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APPRAISAL AND MAPPING OF SOIL SALINITY PROBLEM IN AMIBARA IRRIGATION FARMS, MIDDLE AWASH BASIN, ETHIOPIA

T. Frew Abebe[1], Tena Alamirew[2], and Fentaw Abegaz[3]

[1]Adama Science and Technology University, PO Box 1888, Adama, Ethiopia

[2]Water and Land Resources Centre, Addis Ababa, Ethiopia

[3]Ethiopian Agricultural Research Organization, Addis Ababa, Ethiopia

ABSTRACT: One of the main reason for the loss of productive land in irrigated fields is the buildup of salinity in the soil. In Amibara irrigation Scheme, though no systematic appraisal and mapping has been made before, large tract of land has been abandoned because of salinity problem. Hence a study was conducted to appraise the salinity problem of the Amibara irrigation farms in Middle Awash Basin and to generate thematic maps using Arc GIS for further management recommendation. A total of 249 surface soil samples representing 15,256.22 ha Amibara Irrigation farms were collected and analyzed. Standard methods were followed to measure pH, electrical conductivity (EC) and soluble cations. Arc GIS 9.3 was used to map the overall salinity and sodicity problem of the area. Results showed that around 34 % (5239.79 ha) of the command area has been mapped as saline soil (ECe > 4 dS/m and SAR < 13). On the other hand, only 0.05% (9.13ha) scheme was classed as saline sodic (ECe > 4 dS/m, and SAR >13). From the thematic maps generated, it is concluded that proportion of the land taken up by salinity is rapidly increasing. More and more land is fully abandoned due to salinity problem. The water table control by rehabilitating the subsurface drainage system seems to be the only feasible way to improve sustainability of the scheme.

KEYWORDS: Soil Salinity/Sodicity, GIS.

1 INTRODUCTION

In Ethiopia, the Amibara Irrigation Scheme (AIS), which covers about 15,256 ha of irrigable land in the Awash River Basin, encounters problems of salinization and rising water tables to varying degrees. Irrigated agriculture at Amibara Irrigation Project, located in the Middle Awash region, was started towards late sixties [7]. The soils at the farm area were generally non-saline & groundwater table in the area was below 10 meter [8]. However, subsequent miss-management of irrigation water, in the absence of a complementary drainage system, gave rise in water logging, Salinization of fully productive areas and considerable losses in crop yields. This severe problem resulted in abandoned of substantial areas of Melka Sedi cotton producing areas.

Effective control of soil salinity necessitates a good knowledge of the cause, extent, distribution, and speciation of salt. Moreover, problem of salinity is never a static soil behavior. Therefore, spatial and temporal variability of this behavior are important issues to be considered in soil management [16]. Reliable and up-dated information on the spatial and temporal variability of soil salinity is required to effectively manage the limited natural resources and maintain a viable agricultural industry that is highly dependent on conjunctive use of surface and ground waters with varying salinity levels [2] and [6].

Reasonably a number of studies have been conducted in Amibara irrigation scheme, reviewing through the progress and the current status of salt affected area, irrigation and groundwater quality analysis of the study area [9], [10], [15], [5] and[3]. According to these studies, poor drainage and lack of appropriate irrigation water management were the main causes, which

Corresponding Author: T. Frew Abebe

facilitated secondary salinization. Though different attempts have been made by different researchers, there has never been a comprehensive mapping of the salinity problem in the study area. Hence, the main goal of this study is to characterize the salinity problem in a command area and generate thematic maps using GIS to be used for further management decision.

2 MATERIALS AND METHODS

DESCRIPTION OF THE STUDY AREA

The Amibara irrigation scheme, found in Amibara Wereda (province), Gebiresu zone of Afar National Regional State, cover a long broad alluvial plain along the right bank of the Awash river, locally known as Melka Sedi and Melka Werer (Amibara Plain) with a gross command area of about 15,256 ha (Figure 1). The area is at an elevation of about 740 meters above sea level and it is located at $9^0$16'N latitude and $40^0$9'E longitude in the Middle Awash Valley. The average annual rainfall is around 560 mm, accumulated with the long and short rains. The mean maximum temperature is 35^0C and means minimum falls down to 19^0C. The mean annual free water evaporation as recorded by the class A pan is around 3000 mm (Werer Agricultural Research Centre, unpublished data). The area is classified as semi-arid. The principal soil types in the study area are recent alluvial and vertisols with its textural class as clay, clay loam, silty clay loam, silty loam and silty clay [7] and [3]. The major crop grown is cotton, with minor crops including maize, sesame, banana and vegetables in some areas of Werer research center.

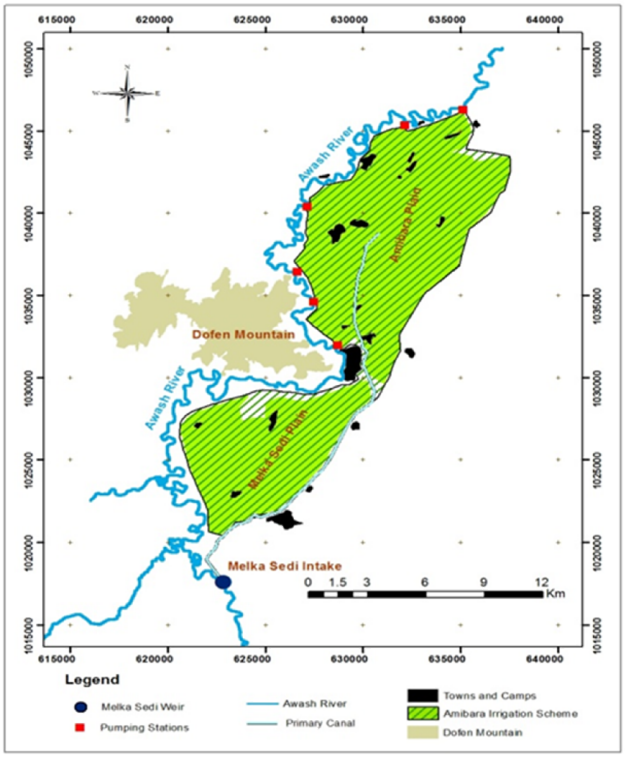

Fig. 1. Location map of Amibara Irrigation Scheme.

