# **Soil Ripping Assessment**

Monterey Pacific Prison Site Gonzales, Monterey County, California

Presented by

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# **Evaluation of Ripping Quality on Monterey Pacific Prison Site**

# Summary

The importance of ripping as an essential component of site preparation in establishing vineyards focuses attention on the need to routinely evaluate the quality of ripping. The quality of ripping largely reflects the future quality of the root systems of the vines.

Several numerical parameters are available for judging the effectiveness of ripping:

- volume of soil decompacted (size of the root zone),
- extent of decompaction (the strength of the soil in the root zone),
- Sustainability of decompaction (persistence of favorable root growth conditions).

We evaluated these parameters on the Monterey Pacific Prison Site after ripping soil using standard slip plows and a SoilWorks 700 mm ripping tool. The SoilWorks tool created better conditions for vine root growth as judged by these parameters.

However, the soil water content on much of the development site is too high for optimum ripping conditions using the SoilWorks tool and certainly too wet for the slip plow operation. A cover crop should be sown to dry the site to the soil plastic limit water content and further ripping should be delayed until then.

## Introduction

Site preparation is a fundamental activity in establishing vineyards. The type of work and attention to detail in site preparation has a profound impact on the future success of the vineyard. In particular, soil tillage by ripping is an intrinsic component of site preparation and a critical part of other preparatory activities including amendment addition and row configuration. The basic aim of soil "ripping" in establishing vineyards is to decompact and loosen soil to create a vine root zone that will facilitate survival, growth and performance of the vines to sustain fruit production for as many years as possible. Achieving this objective involves considerations relating to promoting root growth, creating optimum root volume and enhancing sustainability of the vineyard.

Each of these concepts has considerable ramifications that will affect fruit production capacity and quality and future management of the vineyard. Consequently, the effect of any particular ripping operation needs to be closely tied to the overall business plan for the vineyard and the design of the vineyard being established.

The purpose of the work reported here was to characterize, in quantitative terms, the effects of different types of ripping on the soils of the "Prison Site" near Soledad, California and to select an optimum tool configuration to ensure best possible site preparation quality.

The site is a level alluvial plain of about 400 acres situated just north of the Salinas Valley State Prison and lying between Highway 101 and the Gabilan Mountains. The soils have been evaluated for viticultural production and those soil observation points closest to the ripping observation points have been cross-referenced to the ripping evaluation observation points. Broadly, the soils in the northern and eastern areas where ripping was evaluated are dominated by sandy clay and sandy clay loam textures and are designated as "Clay N" and "Clay E". In the southern parts, sandy loam soil textures predominate and are referred to as "Sand S".

Two ripping tools were in use for developing the site. A pair of standard slip plows (Figure 1) powered by two D8 Caterpillar steel track tractors, were used to rip soil at 45 degrees to the proposed row direction in the Clay N and the Sandy S areas, receptively. On both these areas a Challenger rubber track tractor powering a SoilWorks "Curved Flat 700 mm" Vibrosoiler with low-set secondary wing (Figure 1) was used to rip experimental lines for evaluating the tool performance. However, a 500 mm wing was fitted for a test rip on clay soils on the eastern side of the block (Clay E).



Figure: 1 Standard slip plow (left) and a SoilWorks "Curved Flat 700 mm" Vibrosoiler with low-set secondary wing (right).

# Parameters for Evaluating Ripping Quality

The essential aim of soil ripping is to create a favorable root zone for vine growth to facilitate in survival, growth and performance of the vines that will be established on the site. In these terms, the quality of soil ripping can be judged by considering the volume of soil decompacted ("breakout"), the effectiveness of the decompaction (soil strength), and the sustainability of the decompacted condition (persistence through time). Numerical criteria can be defined for these factors that enable ripping quality to be evaluated objectively.

# Increased Root Volume ("Breakout")

Vines need a certain optimum root volume to function properly but there is no absolute root volume that can be defined as a criterion for judging ripping quality. The optimum root volume is site and enterprise specific, depending on many factors related to climate, vine type, rootstock and soil type. Consequently, criteria for defining the root volume created by ripping must be related to the performance characteristics of the ripping tool.

If we consider a hypothetical ideal ripping profile, a reasonable postulation would be that the width of decompaction should be at least twice as wide as the depth of insertion below the surface. In this ideal model, the ripped profile is a rectangle, twice as wide as it is deep. This ideal model provides a standard against which we can evaluate real ripping tines and we can define the Decompacted Area Index (DAI) as

 $DAI = 2D_{rip}^2/A_{decom}$ 

where  $D_{rip}$  is the depth from the original soil surface to the level where soil properties have been measurably changed and  $A_{decom}$  is the decompacted area (rip profile) where soil properties have been measurably changed, notably soil strength.

The expected range in values for DAI is between 0 and 1. An efficient ripping tool would be expected to have a Decompaction Area Index (DAI) of about 1 although an exceptionally efficient tool might exceed 1. Poor ripping tools exhibit DAI of less than 0.5. A subjective interpretation of the expected range of DAI for ripping evaluation is given in Table 1

# Decompaction

Decompaction of soil involves fracturing the inherent soil structure of an element of soil to increase the volume, so reducing the bulk density (mass of soil per unit of volume) and increasing the air-filled porosity. Effective fracturing of the soil structure and manufacture of large air-filled pores reduces the strength of soil and enhances root growth of plants established in the soil after ripping.

The most convenient way of measuring compaction and decompaction is via soil strength measurement. A standardized method for quantifying soil strength is to measure penetration resistance using a cone penetrometer (Weaich et al. 1992). A cone penetrometer has a standard steel cone on a relieved shaft (ASAE 2000) attached to a device that records the force on the cone (strain gauge) as it is inserted into soil at a slow rate. Calibration of the strain gauge output allows the force to be expressed as a pressure (kPa, MPa or psi).

The ability of grape vine roots to grow through soil has been determined and calibrated against a standard cone penetrometer. Van Hussteen (1983) reported this critical limit to be 2.5 MPa but Myburgh et al. (1992) reported more convincing data that showed

vine root growth stopped at 2.0 MPa. This information provides criteria for evaluating soil strength reduction after ripping. However, because soil strength is so variable in soil, we need to consider the average and peak values as well as the variability. A criterion for quality evaluation in soil preparation is the need to create uniformity of soil conditions as well as to achieve absolute levels of soil quality.

So, in evaluating decompaction we evaluate soil penetration resistance in terms of the average value measured in a particular penetrometer insertion into various locations on the face of a ripped profile as well the maximum value obtained and the standard error of the average. The critical absolute penetration resistance value we use, for a moist soil, is  $PR_o$  less than or equal to 2 MPa (2000 kPa or 290 psi). But we wish also to reference this critical value to the soil strength outside the ripped profile. So, we define a "Decompaction Index" (DI) as

 $DI = PR_{out}/PR_{in}$ 

where  $PR_{out}$  is the average or the maximum of penetration resistance outside the rip zone and  $PR_{in}$  is the average or the maximum or the standard error of penetration resistance inside the rip zone.

The Decompaction Index (DI) is dimensionless and in practice may range between about 1 and about 10. If the DI is 1 then essentially no decompaction has occurred in ripping. If DI is greater than 1 and penetration resistance is greater than 2 MPa then the ripping operation did decompact the soil but not enough to enhance root growth. If DI is greater than 1 and penetration resistance is less than 2 MPa then the ripping operation has been successful and a measure of success is the magnitude of the DI. If the DI is less than 1, the ripping operation caused compaction instead of decompaction. If DI is 1 and penetration resistance is 2 MPa or less, the soil did not need ripping.

Not only do we wish to decompact soil by ripping, but we would like to create uniform conditions in the root zone to promote uniform vine growth and uniform fruit ripening. Uniformity of decompaction, UDI is defined as

 $UDI = SEPR_{out}/SEPR_{in}$ 

where SEPR<sub>out</sub> is the standard error of penetration resistance outside the rip zone and SEPR<sub>in</sub> is the standard error of penetration resistance inside the rip zone.

As for DI, the Uniformity of Decompaction (UDI) is also dimensionless and may also range from about 1 to 10. If UDI is 1, there has been no change in uniformity of penetration resistance from ripping. If less than 1, more variability has been created by ripping. If UDI is greater than 1 then the ripping operation has been successful in creating uniformity and the magnitude of the UDI is a measure of success.

Ripping	Pene	tration Resistance	e (PR)	Decompaction Index (mean or	Uniformity Decompaction	Decompaction Area Index
Quality	MPa	kPa	psi	maximum PR) (DI)	Index (UDI)	(DAI)
Excellent	< 0.5	< 500	< 70	> 6	> 6	> 0.75
Good	0.5 to 1.5	500 to 1500	70 to 200	3 to 6	3 to 6	0.5 to 0.75
Moderate	1.5 to 2.5	1500 to 2500	200 to 350	1 to 3	1 to 3	0.25 to 0.5
Poor	> 2.5	> 2500	> 350	< 1	< 1	< 0.25

Table 1: Parameter values for judging ripping quality.

