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Alkali and the Treatment of Alkali Lands

PART II

ALKALI CONDITIONS IN THE PAYETTE VALLEY

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BULLETINS

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Alkali Conditions in the Payette Valley

J. S. BURD.

In accordance with plans heretofore outlined in a publication of this Station, the work on the alkali of the arid lands of southern Idaho has been continued. And because of its vital importance to that section of the State, the Payette Valley has received considerable attention in this connection. This Valley has already arrived at a position of considerable agricultural importance on account of the good quality of its product and the yield of its lands, in a state where the grazing and mining industries have heretofore been of greater magnitude and importance than agriculture. Although this area is of recent development, the length of time which portions of it have been under cultivation has now become sufficient to show the settlers the worst effects arising from the necessary use of water on their lands and enable them to appreciate to the full the disadvantages as well as the manifold advantages of farming in the arid regions.

Geography and Typography of the Payette Valley.

The Payette Valley lies wholly within Canyon County and comprises the basin of the Payette River for the last

part of its course just before its confluence with the Snake River, at the western boundary of the State. From this point it extends in a general south-easterly direction for a distance of about thirty miles and varies in width from three to five miles. Its geographical limits are sharply defined by a border of broken hills which entirely surround it with the single exception of the western extremity where it merges into the greater Valley of the Snake.

In its course through the Valley the Payette River adheres rather closely to the hills on its north bank. So that most of the land available for agriculture lies south of this stream. There are, however, two important exceptions to this in the high and comparatively level bench at the eastern end of the Valley just north of the town of Emmet, and the low lying strip at the western end embracing the City of Payette and its vicinity.

The entire acreage of the Valley is somewhat less than one hundred thousand, of which about fifty thousand is located under existing irrigation canals while perhaps twenty thousand more could be thus watered. Of the land at present under canals a considerable portion has not yet been brought under cultivation and much of this is highly alkalied.

One of the principal features of the topography of the area is the existence of so called bench lands which lie between the River and the surrounding hills. In some localities the benches approach the River quite closely and terminate in steep bluffs but in general they are separated there from by a strip of varying width of comparatively level bottom land. The benches usually have a slight dip from the hills towards the River and are laterally traversed

by draws or depressions of greater or less magnitude. This is sometimes unfortunate for the farmer in that considerable leveling is frequently necessary to secure economical and expeditious irrigation. On the other hand the general distribution of water is facilitated by such a condition, since the main laterals from the high lying irrigation canals are carried along the ridges between the draws, while these latter serve as drainage ways.

Owing to the low annual precipitation (10 inches) the agricultural development of this area has progressed hand in hand with the opening of the irrigation canals. Prior to the opening of the large high lying ditches which now supply the larger proportion of the water used, some successful farming was carried on along the low lying banks of the Payette River by means of small private ditches. After the advent of the high lying ditches much of these river lands became so badly alkalied as to necessitate their abandonment. So that at present the higher land is correctly recognized as the more desirable for agricultural purposes.

Plan of Work and Presentation of Results.

The purpose of this investigation is to determine the general character of the alkali here to be met with, its distribution through the soil column, its topographical and geographical distribution and the causes of its accumulation at various places and under varying conditions. The data upon which the work is based was secured by reconnoissances of the field conditions, the collection of samples of soils at varying depths, of water, hardpan, etc., followed by the laboratory examination of the materials so collected.

In many cases the samples of soil were only taken to a depth of one foot and their examination of course gives no information as to the amounts of alkali at a greater depth. Other samples were taken in separate portions from

the first and second foot and still others from the first, second, third, fourth and fifth foot. These latter give complete information as to the vertical distribution of the alkali to depth beyond which it is seldom necessary to go, since it is improbable that salts from greater depths will soon be brought to the surface or come within reach of the roots of most plants. The results of the examination of soils are presented herein in tabular form showing the amounts of each alkali constituent for each foot of the soil column or profile to the depth taken and the average for the entire depth. Most of the deeper profiles were taken in a locality where the conditions were typical. That is along a north and south line running through the New Plymouth Bench, near the middle of the Valley, from the town of New Plymouth to the Payette River. Here samples were taken from the trough, sides and ridges between the draws and are considered to be fairly representative of the conditions existing under such a topography. All of the water samples were taken from wells located along this same line.