DATA COLLECTION

Soil samples were collected during the month of October and November 2011. A total of 249 representative auger samples were taken from Melka Sedi and Melka Werer farms at a soil depth of 0-30 cm. Considering extreme heterogeneity of soils of Melka Sedi area with respect to salinity and sodicity and occurrence of wide range of the problem; attempt was made to collect soil sample systematically from every farm units of Melka Sedi area. While for Melka Werer area, with lesser extent of salinity and sodicity problems, soil samples was collected randomly at 2 km interval. Collected samples were delivered to the laboratory of Werer Research Centre, air-dried, ground to pass through 2 mm sieve and prepared for selected chemical analysis. Each of the soil sampling points was spatially referenced using GPS (Figure 2).

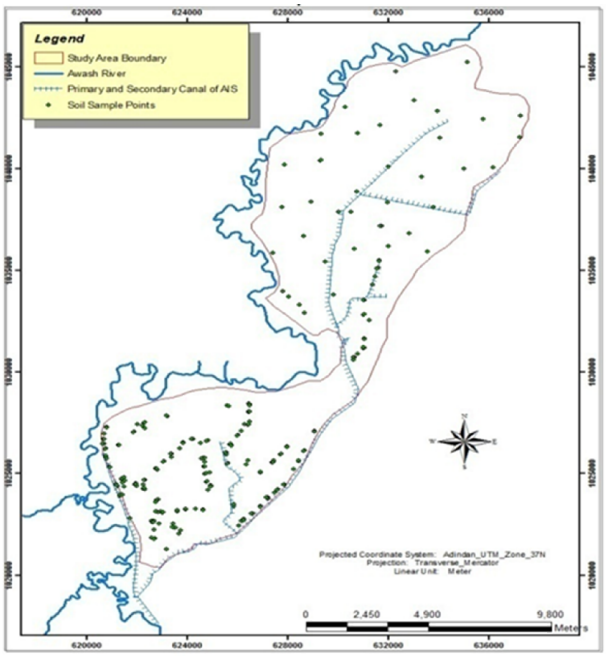

Fig. 2. Spatially Referenced Soil Samples

LABORATORY ANALYSES

Soil samples were air dried and ground to pass through 2 mm size sieve. The saturation paste extract were then prepared following the methods described in Rhoades *et al.* [13].Soil reaction (pH), electrical conductivity (EC), water soluble cations (Ca^{2+}, Mg^{2+} and Na^{+}) were determined from saturated paste extract. Soil pH was measured using a digital pH-meter and Electrical conductivity (EC) by digital conductivity meter according to the method outlined by the USSLS [14] and Rhoades *et al.* [13] respectively. Basic water soluble cations (Ca^{2+} + Mg^{2+} and Na) were determined by EDTA titration and flame photometer, and expressed as meq/l of extract [12]. Sodium adsorption ratio (SAR), of the soil solution was calculated from the concentrations of soluble Na, Ca and Mg. Finally, soils under investigation were classified to the different salt affected soil classes based on the criteria established by the USSLS (14) and Abrol *et al* [1].

SOIL SALINITY APPRAISAL

Soil salinity appraisal and mapping was conducted in Arc GIS environment. To carry out the soil salinity appraisal, field collected data were used (Figure 2). Taking the ECe value of a randomly collected soils samples, a soil salinity raster map was created using Arc GIS 9.3 with Inverse Distance Weight (IDW) interpolation techniques. IDW interpolation method was selected for soil salinity map of the study area based on the minimum errors resulted from the methods used when compared to each other. According to Abrol *et al* [1] classification standards, the generated raster layers were further reclassified using reclassify tool in spatial analyst extension as salinity classes using different ECe ranges. Finally, layouts were prepared for the developed raster layers using layout view.

SOIL SODICITY APPRAISAL

Exchangeable sodium percentage (ESP) is widely used to measure sodicity status of soils but experimental determination of exchangeable sodium percentage is tedious, time consuming and subject to errors (FAO, 1988). To overcome some of these difficulties several workers prefer to obtain an estimate of the exchangeable sodium percentage from an analysis of the saturated soil extract [3] and [11]. Sodium adsorption ratio of the saturation extract (SARe) is another parameter that has long been recognized as an index or indicator of sodicity hazard [14] and [1]. It is the proportion of water soluble sodium to calcium plus magnesium in the soil and is expressed in an equation form as:

$$SAR = \frac{\left(Na^{+}\right)}{\left(Ca^{2+} + Mg^{2+}\right)^{0.5}}$$

Where concentration of the cations are expressed in meq/l

The calculated SARe for a randomly selected surface soil samples (Figure 2) were interpolated using IDW interpolation technique to create a potential soil sodicity raster map. Using reclassify tool the generated raster layers were classified to show the soil sodicity hazard of the study area. A layout for soil sodicity raster layer was also developed.

Moreover, to develop salt affected soil raster layer, the developed soil salinity and sodicity raster layers were combined to generate a single rater layer using combine tool in local toolset of spatial analyst extension of the software. Further the combined raster layer was reclassified on the basis of USSLS [14] soil salinity/ sodicity standard analysis. Here also layouts were prepared for the developed raster layers using layout view in the Arc GIS environment.

DATA PROCESSING

In preparation for the overlaying and analyses, topographic map (1:50,000) of the study area was scanned and vectorized. The ECe and SAR value of a randomly selected soil samples were used for soil salinity and sodicity map preparation. Polygons having similar attributes were merged in every process. Analysis were made easy by applying expressions and conditional statements using spatial manipulation language (SML). These techniques are very efficient method of identifying and merging thousands of features that met the set of criteria to generate the final category [11]. Polygons will be given a unique identity and assign a corresponding name registered as attributes to determine the features projected in the map. Various digital and statistical data were combined to generate final output.

3 RESULT AND DISCUSSION

SOIL SALINITY AND SODICITY CHARACTERISTICS

Analytical results of electrical conductivity, pH, SAR, concentration of major cations of the soil solution used as an important parameter to explain salinity and sodicity characteristics of soils of the studied area, are presented in Appendix Table 1. Four classes of soils were defined based on their chemical properties, accounting for changes in pH, ECe and Sodium Adsorption Ratio (SAR): non-affected, saline, sodic, and saline-sodic soils, each of the last three with different degrees of salinity/sodicity. The threshold value for ECe was set at 4 dS/m according to the saline or non-saline boundary in USSLS soil salinity standard analysis; and for SAR, which is an indicator of sodic or non-sodic characteristics, was set at 13.