# Sustainability of Ripping Improvement

Sustainability of decompaction created by ripping is usually addressed by application of amendments such as gypsum and compost and incorporating them into the ripped profile. Sustainability of ripping can also be promoted by adopting subsequent management practices such as cover cropping and traffic management that promote good soil structure. These practices stabilize and protect the beneficial soil aggregates created by ripping against the tendency of wetting and drying and vineyard traffic to recompact the soil over time. Consequently, the sustainability of the physical improvements to soil properties created by ripping can really only be measured as a function of time which we could not do here.

However, soil moisture at the time of ripping can have an effect on sustainability. Dry soil behaves as a brittle solid and fractures explosively to produce large hard clods and fine powder. If soils are ripped when dry, much of the soil will fracture into fine aggregates (< 1 mm, < 0.04 inch) that will rapidly coalesce (weld together) when wetted, reducing the sustainability of the ripping. Soils ripped too wet will not fracture optimally either since they are plastic enough to tend to flow past the ripping tool and may compact in the process.

Ripping at the correct subsoil moisture content is critical for effective decompaction of all soils with significant clay content (sandy clay loams through to clays). This optimum water content is called the (Lower) Plastic Limit. It is the water content at which the soil mechanical behavior changes from brittle to plastic. At this water content the soil will fracture correctly to yield moderate (5 to 25 mm diameter) fragments necessary for optimum root penetration. The texture of soil affects the Plastic Limit water content. Sandy soils have quite low Plastic Limit water contents, generally around 10 % or less and loamy soils 10 to 20 % depending on clay content while clayey soils only show plastic behavior at more than about 20 % volumetric water content.

Other factors which have a bearing on sustainability are the weight of machinery used for ripping and the number of passes necessary to create acceptable conditions. Generally heavier machinery damages soil structure more than lighter machinery, creating more dust and powder. The more passes needed to complete the work, the greater the structural damage and the greater the chance of creating dust and powder.

### **Measurement of Ripping Quality Parameters**

We excavated trenches at right angles to rip lines produced by the slip plows and the SoilWorks ripping tools. Some slip plow profiles were excavated at right angles to the future row direction to obtain a perspective on root zone size. This means they were at about 45 degrees to the rip direction.

The rip profile was identified by feel using a geological hammer and demarcated with white paint sprayed onto the soil surface. The extent of the rip profile was verified using a hand-held penetrometer fitted with a standard cone (ASAE 2000) and representative values recorded. The original soil surface was also located and demarcated with white paint. The dimensions of the rip profile were determined and recorded. A photograph was taken of the rip profile, identified by a code consisting of the date (20090203) and a unique number (01 to 19).

The penetrometer consists of a stainless steel 6 mm scaled down version of the standard ASAE (2000) cone fixed to a 3 mm stainless steel shaft 200 mm long. The shaft is attached to a small computer via a 250 N strain gauge which measures the force on the cone and passed the signal to the computer. The computer converts the force to a pressure (kPa) via a preprogrammed calibration factor unique to the cone and strain gauge. The computer measures the pressure on the shaft at regular intervals (5 to readings over 200 mm) and calculates a mean value and the standard error of the mean to enable assessment of the variability of the chain of readings. The maximum value of the set of readings is also recorded. These measurements were made at 3 levels down the depth of the rip profile, both within and outside the decompacted profile as shown in Figure 2.

Volumetric water content of the soil in the ripped profile was also measured at selected sites. A Stevenson Hydroprobe sensor connected to a hand-held computer was used for this purpose.

The data obtained are listed in the Appendix tables attached to this report. Table A1 is a catalogue of all the data obtained, Table A2 is a record of the profile photographs, Table A3 is a record of all the computed data and Table A4 is a reference description of the soil profiles data obtained near the rip sites during the soil evaluation.

Table 2, in the body of this report, summarizes the important physical data obtained in this investigation

Table 2: Average of the mean, maximum and standard error pentration resistance values measured in the ripped profiles of two ripping tools:two standard slip plows working in sandy and clayey soils and one SoilWorks Vibrosoiler working in the same clayey and sandy soils

	-X.XX	Ripping has caused compaction				Marginal b	enefit from	ripping			Substantia	I benefit fro	m ripping	in terms of	ripping quality	parameters	
						Penetrati	on Resisist	ance inside	and outsid	e the rip zo	one (MPa)				Decompac	cted Profile D	imensions
	Texture			Average of	f Mean PR		A	verage of N	Aaximum P	R	ļ	Average Sta	indard Erro	Dr	Depth (inch)	Nominal Area	
Trench ID	and Location on Site	Tine Name	Outside Rip Zone	Inside Rip Zone	Differ- ence	Average Decom- paction Index	Outside Rip Zone	Inside Rip Zone	Differ- ence	Max Decom- paction Index	Outside Rip Zone	Inside Rip Zone	Differ- ence	Uniform- ility Decom- paction Index	Outside Rip Zone	Inside Rip Zone	Decompact ed Area Index
1			2.0	1.1	0.86	1.8	3.4	1.8	1.6	1.9	0.40	0.28	0.12	1.4	47	940	0.21
2	Sandy S	Slin nlow #1	2.7	0.77	1.9	3.5	4.0	1.4	2.7	3.0	0.53	0.26	0.27	2.1	48	1176	0.26
3	Sundy S		1.9	0.67	1.2	2.8	3.5	1.1	2.4	3.1	0.39	0.17	0.21	2.2	44	1320	0.34
4			1.4	0.81	0.60	1.7	2.2	2.1	0.18	1.1	0.30	0.28	0.03	1.1	36	1008	0.39
14			1.6	1.4	0.21	1.2	2.4	2.1	0.30	1.1	0.29	0.25	0.04	1.2	29	841	0.50
5			1.9	1.3	0.66	1.5	3.1	3.3	-0.17	0.9	0.40	0.39	0.01	1.0	45	1800	0.44
6	Clay N	Slip Plow #2	1.6	1.1	0.48	1.4	2.8	2.3	0.43	1.2	0.37	0.47	-0.09	0.8	46	1380	0.33
7	olayn	0111101112	2.4	2.2	0.2	1.1	4.0	3.2	0.85	1.3	0.46	0.51	-0.05	0.9	39	1034	0.34
8			2.4	1.2	1.2	2.0	4.3	1.9	2.4	2.3	0.51	0.32	0.19	1.6	38	893	0.31
17			1.9	1.5	0.41	1.3	3.1	2.4	0.70	1.3	0.33	0.28	0.05	1.2	35	1050	0.43
9			1.9	0.59	1.3	3.3	3.0	0.78	2.3	3.9	0.46	0.15	0.31	3.0	43	1763	0.48
10		SoilWorks First Pass	2.9	1.2	1.8	2.6	4.9	2.3	2.6	2.2	0.60	0.36	0.24	1.7	44	2024	0.52
11	Sandy S		3.5	0.65	2.9	5.5	5.5	1.0	4.5	5.7	0.73	0.16	0.57	4.7	46	2047	0.48
12		SoilWorks Second Pass	3.4	1.0	2.4	3.4	5.2	1.6	3.6	3.3	0.59	0.27	0.32	2.2	46	2047	0.48
13			1.7	1.1	0.56	1.5	2.6	1.9	0.76	1.4	0.42	0.37	0.05	1.1	39	2184	0.72
16	Clay N	Soliworks Second Pass	3.3	0.94	2.4	3.5	5.0	1.2	3.8	4.3	0.51	0.13	0.38	4.0	36	2142	0.83
18	Olau E	SoilWorks Second Pass No	2.4	0.83	1.5	2.9	4.2	1.3	2.9	3.2	0.43	0.18	0.24	2.3	34	884	0.38
19	Clay E	Mounding Train	2.4	0.87	1.5	2.8	3.9	1.4	2.5	2.7	0.46	0.24	0.23	2.0	35	1260	0.51
Average Val	IIPS.																
Average val	Slip Plows o	overall # 1 and 2	2.0	12	0.77	18	33	22	11	17	0.40	0.32	0.08	13	41	1144	0 35
	Slip Plow #1	, Sandy S	2.0	0.84	1.1	2.5	3.3	1.6	1.7	2.3	0.40	0.25	0.16	1.7	44	1111	0.30
	Slip Plow #2	2, Clay N	2.0	1.4	0.5	1.4	3.3	2.5	0.75	1.3	0.39	0.37	0.02	1.1	39	1166	0.39
						1					T T			1			
	SoilWorks of	verall	2.7	0.9	1.8	3.2	4.3	1.4	2.9	3.3	0.53	0.23	0.29	2.6	40	1794	0.55
	SoilWorks 1	st Pass, Sand	2.4	0.9	1.6	2.9	4.0	1.5	2.4	3.0	0.53	0.26	0.27	2.4	44	1894	0.50
	SoilWorks 2	nd Pass, Sand & Clay	2.8	0.9	1.9	3.3	4.4	1.4	3.0	3.4	0.52	0.22	0.30	2.7	39	1761	0.57
	SoilWorks S	andy Soil, 1st & 2nd Pass	2.9	0.8	2.1	3.7	4.6	1.4	3.2	3.7	0.60	0.24	0.36	2.9	45	1970	0.49
	SoilWorks C	Clayey Soil, 1st & 2nd Pass	2.4	0.9	1.5	2.7	3.9	1.4	2.5	2.9	0.45	0.23	0.23	2.4	36	1618	0.61
	Slip Plow &	SoilWorks, all data	2.3	1.1	1.2	2.4	3.7	1.8	1.9	2.4	0.45	0.28	0.17	1.9	41	1433	0.44

## **Discussion of Results**

The data in Table 2 and the images in Appendix Table A2 show that, generally the SoilWorks ripping tool created a better quality root zone than the slip plow. The area of the rip profile created by the SoilWorks tool is greater than that for the slip plows and the absolute strength of the soil is generally less. The Decompaction, Uniformity and Area Indices for the SoilWorks tool were superior to the slip plow Indices and the rating of the SoilWorks is generally "Good" according to the class limits shown in Table 2, although the Uniformity of Decompaction Index for the SoilWorks ripper is just below 3 due largely to high soil moisture in the "Clay" areas. The data suggest that uniformity of soil strength is increased by two passes of the SoilWorks ripper.

