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S.O.L.P. - Report

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Dept. of Agriculture - Canada
Prairie Farm Rehabilitation Act

Seepage Studies
South Okanagan Lands Project - 1950
G.P. Williams

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1955 - Total irrigated acreage 4800

INTRODUCTION

General

The South Okanagan Lands Project is administered by the Provincial Government of British Columbia. The portion of this project extending into the Osoyoos area was first irrigated from 1928 to 1930. Since that time the irrigated area has gradually increased to the present total of approximately 1500 acres. With this increased acreage, there has been a steady rise of the water table throughout the area.

Small areas show definite signs of excess salts and high water table as illustrated by Figure 1, page 3. Several areas have bank instability as shown by Figure 2, page 4. Water levels in various ponds have risen dangerously as illustrated by Figure 3, page 5.

Approximately 965 acres of arable benchland above the present irrigated area are proposed to be developed for the settlement of veterans from World War II, 1939-45. Before development proceeded, information regarding possible seepage from this bench was needed. At the same time information was required on the extent of the existing problems. The purpose of this study was to report on this area from these two approaches.

Studies were started in 1948 with the installation of observation wells throughout the area. Readings were taken during the years 1948, 1949, and 1950. In 1950 an investigational survey compiled existing data and extended the field work as required. The conclusions reached have been assembled in this report.

Figure 4, page 45, shows the general location and details for this area.

Farms

The first few years, while an orchard is being established, tomatoes, cucumbers, watermelons, and cantaloupes are grown. Later apple, pear, plum, peach, apricot, and cherry orchards reach maturity and are the mainstay of the farm unit. The average size farm is 10 acres. Thus, with high-value crops and small acreages, land is valuable.

DESCRIPTION OF AREA

Climate

The climate is one of the mildest in Canada. The 23 year average for temperatures at Oliver, 14 miles north of Osoyoos, is 26 degrees Fahrenheit for January, 74 degrees Fahrenheit for July. The average frost-free period at Oliver is 162 days with an average growing season of 226 days (6).

Soils

General

Information concerning the soils in this area was obtained from a Soil Survey Report by Kelley (6).

Figure 5, page 46, illustrates the distribution of soil types. The map does not give detailed boundaries. Within each soil type considerable variation can be found.

Osoyoos Loamy Sand

The upper bench is composed of Osoyoos Loamy sand. The surface three feet contains some silt and clay. The layer from three feet to the underlying silt clay comprises clean, coarse, porous sand, with the occasional layer of gravel. From field observation of water loss in auger holes, this soil will be very pervious.

Cont final

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Skaha Sandy Loam

Much of the irrigated area consists of Skaha sandy loam. The surface sandy loam contains some silt and clay. Below 2 feet the parent material is loose sand and gravel until the underlying silt clay is reached. The area is marked by kettle holes as illustrated in Figure 7, page 47. Except where silt was mixed with the gravel and sand, this soil would be pervious to the flow of ground water.

Penticton Silt Clay

The Penticton silt clay is the surface equivalent of the semi-impervious parent material underlying the whole area. The surface three feet has often gravel and sand intermixed with the silt clay. Below three feet the silt clay is remarkably uniform presenting a varved appearance as shown in Figure 6, page 12.

Use of Irrigation Water

Methods of Irrigating

Furrow irrigation is the predominant method of irrigation in this area. However in the past ten years sprinkler irrigation has increased considerably. Sprinkler irrigation has been much more satisfactory on land with slopes over 6 percent. The reason it is not used entirely is the high initial cost of installing the sprinkler system.

Actual use 1955
155 c.f.s. for 135 days
155 x 135 x 1.98 / 4800 = 8.6 A.F/Ac
(Losses?)

Recommended Use

According to a study (13) on the use of irrigation water in this area, farm use, even under the worst conditions, should not exceed one acre foot per month, or approximately 3.5 to 4 acre feet during the irrigation season.

In 1945 a careful record of irrigation water applied was kept for a 9 acre farm on lot 457 in this area. 2.38 acre feet of water per acre was used by furrow irrigation methods for the entire irrigation season. The owner** of this farm felt that 3 acre feet per acre was the best average farm use that could be expected for this area.

Thus the range of farm use given by these two sources is from 4 to 3 acre feet per acre per irrigation season.

Actual Use

All available evidence points to the inefficient use of irrigation water in this area. The writer has observed furrow irrigation in this area where as much as 80 to 90 percent appeared to be lost through direct runoff. The outflow as evidenced by seepage, surface springs, rise of the water table and rise of the water levels of ponds indicates excess water use. The evidence tabulated later in the report under "Hydrology of the Area" supports these observations.