SOIL REACTION (PH)

Soil pH varied between 6.9 to 8.9 for Melka Sedi and 7.06 to 9.1 for Melka Werer farm areas (Appendix Table 1). The pH values appeared to be low in saline soils, where calcium and magnesium were dominant and on the other hand the pH is high in sodic and saline sodic soils where sodium seems dominant.The pH of the study site is in general greater than 7, indicating alkalinity reaction. Since the pH value or the soil reaction is influenced by the presence and concentration of cations, its ranges varies in salt affected soils. Early reports by Girma and Geremew [4] and recent study conducted by Gedion [3] also reveals that the pH of the study area has a value greater than 7. The probable reason for this high pH value could be attributed due to high concentration of bicarbonates [10]and [15].

SOIL SALINITY APPRAISAL

Soils of the area exhibited high range of variation with respect to ECe values (Appendix Table 1). ECe value varied from 0.33 dS/m to 82.1 dS/m and 0.4 dS/m to 37.5 dS/m, respectively for soil samples taken from Melka Sedi and Melka Werer farms. Regarding the magnitude of the problem, sever salinity problem was observed at Melka Sedi farms, especially on the former Banana farm areas. Even though the extent was less in terms of area affected, salinity problem in Melka Werer farm area was also observed. It was also observed that several hectares of cotton cultivated farms were at saline phase as witnessed from manifestation of frequent salinity patches elsewhere in the command area indicating the possibility of salinity expansion to take place in near future at faster rate than ever seen before.

According to the classification system of the USSLS [14] and Abrol *et al* [1], out of 249 soil samples, 48 % of the soil samples were mapped as non saline soils with ECe values less than 2 dS/m. 18 % of the soil ranges for slightly saline soils with

ECe values between 2 dS/m to 4 dS/m and the rest 34 % of the soil ranges between moderately saline to severe sainity with ECe values greater than 4 dS/m (Table 1).

Table 1. Area coverage per salinity levels for 0-30cm depth

Farm Unit	Percentage area per salinity level					
	Total Area (ha)	Non Saline	Slightly Saline	Moderately Saline	Strongly Saline	Severe Salinity
ECe (dS/m)		0-2	2-4	4-8	8-16	>16
Amibara Farms	15256.22	7294.65	2712.65	2089.68	2013.42	1145.82
% Area	100	47.8	17.8	13.7	13.2	7.5

Hence Cotton yields may start to decrease when ECe value is greater than 7 dS/m [1]. Even now relative decrease in cotton yield occurred in Melka sedi and former banana farms and it will be aggravated unless salinity levels are controlled using proper reclamation measures.

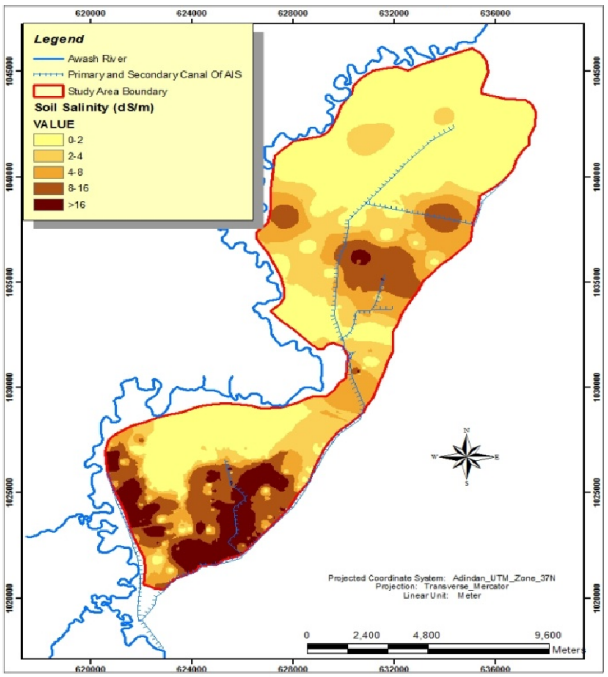

Fig. 3. Soil salinity map of AIS

SOIL SODICITY MAP

The sodium adsorption ratio ranges from 0.7 to 27.2 in Melka sedi and 0.6 to 9.4 in Melka Werer farm areas (Appendix Table 1). Soil sodicity problem were observed in Melka Sedi farm areas especially in some fields of former Banana farms, which had a very strongly sodic character. Soils of Melka Werer were not very much affected by sodicity problems so far.

The probable reason for high SAR value on the former Banana farms may be explained by the fact that this part of the farm had been waterlogged for many years compared to other farms. During this time, due to annual variation in dynamic nature of the water table, much of the calcium and magnesium might have precipitated having behind the sodium to accumulate.

According to Abrol *et al* [1] classification, taking the SARe values of the saturated extract at a soil depth of 0-30 cm, out of 249 soil samples 78 % the soil is mapped as non sodic with SARe values less than 3. About 21 % of the soil is very slightly sodic with SARe value ranges between 3 and 7. The rest 1 % is fall under classes of slightly sodic to very strongly sodic (Table 2).

Table 2. Area Coverage per Sodicity Levels for 0-30cm depth

Farm Unit	Percentage area per salinity level					
	Total Area (ha)	Non Sodic	Very slightly sodic	Slightly Sodic	Moderately Sodic	Strongly Sodic
SARe		0-3	3-7	7-13	13-21	21-37
Amibara Farms	15256.22	11863.49	3168.93	214.74	6.71	2.35
% Area	100	77.76	20.77	1.41	0.04	0.02