Character of Soils.

In general the soils of this Valley are an alluvial silty loam and are light in texture and color. None of the upland soils contain any gravel or particles larger than 0.5 mm. diameter. Only a few soils all of which were collected at Emmett at the eastern end of the Valley and along the north side of the river between Willow creek and Payette city showed larger particles or sandy texture. Most of the soils take water well. On the other hand the fineness of their texture and the amounts of clay they contain makes them hold on to the water rather tenaciously and they consequently drain poorly.

Waters.

The samples of water were all taken from open wells on the sides of draws and ridges between same. Those

from the ridges of the upper bench lands do not show abnormal amounts of total salts or the various constituents thereof (See samples 145 to 147). Samples taken lower down on the bench (Samples 148 to 150) show a considerable increase of total and soluble salts and indicate a considerable transposition of the soluble salts from the higher towards the lower lands. The tendency of which is to improve the upland at the expense of the low land soils. Sample 151 in comparatively low ground contained ex-

Proximate Analyses of Well Water.

Expressed in parts per million.

Sample Number	Organic Matter and Loss	Sodium Carbonate	Sodium Cloride	Sulfates of Lime, Magnesia, Etc.	Silicia	Total	Remarks
145	109	140	15	142	60	466	Top of ridge.
146	70	137	39	184	68	498	Side of ridge, 20 feet deep, below preceding.
147	127	118	41	174	128	588	Side of ridge below preceding.
148	319	326	250	902	69	1866	Level upland 20 ft. deep, water rising.
149	43	263	1119	669	96	2190	Lower ridge.
150	478	208	28	454	73	1241	Side of lower draw.
151	522	337	3245	2688	54	6846	Side of lower draw.
152	499	124	3	100	50	776	Artesian.

traordinary amounts of all the soluble constituents. But possibly the greatest commentary on existing conditions is offered by the rise of water in the wells. In many of these the water approaches the surface closely and in all cases the ground water appears to be rising steadily. Indicating clearly that the natural drainage is insufficient to dispose of the quantities of water now being used.

Hardpan.

A few samples of hardpan were picked up at the edges of irrigation ditches and examination showed that the cementing material consisted of calcium carbonate, the sulfate being present in small amounts only. Hardpan however does not seem to be a very potent obstacle to cultivation or to influence alkali accumulations to any extent in this area. It was seldom encountered in boring for soil samples. In cases where it does occur and approaches the surface nearly it is readily broken up by deep plowing.

Superficial Evidences of Alkali.

These consist of white coatings or efflorescences and brown or blackish spots of irregular size and extent. Their occurrence is always associated with water and usually in this valley with artificially applied water. Consequently these appearances are not very much in evidence at elevations above the highest irrigation ditches. Below the ditches however they are quite numerous. Thus along the sides of the draws there is frequently observed a line of whitish spots apparantly at the outcrop of the drainage water used in irrigating the ditches above. Evidences are also seen in the troughs of draws and depressions and wherever water has collected. Below the irrigated benches evidences both of alkali and water are continuous. This is particularly the case on the low river lands below the ends of the draws which serve as natural drainage ways for both surface and underground water.