** Mr. D.G. McCrae, Professional Engineer, formerly project manager of the South Okanagan Lands Project for 11 years.

Conclusions

Sprinkler irrigation should be used wherever possible. In the areas requiring drainage considerable improvement has been noted once sprinkler irrigation was introduced. It is no accident that the areas having high water table and saline conditions invariably are irrigated by furrow irrigation.

Although more efficient use of irrigation water is required, too much progress cannot be expected. Irrigating these soils is a difficult task, requiring much experience and judgement. As long as there is plenty of water available the use of water is likely to remain high. Certainly this has been the experience in other irrigated areas (5, page 22).

Seepage From The Main Canal

Evidence of Seepage

Piezometers and observation wells located at right angles to the main concrete-lined canal generally gave no indication of water table build up. However in areas where it was impractical to install piezometers because of fruit trees, rank vegetation alongside the main canal indicated some seepage. Also local farmers stated that large leaks have occurred in the past, raising the water table of critical areas appreciably.

Detailed seepage investigations were not undertaken because of the difficulties in taking worthwhile measurements, and because such a study to be of value would have to be undertaken along the whole length of the canal.

Reason for Seepage

The present project manager++ states that wherever the canal excavation is in silt clay much frost heaving occurs, resulting in great cracks in the concrete. These cracks permit considerable leakage. Each spring it has been necessary to inspect the bottom of the canal, and asphalt the open cracks. The much patched-up bottom of the canal indicates how often this has been required.

Conclusions

All available evidence points to much variation in water losses between sections depending on how effectively the asphalt has repaired the cracks.

If this main canal did leak, several low-lying areas would be affected by the resulting higher water table. At present it would appear that good maintenance has kept this problem under control.

++ Mr. D.W. Hodsdon, Professional Engineer, B.C.L.S.

RELATION OF STRATUM SURVEY TO GEOLOGY OF AREA

Geology of Area

General

Before investigating the subsurface materials in this area a study of geological conditions was essential. In fact because of the variable nature of the surface and subsurface soils, geology was the key to the final solution. Once the geological origin of different soils was established, it was much easier to correctly interpret the stratum survey, and hence understand the drainage problems in this area.

Much useful information on the geology of this region was obtained from a report by Mollard (8). This information was added to by a careful study of air photographs, and by a field study of outcrops and surface topography.

The sequence of geologic events are best shown by means of Figure 7, page 47. (Apparently follows Fig 5

Conclusions

The Osoyoos region is underlain by a semi-impervious silt clay with eroded, irregular contours. This material was deposited by slow moving glacial rivers into well defined varved layers. Earth movement and surface erosion has resulted in much surface irregularity of this deposit. Figure 6, page 12, shows a representative profile of this silt clay.

This clay layer slopes toward Osoyoos Lake. The layer will generally extend down to bedrock, permitting no appreciable deep percolation under it. The upper surface of the silt clay will govern ground water movement, as ground water will move more readily down the slope of this material than penetrate into it. The semi-impervious nature of this material might result in perched water tables, especially during the irrigation season.

The overlying mantle covering the silt clay is variable on the lower benches, but is fairly uniform on the upper bench. This material was deposited by wave action, and by streams bringing down eroded material from the mountains. This mantle will consist of fine and coarse sand, with large gravel banks wherever the streams were fast enough to carry these larger particles. On the lower benches this mantle is often intermixed with eroded silt changing it from a pervious material to a semi-impervious one. Figure 8, page 13, shows the pervious mantle overlying the silt clay layer in a recently eroded gully.

Stratum Survey

Methods of Obtaining Data

A large number of auger holes and wash bore holes (1, pp95, 96,97) were put down during the spring of 1948. The information obtained from these holes was extremely helpful in evaluating the problem and in directing future work.

During the summer of 1950 the number of holes was increased by further hand augering and by cable-tool drilling (7, page 377). In addition a jetting rig (2) was used to locate the silt clay layer. Figure 9, page 16, illustrates this unit in operation.

Difficulties were encountered with all types of equipment, with the exception of the cable-tool drill. This type of drilling was limited by high cost. Extensive gravel layers were very hard to penetrate by hand augering or jetting. Jetting was also very difficult in the loose, pervious sand on the upper bench. Eighteen feet was the maximum depth reached by jetting, before the sides of the hole collapsed making further progress impossible. Driller's mud was used to keep the sides of the hole from collapsing, but even this measure proved unsatisfactory at depths greater than 20 to 22 feet. Because of these difficulties limits were set on the depth which could be reached, and thus a knowledge of local conditions was necessary to interpret the logs of the different holes.