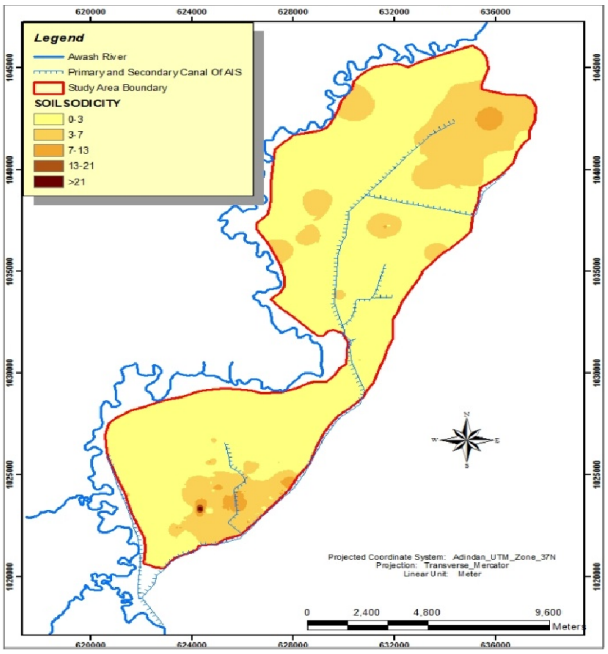

Fig. 4. Soil sodicity map of AIS

SALT AFFECTED SOILS IN AMIBARA IRRIGATION SCHEMES

The analytical result obtained (Appendix Table 1) indicates that the electrical conductivity of the saturated extract at soil depth of 0-30 cm varies from 0.33 to 3.93 dS/m for non saline, 23.00 to 45.90 dS/m for saline sodic soils and 4.02 to 82.10 dS/m for saline soils. Whereas the sodium adsorption ratio of the saturated extract varies from 0.6 to 4.05 for non saline, 12.75 to 27.19 for saline sodic and 0.79 to 11.80 for saline soils. Hence considering the distribution of salt affected soils in Amibara Irrigation Schemes, about 34 % of the soils are salt affected soils (Table 3).

According to U.S. Salinity Laboratory Staff [14] classification, significant part of Melka Sedi farm and former Banana farms are mapped as saline and saline sodic soils. Around 34 % of AIS soils are saline soils with ECe greater than 4 dS/m and SARe less than 13. About 0.05 % of the area is mapped as saline sodic soils with ECe and SARe values greater than 4 dS/m and 13. This saline sodic soils were found in Melka Sedi former Banana Farm (Appendix Table 1, Field Number 2A4). Sodic soils, with ECe less than 4 dS/m and SARe greater than 13, in the farm area were not identified (Table 3).

Table 3. Area Coverage of Salt Affected Soils in AIS

No.	Salt affected soils Class	ECe (dS/m)	SARe	Area (ha)	% Area
1	Non Saline –Non Sodic Soils	< 4	< 13	10007.30	65.60
2	Saline Soils	> 4	< 13	5239.79	34.34
3	Saline Sodic Soils	> 4	> 13	9.13	0.06
			Area	15256.22	100%

Because of the insufficient annual rainfall, evapotranspiration exceeding rainfall (evapotranspiration rate of 3000 mm/year, as compared with 500 mm annual precipitations) to leach down salts from the plant rooting zone and lack of

natural drainage, soils of Amibara irrigated command areas were developed into salt affected soils. Here also, due to poor irrigation practice and lack of appropriate drainage, the groundwater levels have come closer to the surface; the farm areas are prone to secondary salinization. Development of productive and sustainable irrigated agriculture in such areas must then be preceded by necessary precautionary measures and followed by proper management practices.

From the map it can be shown that about 66 % of the farm area is non saline and non sodic with ECe and SARe less than 4dS/m and 13. But soil salinity and sodicity problem is never a static soil behavior; there will always be change in the distribution of salt affected soils spatially. Unless salts are leached down and drainage is provided soon, more areas will be affected by salinity and sodicity.

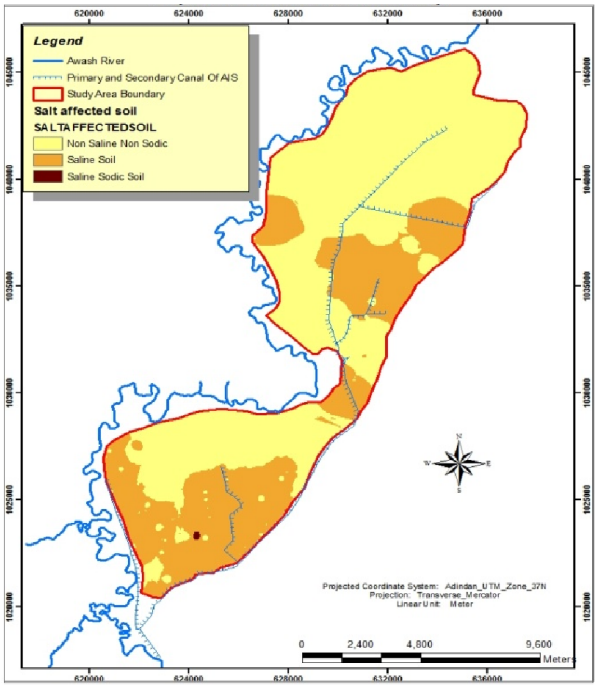

Fig. 5. Salt affected soils map of AIS

4 CONCLUSION AND RECOMMENDATION

CONCLUSION

Based on the findings reported in the previous section, soil salinity and sodicity assessment of the study area revealed that substantial parts of Amibara farm areas were consistently and continuously affected by salinity problem. Significant proportion of the irrigated land has been abandoned or soon will be abandoned mainly because of secondary salinization resulted from shallow saline groundwater table.

RECOMMENDATION

Given the conclusion stated and the field observation, the following recommendations are forwarded

1. The subsurface drainage system should be rehabilitated and operationalized with immediate effect.
2. There are areas of farm where sign of sodicity is showing up. The sodic soil should be treated at the earliest before the soil structure is fully destroyed.
3. More and more lands are being abandoned. Hence further research on other alternative management options should be done.
4. There is no clarity on what to do with already affected and abandoned soil. This has to be addressed immediately.