Sample Number	Layer of Soil Represented	Appearance of Soil Solution after 24 hours	Texture	Sulfates as Sodium Sulfate	Clorides as Sodium Cloride	Carbonates as Sodium Carbonate	Remarks
161	1st ft	Clear	Medium Silt	0.297	1.228	0.392	Profile I.—Trough of upper draw, New Plymouth. No vegetative growth. Water at 3-4 feet.
162	2nd ft	"	Fine Silt	0.255	0.889	0.392	
163	3rd ft	"	" "	0.280	0.491	0.265	
164	4th ft	"	" "	0.158	0.269	0 286	
	Av.			0.247	0.719	0.334	
165	1st ft	Light clayey	Fine Sand	0.007	0.129	0.095	Profile II.—Trough of upper draw, New Plymouth. Uncultivated at time of sampling. No water found.
166	2nd ft	" "	" "	0.007	0.094	0 095	
167	3rd ft	Medium clayey	Coarse Silt	0.005	0.058	.138	
168	4th ft	" "	Medium Silt	0 028	0 047		
	Av.			0.012	0 082	0.169	
337	1st ft	Medium clayey	Fine Silt		0 047	0.064	Prof. III.—Same spot as preceding after one season of irrigation and cultivation.
338	2nd ft	" "	Medium Silt		0.058	0.074	
339	3rd ft	Heavey clayey	" "		0.174	0.095	
340	4th ft	" "	Coarse Silt		0.117	0.138	
341	5th ft	Medium clayey	" "		0.058	0.148	
	Av.				0.091	0.104	
169	1st ft	Ligh clayey	Coarse Silt	0.141	0.047	0.414	Prof. IV.—Slick spot on side of upper draw, New Plymouth. Trees repeatedly killed.
170	2nd ft	Clear	Medium Silt	0 470	0 047	0.392	
171	3rd ft	"	" "	0.296	0.082	0.446	
172	4th ft	"	Fine Silt	0.371	0.296	0.244	
173	5th ft	"	Fine Sand	0.368	0.334	0 233	
	Av.			0.329	0.140	0.376	
174	1st ft	Clear	Fine Silt	0.005	0.047	0.255	Prof. V.—Trees fair. Clover very fair.
175	2nd ft	Medium clayey	Medium Silt	0.000	0.047	0.244	
176	3rd ft	" "	" "	0.015	0.047	0.276	
177	4th ft	" "	Fine Silt	0.051	0 047	0.371	
	Av.			0.017	0.047	0.286	

Sample Number	Layer of Soil Represented	Appearance of Soil Solution after 24 hours	Texture	Sulfates as Sodium Sulfate	Clorides as Sodium Cloride	Carbonates as Sodium Carbonate	Remarks
178		Heavy Clayey	Medium Silt	0.014	0.058	0.382	Composite. Ridge between lower draws.
179	1st ft	Heavy Clayey	Coarse Silt	0 049	0 058	0.244	Profile VI.—Flat in draw. North of New Plymouth
180	2nd ft	Clear	" "	0.192	0.211	0.509	Saturated with water.
181	3rd ft	"	" "	0,204	0.304	0.488	
182	4th ft	"	Medium Silt	0 166	0.328	0.467	
183	5th ft	"	" "	0.166	0.304	0 499	
	Av.			0.155	0.241	0.441	
184	1st ft	Medium Clayey	Fine Silt	0.019	0.082	0.138	Profile VII.—Virgin soil
185	2nd ft	Clear	Coarse "	0.078	0.152	0 329	of lower bench. North of New Plymouth.
186	3rd ft	"	" "	0.192	0.269	0.329	
187	4th ft	"	" "	0.402	0.269	0.339	
188	5th ft	"	" "	0.160	0.164	0.350	
	Av.			0.170	0.187	0.297	
189	1st ft	Medium Clayey	Fine Sand	0.046	0.082	0.212	Profile VIII.—Reputed
190	2nd ft	r	Medium Silt	0.044	0,129	0.244	slick spot Side upper draw. New Plymouth.
191	3rd ft	"	" "	0,139	0 503	0.191	
192	4th ft	"	" "	0.083	0.643	0 297	
193	5th ft	"	" "	0.078	0.632	0.223	
	Av.			0.078	0.398	0.233	
194	1st ft	Clear	Medium Silt	0.005	0.094	0.148	Prof. IX—Adjacent to preceding Alfalfa fine.
195	2nd ft	Medium Clayey	Fine Silt	0 097	0.022	0.371	
196	3rd ft	" "	Coarse Silt	0.027	0.058	0.403	
197	4th ft	" "	Fine Silt	0 038	0.070	0.456	
198	5th ft	Clear	Medium Silt	0.450	0 117	0 339	
	Av.			0.123	0.072	0.343	
199	1st ft	Clear	Medium Silt	0.175	0.468	0.350	Composite. Trough of upper draw.
200	1st ft	Medium Clayey	Medium Silt	0 000	0.105	0.148	Prof. X—Level upland New Plymouth. Alfalfa
201	2nd ft	" "	Fine Sand	0.007	0 070	0.212	fine. Samples taken at beginning of season.
202	3rd ft	Light "	Coarse Silt	0.017	0.140	0.371	
203	4th ft	Clear	Medium Silt	0.090	0.351	0.286	
204	5th ft	"	Coarse "	0.093	0 444	0.286	
	Av.			0.041	0.225	0 261	

