MD of Provost #52 Gravel Road Rating System for Asset Management

With the use of LiDAR

THE SOCRATIC CAO'S QUESTIONS

- What IS it and what does it DO?
- Why are we doing it?
- Can Council understand it and does it help Gary?

WHY ARE WE DOING IT?

THE RURAL MUNICIPAL MANDATE

Primary Political Topic:

-Roads

Primary Point of Operational Interference and Public Angst

- Roads

- Primary Expense
  - Roads

Primary Mandate:

-Roads

Conclusion?

It’s the roads, stupid.

What makes a good gravel road?

- Three things: profile, profile and profile.
- A gravel road with a poor base and a good profile is better than a gravel road with a poor profile and a good base
- Water management is the key to success, and profile is critical to water management.
- Good maintenance without proper profile is wasted money and effort.
- Profile is measurable, and easy to define as a metric.
- Difficult to measure without the application of technology.

BACKGROUND

In the fall of 2019 the M.D. of Provost began collaborating with MRF Geosystems out of Calgary to develop a system using LiDAR to provide automatic, baseline condition measurements for our gravel roads.

Starting late fall of 2019, we began working on a formulaic rating system to automatically generate condition ratings using LiDAR information. This rating system was finalized in 2020.

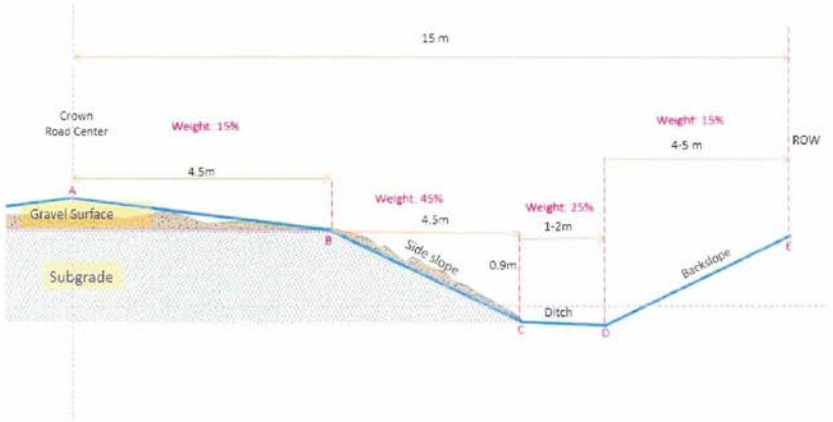
What IS it and what does it DO?

The process uses LiDAR to scan every gravel road from fenceline to fenceline and provide an automatic evaluation using pre-determined metrics.

The formula breaks the road surface from property line to property line into a right side and left side with each side broken down to four sections: driving surface, shoulder/fore slope, ditch bottom and back slope, with each section having its own weighting.

Gravel Road Slope Evaluation

Class A Road (always 30 meters ROW width)



A: crown -road center, B: Road surface boundary, C: Side slope toe

D: Ditch toe, E: Backslope boundary (ROW)

Step 1: In the whole gravel road network, take 1 mile for TWP RD or 2 miles for RGE RD as one individual evaluation unit. If a piece of road is longer than 1 mile or 2 miles, then break it into pieces in terms of each mile.

For each evaluation unit, apply the following steps to evaluate the road:

Step 2: For each 25 meters interval along the road direction:

Step2.1: Extract road left side profile to calculate the rating points

a. Calculate road surface score of AB scoreAB (15 points)

// If AB is 0% - 3%: 15 points at 3%, 0 points at 0%, interpolating scores

if 3%>slopeAB>0%: scoreAB= 15*slopeAB/0.03

// If AB is 3% - 5.5%: 15 points.

else if 5.5%>=slopeAB>=3%: scoreAB=15

// Every 0.5% above 5.5%: lose 5 points.

else if 8.5%>slopeAB>5.5%: scoreAB=15- 5*int((slopeAB-5.5%)/0.5+0.5)

// If slopeAB >8.5% or slopeAB<0

else: scoreAB =0;

b. Calculate side slope score of BC scoreBC (45 points)

C is a point where the drop of BC is 0.9 meters.