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APPENDIX

Top soil (0-30 cm) salinity and sodicity status of Amibara farms

lab.no.	Coordinate		Field no.	Ec (ds/m)	pH	Ca+Mg (meq/l)	Na (meq/l)	Sum Cation	SAR
	Easting	Northing							
1	622260	1027505	F1/3/37	0.74	7.9	3.40	2.94	6.34	2.3
2	620683	1026970	F1/3/29	2.15	8.0	15.20	3.67	18.87	1.3
3	627456	1024073	F1/1/0	2.39	8.4	6.30	6.08	12.38	3.4
4	624577	1025751	3B15	20.60	7.3	121.20	23.69	144.89	3.0
5	626228	1022760	F3/1/3	0.88	8.4	3.20	2.46	5.66	1.9
6	621242	1026421	F1/3/27	0.89	8.5	4.40	2.46	6.86	1.7
7	626280	1027425	F3/3/42	0.79	8.1	5.20	2.22	7.42	1.4
8	623201	1027838	F1/3/41	0.37	8.2	1.70	1.98	3.68	2.1
9	622254	1024257	F1/1/10	9.98	7.5	88.80	8.73	97.53	1.3
10	622305	1027527	F1/3/38	1.26	8.1	7.00	2.46	9.46	1.3
11	620757	1025826	F1/2C/25	10.60	7.7	94.00	11.87	105.87	1.7
12	624808	1026633	F1/20/66	0.47	8.2	0.60	2.22	2.82	4.1
13	625567	1028343	F1/2B/74	0.70	8.5	2.70	2.94	5.64	2.5
14	624754	1026605	F1/2D/65	0.40	8.4	1.20	1.74	2.94	2.2
15	624215	1026704	F1/2D/63	0.86	8.4	6.30	2.22	8.52	1.2
16	620766	1026249	F1/3/26	26.90	7.3	281.60	16.69	298.29	1.4
17	622307	1024224	F1/1/9	21.90	7.3	269.20	11.63	280.83	1.0
18	623936	1023232	2A2	0.50	8.9	2.70	1.98	4.68	1.7
19	620778	1027295	F1/3/31	4.70	8.4	26.40	8.49	34.89	2.3
20	625857	1023405	F3/1/5	70.90	7.3	496.60	131.81	628.41	8.4
21	622202	1027353	F1/2B/49	0.80	8.9	4.00	2.22	6.22	1.6
22	622739	1025238	F1/2A/9	0.87	8.8	5.40	2.94	8.34	1.8
23	622596	1022655	1A6	12.90	7.9	121.40	10.90	132.30	1.4
24	620782	1027268	F1/3/30	0.65	8.2	3.20	2.70	5.90	2.1
25	626446	1028440	F3/4/53	0.33	8.1	1.80	1.74	3.54	1.8
26	620711	1026204	F1/3/26	40.80	7.0	439.80	33.42	473.22	2.3
27	624824	1024178	3B11	3.19	8.3	16.60	5.84	22.44	2.0
28	622861	1022545	1B5	0.76	8.6	4.60	2.46	7.06	1.6
29	626437	1028025	F3/4/51	0.40	8.6	1.00	1.98	2.98	2.8
30	624700	1024990	3B/3	1.43	8.4	8.60	3.91	12.51	1.9

……(Continued)

lab.no.	Coordinate		Field no.	Ec (ds/m)	pH	Ca+Mg (meq/l)	Na (meq/l)	Sum Cation	SAR
	Easting	Northing							
31	632294	1044778	P9	0.55	8.2	2.20	2.64	4.84	2.5
32	632005	1040104	AIP46	0.62	8.8	3.80	2.46	6.26	1.8
33	626474	1028437	F3/4/56	0.99	8.6	6.60	2.70	9.30	1.5
34	624327	1023272	2A4	45.90	7.8	109.00	200.73	309.73	27.2
35	630768	1030889	F5/6B	0.66	8.4	4.00	3.18	7.18	2.3
36	626182	1022656	F3/1/2(aban.)	31.90	7.6	78.00	83.40	161.40	13.4
37	627797	1033981	P2	0.81	8.4	5.80	1.25	7.05	0.7
38	628422	1025599	F3/1/17	0.93	8.7	5.00	2.32	7.32	1.5
39	626586	1023046	F3/1/5	0.80	8.7	6.00	2.05	8.05	1.2
40	626895	1025044	F3/2/24	0.83	8.5	3.80	1.79	5.59	1.3
41	626008	1026893	F3/3/39	0.65	8.4	3.00	1.52	4.52	1.2
42	631387	1045097	AIP62	0.61	8.5	3.60	1.25	4.85	0.9
43	626917	1025077	F3/2/25	0.78	8.7	6.80	1.25	8.05	0.7
44	625559	1026032	F3/3/33	1.76	8.3	12.80	2.59	15.39	1.0
45	626142	1027102	F3/3/41	0.55	8.6	4.70	1.25	5.95	0.8
46	626526	1023033	F3/1/4	0.39	8.2	2.80	0.99	3.79	0.8
47	626921	1023381	F3/1/7	4.02	8.4	11.20	9.79	20.99	4.1
48	624756	1024592	3B12	0.50	8.3	3.40	0.99	4.39	0.8
49	627684	1025949	F3/2/28	0.82	8.6	3.00	1.52	4.52	1.2
50	631022	1031195	F5A/7B	0.51	8.2	2.50	2.33	4.83	2.1
51	627594	1024235	F3/1/11	10.67	8.0	73.20	18.93	92.13	3.1
52	627214	1023812	F3/1/9	11.51	7.7	76.60	15.40	92.00	2.5
53	626460	1027548	F3/4/50	0.81	8.4	4.60	1.52	6.12	1.0
54	629051	1027109	F4/1/5A	2.72	8.1	19.00	3.12	22.12	1.0
55	627726	1025982	F3/2/29	1.92	8.3	10.40	2.85	13.25	1.3
56	628647	1026124	F4/1/1B	2.50	8.2	14.60	2.85	17.45	1.1
57	621281	1026408	F1/3/26	2.46	8.2	15.00	2.85	17.85	1.0
58	625692	1026439	F3/3/33	0.60	8.2	4.20	0.99	5.19	0.7
59	627577	1024192	F3/1/11	28.80	7.5	66.80	42.89	109.69	7.4
60	626034	1022450	F3/1/1	0.79	8.4	3.00	1.79	4.79	1.5