Interpretation of Data

The profile of the different test holes at right angles to the main canal have been plotted as shown in Figure 10, page 48. On line B the underlying silt clay forms a basin just

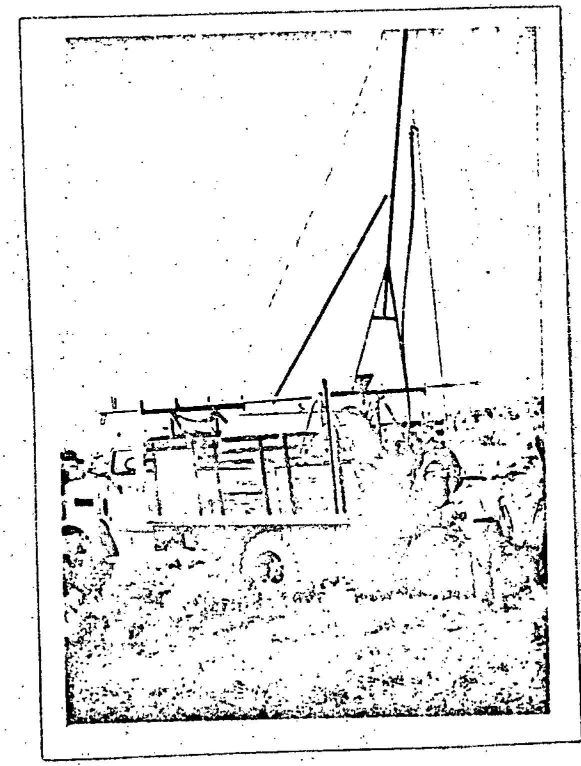

Figure 9 Jetting Unit in Action
Osoyoos, B.C. August 1950.

below the main canal, where excess irrigation water can collect from both sides. Wherever the outlets of such a basin are restricted, critical drainage areas result.

Figure 11, page 49, shows the type of material encountered under the main canal. On the same figure is plotted a plan view of the areas directly below the canal. This plan view was necessary for a more complete explanation of the profile plotted above it, and should be used in conjunction with Figure 10 as well.

For example from Figure 11 it is obvious that the deepened sand pocket on Line B would provide no outlet for the excess irrigation water in this area. The old stream channels, while evident, do not provide good outlets now. Instead an intermixed gravel and silt formation result in restricted drainage areas.

South of Line C the silt clay layer is further from the surface, resulting in better drainage of excess irrigation water. A study of the groundwater map later in the report confirms this point.

The main value of the stratum survey was in predicting where ground water would flow and collect if the upper bench were irrigated. Also a knowledge of the subsurface conditions combined with an understanding of the geology of the area was the first basic step in deciding the nature of the present drainage problems.

HYDROLOGY OF AREA

Inflow-Outflow Data for Area

All available data on inflow into the area and outflow from the area were compiled during the irrigation season of 1950. The results were difficult to evaluate because of unknown factors such as seepage to Osoyoos Lake and ground water flow into the area. Figure 12, page 50 illustrates the inflow-outflow data compiled.

Strawberry Creek, the only natural stream flowing into this area, was measured by recording the amount of water flowing into a barrel in a given time. The hydrograph, shown on Figure 12, indicates that peak flow occurs before June. The stream was measured where underlying-impervious limestone prevented appreciable ground water flow. The stream disappeared underground when it reached the pervious benches.

As Strawberry Creek drains approximately 30 percent of the total watershed area it seems reasonable to assume that natural runoff into the area is slight. If the rest of the area had an equivalent flow, less than one c.f.s. would have been flowing into the area during June 1950. Also, according to local information, Strawberry Creek is often dry during the dry years. Therefore for practical purposes the main inflow is through the main irrigation canal servicingthis area.

e outflow appearing in the numerous ponds have been compiled in Table 1, page 51. In addition an undetermined amount of outflow seeps through to Osoyoos Lake.

Ground Water Survey

General

In 1950 all available farmer's wells and ponds were surveyed and water levels recorded. These, combined with the previous water level gauges and observation wells installed in 1948, were sufficient to construct a ground water map. Interpretation was necessary, therefore this map is only as accurate as the number of water levels available. For that reason and because of the small scale, 5 foot contours were used as shown in Figure 13, page 52.