Sample Number	Layer of Soil Represented	Appearance of Soil Solution after 24 hours	Texture	Sulfates as Sodium Sulfate	Clorides as Sodium Cloride	Carbonates as Sodium Carbonate	Remarks
361	1st ft	Heavy clayey	Fine Silt		0.070	0.117	Prof. XI.—Same spot as preceding, but taken at end of season.
362	2nd ft	Light clayey	Medium Silt		0.058	0.117	
363	3rd ft	Clear	Fine Silt		0.292	0.170	
364	4th ft	"	Medium Silt		0.409	0.148	
365	5th ft	"	Fine Silt		0.433	0.180	
	Av.				0.252	0.146	
366	1st ft	Very hvy clayey	Medium Silt	0.024	0.070	0.562	Spot in wheat field, level upland, New Plymouth.
367	2nd ft	" " "	Coarse Silt	0.029	0 058	0.530	
	Av.			0.026	0.064	0 546	
368	1st ff	Very hvy clayey	Medium Silt	0.031	0.023	0.212	Adjacent to preceding spot. Growth only fair.
369	2nd ft	Medium clayey	" "	0.046	0.047	0.477	
	Av.			0.038	0.035	0.344	
205	1st ft	Medium clayey	Coarse Silt	0.015	0.094	0.127	Prof. XII.—Level upland. uncultivated, New Plymouth.
206	2nd ft	Clear	" "	0.100	0.503	0.201	
207	3rd ft	"	Medium Silt		0.748	0.286	
208	4th ft	"	" "	0.148	0.550	0.286	
209	5th ft	"	Fine Silt	0 101	0.386	0.297	
	Av.			0 091	0.456	0 239	
394	1st ft	Medium clayey	Coarse Silt	0.107	0.070	0.127	Level upland. Black spots where water has stood.
395	2nd ft	Light clayey	" "	0,051	0.234	0.180	
	Av.			0,079	0.152	0.148	
210	1st ft	Medium Clayey	Fine Sand	0 000	0.094	0.233	Level upland. Slick spot. New Plymouth.
211	1st ft	Clear	Fine Silt	0.000	0.070	0.106	Level upland, just off preceding. Alfalfa fine.
212	1st ft	Medium Clayey	Medium Silt	0.010	0 070	0.201	Uncultivated. Similarly situated to preceding.
213	1st ft	Medium Clayey	Fine Sand	0.000	0.058	0.106	Trough of an upperdraw. just above ditch. Uncultivated.
214	1st ft	Medium Clayey	Coarse Silt	0.010	0.129	0.095	Similarly located, but below ditch.
218	1st ft	Heavy clayey	Coarse Silt	0.063	0.585	0.520	Bottom lands. Black spots all about.
219	1st ft	" "	Fine Sand	0.246	0.291	0.560	Bottom lands. Black spots all about.
220	1st ft	" "	Coarse Silt	0 022	0.292	0.488	Bottom lands, 3 miles west of Emmet.
221	1st ft	" "	Fine Sa	0.019	0.070	0.085	Sandy river land. Emmet, Head of Farmers' ditch.
396	1st ft	" "	Fine Silt	0.037	0 047	0.201	Bottom land 5 miles west of Emmet.