The poorer performance of the slip plows is not unexpected since this tool has been falling from favor for at least 10 years because of several undesirable characteristics, notably the tendency to bring subsoil to the surface and the large operational draft. The data obtained for the slip plows reflects poor performance characteristics for decompaction, uniformity and root zone volume. There was some evidence in the data of recompaction in previously ripped lines because the tractor tracks ran in previously ripped lines.

The moist conditions prevalent on the site might have interfered with the flow of soil up the slip plows. A soil body seems to have built up on the slip plane (see Figure 1) which deformed the soil-engaging profile of the tool and which might explain the considerable soil disturbance and mixed decompaction results. The deeply disturbed soil surface will require considerable reworking to create a smooth surface for planting. Part of the reworking will need to address the recompaction problem. This raises questions about the sustainability of slip plow ripping, whether done when the soil is dry or moist.

The soil water content of the "Clay" areas to the north and East was high. For example at Rip Profile 13 water content was 30 % at a depth of about 24 inches and at Rip Profile 19 water content was over 20 % in the top 12 inches (Appendix Table A1). Since these soils have a sandy clay or sandy clay loam texture, this indicates that the soil water content is greater than the Plastic Limit and the best results from ripping are not likely until the overall water content on site has declined. Since there was no vegetation established on the site when the evaluation was done and further rain was expected, significant soil drying is unlikely unless a cover crop is planted.

To ensure the best possible ripping result before establishing vines, a cover crop needs to be sown as soon as possible. Drying the soil to the plastic limit can be accomplished using an appropriate cereal cover crop growing through the winter and spring months. The plastic limit will be reached some weeks after the last spring rains and will be indicated by a decline in the color and condition of the cover crop. Because the surface soil will usually be much drier than the plastic limit at this time, ripping at these low water contents is very destructive to surface soil structure. Precautions should be adopted to preserve surface structure such as minimizing the number of passes of the

tractor and application of as much compost as possible, provided it is low in salinity and nitrogen (see Cass and Roberts 2005).

It was not possible to evaluate the optimum SoilWorks tool configuration because too few options were available for testing. The only difference in the way that the tool was configured was substitution of 700 mm wings for 500 mm wings (see Appendix Table A1). There were too few 500 mm test rips to fully evaluate the effect of this configuration and it was treated as part of the overall SoilWorks dataset. A proper evaluation of the various options available from the SoilWorks tools should be made with more test runs and when soil water content is at the plastic limit.

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Figure 2: Data plan for soil strength measurements (1=mean value, 2=maximum, 3=standard error, 4=volumetric water content ratio) and dimensions of ripped profiles.

#### Appendix Table A1: Field Data for plow, tine configuration, rip profile dimensions and image (see Legend below and measurement diagram in Table 2)

Tino Namo	Tron	ch ID	Tractor/Ming	Configuration	Wing Dim	ensions	Rip Dimen:	sions (inch,	Data	Penetra	ation Resis	Out Left	Penetr	ation Resis	s In Rip	Penetrat	ion Resis (	Jut Right
The Mane	Tien	UIID	Tractor/Willy	Configuration	(inch,de	grees)	degr	ess)	Statistic	Level 1	Level 2	Level 3	Level 1	Level 2	Level 3	Level 1	Level 2	Level 3
	Rip No.	1	Speed mph	3	Width	17.5	Тор	28	Mean	1482	1863	2098	893	1471	997	1327	1361	3755
Slin nlow #1	Location	Sandy S	1st Wing Des	Slip	Length	97	Bottom	12	Max	3458	2786	3277	1773	2364	1342	2383	2287	6379
	Near Pit #	12, 7	2nd Wing	0	Angle	45	Depth	47	SE	531	291	369	255	362	212	242	293	666
	Alignment	45	2nd Pos	0	Oscillation	0	Angle L, R		VWR				0.1	0.15	0.16			
	Rip No.	2	Speed mph	3	Width	17.5	Тор	43	Mean	683	3859	4123	427	1249	629	683	1100	5666
Slin plow #1	Location	Sandy S	1st Wing Des	Slip	Length	97	Bottom	6	Max	1243	5200	7475	701	2316	1041	1044	1827	7473
	Near Pit #	12, 7	2nd Wing	0	Angle	45	Depth	48	SE	178	473	1011	115	472	178	145	274	1088
	Alignment	45	2nd Pos	0	Oscillation	0	Angle L, R		VWR				0.11	0.17	0.19			
	Rip No.	3	Speed mph	3	Width	17.5	Тор	48	Mean	214	700	3696	309	749	954	588	1336	4724
Slin nlow #1	Location	Sandy S	1st Wing Des	Slip	Length	97	Bottom	12	Max	1219	1217	7473	424	1398	1542	1084	2619	7478
	Near Pit #	12, 7	2nd Wing	0	Angle	45	Depth	44	SE	77	173	907	49	206	268	130	288	756
	Alignment	90	2nd Pos	0	Oscillation	0	Angle L, R		VWR									
	Rip No.	4	Speed mph	4	Width	17.5	Тор	42	Mean	272	764	1732	114	811	1494	303	1464	3883
Slin nlow #1	Location	Sandy S	1st Wing Des	Slip	Length	97	Bottom	14	Max	385	1043	2771	416	1723	4031	469	2454	6273
	Near Pit #	12, 7	2nd Wing	0	Angle	45	Depth	36	SE	52	152	362	36	274	526	68	267	923
	Alignment	90	2nd Pos	0	Oscillation	0	Angle L, R		VWR									
	Rip No.	5	Speed mph	4	Width	17.5	Тор	50	Mean	344	1400	4563	880	1652	1310	580	1610	3129
Slin nlow # 2	Location	Clay N	1st Wing Des	Slip	Length	97	Bottom	30	Max	583	2559	7256	2508	2691	4641	843	2781	4624
	Near Pit #	4	2nd Wing	0	Angle	45	Depth	45	SE	88	341	873	344	397	432	142	396	575
	Alignment	90	2nd Pos	0	Oscillation	0	Angle L, R	90	VWR									
	Rip No.	6	Speed mph	4	Width	17.5	Тор	46	Mean	1642	1713	2625	621	1533	1257	255	1595	1849
Slin nlow # 2	Location	Clay N	1st Wing Des	Slip	Length	97	Bottom	14	Max	3434	2477	4243	1689	2499	2822	701	2945	2790
	Near Pit #	4	2nd Wing	0	Angle	45	Depth	46	SE	478	376	562	295	425	678	105	330	388
	Alignment	90	2nd Pos	0	Oscillation	0	Angle L, R	90, 45	VWR									
	Rip No.	7	Speed mph	4	Width	17.5	Тор	47	Mean	1058	1201	3990	2327	2623	1790	1743	2322	4111
Slin nlow # 2	Location	Clay N	1st Wing Des	Slip	Length	97	Bottom	6	Max	1638	1583	6488	3588	3868	2031	3602	3759	6974
	Near Pit #	4	2nd Wing	0	Angle	45	Depth	39	SE	217	208	820	464	531	528	445	367	678
	Alignment	45	2nd Pos	0	Oscillation	0	Angle L, R	45, 45	VWR									
	Rip No.	8	Speed mph	4	Width	17.5	Тор	35	Mean	2362	1848	2924	1644	1127	759	1817	1184	4018
Slin nlow # 2	Location	Clay N	1st Wing Des	Slip	Length	97	Bottom	12	Max	4446	3357	5927	2657	2021	988	3820	1874	6176
Ship plow # 2	Near Pit #	4	2nd Wing	0	Angle	45	Depth	38	SE	517	451	588	504	308	154	558	209	747
	Alignment	45	2nd Pos	0	Oscillation	0	Angle L, R	45, 45	VWR									
	Rip No.	9	Speed mph		Width	700 mm	Тор	70	Mean	1225	1149	1616	525	430	809	984	1460	5064
SoilWorks	Location	Sandy S	1st Wing Des	Flat Curved	Length	0	Bottom	12	Max	2128	1600	2400	730	551	1070	1624	3053	7475
First Pass	Near Pit #	12, 7	2nd Wing	Yes	Angle		Depth	43	SE	335	243	419	152	56	242	227	450	1067
	Alignment	90	2nd Pos	Low	Oscillation		Angle L, R	30, 45	VWR									