Interpretation of Ground Water Map

The direction of ground water flow can be determined once a ground water map is constructed, as the flow lines of underground water can be represented by a set of curves which cut the contours of the water table at right angles, (9, page 35). Also knowing the direction of flow, it is possible to estimate recharge areas serving various wells and ponds. For example a study of the ground water map shows why pond G21 has such a large flow into it. Ground water must move at right angles to the contour lines, as indicated, from a large area of irrigated lands. In analysing the present problem and in assessing the possibilities of re-use of irrigation water a similar procedure was adopted for other ponds and wells in the area. To avoid the confusion of too many lines on the ground water map the recharge areas were not marked on it.

The ground water map also provides information on the type of subsurface material. Wherever a steep hydraulic gradient exists, as evidenced by the closely spaced contours, ground water must be impeded by semi-impermeable material; conversely wherever the contours are widely spaced, ground water must move more freely through pervious material, (1, page 66). The surface topography and the amount of ground water moving will also affect the slope of the hydraulic gradient, but generally the contours of the water table map is a guide to the type of water-bearing formation, (90, page 36). Certainly when the ground water map is used with a stratum survey map this principle is of value in determining the subsurface material.

Fluctuations of Water Levels In Area

General

The records kept on observation wells and gauges installed in this area have been plotted and are presented in Figure 14, page 53. The average monthly fluctuations of water levels has been shown for observation wells above and below the main canal, and for ponds in the area. This figure was compiled from data presented in tables 2, 3, 4, pages 54, 55, 56, respectively.

Fluctuations of Water Levels in Observation Wells

The water levels in observation wells below the main canal reach their peak in July and August, then gradually recede. Many local factors such as difference in irrigation methods, difference in topography will be reflected in individual water table fluctuations. The general average over the past three years shows an upward trend.

The water levels in the wells above the main canal follow the pattern of observation wells below the main canal. The fluctuations are less as these wells are not on irrigated farms and therefore do not reflect immediate irrigations but rather reflect the general rise of the water table due to excess irrigation. If canal seepage was a major cause of these rising water tables the peak should last until late September, as the canal is full until that time.

These ovservation well readings should be continued over a number of years for maximum value. Not only would the future trend become obvious, but also the effect of irrigation of the upper bench should become apparent.

Fluctuations of Water Levels on Ponds

The water levels in the ponds reach their peak in late September, then gradually recede until April, proving that excess irrigation water is causing these ponds to rise. The peak is later than observation wells because there is a delayed flow from excess irrigation water applied to areas above them. The record is too short to show a definite future trend, however in the past the water levels have been higher each year. According to local information, all these ponds have filled in the last twenty years, since irrigation was first practised in the area.

Table 5, page 57, shows all pertinent data regarding ponds in this area. It will be noted that water levels are highest in 1949, declining in 1950. Such a trend is closely related to the use of irrigation water and pumping. The pumping data shown are but approximate. Most pumps run fairly continuously throughout the irrigation season. They do not effect the water levels as much as would be expected because a large portion of the pumped water returns quickly to the ponds by surface and underground flow.

ANALYSIS OF PRESENT PROBLEMS

General

It is beyond the scope of this report to give a detailed analysis of the existing problems. Each problem requires a separate solution and a separate study. However from the data assembled it was possible to assess the present problem and the general improvements required.

Figure 15, page 58, shows the extent of the present problems.

Flooding Problems

Analysis of Ponds

Excess irrigation water has caused the water levels of several ponds to rise, resulting in the flooding of orchards and often buildings. Ponds G20, G21, G10, G9, G7, G14, G13, and G3 show the greatest fluctuation in water levels. A study of the ground water map, Figure 13, shows that a large recharge area is required to produce the fluctuations recorded in Table 5, page 57.

So far the flooding has been more of an inconvenience than a problem. Some farmers have lost as much as an acre of fruit trees, but in most instances the damage has been limited to a few trees on marginal soil. The advantage of having a supply of water to pump from has more than offset the damage produced by the flooding. Flooding problems are more spectacular than salinity problems and as a result more concern is expressed.

The ponds are formed by excess irrigation water collecting in the kettle holes described in the geologic sequence. Fortunately the banks of these kettle holes are steep, so that the water levels can fluctuate considerably without much land being affected. Also, the higher the water level, the greater the outflow from these ponds so that a limit is set on the amount of fluctuation possible.