Search for the point C along the side slope, on which the drop of BC is 0.9 meters,

If point C can be found, calculate the horizontal distance of BC (hordis_BC):

//3-4 meters: 45 points.
if 3=<hordis_BC<=4 meters: scoreBC=45
//4-5 meters: 35 points
else if 4<hordis_BC<=5 meters: scoreBC=35
//5-6 meters: 25 points
else if 5<hordis_BC<=6 meters: scoreBC=25
//2 meters -3 meters: 3 meters 45, 2 meters 0 points, interpolating
else if 2=<hordis_BC<3 meters:
scoreBC =45* ((horizontal distance of BC-2) /1.0)
//2 meters or less: 0 for BC only. CD and DE can still have their scores.
else if hordis_BC<2: scoreBC=0
//>=6 meters: 0 for BC, CD, and DE
else:
scoreBC=0, scoreCD=0, scoreDE=0,
skip **c,d,** and goto **e**

Else: scoreBC=0 //if the point C with 0.9m drop cannot be found.

c. Calculate ditch score of CD scoreCD

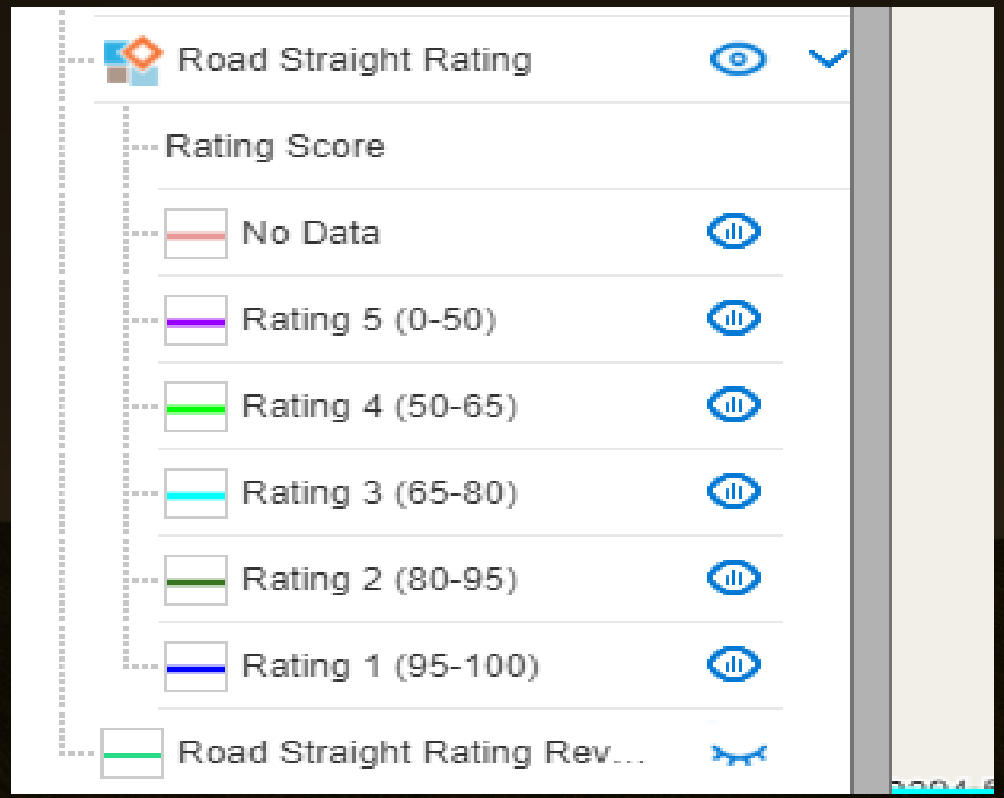
D is a point where the elevation starts to rise. Let the horizontal distance of CD be hordis_CD