…… (Continued)

lab.no.	Coordinate		Field no.	Ec (ds/m)	pH	Ca+Mg (meq/l)	Na (meq/l)	Sum Cation	SAR
	Easting	Northing							
61	628636	1026098	F4/1/1A	0.90	8.3	5.20	1.25	6.45	0.8
62	626444	1028059	F3/4/52	0.77	8.1	5.10	1.25	6.35	0.8
63	631369	1034293	F6/9	1.60	7.9	6.20	2.05	8.25	1.2
64	631040	1033535	F5B/12A	2.70	7.8	14.40	2.32	16.72	0.9
65	627186	1023774	F3/1/8	0.82	8.2	6.60	1.52	8.12	0.8
66	627421	1025610	F3/2/27	64.50	6.9	671.80	30.30	702.10	1.7
67	626153	1022653	F3/1/2	27.00	7.3	236.20	11.19	247.39	1.0
68	627437	1025631	F3/2/27	1.30	8.4	6.80	2.05	8.85	1.1
69	625604	1025506	F3/2/19	1.22	8.4	8.00	1.52	9.52	0.8
70	623462	1022323	1C6	2.77	8.1	17.30	3.72	21.02	1.3
71	622810	1025165	Banana farm	0.61	8.5	4.00	1.52	5.52	1.1
72	622931	1023118	1A8	2.08	8.5	10.60	2.85	13.45	1.2
73	627383	1025553	F3/2/26	0.99	8.4	5.40	1.79	7.19	1.1
74	623601	1023147	2B1	0.78	8.4	3.70	1.25	4.95	0.9
75	626900	1023352	F3/1/6	1.74	8.6	12.20	3.92	16.12	1.6
76	630999	1031166	F5A/7A	0.50	8.3	1.80	1.34	3.14	1.4
77	626601	1023026	F3/1/5(Aban.)	25.10	7.6	243.20	36.28	279.48	3.3
78	630636	1030726	F5A/6A	0.65	8.7	3.10	1.61	4.71	1.3
79	623351	1025810	AIP8	0.58	8.1	4.20	1.08	5.28	0.7
80	631009	1033540	F6/6B	5.99	7.7	43.00	5.32	48.32	1.1
81	627951	1026303	F3/2/31	0.45	8.2	4.00	1.08	5.08	0.8
82	632000	1036193	AIP42	15.19	7.2	145.20	9.04	154.24	1.1
83	626237	1022692	F3/1/3(aband.)	34.50	7.2	252.60	42.83	295.43	3.8
84	627849	1024463	F3/1/12	19.86	8.3	36.00	80.22	116.22	18.9
85	626130	1027086	F3/3/40	3.02	8.0	22.80	3.73	26.53	1.1
86	625535	1025953	F3/2/22	0.76	8.4	3.90	1.34	5.24	1.0
87	620893	1025346	F1/2C/23	0.82	8.4	5.80	1.34	7.14	0.8
88	621993	1024389	F1/1/10	0.63	8.4	3.60	1.08	4.68	0.8
89	621309	1023901	F1/1/9	1.12	8.5	6.20	2.14	8.34	1.2
90	622704	1021805	1B3	0.42	8.1	2.60	1.08	3.68	0.9

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lab.no.	Coordinate		Field no.	Ec (ds/m)	pH	Ca+Mg (meq/l)	Na (meq/l)	Sum Cation	SAR
	Easting	Northing							
91	624790	1024634	4A7	21.90	7.4	127.10	34.08	161.18	6.2
92	622310	1024690		0.52	8.4	3.20	1.08	4.28	0.9
93	622683	1022670	A6	10.88	7.4	92.20	7.45	99.65	1.1
94	626544	1023044	F3/1/4 (aband)	35.20	7.5	192.20	83.96	276.16	8.5
95	624909	1024429	4A6	16.25	7.3	114.00	18.07	132.07	2.4
96	624635	1025774	4A10	7.70	7.7	64.20	7.98	72.18	1.4
97	623585	1023182	2B2	0.27	8.4	2.10	0.81	2.91	0.8
98	624741	1025004	4A8	3.16	8.0	25.50	3.20	28.70	0.9
99	627212	1023784	F3/1/9	30.50	7.9	93.00	80.50	173.50	11.8
100	624681	1025775	4A10(aband.)	32.70	7.3	287.20	35.89	323.09	3.0
101	632834	1036830	AIP66	1.63	8.1	9.40	2.93	12.33	1.4
102	631595	1035129	F6/16	6.54	8.0	41.30	6.39	47.69	1.4
103	636163	1040072	AIP52	0.91	8.5	5.60	2.14	7.74	1.3
104	630752	1038862	AIP44	1.44	8.2	7.90	3.10	11.00	1.6
105	626059	1022436	F3/1/1	15.60	8.1	44.20	34.78	78.98	7.4
106	631049	1031664	F5B/6B	6.60	8.0	35.90	10.10	46.00	2.4
107	630592	1030720	F5A/5	25.30	7.4	254.40	12.31	266.71	1.1
108	630023	1037868	AIP40	1.54	8.9	8.40	3.73	12.13	1.8
109	624155	1026709	F1/2D/62	0.53	8.5	2.60	1.61	4.21	1.4
110	628650	1032917	AIP32	0.49	8.3	3.70	0.81	4.51	0.6
111	631959	1038345	AIP43	0.77	8.4	4.20	1.61	5.81	1.1
112	626407	1025645	F3/2/25(aband.)	32.30	7.2	308.00	18.33	326.33	1.5
113	624632	1023216	2A5	0.42	8.5	3.40	0.81	4.21	0.6
114	621870	1027076	F1/2B/48	0.50	8.7	3.20	1.34	4.54	1.1
115	626421	1027389	F3/2/32	0.48	8.3	3.20	1.34	4.54	1.1
116	626486	1028366	F3/4/55	0.49	8.2	2.60	0.49	3.09	0.4
117	627399	1025553	F3/2/26	42.60	7.2	282.70	54.31	337.01	4.6
118	626431	1027414	F3/2/31	0.78	8.6	3.60	2.79	6.39	2.1
119	627483	1024058	F3/1/10	15.00	8.3	47.40	47.16	94.56	9.7
120	624948	1024379	4A6(cold store)	24.30	7.8	65.00	72.67	137.67	13.8