While there is every possibility the 1949 levels as recorded in Table 5 can be exceeded, it is unlikely they will be exceeded by very much.

Recommendations

In many instances the easiest solution would be to provide compensation to the farmer for the land and property flooded. The buildings affected could be moved to higher land. If the farmers were compensated this would satisfy a major complaint: namely the paying of taxes on land that is worthless.

If the costs are justified, and no study of this has been made, the ponds could be controlled by a system of outlets to Osoyoos Lake. The ponds where this approach appeared possible have been listed as shown on Figure 15.

The water levels could also be controlled by pumping. The possibility of combining re-use of irrigation water with water level control is discussed later in the report. This solution appeared especially attractive for pond C20, where not only can a good volume of water be obtained but also flooding of a portion of the townsite of Osoyoos can be prevented.

Drainage Problems

Drainage Areas 1, 2, 3

Drainage areas 1, 2, 3, as shown on Figure 15, have a water table 4 feet or more from ground level. Thus, at present these are not critical areas (10). However they have been listed because the water table was very near the critical range. Also, previous attempts at drainage were noted, indicating that drainage might have been more acute in previous years. With proper use of irrigation water these three areas will not become critical drainage problems.

Drainage Area 4

Drainage area 4 shows evidence of water table depth at 2 feet, and salt appearing at the surface. Sprinkler irrigation should be used immediately. As the ground water map indicates considerable flow from upper areas, tile drainage will probably be required.

Drainage Area 5

Drainage area 5 is the major problem area and thus a detailed map of it is included later in the report. The salt content of the samples of soil taken in this area as shown by Table 6, page 15, varies considerably throughout the profile. Three samples can be classified as Saline while two samples can be classified as Nonsaline-Alkali (12, page 71). As the samples were taken in a badly affected section further samples should not show such a high salt content. This analysis, along with the favorable water tests discussed later in the report, indicates proper drainage would probably be sufficient to reclaim this soil. However the samples also indicate reclamation of these soils will become a problem if proper drainage is not provided and maintained.

Fortunately because of surface topography, this drainage problem will not increase appreciably in area. As in drainage problems 1, 2, 3, 4, excess irrigation water has collected in basin-like areas with silt clay at or near the surface. The area that can be affected is well defined by the edges of the basin.

Drainage Areas 6 and 7

Drainage areas 6 and 7 show evidence of salt at the surface and water table within 2 feet of the surface. If the natural drainage ditch in this area were cleaned, widened and proper outlets provided at road crossings, there would be no problem in these areas.

Analysis of Bank Erosion

The bank erosion is caused by the excess irrigation water saturating the underlying silt clay. In a saturated state this soil appears to have no shear strength, which results in bank instability. Erosion continues rapidly because the banks which crumble, as a result of this condition, are left in an unstable state. As pointed out by Taylor (11, page 365), shear strength investigations on such stiff clays are relatively unimportant, and studies should attempt to prevent the entrance of water which leads to loss of strength. Sprinkler irrigation and the stabilization of banks with vegetation would control this problem.

Conclusions

In this area only a few land owners are affected by any of these problems. Thus one of the major difficulties will be to obtain the proper co-operation of all members of the community. What is likely to happen is direct action by the landowners involved at each individual's expense. Wherever remedial work is beyond the scope of an individual, either financially or legally, one or two property owners will suffer the resulting damage. An effort should be made to get these problems treated as an overall project responsibility, so that remedial works can be charged to all users.

RE-USE OF IRRIGATION WATER

General

If the re-use of irrigation water can be planned economically it would prevent the water levels of critical ponds from rising too high. In addition, as the source of water to be used for irrigating the upper bench is still doubtful, any supplemental supply might hasten development of this upper bench.

In 1950 several well locations were investigated as possible sources of irrigationwater. These along with possible ponds which could be used, are shown in Figure 19, page 63. For ease of reference all pertinent data is included on this map.

It will be noted during the following analysis the emphasis is placed on recharge area. The writer believes that in every case of possible re-use of water development in this area the amount of annual flow or recharge is the limiting factor. According to Israelson (4, page 88) ground water supplies should be determined on the basis of long-time investigations of the quantity of annual inflow or recharge to the ground water streams, basins or reservoirs.

Analysis of Re-use of Water from Ponds

Analysis of Sample Pond G6

Figure 20, page ~~64~~ 65, gives a sample calculation to illustrate

The procedure used to find the amount of water available for pumping from these ponds. Figure 21, page 66 65, illustrating the inflow-outflow pattern for one of these ponds should be referred to in analysing this sample calculation.