#### Appendix Table A1: Field Data for plow, tine configuration, rip profile dimensions and image (see Legend below and measurement diagram in Table 2)

Tino Namo	Trop	ch ID	Tractor/Ming	Configuration	Wing Dim	ensions	Rip Dimen	sions (inch,	Data	Penetra	ation Resis	Out Left	Penetr	ation Resis	s In Rip	Penetrat	tion Resis (	Jut Right
The Name	Tien	CITID	Tractor/Wing	Coninguration	(inch,de	grees)	degi	ress)	Statistic	Level 1	Level 2	Level 3	Level 1	Level 2	Level 3	Level 1	Level 2	Level 3
	Rip No.	10	Speed mph		Width	700 mm	Тор	80	Mean	1181	3081	4969	1034	1024	1408	2007	1747	4692
SoilWorks	Location	Sandy S	1st Wing Des	Flat curved	Length	0	Bottom	12	Max	2347	4844	7389	1956	2156	2645	3583	4169	6897
First Pass	Near Pit #	12, 7	2nd Wing	Yes	Angle		Depth	44	SE	374	584	678	328	388	374	550	584	853
	Alignment	90	2nd Pos	Low	Oscillation		Angle L, R	45, 45	VWR									
	Rip No.	11	Speed mph		Width	700 mm	Тор	71	Mean	2573	1750	5915	204	816	927	1309	4840	4880
SoilWorks	Location	Sandy S	1st Wing Des	Flat curved	Length	0	Bottom	18	Max	4711	2728	7466	400	1337	1171	3111	7466	7466
Second Pass	Near Pit #	12,7	2nd Wing	Yes	Angle		Depth	46	SE	679	449	966	72	188	210	388	902	999
	Alignment	90	2nd Pos	Low	Oscillation		Angle L, R	45, 70	VWR				0.11	0.14	0.14			
	Rip No.	12	Speed mph		Width	700 mm	Тор	71	Mean	2016	3042	5461	610	1169	1203	2096	2299	5407
SoilWorks	Location	Sandy S	1st Wing Des	Flat curved	Length	0	Bottom	18	Max	3588	5256	7148	1053	1899	1797	3776	3821	7473
Second Pass	Near Pit #	12,7	2nd Wing	Yes	Angle		Depth	46	SE	350	637	750	169	315	333	467	501	845
	Alignment	90	2nd Pos	Low	Oscillation		Angle L, R		VWR									
	Rip No.	13	Speed mph		Width	700	Тор	76	Mean	1156	2444	2458	1443	968	992	522	1885	1723
SoilWorks	Location	Clay N	1st Wing Des	Flat Curved	Length	0	Bottom	36	Max	2306	3366	3733	2685	1506	1447	640	2836	2952
Second Pass	Near Pit #	10	2nd Wing	Yes	Angle		Depth	39	SE	452	640	401	524	297	286	62	412	559
	Alignment	90	2nd Pos	Low	Oscillation		Angle L, R	90, 90, 45,	VWR				0.16	0.3	0.21			
	Rip No.	16	Speed mph		Width	700	Тор	79	Mean	1864	4238	2598	1191	938	684	2343	3725	5092
SoilWorks	Location	Clay N	1st Wing Des	Flat Curved	Length	0	Bottom	40	Max	2641	6788	4239	1479	1327	710	3574	5432	7222
Second Pass	Near Pit #	10	2nd Wing	Yes	Angle		Depth	36	SE	453	667	535	107	250	25	341	405	650
	Alignment	90	2nd Pos	Low	Oscillation		Angle L, R	60, 60	VWR									
	Rip No.	14	Speed mph	4	Width	17.5	Тор	52	Mean	702	2223	2110	515	1612	1947	618	1813	1944
Slin Plow # 2	Location	Clay N	1st Wing Des	Slip	Length	97	Bottom	6	Max	1139	3434	3299	770	2581	3017	951	2884	2817
	Near Pit #	10	2nd Wing	0	Angle	45	Depth	29	SE	214	355	338	127	232	379	187	278	360
	Alignment	90	2nd Pos	0	Oscillation	0	Angle L, R	30, 30	VWR									
	Rip No.	17	Speed mph	4	Width	17.5	Тор	36	Mean	1326	1699	3143	435	2332	1637	196	313	4620
Slin Plow # 2	Location	Clay N	1st Wing Des	Slip	Length	97	Bottom	24	Max	2132	2730	6497	1038	3521	2773	537	749	6205
	Near Pit #	10	2nd Wing	0	Angle	45	Depth	35	SE	302	282	621	204	327	321	82	158	557
	Alignment	90	2nd Pos	0	Oscillation	0	Angle L, R	75, 75	VWR									
	Rip No.	18	Speed mph		Width	500	Тор	44	Mean	770	2998	3703	696	370	1425	951	2629	3206
SollWorks 2 Dass No Bod	Location	East	1st Wing Des	Flat Curved	Length	0	Bottom	8	Max	1433	5159	7471	1009	662	2224	2031	3966	5157
Former	Near Pit #	29, 30	2nd Wing	Yes	Angle		Depth	34	SE	203	407	814	153	103	298	279	423	437
	Alignment	90	2nd Pos	Low	Oscillation		Angle L, R	45, 45	VWR									
0 1044 1 0	Rip No.	19	Speed mph		Width	500	Тор	48	Mean	1044	1586	5154	928	902	779	613	1724	4346
SollWorks 2 Dass No Bod	Location	East	1st Wing Des	Flat Curved	Length	0	Bottom	24	Max	1443	3246	7468	1559	1450	1289	1154	3010	7075
Former	Near Pit #	29, 30	2nd Wing	Yes	Angle		Depth	35	SE	251	429	877	264	224	222	187	334	696
	Alignment	90	2nd Pos	Low	Oscillation		Angle L, R	60, 30	VWR				0.21	0.19	0.16			

							Approxima	ate Scale (fe	eet)			
		(	)	1	2	3		4	5	6	7	
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	Rip No.	<u> </u>	and the	and the		1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2	at t	AL	1			
1# wolg ailS	Location	Sandy S	June S	18:20	14 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -	A. T. MAL		Rodi				
	Near Pit #	12, 7	10113	and the second	n'antes -		4	ALT REALS	20			
	Alignment	45		W. W. M	A.M.	A		The state of the s	003			
The standalin a	Speed mpn	3 Clim	- Aller		E-V a	3 Back	the state	C And	44			
Configuration	TSI WINY Des	Silp	C. M.	The state	and a	in the	( K.					
Configuration	2110 Willy 2nd Dos	0		10-1-10	, inter	No the		Angel				
	2110 T US Width	17.5		a 1. 14	二日	F		C. Ch	2			
Wing Dimensions	Lenath	97	- A				A States	55 V	1 and			
(inch,degrees)	Angle	45		12.3	AL AND S	3 5	a star	TA				
	Oscillation	0	200	C. S. T.	S. C. S.	Price - T	et all		1. An Ba			
	Тор	28	a francis		1	an de Gra	ma into	225	1 455			
Rip Dimensions	Bottom	12		Res a	A Start		1820	And And And	a second			
(inch, degress)	Depth	47	A.F.		ALC: NO	1.2	-	A I	Sine Ar			
	Angle L, R	0	- States	and an and	and the sea		and the p	-				
	Rip No.	2	1ª	A CONTRACTOR	and the second s	Ser is	and the		C and			
Slip plow #1	Location	Sandy S	prime and	A COL			R D D D D D D D D D D D D D D D D D D D	11 A. 1	77			
	Near Pit # Pit	12, 7	al al	The states	1 22	and the second	Contraction of the second	State 1	20			
	Alignment	45		-	Light -	- the		MA THE A	09			
	Speed mph	3	144		and a	and the second	the man	AL ST	02			
Tractor/Wing	1st Wing Des	Slip	and the second s	a state	effer "	CEN.	and the second second		1			
Configuration	2nd Wing	0			Y		A	A MARTIN	K-			
	2nd Pos	0	tone"		Sec.	Store A	S. C.		***			
	Width	17.5		a sport .	a sta	the state	A. R.	Stall.	5.1			
Wing Dimensions	Length	97	A CON		de h	ter	A New Y	CA IT	1.1			
(incli,ucgrees)	Angle	45	1964	A THE P	Halpert.							
	USCIIIdIIUII	13	112	1 - 7 - 83		1. 1.18	S.A.		and a			
Pin Dimonsions	Bottom	43	1 Jord	11		1.41						
(inch, degress)	Denth	48	WE_ 1	1. Art	la la si	Ster 1	19 A.	Let-	10			
ι. <u>σ</u> γ	Angle L. R	0	a Va	and the second second	1 AN	C.C.		-1				
	Rip No.	3		S. S. Barr	and and		Contraction of the		1 1422			
Clim	Location	Sandy S	25.2	Vie y	1 have			1				
Slip plow #1	Near Pit # Pit	12, 7		175 J. 19	3 24	WALL CO.		WEIS	-1-4			
	Alignment	90		ALL SA	We ge	*	A. Y.	N. New	20			
	Speed mph	3	10.00	AND I		i suit			09			
Tractor/Wing	1st Wing Des	Slip	131 -1	1-4-1	10.00	XX Y		A	03			
Configuration	2nd Wing	0	a all all	1.74	a the		-R	13				
	2nd Pos	0	44436		$\sim 10^{-10}$			1				
	Width	17.5			ser.	Q		1 14	1 State			
Wing Dimensions	Length	97	N 14 15			See 1	and the					
(inch,degrees)	Angle	45		A	Saint 1	1.	17 M	1 300	1.2			
	Oscillation	0	The second				1.1.1	Mary	Case of A.L.			
	lop	48	A BAR	a series	and the second		AN SUM	No. 1	1 Jacob			
Kip Dimensions	Bottom	12	A La La		C. Al	and the second	Ser 1		and the second se			
(incir, degress)	Depth	44		a second life		ALLAN	76		-			
	Angle L, R	U				A 1/ 2/ 2/	A CONTRACTOR OF					