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lab.no.	Coordinate		Field no.	Ec (ds/m)	pH	Ca+Mg (meq/l)	Na (meq/l)	Sum Cation	SAR
	Easting	Northing							
121	627958	1026330	F3/2/32	7.36	7.8	51.90	7.85	59.75	1.5
122	626480	1028060	F3/3/45	0.68	8.7	1.90	1.56	3.46	1.6
123	629482	1035419	AIP63	0.50	8.2	2.60	2.28	4.88	2.0
124	621926	1024463	F1/1/14	2.19	7.8	18.00	2.99	20.99	1.0
125	623527	1022336	1C6	21.30	7.5	135.60	68.14	203.74	8.3
126	622758	1025250	F/2A/20	0.58	8.4	4.00	2.10	6.10	1.5
127	630636	1036047	AIP42	1.56	8.0	9.00	3.71	12.71	1.7
128	621941	1024521	F1/115	6.82	7.5	63.00	4.42	67.42	0.8
129	629043	1027064	F1/4/1B	0.65	8.8	2.00	2.99	4.99	3.0
130	624905	1024339	4A6	24.60	7.9	138.60	75.78	214.38	9.1
131	631548	1035113	F6/16	20.40	7.3	183.60	19.60	203.20	2.0
132	622588	1022659	1A6	1.07	8.4	4.20	2.63	6.83	1.8
133	621146	1024499	F1/1/11	4.72	8.0	40.00	4.24	44.24	0.9
134	623057	1025625	F1/2B/55	0.97	8.5	4.80	2.10	6.90	1.4
135	624520	1026517	4A11	0.66	8.3	5.20	1.74	6.94	1.1
136	637207	1041551	AIP54	1.18	8.6	4.50	2.99	7.49	2.0
137	625994	1026860	F3/3/38	0.67	8.8	5.20	2.28	7.48	1.4
138	624549	1025744	3B15	5.29	7.9	39.60	5.85	45.45	1.3
139	621391	1024722	F1/1/12	47.90	7.0	352.80	23.27	376.07	1.8
140	620677	1026479	F1/3/27	26.60	7.3	218.00	31.69	249.69	3.0
141	622614	1022602	1A5	22.80	7.1	260.00	18.68	278.68	1.6
142	624652	1025336	3B13	1.77	7.9	13.00	3.17	16.17	1.2
143	627347	1033551	WRC130	24.30	7.2	281.60	18.42	300.02	1.6
144	624877	1025048	4A8	20.40	7.4	155.20	31.35	186.55	3.6
145	630516	1037890	AIP64	0.78	8.1	4.20	3.10	7.30	2.1
146	622827	1023719	2B4	0.43	7.9	3.43	1.02	4.45	0.8
147	633795	1038110	AIP47	15.33	7.3	156.20	9.43	165.63	1.1
148	625758	1026413	F3/2/23	0.60	8.3	4.67	1.38	6.05	0.9
149	630618	1030617	F5A/1	0.47	8.1	3.90	4.78	8.68	3.4
150	626979	1036360	AIP60	14.48	7.4	153.40	9.43	162.83	1.1

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lab.no.	Coordinate		Field no.	Ec (ds/m)	pH	Ca+Mg (meq/l)	Na (meq/l)	Sum Cation	SAR
	Easting	Northing							
151	631008	1032835	F5B/1042	1.00	8.1	5.00	2.10	7.10	1.3
152	628447	1033313	WRC224	0.51	8.4	3.25	1.38	4.63	1.1
153	631029	1032840	F5A/11A	1.45	7.8	11.60	2.45	14.05	1.0
154	628427	1025639	F3/1/18	1.85	8.4	13.00	4.42	17.42	1.7
155	631234	1032553	F5B17	0.77	8.8	3.10	2.28	5.38	1.8
156	627834	1024458	F3/1/12	2.10	8.7	6.60	6.28	12.88	3.5
157	625527	1026042	F3/3/33	35.10	7.5	382.80	20.30	403.10	1.5
158	625705	1026461	F3/3/34	1.41	8.4	8.70	3.78	12.48	1.8
159	626331	1025441	F3/2/24	53.00	7.4	435.20	103.22	538.42	7.0
160	631635	1035494	F9/1/4	3.93	8.0	32.30	3.24	35.54	0.8
161	625592	1025494	F3/2/19	27.60	7.2	270.00	27.64	297.64	2.4
162	621026	1033536	F5B/12A	4.51	7.9	33.40	4.49	37.89	1.1
163	627761	1038107	AIP39	12.76	7.5	114.20	10.59	124.79	1.4
164	630994	1031220	F5A/4A	0.49	9.0	2.30	1.27	3.57	1.2
165	628234	1025230	F3/1/16	0.82	8.4	4.60	2.63	7.23	1.7
166	624691	1025356	4A9	0.72	8.2	5.60	1.27	6.87	0.8
167	620914	1025319	F1/2C/22	6.21	7.4	66.10	7.89	73.99	1.4
168	621526	1024655	F1/1/13	82.10	6.5	656.40	45.80	702.20	2.5
169	620667	1026719	F1/3/28(Aband.)	32.70	7.1	362.00	23.80	385.80	1.8
170	623357	1025987	F1/2B/57	0.84	8.5	5.30	2.63	7.93	1.6
171	623154	1027849	F1/3/42	0.66	8.7	4.30	0.91	5.21	0.6
172	620617	1026474	F1/3/27(Aband.)	27.90	7.2	258.60	20.63	279.23	1.8
173	621371	1024736	F1/1/12	3.80	7.9	33.40	3.42	36.82	0.8
174	623651	1022034	1C5(Abandand)	34.10	7.1	439.20	21.70	460.90	1.5
175	622252	1024454	Banana farm	0.57	8.8	3.50	1.27	4.77	1.0
176	622778	1023128	1A7	65.50	6.9	457.00	41.12	498.12	2.7
177	621316	1023948	F1/1/10	23.40	7.5	169.60	19.31	188.91	2.1
178	623010	1023066	1B6	0.75	8.8	4.80	2.34	7.14	1.5
179	622674	1022234	AIP2	1.29	9.1	4.60	3.24	7.84	2.1
180	622305	1027241	F1/2B/50	0.45	8.5	2.30	1.27	3.57	1.2