From Figure 20 the range of pumping would be from .17 to .27 c.f.s. The high excess irrigation water, 1.2 feet per acre of recharge area in 3 months, would indicate .27 c.f.s. is near the maximum available for pumping. The amount given is in excess of water already pumped from this pond.

Because of the assumptions listed in Figure 20, the amounts cited are estimates. However for the porpose of investigating the feasibility of re-using this irrigation water this approach seems worthwhile.

<u>Re-use of Irrigation Water from All Ponds</u>

A similar procedure was used to estimate the water available for pumping from ponds G21, G14, G3, G10. A summary of these calculations has been compiled in Figure 22, page 66.

The average inflow per acre of recharge area in 3 months is 1.15 feet. Even with all the assumptions made and with the difference in topography and soils between various areas the range of inflow per acre of recharge is from 1.06 to 1.30 feet. This inflow represents excess irrigation water. The excess would be higher because evaporation has been neglected, outflow through other outlets not considered, and the inflow for the first 6 weeks of irrigation season not calculated. If all these factors were included the excess irrigation water applied would average at least 1.5 to 2 feet per acre per irrigation season.

Disadvantages to Re-use of Irrigation Water from Ponds

One disadvantage is the high lift and distance to the main canal. If pumping is considered, it would be worthwhile to investigate pumping into the present irrigation system laterals so that more water in the main canal would be available for pumping to the upper bench.

Another disadvantage is that early in the irrigation season the water would be too low for pumping. Therefore the ponds could not be relied on for water until July.

In some instances the fluctuation in water levels has been enough to prevent pumping in the early spring because of high suction lift, and to stop pumping in late summer because the installation would have been flooded out. Therefore any installation would have to be large enough to control this fluctuation.

A pump test would be valuable in checking this required capacity. The test would have to be done during the irrigation season, as the flow into these ponds depends upon a constant recharge from excess irrigation water. G20 has the highest capacity and would be best suited to such a test.

Analysis of Re-use of Water from Wells

Drill Hole 4

Drill hole 4 was developed for use as a test well. Six inch casing was installed to a depth of 72 feet. The bottom 11 feet of 5 3/8 inch perforated casing was used as a well screen for pump testing this well.

The well was pumped for 20 hours at 43 g.p.m., with no drawdown observed at the casing, or on the system of piezometers around the well. Then it was pumped at 55 g.p.m. with 3 feet of drawdown at the well casing after 4 hours pumping. No drawdown was observed in the piezometer observation wells. As 55 g.p.m. was the maximum capacity of the driller's cylinder type pump, pumping was discontinued. As no drawdown was recorded on the piezometers, detailed calculations could not be made.

The field log of the well as shown on Figure 19 indicates favourable conditions for well development. This log was confirmed by the grain size curves shown on Figures 23 and 24, pages 67, 68.

From the ground water map, Figure 13, the recharge area is approximately 80 acres. Assuming an average of 1.5 feet of

SUMMARY

1. A seepage investigation was conducted in the summer of 1950 on the South Okanagan Lands Project, Osoyoos, B.C., to determine the extent of present drainage problems, and to determine the effect of irrigation of an upper bench on these problems.

2. Seepage from the main canal would contribute to the existing problems if the canal was not properly maintained. At present good maintenance has kept seepage losses from this main canal to a minimum.

3. A substratum survey by hand augering, wash bore drilling, churn drilling, and jetting defined the areas where additional seepage problems can be expected if the upper bench is irrigated.

4. A study of water levels in observation wells throughout the area indicated excess irrigation water was responsible for the rising water tables and drainage problems. A ground water map was constructed which defined the recharge areas for numerous ponds and wells in the area.

5. The existing problems are: flooding caused by high water levels in ponds, salinity and high water table retarding normal growth, and bank erosion. The solutions are; control of excess irrigation water by tiles, control by more

efficient application of irrigation water, and control by pumping where the re-use of irrigation water is feasible.

6. An estimate was made of the effect of irrigation of the upper bench on the present irrigated area. Small areas will require additional control, but the possibility of resulting seepage is not great enough to prohibit development of this upper bench.

7. The re-use of irrigation water by pumping from wells and ponds was investigated. Estimates were made of the capacities to be expected. The scheme would require several small pumping units with a total capacity of approximately 3.75 to 4.65 c.f.s. The possibility of using this source of irrigation water will depend upon whether or not this irrigation will be essential for the development of the upper bench.

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