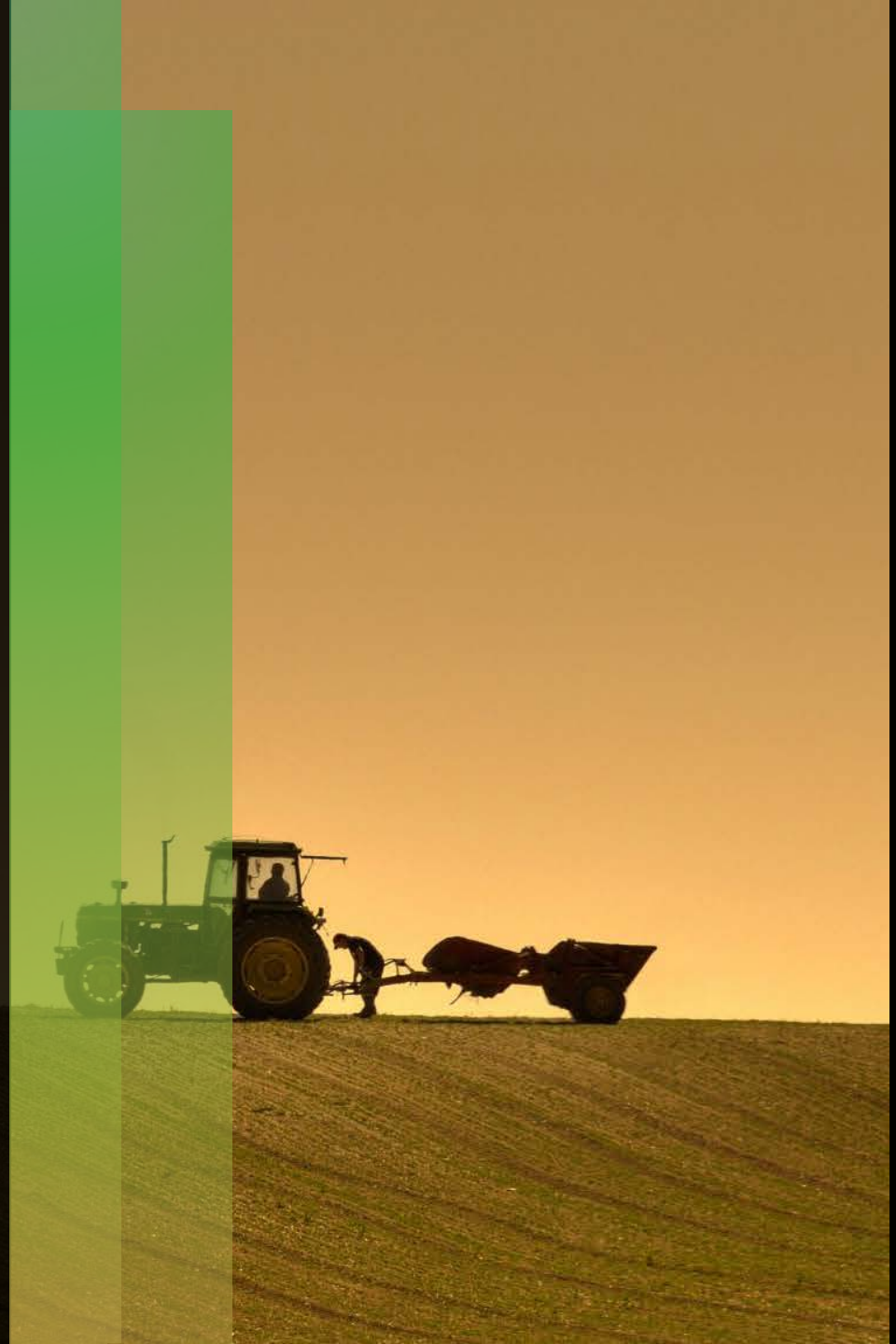
//CD should be 1 to 2 meters: 25 points. Do not worry about the slope of CD.
if 1<=hordis_CD <=2: scoreCD=25