Sample Number	Layer of Soil Represented	Appearance of Soil Solution after 24 hours	Texture	Sulfates as Sodium Sulfate	Clorides as Sodium Cloride	Carbonates as Sodium Carbonate	Remarks
227	1st ft	Heavy Clayey	Coarse Silt	0.007	0 022	0.244	Prof. XIII.—Sandy Soil. West Emmett.
228	2nd ft	" "	Fine Sand	0 016	0.022	0.308	
229	3rd ft	" "	" "	0.010	0 047	0.286	
230	4th ft	" "	" "	0.005	0.035	0.265	
231	5th ft	" "	" "	0.010	0.035	0.285	
	Av.			0.009	0.032	0.278	
397	1st ft	Light Clayey	Fine Sand	0 041	0 023	0.106	Sandy Soil. South Emmett.
222	1st ft	Heavy Clayey	Coarse Silt	0.012	0 058	0.117	Prof. 14—High lying bench North of Emmett. Uncultivated.
223	2nd ft	" "	Fine Sand	0.000	0 105	0.329	
224	3rd ft	Medium "	Coarse Silt	0 024	0.140	0.233	
225	4th ft	" "	Fine Sand	0.032	0.047	0.233	
226	5th ft	" "	Course Silt	0.017	0.035	0.244	
	Av.			0.017	0.077	0.231	
370	1st ft	Medium Clayey	Fine Sand		0 082	0.117	Willow creek, bottom lands.
371	2nd ft	" "	"		0.035	0.148	
	Av.				0.058	0 132	
372	1st ft	" "			0.035	0 127	Willow creek, bottom lands.
373	2nd ft	" "	Fine San		0.023	0.127	
	Av.				0.029	0.127	
374	1st ft	Heavy Clayey	Fine Sand		0 035	0 286	Slick spot on so-called bar. North of Payette river. Land high and level, underlai" by gravel. Crops poor.
375	2nd ft	" "	" "		0.047	0 350	
376	3rd ft	Medium "	" "		0 035	0.233	
	Av.				0 039	0.289	
377	1st ft	Medium Clayev	Fine Sand		0.022	0.159	Similarly situa'ed to preceeding. Alfalfa fine.
378	2nd ft	Light "	" "		0.023	0 095	
	Av.				0 023	0.127	
379	1st ft	Heavy Clayey	Medium Silt	0.163	0.058	0.753	Level lowland. North of Payette river. Underlain by gravel.
380	2nd ft	Medium Clay	" "	0.095	0.058	0.456	
	Av.			0.129	0.058	0.604	

Sample Number	Layer of Soil Represented	Appearance of Soil Solution after 24 hours	Texture	Sulfates as Sodium Sulfates	Cloridés as Sodium Clorides	Carbonates as Sodium Carbonate	Remarks
384	1st ft	Heavy Clayey	Fine Sand	0.088	0.035	0.170	Soil from center of City of Payette. Soil moist.
385	2nd ft	" "	Coarse Silt	0.209	0.035	0 212	
				0 148	0 035	0.191	
381	1st ft	Light Clayey	Fine Sand	0.026	0.023	0.148	Foot hill. Northwest of Payette. Uncultivated. No sign of alkali at surface.
382	1st ft	Medium Clayey	Medium Silt	0.095	0.023	0 170	Bank of Snake River west of Payette. Uncultivated and poor.
383	2nd ft	" "	" "	0.210	0.094	0.382	
				0.152	0.053	0.276	
386	1st ft	Light Clayey	Fine Sand	0.051	0.047	0 095	Upland south of Payette River. No sign of alkali. Good growing.
387	2nd ft	" "	" "	0.039	0.023	0.085	
				0.045	0.035	0 090	
388	1st ft	Medium Clayey	Fine Sand	0,022	0.023	0.095	Top of bench lands south of Payette River.
392	1st ft	Medium Clayey	Fine Silt	0.431	0.398	0.106	
393	2nd ft	Heavy "	" "	0.516	0.392	0.159	Flat south of Payette River. Alkali spots abundant.
				0.473	0 345	0 132	

Discussion of Tabulated Results.