						Ap	proximate Scale	(feet)			
		(	)	1	2	3	4	5	6	7	8
										ł	
	Rip No.	4	A State of the second			12 Marsh					
Slip plow #1	Location	Sandy S	1111	1				AN I			
	Near Pit # Pit	12, 7	ALCOND.	Construction in the	In II in its en		A CONTRACTOR OF A CONTRACTOR OF A CONTRACTOR OF A CONTRACTOR AND A CONTRAC	THESE PARTS			
	Alignment	90	ALL PROPERTY.	el-	26.74	AND STREET	and S.S.	20			
	Speed mph	4			1 26	"Realing"	And and	02			
Tractor/Wing	1st Wing Des	Slip	. 15.	the str			Aust	04			
Configuration	2nd Wing	0			C.C.A.	21/	NY SA	To all the second			
	2nd Pos	0		the The	1.8	Star Star	C. March	1 Sin			
	Width	17.5	140	A STATE	and f	4		1205			
Wing Dimensions	Length	97	6	2. 2.			N ANT				
(incn,degrees)	Angle	45	ter 1			C. A.		2 CARA			
	Oscillation	0		AN PALLAR	67 A.	ALL TO	ALC: NO				
	lop	42	S. St.	1. A. A.		17 2 5					
Rip Dimensions	Bottom	14	Stark 1	1	1.15						
(Inch, degress)	Deptn	36	3 . SA	1 million	14	The second					
	Angle L, R	5			Ste Ste			CORA - NOT			
Slin nlow #	RIP NO.		1000	46-14	Con the	A Par	Asam	NO P			
יייטו און אונג <i>א</i>	Near Pit # Pit		- Xak	C COLONIA	ALL PARTY						
Z	Alignmont	4	-	1 2 3	No.	1 (S) 7 (S)	C. Y M.	20			
	Speed mph	<del>70</del> 1	- 100	4.4.		Standard	18 3	09			
Tractor/Ming	1st Wing Des	4 Slin				and the	100	03 4			
Configuration	2nd Wing	0	Tip .	1 Sec.			A ANT				
J. J. J. L. J.	2nd Wing 2nd Pos	0	- Star			S. S. S. S.	ACT IN				
	Width	17.5			Sec		T				
Wing Dimensions	Length	97	- Star	1			the second	2			
(inch,degrees)	Angle	45	1	A. S. C.	Terra	J. W. St.	27.201.5				
	Oscillation	0	199.9	and the second	1.		Asia	264 3			
	Тор	50			and and	a start	C. For south				
Rip Dimensions	Bottom	30	and the			ALL AND	The State N				
(inch, degress)	Depth	45					and the second second	A			
	Angle L, R	90	Maria and	and have a	do the	Sense of	and the second second	13 T			
	Rip No.	6	the first	States :	1	7.81		19 6 19			
Slip plow #	Location	Clay N		the first	and .	1.19	N.983	200-12.			
2	Near Pit # Pit	4	A.	A TO A	1	See Cha	A AND A				
	Alignment	90	and the second second	a set ha ha an ar ar ar ar ar	1	CONST !		09			
	Speed mph	4	C. Statistical Statistics			and the	and o	6			
Tractor/Wing	1st Wing Des	Slip	1.300	Ry Market		A Trach	小说 并汉	本一部			
Configuration	2nd Wing	0	- 1 · ·		S.C.	Printer Charles	15 F 80				
	2nd Pos	0			E. KS		Strack.	<b>发</b> 增			
	Width	17.5	A P		(m) 20	and the state	A COLA	2-			
Wing Dimensions	Length	97	- AN		A COL						
(Inch,degrees)	Angle	45	14	1000		ALT .	The Part				
	Oscillation	0		We ch	· ·	E have to be	A Starte				
	Тор	46		Lot All		The Chi	A CONTRACTOR	3			
Rip Dimensions	Bottom	14	C ASSA	CI D		1 Action	All will				
(inch, degress)	Depth	46		an and the	and and			The Party			
	Angle L, R	90, 45	a second second	ARE PARAMENT	1	A STATE OF A	Contraction of the second	A DECK			

					Approximate Sca	le (feet)		
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	·	-						<u> </u>
011	Rip No.	1	N 7 11 34	125 1	2 . A 19 841	1-22	J.	
Slip plow #	Location	Clay N	3-	1 2 1 3			18 18 1	
2	Near Pit # Pit	4	1 3 S in the	Will be	a set of the set	= 20		
	Alignment	45	St State	· Staff	Real Carlos	- 02		
	Speed mph	4	a tank of	- All and	and then it of	07		
I ractor/Wing	Tst Wing Des	Slip	- 23 J. 1 12	N Sitte	A TANK	151	ft. o	
Connyuration	2fiu Wifiy 2nd Dos	0	- MALLA	1. 1.				
	ZIIU FUS Width	17 5	- A.	her the	11/1	A Br		
Wing Dimonsions	Length	07		11	5. 13 A	A PR		
(inch.dearees)	Angle	71 15	10 50 8	1 . 10	1131 - 34	2		
(1101),009.000	Oscillation	4J 0	- Parties	AN FILL	y states			
	Ton	47	1.1.7.1	A THE AGE		公开的		
Pin Nimensions	Bottom	 6	- A Marked	A CYCLA	And Market	3		
(inch, degress)	Depth	39	- A CARLER	A State of the	and the second	the former	12	
•	Angle L, R	45.45		Carpon Carpon Carpon				
	Rip No.	8		13000				
Slip plow #	Location	Clay N	-	P IN THE	IN HE WAY HE HAVE TO BE	CL		
2	Near Pit # Pit	4		A A				
	Alignment	45	the los in the	L. St	20	4		
	Speed mph	4	A Carlot	strat the	02			
Tractor/Wing	1st Wing Des	Slip	A Barrens	" ital	08			
Configuration	2nd Wing	0	T- Condition	The fight of	57471	<i>y</i> .		
	2nd Pos	0		3 Contraction	The fill			
	Width	17.5	Arma	Alt of the	1 CAT			
Wing Dimensions	Length	97	all all	1 Charles	2			
(inch,degrees)	Angle	45	たいため	A HAY	MARTIN K			
	Oscillation	0	1. pm 15	A Plan	A and a second			
	Тор	35	61 1 5 pt	12.00	S BALL			
Rip Dimensions	Bottom	12		Barrie Commence	A SUCHER TH			
(Inch, degress)	Depth	38	- A K M	and the factor	A PAR			
	Angle L, R	45, 45				NET CEL TRATING	TANK SHITTER	
SailMorks	Rip No.	<b>7</b>	San Table Land	1. 16 M	PL AR		1. 1. 11	1 M
JUIIWUIKS	LOCallOII Noar Dit # Dit	Sanay S	CHE COLONY, MELLER	-	A AN STANK			
FILSI Pass	Alianment	12, 1		11.13	N. AND		. I. I.	
		0			Contraction of the second	de state	100	174 104
Tractor/Wing	1st Wing Des	Flat Curved	11. 100	and the second se				20
Configuration	2nd Wing	Ves			al 13	APP AL	A Start	02
	2nd Pos	low	-	158. 14 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1		- Call	A State	
	Width	700 mm	Auto and an a	A. Barris			機能	1
Wing Dimensions	Lenath	0		He and		KI with The	241	1 134
(inch,degrees)	Angle	0	- All Print	Alle	Pierry a method	the state	12 1 3	
	Oscillation	0		A. Con	AL AL	41.11	1 mile	
	Тор	70	and the second second		1	1. 8 M		- 21A 114
Rip Dimensions	Bottom	12				J. A.		
(inch, degress)	Depth	43	- Antonio Antonio		and the second	-		- English
	Angle L, R	30, 45				to Martin Bart	Charles	