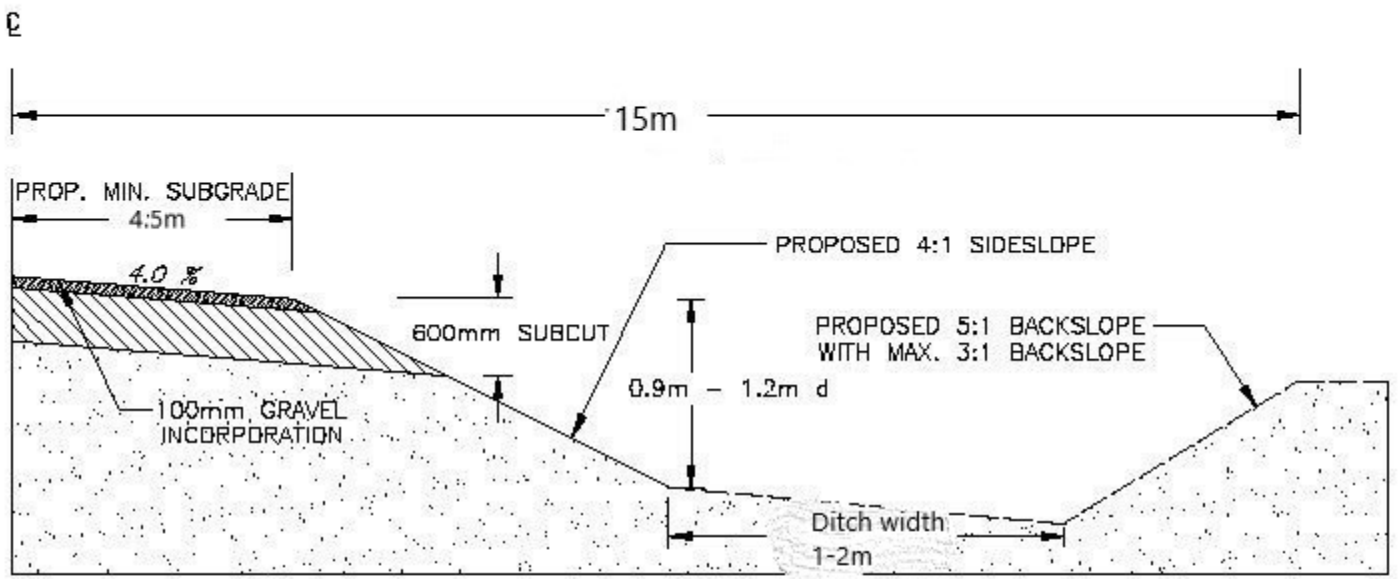
// If CD is longer than 2 meters + no back slope: 25 points. Back slope also gets 15 points.

else if hordis_CD>2 meters:
if backslope not exists:

- We used this formula on four different classes of roads, separated by major use:
- Class A - 9m driving surface industrial to a Class D being a 6-7m driving surface gravel access for agriculture or residential use.
- In each class the roads are rated from 1 being best condition to 5 being the worst condition, using a range of LiDAR measurement to determine the condition ranking.