Soils Apparently Suffering from Excess of Water. Profile 1. samples 161-164. The conditions at this place are apparently such as to cause excessive accumulations of salts both from the subsoil and neighboring lands, lying as it does in a flat depression in the broadened trough of a draw leading from the upper part of the bench. The soil was wet, free water being found at three feet and this in spite of the fact that irrigation had not begun at the time of sampling. Sodium cloride or common salt is the salt present in greatest amount, reaching a maximum of over one per cent in the surface foot. Sodium sulfate or Glaubers salt and sodium carbonate or sal soda are also present in excessive amounts and are fairly uniformly

distributed throughout the profile. The presence of the ground water within capillary distance of the surface is so evidently the cause of the accumulations as to scarcely merit comment.

Profile VI. samples 179-183. This represents a most aggravated case of injury from alkali and water. The location is in the broadening out of a draw at its lower end and is directly exposed to seepage and drainage from the lands above it. At the time the samples were taken (before irrigation had commenced) the soil was quite wet with free water at five feet. Later in the season it became a marsh. The profile indicates large amounts of all the salts, but the carbonates are present in greatest amount. Any attempt to utilize it would be absolutely useless until the excessive quantities of water had been removed.

Samples 218, 219 and 220 taken at various places along the low lying river lands below the irrigated benches present every evidence of owing their condition to accumulations of salts washed down from above. Under such conditions the carbonate appears to predominate and determine the character of the alkali. The black deposits and pools all about contribute to this view.

Virgin and Well Drained Cultivated Soils. Profile II samples 165-168 and Profile III samples 337-341. The samples comprised in these were taken respectively in the spring and near the end of the irrigation season from the same locality. At the time of the first sampling the land had never been irrigated and profile II indicates this condition in a very satisfactory manner, both the sulfates and carbonates being lowest in the surface foot and increasing in amount with the depth, reaching their maxima at the fourth foot. The clorides are however a little higher at the surface. After one seasons irrigation as represented in the profile III the carbonates had not essentially changed but the maximum amount of clorides was then in the third foot. The sulfates being inconsiderable in this soil were not determined at this time.

Profile X samples 200-204 and Profile XI samples 361-365

represent a level upland soil taken respectively at the beginning and end of the irrigation season. The land was growing a fine crop of alfalfa. The little change observable in the amounts and distribution of salts is in the way of improvement, the carbonates having been lowered. This land is well drained and represents a most desirable condition where the water applied tends to improve instead of destroy the land.

Profile XII samples 205-209 represents a level upland virgin soil. The salts are all present in large amounts but their maxima all lie below the surface foot. If the subdrainage is good, irrigation might improve such a soil, otherwise it would probably soon be ruined by the rise of salts from the subsoil.

Samples 394-395. Level upland orchard, a few small spots occur but as yet have done little damage. The dark spots appearing at the borders of the sub-laterals and wherever water has evaporated together with the amounts of carbonates found in the first and second foot indicate it to be near the danger line.

Sample 212 unirrigated is high in carbonates for the surface foot. Sample 211 irrigated and similarly situated contains less alkali and the difference would appear to be due to its being washed out or at least down into the subsoil by the added water.

Sample 213 and 214 taken just above and below a main ditch contain about the same amount of carbonates in the surface foot, so that the accumulations frequently arising from the leaking of near-by ditches do not appear to exist here.

Samples 386-387 and 388. Both high-lying and well drained evidently show the amounts of the various constituents to be expected in the best type of soil under the most favorable conditions.