			Approximate Scale (feet)
		0	1 2 3 4 5 6 7 8
		10	
SoilWorks	Rip No.	10	
SOUWORKS	Location	Sandy S	
First Pass	Near Pit # Pit	12, 7	
	Alignment	90	
T	Speed mph	0	
Tractor/Wing	Ist wing Des	Flat curved	
Configuration	2nd Wing	Yes	
	2110 PUS	200 mm	
Wing Dimonsions	Viluti Longth	700 11111	
(inch degrees)	Anglo	0	
(inon,acgrees)	Angle	0	
	Ton	80	
Din Dimonsions	Bottom	12	
(inch, degress)	Depth	44	
	Angle L. R	45, 45	
SailWorks	Rip No.	11	
SUIWUIKS	Location	Sandy S	
Second	Near Pit # Pit	12,7	
Pass	Alignment	90	
	Speed mph	0	
Tractor/Wing	1st Wing Des	Flat curved	
Configuration	2nd Wing	Yes	
	2nd Pos	Low	No photo available
	Width	700 mm	
Wing Dimensions	Length	0	
(inch,degrees)	Angle	0	
	Oscillation	0	
	Тор	71	
Rip Dimensions	Bottom	18	
(inch, degress)	Depth	46	
	Angle L, R	45, 70	
SoilWorks	Rip No.	IZ Constant	A CARLEN AND A CARLEN AND A COMPANY
Second	LOCATION	Sandy S	A A A A A A A A A A A A A A A A A A A
Pass	Alianmont	12,7	
	Aiignment Spood mph	0 7U	
Tractor/Ming	1st Wing Dec	Flat curved	
Configuration	2nd Wing	Vac	
u.u.u.u.	2nd Willy 2nd Pos	low	
	Width	700 mm	A PART AND AND A CARD STATE
Wing Dimensions	enath	0	
(inch,degrees)	Angle	0	A CRAMER AND A CONTRACT OF PERSON
,	Oscillation	0	A A A A A A A A A A A A A A A A A A A
	Top	71	
Rip Dimensions	Bottom	18	
(inch, degress)	Depth	46	
	Angle L, R	0	

						Approxima	ate Scale (feet	:)			
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		10		_	-	-					
SoilWorks	Rip No.	13		17.19	the state	ST ST	San An		S THE		
Second	Location	Clay N	- Andrew		A start				AN Argent	P	
Pass	Near Pit # Pit	10	14.04	to the	in the		1.1.2	NAX S	Tarel	Cart -	
1 033	Alignment	90	- man to		1.53	Sher. 6	Store all	141	TO MAKE BE TO ALL DATES IN ALL DATES		
	Speed mph	0	A Si	CAN BERRY	2.31 6 - 3		NIS MA	No. 1	10 1 1 K	- 09	
Tractor/Wing	1st Wing Des	Flat Curved	1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1	General State			the state	W-18	1 Sound	-1 03	
Conliguration	2nd Wing	Yes	16 6	1			A starter		SUD ST	10	
	2nd Pos	Low					The second	Sec. 1	E A	1.1.5	
	Width	/00	A TRANSPORT		And States			Sec. 1	18		
Wing Dimensions	Length	0	and SER.		1.2.1		1.00	N. S. C.	1 And		
(incri,degrees)	Angle	0	-			S. Ask					
	Oscillation	0	-	State of the			A N	S LAR			
	Тор	/6	1323			200 L	1 1 2 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -	STORE S	Carlon .		
Kip Dimensions	Bottom	36	Ep. The	- Sumain		the second	and a set	Carlo Carlo			
(inch, degress)											
0 104/	Angle L, R Pin No	90, 90, 45, 45							These services 24 144	the last state of the	1000
SollWorks	Location	Clay N	AND AND	SAL CO		Cover sind	100	Part and A			
Second	Near Pit # Pit	10		The Part	and the second	S. Sameta S.		$\mathcal{F}_{1}$		100	
Pass	Alianment	90	The same			The land	and	in the second	No. Alt	-	Par S
	Speed mph	0						all and see	4 MAN	A.	- 34
Tractor/Wing	1st Wing Des	Flat Curved		State-	St MAC		and a	and the	The second	10	20 09 02
Configuration	2nd Wina	Yes	- An	F.Y.		and the		Sand .	1 20	1	03
-	2nd Pos	Low	and the second s	Part F	F. C.	6. J.M.	A MARIE	3			1
	Width	700	A LOSA A		A		AP144	The first	645		E State
Wing Dimensions	Length	0		The second	Sel No	12 1-12		NO F	a Salara	and -	- Carl
(inch,degrees)	Angle	0		A. (4 20		IT WAS A		Maria	1 Maria	2	and the second
	Oscillation	0		and the second	~ 171	ET A	A CAMP	gin -		and the	
	Тор	79	A A A	Too the	上 7-16 词	大学会	and the second	1 P			ST.
Rip Dimensions	Bottom	40	and the		Sec. 1	A REAL	7.0	記法が	all and	2	and the second
(inch, degress)	Depth	36	E F	Alla	A STATE					-	1
	Angle L, R	60, 60				Stern Call	in the	Marrie 1	in the second		No.
	Rip No.	14	arres 1	Le &	in it						
Slip Plow #	Location	Clay N	2 13 14 14	in the second	The second	1 2 2 2 2 3 1 2 2 2 2 1 2 2 1 2 2 1 2 2 2 2	11 12 10 17 18 19 19 19 19	1001-1			
2	Near Pit # Pit	10		1			the first of	09			
	Alignment	90	(m)		A.	MAR MA		02 1			
l	Speed mph	4	And the second	and the little		1. 200	the second	14 -2			
Tractor/Wing	1st Wing Des	Slip	St 4. 8	Solom an		7 4 C	180.0				
Configuration	2nd Wing	0	Stree .			Constanting	14 114	STA &			
	2nd Pos	0			the hash	- I land	A Start				
	Width	17.5	Mark.		C I C		and the second	A Play			
Wing Dimensions	Length	97		311	PAR BER	****	A STAR	1 4 24			
(inch,degrees)	Angle	45	- (	· · · · · · ·	and by	A Series		2			
	Oscillation	0		THE AN	provide the second		a Barba an				
	Тор	52		and the second second	Ser. 2		and the second	1			
Rip Dimensions	Bottom	6	N. A.		and the			1			
(inch, degress)	Depth	29	25.5		The second						
	Angle L, R	30, 30		A CONTRACTOR OF THE	STATISTICS INCOMENTS	T M AND		- the of the life			

					Approximate So	cale (feet)			
		0	) 1	2	3 4	5	6	7	8
	Rip No.	17	ACC X						
Slip Plow #	Location	Clay N	A ALASSA	State of Later	S 61 1 2 5				
2	Near Pit # Pit	10	PARSING 1	All and a state	20				
	Alignment	90	and Colores and	1 24					
	Speed mph	4		The second of the	17				
Tractor/Wing	1st Wing Des	Slip	MARCE I						
Coningulation	2nd Wing	0			100				
	2nd Pos	17.5							
	Width	17.5		and the	AN Pr				
(inch degrees)	Length	97	in the	A wat					
(incli,degrees)	Angle	45	174 M		1.3/2				
	USCIIIATION	U 24		X max man	X A C				
Din Dimonsions	10p Bottom	20 21	A State	Start .					
(inch. dearess)	DullUIII	24 25	and the second	- 48 A 1					
(inteni, dogi oco)		75 75	The second second		3				
SailWarka 2	Rip No.	18							
SUIIWUIKS Z	Location	East	EN AND	4.11:	1 4 6 6 1 4	Sec. 1.			
Pass No	Near Pit # Pit	29, 30	6	A Charles	the subscript	A DEMAND			
Bed Former	Alignment	90	mar and the	A SAL	11 6 11	20			
	Speed mph	0		. Maria	SUL IN	1 A 02			
Tractor/Wing	1st Wing Des	Flat Curved	The Part	A TANK	y in which	18 10			
Configuration	2nd Wing	Yes		The Char	A. M. A.	A ANTIN A			
	2nd Pos	Low	and a second	12 1 1 1	R. M. A.	han all h			
	Width	500	ME SELLY		S CARLINE				
Wing Dimensions	Length	0		1 11 1	the there is				
(inch,degrees)	Angle	0	BLACK HELLEY	Stand and	the state of the state				
	Oscillation	0							
	Тор	44			1	n se 🌈 stat			
Rip Dimensions	Bottom	8	5.5°	-		Carl Association			
(inch, degress)	Depth	34		The second second					
	Angle L, R	45, 45	an all an a stream	and the second		COLUMN AREAS			
SoilWorks 2	Rip No.	19	<b>成一个</b> 演	Sine to	1 State 1	and the fait			
Pass No	Location	East				Canada Para			
<b>Bed Former</b>	Near Pit # Pit	29, 30		And States		and the second second			
	Alignment Spood mph	90		Carl Carl	State 1	- 20			
Tractor/Ming	1st Wing Doc	U Flat Curved		The film.					
Configuration	2nd Wing				一九、武学、学、				
eeninguration	2nd Ming 2nd Pos	Low			、清下 14 &				
	Width	500		1. 1. 1. 1.					
Wing Dimensions	Length	0	BALLAL S.	2 A Pichi	North Co	SAL I			
(inch,degrees)	Anale	0		Mr. Fr.	1999 1991	134 3 2			
с <i>'</i>	Oscillation	0	- Carlor Charles	ANN E	the stand the	1200			
	Тор	48	ALL AND	LAND Same	her have	A STAN			
Rip Dimensions	Bottom	24	The sec	a mainten	APPLAT X.				
(inch, degress)	Depth	35				North B			
	Angle L, R	60, 30				A A A			