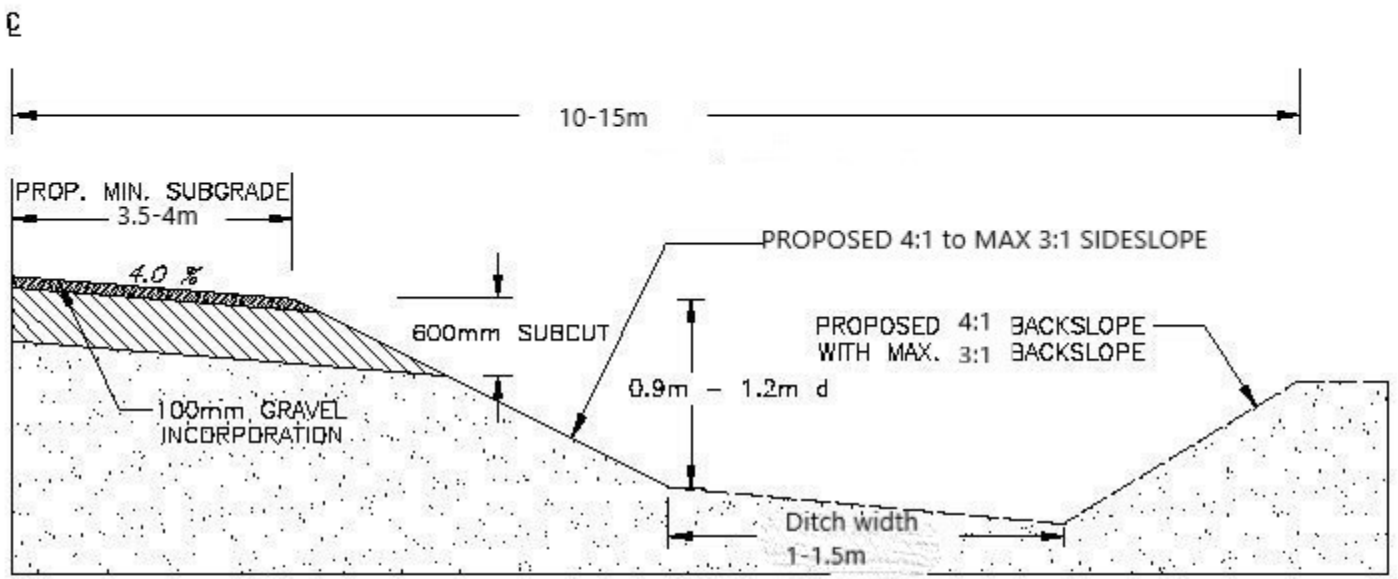


NOTE: SUBGRADE WIDTH FOR HEAVY HAUL–SURFACED ROADS TO BE DETERMINED AFTER COMPLETION OF SURFACING DESIGN.