Profile VII samples 184-188. Virgin soil from lower bench. Water cannot be directly traced to this place and the alkali content and distribution is not very dissimilar to that of profile XII already considered.

Slick Spots. Profile IV samples 169-173 and profile V

samples 174-177 represent locations within a few feet of each other. Those in profile IV were taken from a so-called slick spot where trees had been repeatedly killed. Those in profile V represent good growing land where trees were doing fairly well and clover was good. The location is on the side of a draw where the drainage is apparently excellent.

Profile IV represent the condition nearest the depression and is elevated only slightly above a series of whitish spots which extend along the side of the draw and are evidently caused by the evaporation of outcropping drainage water. Profile IV shows large amounts of all of the salts very irregularly distributed through the soil. Profile V however shows comparatively insignificant amounts of clorides and sulfates. The amounts of carbonates while not so great as in Profile IV are still considerable but increase with the depth in the manner usually associated with a well drained soil. The textures of these two soils are very similar, if not identical, so that the bad condition indicated by the spot must be ascribed to its nearness to the local water table (in this case the out cropping drainage water).

Profile VIII samples 189-193 and profile IX samples 194-198 from adjacent places in a level upland soil. Profile VIII from a so called slick spot and profile IX just off of the spot. The salts represented in both are high and do not indicate any very great advantage in favor of one over the other. The carbonates and sulfates in the surface foot of the spot are, however, higher than in the surface foot of the good growing adjacent land. Comparing 366-367 with 368-9 and 210 with 211 samples taken in an analogous manner to the preceding i. e. from spots and good growing adjacent soil, we find that the same condition exists. So that in every case examined the surface foot of the spots contains considerably more of the carbonates and usually more of the other alkali constituents than the good growing lands surrounding them.

Low Lying Sandy Soils at Eastern End of Valley. Profile VIII samples 227-231. A cultivated soil in

which the distribution of the salts is moderately uniform, being about the same in amount for each constituent throughout the profile. This is apparently accounted for by the looseness of the texture of the soil which permits of the ready transportation of the soil solution. The carbonates are remarkably high considering this condition.

Samples 221 and 397 both contain reasonable amounts of all the salts and are apparently better drained than Profile XIII.

HIGH LYING LEVEL BENCH AT EASTERN END OF VALLEY Profile XIV samples 222-226. Represents an uncultivated upland soil in which the amount and distribution of the various salts is quite similar to the upland soils of the New Plymouth Bench.

ALLUVIAL SOILS NORTH OF PAYETTE RIVER. Samples 370 - 371 and 372-373. These soils occurring at the mouth of Little Willow several miles east of Payette City are exceptionally fertile. The alkali seems to be similar to the best lands south of the Payette River.

LOW LYING SOILS NORTH OF RIVER. Samples 374-6 and 377-8 sandy soils taken from a so called bar, which is evidently of alluvial formation and is underlain by gravel. The soil is very compact and of clayey texture and in spite of its apparantly favorable opportunity for underdrainage contains considerable amounts of carbonates. Samples 374-6 from a spot contain the larger quantity.

Samples 379-380 from the same vicinity as the preceding are underlain by gravel and contain unusual amounts of alkali. The land is however, very low and the drainage is necessarily poor.

SOILS IN AND JUST WEST OF PAYETTE. Samples 381, 382-383, 384-5. These soils like those similarly situated south of the river contain considerable amounts of carbonate and are comparatively low in the other constituents.

General Character of the Alkali.

The wide distribution of dark spots and stains on

the soils of this area so frequently noted above indicate that the predominating alkali is of the so called black variety and this is amply borne out by the chemical examinations. In almost all of the samples taken the black alkali or sodium carbonate is present in amounts greater than the other constituents. In the lands whose fertility has been the most affected by alkali accumulations the carbonate equivalent is frequently as great as 0.3-0.5 per cent which of course precludes any attempt at cultivation prior to its removal. Even in the best lands this constituent is fairly high. For instance virgin and cultivated soils growing fine crops which are favorably situated at the top of benches are shown by the tabulated results to contain on the average an equivalent of 0.10 per cent or more of sodium carbonate.

