the dollar income resulting from it is larger than the dollar cost. If an improvement increases the productivity of an area, benefits accrue not only to the primary producers using the improvement, but to the entire economy of the area. Such benefits cannot always be measured in terms of dollars and cents. This fact should be recognized in distributing the costs of the improvement, and in the case of irrigation projects, provision made for the entire economy to contribute toward those costs.

To organize the proposed Willamette Valley projects into irrigation districts in which the irrigators would carry the total costs of the development plus a proportionate cost of the water storage facilities would mean a very heavy investment on the farm land. A charge for irrigation facilities of from \$75 to \$150 an acre on top of a land value of from \$100 to \$500 an acre involves a total investment out of line with irrigated areas elsewhere. Of course, if it pays, the cost doesn't matter particularly. But whether or not it will pay is difficult to predict. Not only must future prices and production costs be estimated, but guesses must be made as to the crops grown and the systems of farm organization and management that would prevail if extensive areas were irrigated in the Willamette Valley. It would be a grave error to assume that extensive areas of the valley could be irrigated in the future as successfully as the relatively small areas now being irrigated.

Crops and markets

At the present time, the Willamette Valley produces roughly 472,000 acres of grain, 325,000 acres of grass and legume seed, 247,000 acres of hay, 82,000 acres of tree fruits and nuts, 17,000 acres of small fruits, 12,000 acres of vegetables, and 35,000 acres of various specialty crops. Over a long period of years the pattern of farming has become fairly well adapted to physical and economic conditions with a high percentage of the crop land used for the main extensive crops—grain, hay, and seed. The crops that will be grown in the valley, if irrigation is to be expanded materially, present a challenging question. Since the grain crops in general do not respond to irrigation and the response of hay and seed crops is doubtful in most instances, they likely would be replaced by other crops under irrigation. Bearing in mind that the choice of alternative crops is limited both by physical and economic factors, what will they be? Up to the present time ladino clover for dairy pasture and vegetable crops for processing have proved most successful under irrigation.

LADINO CLOVER production does not seem to be limited by soil type, for it is now grown on almost all kinds of soil found in the valley and could be grown on any irrigable land with some liming and drainage on the tighter, more acid soils. Production of ladino is limited, however, by the use made of the crop. Its chief value is for dairy pasture, but pasturage for all the dairy cows now in the Willamette Valley would require only a little over 50,000 acres. Consequently, if several hundred thousand acres of the valley are to be irrigated with ladino as an important crop, substantial increase in the dairy industry of the valley would be necessary.

HAY production under irrigation is still of doubtful value. More than half the hay now produced is vetch and grains that do not respond generally to irrigation, since they do not produce a second crop and the spring rains normally are adequate for the first crop. The legume hays can be grown on most of the irrigable land if lime is applied to the more acid soils. If ensiling clover and alfalfa overcomes the difficulty of harvesting the first crop in time to irrigate for the second, it is probable that the acreage of irrigated legumes would expand at the expense of vetch and grain hay now being grown.

MILK production and future market outlets for dairy products will be determining factors in the development of extensive irrigation. At the present time the Pacific Coast is a deficit area in dairy products. For this reason, expansion of production of milk for processing could occur to some extent without material disruption of present marketing conditions. Just how long such a situation will last is difficult to predict. For the past two years the trend in the valley in number of dairy cows and in milk production has been downward. But in the future, development of other irrigated areas in Washington, Oregon, and California may make this a surplus region, thereby placing dairy production here in direct competition with the midwest and other regions. Even so, the Willamette Valley may fare well with its long grazing season if highly productive pastures and hay crops can be grown cheaply enough.

PROCESSING VEGETABLES are much more narrowly limited by soil adaptability than are the hay and pasture crops. Even so, economic limitations are narrower still. Processing vegetables are grown mainly on the Class I soils. Of the 270,000 acres of Class I land in the valley, probably not more than half could ever be used for intensive vegetable crops. In 1945 only about 15,000 acres of the major vegetable crops were grown in the valley and an increase of several times the present acreage still would utilize only a minor portion of the acreage proposed for irrigation.

Whether any increase at all in the production of these crops is justified depends entirely on the markets. Processing vegetables are almost always grown under contracts with the processors, who contract for the volume of goods they think they can sell at a profit. During the war, this volume was virtually all they could get, but whether market outlets will increase substantially in the future is problematical. Population and consumption within the region probably will continue to increase gradually, but local markets absorb a relatively small percentage of the processing vegetables produced. Any material increase in the markets for processing vegetables must come from outside the Willamette Valley.

SPECIALTY CROPS now grown in the valley doubtless could be expanded somewhat under irrigation, but the total acreage involved would be limited by physical and economic factors even under the most favorable circumstances. All the major specialty crops now total about 35,000 acres including hops and flax. About 15,000 to 17,000 acres of this land are in hops and about 12,000 acres in fiber-flax, according to the latest figures that are available.

HOPS are now grown mainly on the river bottom soils where water generally is available for irrigation. Although an increasing proportion of the hops grown is being irrigated, material expansion in the future, either with or without irrigation, seems extremely unlikely. More hops are now being produced than can be used on the domestic markets, and other producing areas are getting more favorable yields and are offering increasingly keen competition to Oregon growers.

FIBER FLAX has been expanded considerably in the Willamette Valley during the war because of the acute need for cordage and other fiber products, the importation of which was denied by war conditions. Considerable difficulty is now being experienced in maintaining the industry at anywhere near its wartime level. That fiber-flax production will absorb any major proportion of the acreage proposed under extensive irrigation seems unlikely.

MINT production also expanded in the valley during the war, but it probably will never account for a very large part of the agriculture of the region. Only about 45,000 acres of mint are produced in the entire United States, with more than three-fourths of that in Michigan and Indiana. If all the mint in the United States were produced in Oregon, it still would not utilize much of the proposed irrigated land.

Irrigation of other specialty crops might be expanded somewhat without material disruption of marketing conditions, but at best the total acreage involved is likely to be small. Full utilization of extensive irrigated areas of the Willamette Valley in the future will require the development of crops that will substitute in the farming system for crops now grown without irrigation. Such crops would have to be adapted to the soil and climatic conditions and would need to have favorable market outlets either directly or through livestock products. No one is yet prepared to say just what crops will be grown under extensive irrigation projects.

UNANSWERED QUESTIONS

Although irrigation to some extent has been practiced in the Willamette Valley for a long time, much information needs to be

developed on just what crops should be irrigated, how they should be irrigated, and what costs and returns can be expected. Irrigation of vegetables for processing is not questioned under present economic conditions, but whether processing vegetables can be produced profitably outside the river bottom areas and what acreage of such crops might be justified by marketing conditions are as yet unanswered questions. The Division of Agricultural Economics at the State College is initiating a study of the vegetable processing industry that should be of value to the planners of irrigation developments.

The irrigation of relatively small acreages of ladino clover for dairy pastures has proved profitable in the past, and ladino doubtless will be an important crop on any irrigated land in the future, but the extent to which the dairy industry can be expanded to justify future extensive irrigated pastures is not known. Some hay has been irrigated in the valley, but whether or not such a practice would prove practicable on the scale anticipated in the proposed irrigation projects is another unanswered question.

Both tree fruits and small fruits have been irrigated to some extent, but no clear data exist as to whether such a practice would be profitable on an extensive scale. Much experimental work needs to be done both by Oregon State College and by producers before widespread advocacy of the practice can be justified on a major part of the valley's agricultural land.

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