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lab.no.	Coordinate		Field no.	Ec (ds/m)	pH	Ca+Mg (meq/l)	Na (meq/l)	Sum Cation	SAR
	Easting	Northing							
181	621719	1022786	F1/1/5	1.10	8.8	4.00	3.06	7.06	2.2
182	624626	1023191	2A4	0.38	8.4	2.50	1.09	3.59	1.0
183	622767	1023695	1A9	0.57	7.9	2.50	1.27	3.77	1.1
184	623841	1026527	F1/2B/60	0.59	7.9	1.90	1.27	3.17	1.3
185	621425	1024557	F1/1/12(Aband.)	56.90	6.7	375.90	30.03	405.93	2.2
186	621857	1027019	F1/2b/47	0.41	8.4	2.30	1.27	3.57	1.2
187	625664	1028309	F1/2b/73	0.36	8.3	2.40	0.91	3.31	0.8
188	621477	1024834	F1/1/13	22.60	7.1	162.40	12.71	175.11	1.4
189	623726	1022221	1C7(Aband.)	78.30	6.5	580.80	49.44	630.24	2.9
190	622849	1023095	1A7	20.10	7.3	211.00	20.63	231.63	2.0
191	623037	1023109	1B7	0.76	8.3	4.50	1.99	6.49	1.3
192	621232	1024390	F1/1/11	44.10	6.9	334.60	23.01	357.61	1.8
193	621949	1024482	F1/1/15	14.58	7.4	177.00	8.48	185.48	0.9
194	622636	1022592	1A5	19.49	7.3	115.50	16.93	132.43	2.2
195	622576	1021839	1A4	0.69	8.2	4.70	1.76	6.46	1.1
196	623818	1026511	F1/2B/59	1.38	8.2	10.10	2.54	12.64	1.1
197	623932	1023260	2A3	0.97	8.5	7.00	2.72	9.72	1.5
198	621184	1024422	F1/1/11(Aband)	37.00	7.0	261.40	27.32	288.72	2.4
199	622733	1023132	A7(Aband)	31.20	7.4	211.20	24.09	235.29	2.3
200	623036	1025591	F1/2A/21	0.40	8.0	2.60	1.23	3.83	1.1
201	622679	1021776	1B2	0.91	8.6	3.50	2.90	6.40	2.2
202	622281	1024671	F1/2A/16	0.50	8.3	3.40	1.47	4.87	1.1
203	623390	1022360		19.70	8.0	110.60	58.21	168.81	7.8
204	623329	1025969	F1/2B/56	0.76	8.6	3.80	2.36	6.16	1.7
205	621409	1023973	F1/1/10	24.70	7.8	151.20	38.77	189.97	4.5
206	623434	1022544	1C8	15.62	7.6	143.20	13.53	156.73	1.6
207	622862	1022526	1B4	1.10	8.6	7.10	2.72	9.82	1.4
208	622745	1023606	1A9	0.79	6.9	3.70	2.18	5.88	1.6
209	623154	1021296	AIP27	0.43	8.4	2.00	1.29	3.29	1.3
210	620745	1025870	F1/2C/25	6.72	7.8	51.80	7.91	59.71	1.6

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lab.no.	Coordinate		Field no.	Ec (ds/m)	pH	Ca+Mg (meq/l)	Na (meq/l)	Sum Cation	SAR
	Easting	Northing							
211	630652	1036076	AIP42	37.50	6.8	295.50	21.98	317.48	1.8
212	622019	1027441	F1/3/35	12.57	7.2	114.90	9.88	124.78	1.3
213	620787	1025728	F1/2C/24	9.87	7.6	69.90	12.92	82.82	2.2
214	620702	1026711	F1/3/28(Aband)	42.80	8.0	225.60	31.87	257.47	3.0
215	623706	1026248	AIP25	0.74	8.5	5.90	1.41	7.31	0.8
216	621476	1024362	F1/1/12	47.00	7.9	291.10	23.12	314.22	1.9
217	622285	1024275	F1/1/10	77.70	7.8	661.20	33.26	694.46	1.8
218	625856	1023508	F3/2/19	25.00	8.6	59.40	62.26	121.66	11.4
219	625738	1026386	F3/2/22	10.73	7.2	84.50	7.55	92.05	1.2
220	631454	1034716	F6/12(Aband)	17.85	7.1	170.40	13.53	183.93	1.5
221	631482	1034719	F6/12	0.65	8.0	3.30	1.47	4.77	1.1
222	631046	1031625	F5B/5	0.40	8.2	2.10	1.41	3.51	1.4
223	631625	1035481	F9/1/4(Aband)	16.20	7.1	159.80	11.85	171.65	1.3
224	627971	1026321	F3/2/32	10.90	7.5	80.80	14.89	95.69	2.3
225	628028	1033699	WRC228	0.43	8.2	2.90	1.11	4.01	0.9
226	624694	1025587	4A9(Aband)	34.44	7.2	179.20	69.17	248.37	7.3
227	627127	1023814	F3/1/8	0.41	8.4	3.40	1.29	4.69	1.0
228	629300	1040379	AL	0.52	7.7	3.13	1.36	4.49	1.1
229	631725	1037199	AL	0.86	7.8	4.47	1.59	6.06	1.1
230	635130	1045263	F9/1/7	0.73	7.8	1.27	1.09	2.36	1.4
231	633005	1043371	AM	0.93	7.5	5.50	1.11	6.61	0.7
232	627865	1040187	AL	1.43	7.8	8.20	1.17	9.37	0.6
233	629308	1041710	AL	0.99	7.7	5.30	1.12	6.42	0.7
234	629326	1040410	AL	1.23	7.7	7.85	3.51	11.36	1.8
235	635750	1042434	F11/8/14	0.68	7.7	0.61	5.20	5.81	9.4
236	633936	1042832	F10/9/4	2.54	7.8	14.02	9.02	23.04	3.4
237	633320	1039609	F10/2/4	0.66	8.2	1.95	4.04	5.99	4.1
238	634041	1041505	F10/2/11	0.68	7.6	2.80	3.94	6.74	3.3
239	628609	1036677	C6/1	0.84	7.8	4.53	4.90	9.43	3.3
240	637245	1042590	F11/8/8	0.88	7.9	2.00	6.24	8.24	6.2

…….. (Continued)

lab.no.	Coordinate		Field no.	Ec (ds/m)	pH	Ca+Mg (meq/l)	Na (meq/l)	Sum Cation	SAR
	Easting	Northing							
241	635013	1039985	F11/6/4	0.85	7.9	3.87	5.28	9.15	3.8
242	628928	1038389	D4/5	0.84	7.8	3.33	6.05	9.38	4.7
243	631650	1037173	F9/2/4	0.80	7.8	1.33	7.30	8.63	8.9
244	627384	1035852	1A2/0/P	0.94	7.7	4.80	5.76	10.56	3.7
245	631654	1042139	AM	2.11	7.8	14.66	7.49	22.15	2.8
246	630277	1043051	AM	0.87	8.0	3.20	5.76	8.96	4.5
247	629830	1033808	AB/3	1.97	7.8	10.80	8.16	18.96	3.5
248	633562	1035925	F5B/19	1.48	8.5	6.67	7.01	13.67	3.8
249	630777	1041739	F10/6/4	3.54	7.8	23.59	9.93	33.53	2.9