								I	Penetration	Resisista	nce insid	e and ou	tside the rip	zone (M	IPa)			Root	Zone Dimer	nsions	
Tine Name	Trop		Tractor/Ming	Configuration	Wing Dim	ensions		Average	of Mean	PR	Av	verage of	Maximur	n PR	A	verage S	tandard E	Error	Depth (inch)	Nominal Area	
	nen	CITID	Tractor/wing	Configuration	(inch,de	grees)	Out- side	Inside	Differ- ence	Average Decom- paction Index	Out- side	Inside	Differ- ence	Max Decom- paction Index	Out- side	Inside	Differ- ence	Uniform- ility Decom- paction	inch	inch <sup>2</sup>	Area Index
	Rip No.	1	Speed mph	3	Width	17.5															
Slip plow #1	Location	Sandy S	1st Wing Des	Slip	Length	97	1001	1120	061	10	2120	1026	1602	10	200	276	122	1.4	17	040	0.21
311p pi0w # 1	Near Pit #	12, 7	2nd Wing	0	Angle	45	1701	1120	001	1.0	3420	1020	1002	1.7	377	270	122	1.4	47	940	0.21
	Alignment	45	2nd Pos	0	Oscillation	0															
	Rip No.	2	Speed mph	3	Width	17.5															
Slin nlow #1	Location	Sandy S	1st Wing Des	Slip	Length	97	2686	768	1017	35	1011	1252	2601	3.0	528	255	272	21	18	1176	0.26
	Near Pit #	12, 7	2nd Wing	0	Angle	45	2000	700	1717	5.5		1555	2071	5.0	520	200	275	2.1	-10	1170	0.20
	Alignment	45	2nd Pos	0	Oscillation	0															
	Rip No.	3	Speed mph	3	Width	17.5															
Slin nlow #1	Location	Sandy S	1st Wing Des	Slip	Length	97	1876	671	1206	2.8	3515	1121	2394	31	380	174	214	22	44	1320	0 34
	Near Pit #	12, 7	2nd Wing	0	Angle	45	1070	0/1	1200	2.0	5515	1121	2374	5.1	507	1/4	214	2.2		1520	0.54
	Alignment	90	2nd Pos	0	Oscillation	0															
	Rip No.	4	Speed mph	4	Width	17.5															
Slin nlow #1	Location	Sandy S	1st Wing Des	Slip	Length	97	1403	806	597	17	2233	2057	176	11	304	279	25	11	36	1008	0.39
	Near Pit #	12, 7	2nd Wing	0	Angle	45	1400	000	577	1.7	2200	2007	170	1.1	504	217	20	1.1	50	1000	0.57
	Alignment	90	2nd Pos	0	Oscillation	0															
	Rip No.	5	Speed mph	4	Width	17.5															
Slin nlow # 2	Location	Clay N	1st Wing Des	Slip	Length	97	1028	1281	657	15	3108	3280	-172	0.0	103	201	12	10	15	1800	0.44
Slip plow # 2	Near Pit #	4	2nd Wing	0	Angle	45	1750	1201	037	1.5	5100	5200	-172	0.7	403	571	12	1.0	-13	1000	0.77
	Alignment	90	2nd Pos	0	Oscillation	0															
	Rip No.	6	Speed mph	4	Width	17.5															
Slin nlow # 2	Location	Clay N	1st Wing Des	Slip	Length	97	1613	1127	176	14	2765	2227	128	12	373	166	-03	0.8	16	1380	0 33
Slip plow # 2	Near Pit #	4	2nd Wing	0	Angle	45	1013	1137	770	1.4	2705	2337	420	1.2	575	400	-75	0.0	-10	1500	0.55
	Alignment	90	2nd Pos	0	Oscillation	0															
	Rip No.	7	Speed mph	4	Width	17.5															
Slin nlow # 2	Location	Clay N	1st Wing Des	Slip	Length	97	2/0/	22/17	159	11	1007	3160	8/5	12	156	509	_50	0.0	30	1033.5	0.51
311p pi0w # 2	Near Pit #	4	2nd Wing	0	Angle	45	2404	2241	100	1.1	4007	5102	045	1.3	400	500	-32	0.7	37	1000.0	0.34
	Alignment	45	2nd Pos	0	Oscillation	0															

#### Appendix Table A3: Averaged data for mean, maximum penetration resistance, standard error and root zone dimensions (see Legend below and diagram in Fig. 2)

								F	Penetration	Resisista	nce insid	e and out	tside the rip	zone (M	Pa)			Root	Zone Dimer	nsions	
Tino Namo	Trop		Tractor/Ming	Configuration	Wing Dim	ensions		Average	of Mean	PR	Av	erage of	Maximun	n PR	A	verage S	landard E	Error	Depth (inch)	Nominal Area	
The Name	nen		Tractor wing	Configuration	(inch,de	grees)	Out- side	Inside	Differ- ence	Average Decom- paction Index	Out- side	Inside	Differ- ence	Max Decom- paction Index	Out- side	Inside	Differ- ence	Uniform- ility Decom- paction	inch	inch <sup>2</sup>	Area Index
	Rip No.	8	Speed mph	4	Width	17.5															
Slin nlow # 2	Location	Clay N	1st Wing Des	Slip	Length	97	2250	1177	1102	2.0	1267	1000	2270	22	512	200	100	1.6	20	803	0.31
	Near Pit #	4	2nd Wing	0	Angle	45	2337	11/7	1102	2.0	4207	1007	2370	2.5	J12	JZZ	170	1.0	50	075	0.51
	Alignment	45	2nd Pos	0	Oscillation	0															
	Rip No.	9	Speed mph	0	Width	700 mm															
SoilWorks	Location	Sandy S	1st Wing Des	Flat Curved	Length	0	1016	500	1220	22	2047	701	2262	2.0	457	150	207	2.0	12	1762	0.49
First Pass	Near Pit #	12, 7	2nd Wing	Yes	Angle	0	1710	500	1320	5.5	3047	704	2203	3.7	437	150	307	3.0	43	1705	0.40
	Alignment	90	2nd Pos	Low	Oscillation	0															
	Rip No.	10	Speed mph	0	Width	700 mm															
SoilWorks	Location	Sandy S	1st Wing Des	Flat curved	Length	0	2046	1155	1701	2.6	1070	ງງຽງ	2610	2.2	604	262	2/1	17	4.4	2024	0.52
First Pass	Near Pit #	12, 7	2nd Wing	Yes	Angle	0	2740	1155	1/71	2.0	4072	ZZJZ	2017	2.2	004	303	241	1.7	44	2024	0.52
	Alignment	90	2nd Pos	Low	Oscillation	0															
	Rip No.	11	Speed mph	0	Width	700 mm															
SoilWorks	Location	Sandy S	1st Wing Des	Flat curved	Length	0	3545	640	2806	55	5/01	060	4522	57	721	157	574	47	16	2047	0.48
Second Pass	Near Pit #	12,7	2nd Wing	Yes	Angle	0	3343	047	2070	5.5	J471	707	4322	J.7	751	137	J/4	4.7	40	2047	0.40
	Alignment	90	2nd Pos	Low	Oscillation	0															
	Rip No.	12	Speed mph	0	Width	700 mm															
SoilWorks	Location	Sandy S	1st Wing Des	Flat curved	Length	0	2207	004	2202	24	5177	1502	2504	2.2	502	ารา	210	2.2	16	2047	0.49
Second Pass	Near Pit #	12,7	2nd Wing	Yes	Angle	0	3307	774	2373	5.4	5177	1000	5574	3.5	J7Z	212	317	2.2	40	2047	0.40
	Alignment	90	2nd Pos	Low	Oscillation	0															
	Rip No.	13	Speed mph	0	Width	700															
SoilWorks	Location	Clay N	1st Wing Des	Flat Curved	Length	0	1608	112/	564	15	2630	1970	760	11	121	360	52	11	30	218/	0.72
Second Pass	Near Pit #	10	2nd Wing	Yes	Angle	0	1070	1134	504	1.5	2037	10/9	700	1.4	421	309	JZ	1.1	37	2104	0.72
	Alignment	90	2nd Pos	Low	Oscillation	0															
	Rip No.	16	Speed mph	0	Width	700															
SoilWorks	Location	Clay N	1st Wing Des	Flat Curved	Length	0	3310	038	2272	35	1085	1172	2011	13	500	127	201	4.0	36	2142	0.83
Second Pass	Near Pit #	10	2nd Wing	Yes	Angle	0	5510	730	2312	0.0	4705	11/2	JUII	4.0	507	127	J01	4.0	50	2142	0.05
	Alignment	90	2nd Pos	Low	Oscillation	0															