Sodium cloride is in a few instances present in extraordinarily large amounts. Thus in the lands which are the more contaminated by alkali a few cases occur where this salt reaches 0.50 per cent and over. In general however it averages considerably less than the sodium carbonate and in the good growing upland soils amounts to 0.03 per cent or less.

The soluble sulfates frequently run quite high (0.20-0.40 per cent) in the highly contaminated lands but in the good growing lands are present in small amount compared with the other constituents, frequently running from 0.02 per cent down to none at all. These lands carry considerable sulfate of lime which is doubtless a factor in the formation of the more soluble sulfates.

Vertical Distribution of Alkali.

The virgin soils as a rule contain smaller amounts of soluble salts in the surface foot then in succeeding feet. The amounts in the surface foot are usually below the limit of tolerance for most crops so that most of the land produces well at the start, but its ultimate condition depends on whether the local conditions are favorable to an increase or decrease of the salts near the surface.

In soils containing much free water the alkali is usually

distributed rather uniformly, is high all the way through the profile and is frequently highest in the surface foot.

In soils which are neither saturated nor free from water the distribution of salts may be quite irregular, depending as it does upon the resultant effect of the tendencies of descending water to carry the alkali down and rising water to bring it to the surface.

Topographical and Geographical Distribution.

In discussing the tables above attention was called to the fact that the amount and distribution of alkali in certain soils was not different from that in similarly situated soils in other parts of the Valley. In other words geographical position within the area seems to have little influence as determining the character of the alkali. And this is what we should expect when we consider the smallness of the area under consideration, the identicity of the soil forming materials, climate and other conditions influencing soil formation. On the other hand typical differences in the amounts and distribution of soluble salts have been pointed out between differently situated soils. So that other conditions being equal the approximate nature and distribution of the alkali in soils of this area can be safely predicted from the data at hand and a knowledge of the surrounding topography.

Slick Spots.

Whatever the cause of the slick spots may be their occurrence thoughout the area is always a source of annoyance to the cultivator. As has been pointed out above, these spots always contain considerably more alkali in the surface foot than does the surrounding land. And whether this is or is not an effect of conditions producing the spot it is only reasonable to suppose that the lack of growth is largely if not entirely due to the presence of the accumulated salts. At this time it can only be suggested that the plowing of such spots should be unusually deep and the surface mixed

with the subsoil as thoroughly as possible to secure uniformity of texture and drainage.

Conclusion.

The amounts of so called alkali or water soluble salts in the soils of this Valley are quite large and offer a serious obstacle to the successful farming of large areas. Prior to artificial irrigation the amounts and distribution of the alkali constituents in the various soils were fairly uniform. Since artificial irrigation commenced, however, there have been radical changes in this respect. Irrigation has resulted in improving certain favorably situated soils by working the salts to greater depths or into the drainage or neighboring lands. But on low lying lands or wherever the natural under drainage is poor accumulations have been brought about. These accumulations, as has been noted above, consist largely of sodium carbonate. Unfortunately, however the use of gypsum, the usual antidote for sodium carbonate, is inapplicable here because the amount of resulting sodium sulfate in addition to the sulfate and cloride already present would in most cases still be far above the toxic limit for the crops of this section. In even the most favorably situated soils the alkali is quite high and unless water is sparingly used or the underdrainage is exceptionally good the tendency of the salts to come to the surface is soon observed. The topography of certain portions of the area i. e. the bench lands is admirably suited to artificial underdrainage which would probably solve the alkail problem for lands so situated, if it were introduced. It is difficult to see, however, how the low lying river lands could be successfully underdrained and for the present at least such lands should be avoided or chosen with great care when intended for agricultural purposes.