#### Appendix Table A3: Averaged data for mean, maximum penetration resistance, standard error and root zone dimensions (see Legend below and diagram in Fig. 2)

									F	Penetration	Resisista	nce insid	e and ou	tside the rip	zone (M	Pa)			Root 2	Zone Dimer	nsions
Tine Nome	Troo		Tractor(M/inc	Configuration	Wing Dim	ensions		Average	of Mean I	PR	A۱	verage of	Maximun	n PR	A	verage S	tandard E	Error	Depth (inch)	Nominal Area	
Tine Name	Trer	ich id	Tractor/wing	Conliguration	(inch,de	grees)	Out- side	Inside	Differ- ence	Average Decom- paction Index	Out- side	Inside	Differ- ence	Max Decom- paction Index	Out- side	Inside	Differ- ence	Uniform- ility Decom- paction	inch	inch <sup>2</sup>	Area Index
	Rip No.	14	Speed mph	4	Width	17.5															
Slin Plow # 2	Location	Clay N	1st Wing Des	Slip	Length	97	1568	1358	210	12	2421	2123	298	11	289	246	43	12	29	841	0.50
511p 1 10W # 2	Near Pit #	10	2nd Wing	0	Angle	45	1000	1000	210	1.2	2721	2125	270	1.1	207	240	-10	1.2	27	041	0.00
	Alignment	90	2nd Pos	0	Oscillation	0															
	Rip No.	17	Speed mph	4	Width	17.5														Í	
Slip Dlow # 2	Location	Clay N	1st Wing Des	Slip	Length	97	1002	1140	115	1.2	2142	2444	400	1.2	224	204	FO	1.0	25	1050	0.42
311p P10W # 2	Near Pit #	10	2nd Wing	0	Angle	45	1000	1400	410	1.5	3142	2444	090	1.5	554	204	50	1.2	30	1050	0.43
	Alignment	90	2nd Pos	0	Oscillation	0															
	Rip No.	18	Speed mph	0	Width	500														Í	
SoilWorks 2 Dass No Rod	Location	East	1st Wing Des	Flat Curved	Length	0	2276	020	1576	20	1202	1200	2005	2.2	107	105	242	2.2	24	001	0.20
Former	Near Pit #	29, 30	2nd Wing	Yes	Angle	0	2370	030	1540	2.7	4203	1270	2903	3.2	427	100	243	2.3	54	004	0.50
	Alignment	90	2nd Pos	Low	Oscillation	0															
	Rip No.	19	Speed mph	0	Width	500														Í	
SoilWorks 2 Pass No Bed	Location	East	1st Wing Des	Flat Curved	Length	0	2/11	070	1510	20	2000	1/22	2467	27	440	227	224	2.0	25	1240	0 5 1
	Near Pit #	29, 30	2nd Wing	Yes	Angle	0	2411	070	1342	2.0	3099	1433	2407	2.1	402	237	220	2.0	- 55	1200	0.01
	Alignment	90	2nd Pos	Low	Oscillation	0															

#### Appendix Table A3: Averaged data for mean, maximum penetration resistance, standard error and root zone dimensions (see Legend below and diagram in Fig. 2)

# Soil Assessment: Profiles 1-70, Prison Development, Gonzales, Monterey County, California

Tuk		ind y or som	prome properti	05															
		Very low drainage	L	ow draiange		Q	uestionable		U	ndesirable			Perch	ned wate	er table		Wate	er table	
epth	Color	Texture	Rock	Soil St	ructure	Plasticity	Visible	Mottles	Free	Root density	TAW	рН	Р	К	Ca	Mg	EC	ESP	AI
				Hardness	Туре		pores		mine	uensity	IIICH	-	mg	/kg	cmolo	c+/kg	dS/m	%	mg/kg
in.	Profile 4 Strong	Brown Sandy Cla	y Loam						ERD (in.):	24									
24	Strong Brown	Sandy clay loam	10 % < 1 inch Fractured	Friable	Blocky	Moderate	No	No		Many	3.6								
60	Strong Reddish Brown	Sandy clay loam	15 % < 1 inch Fractured	Firm	Massive	Moderate	Few	No		Zero	4.2								
72	Strong Reddish Brown	Sandy loam	10 % < 1 inch Fractured	Loose	Massive	Low	Few	No		Zero	1.3								

in.	Profile 7 Strong	Grayish Brown S	andy Loam						ERD (in.):	30					
30	Strong Grayish Brown	Sandy loam	15 % < 1 inch Fractured	Friable	Massive	Low	Few	No		Many	2.9				
48	Strong Yellowish Brown	Sandy loam	20 % < 1 inch Fractured	Firm	Massive	Low	Few	No		Zero	1.7				
72	Light Reddish Brown	Sand	20 % < 1 inch Fractured	Loose	Massive	Low	Few	No		Zero	1.7				

# Table A4: Summary of soil profile properties

# Soil Assessment: Profiles 1-70, Prison Development, Gonzales, Monterey County, California

Tuk			promo proporti	00															
		Very low drainage	L	ow draiange		Qu	uestionable		U	ndesirable			Perch	ned wat	er table		Wate	er table	
epth	Color	Texture	Rock	Soil St	ructure	Plasticity	Visible	Mottles	Free	Root	TAW	рН	Ρ	K	Са	Mg	EC	ESP	AI
Ď				Hardness	Туре	,	pores		lime	density	inch		mg	/kg	cmol	c+/kg	dS/m	%	mg/kg
in.	Profile 10 Stron	g Reddish Brown	Sandy Loam						ERD (in.):	22									
22	Strong Reddish Brown	Sandy loam	5 % < 1 inch Fractured	Friable	Blocky	Moderate	No	No		Many	2.5								
54	Strong Reddish Brown	Sandy clay loam	10 % < 1 inch Fractured	Hard	Massive	Moderate	Few	15 % No		Zero	4 <u>.</u> 0								
72	Light Reddish Brown	Sandy loam	5 % < 1 inch Fractured	Friable	Massive	Low	Few	No		Zero	2.0								

in.	Profile 12 Stron	g Grayish Brown	Sandy Clay Loam							ERD (in.)	6					
6	Strong Grayish Brown	Sandy clay loam	10 % < 1 inch Fractured	Firn	ו	Massive	Moderate	Few	No		Many	0.7				
24	Strong Grayish Brown	Sandy clay loam	10 % < 1 inch Fractured	Firn	ו	Massive	Moderate	Few	No		Few	2.2				
48	Strong Reddish Brown	Sandy loam	20 % < 1 inch Fractured	Friab	le	Massive	Low	Few	No		Zero	2.2				
72	Strong Grayish Br	Sandy clay	10 % < 1 inch Fractured	Firn	ו	Massive	Moderate	Few	No		Zero	2.4				

#### Table $\Delta I$ . Summary of soil profile properties

# Soil Assessment: Profiles 1-70, Prison Development, Gonzales, Monterey County, California

Tab	e A4: Sum	mary of soil	profile propert	ies														
		Very low drainage	L	ow draiange	Qu	uestionable		U	ndesirable			Perch	ned wate	er table		Wate	er table	
epth	Color	Texture	Rock	Soil Structure	Plasticity	Visible	Mottles	Free	Root	TAW	рН	Р	К	Са	Mg	EC	ESP	AI
Õ				Hardness Type		pores		lime	density	Inch	-	mg	/kg	cmol	c+/kg	dS/m	%	mg/kg

#### Profile 29 Dark Gravish Brown Sandy Clay Loam in.

in.	Profile 29 Dark	Grayish Brown Sa	indy Clay Loam						ERD (in.): 72					
18	Dark Grayish Brown	Sandy clay loam	10 % < 1 inch Fractured	Friable	Blocky	Moderate	No	No	Few	2.7				
32	Strong Grayish Brown	Sand	10 % < 1 inch Fractured	Loose	Massive	Low	Few	No	Zero	1.1				
72	Strong Reddish Brown	Sand	15 % < 1 inch Fractured	Loose	Massive	Low	Few	No	Zero	3.0				

#### Profile 30 Strong Grayish Brown Sandy Clay in.

20	Strong Grayish Brown	Sandy clay	10 % < 1 inch Fractured	Friable Massive	Moderate	Few	No	Many	2.0				
42	Strong Reddish Brown	Sandy clay loam	15 % < 1 inch Fractured	Firm Massiv	Moderate	Few	No	Zero	2.6				
72	Strong Reddish Brown	Sandy loam	5 % < 1 inch Fractured	Friable Massive	Moderate	Few	No	Zero	3.3				

ERD (in.): 30