PUBLIC WORKS

HEAVY HAUL - TYPICAL CROSS SECTION SUBGRADE

SCALE: NTS

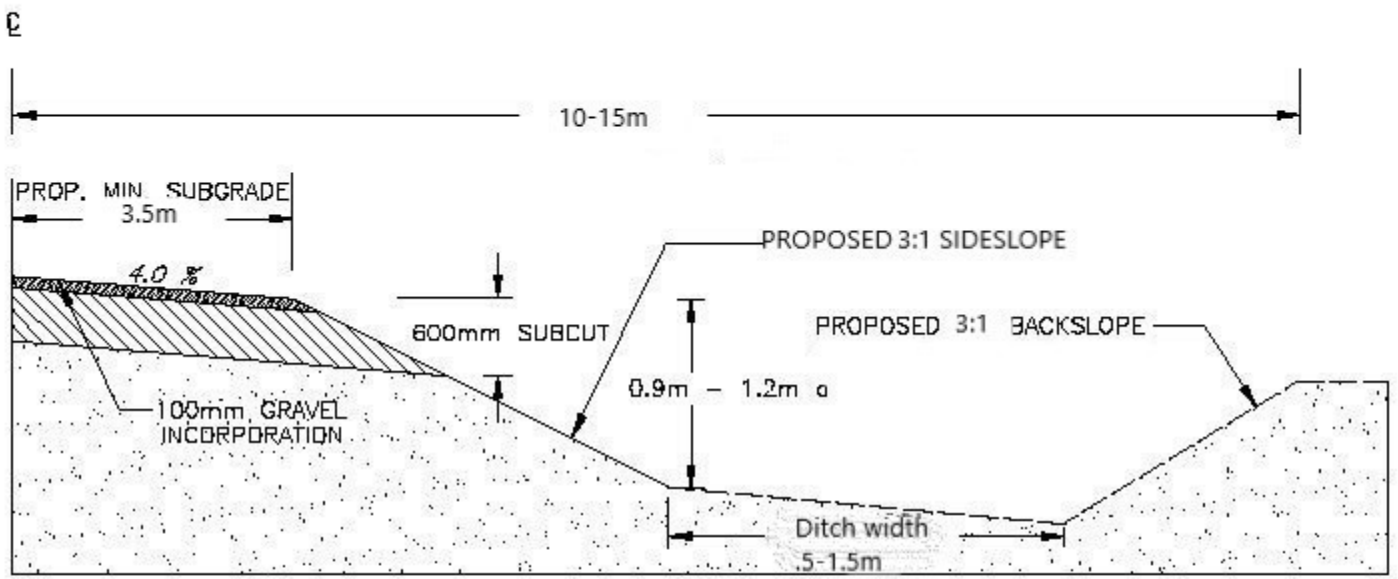


NOTE: SUBGRADE WIDTH FOR HEAVY HAUL–SURFACED ROADS TO BE DETERMINED AFTER COMPLETION OF SURFACING DESIGN.

PUBLIC WORKS

PRIMARY GRID - TYPICAL CROSS SECTION SUBGRADE

SCALE: NTS

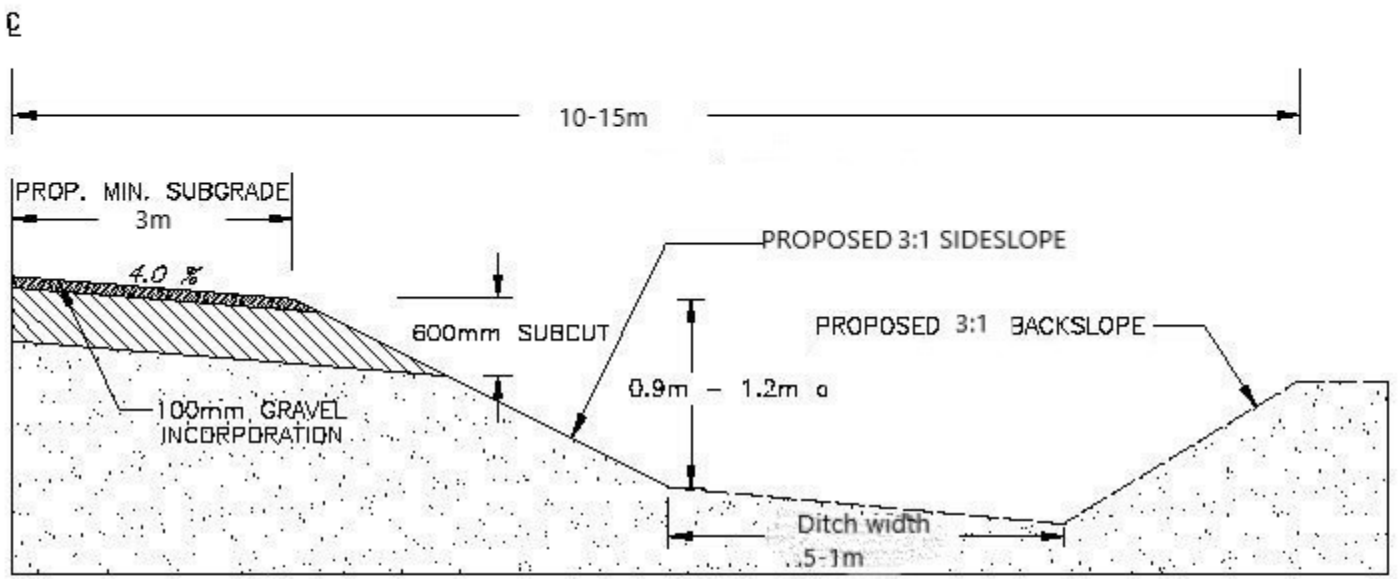


NOTE: SUBGRADE WIDTH FOR HEAVY HAUL–SURFACED ROADS TO BE DETERMINED AFTER COMPLETION OF SURFACING DESIGN.

PUBLIC WORKS

FARM ACCESSS - TYPICAL CROSS SECTION SUBGRADE

SCALE: NTS



NOTE: SUBGRADE WIDTH FOR HEAVY HAUL–SURFACED ROADS TO BE DETERMINED AFTER COMPLETION OF SURFACING DESIGN.

PUBLIC WORKS

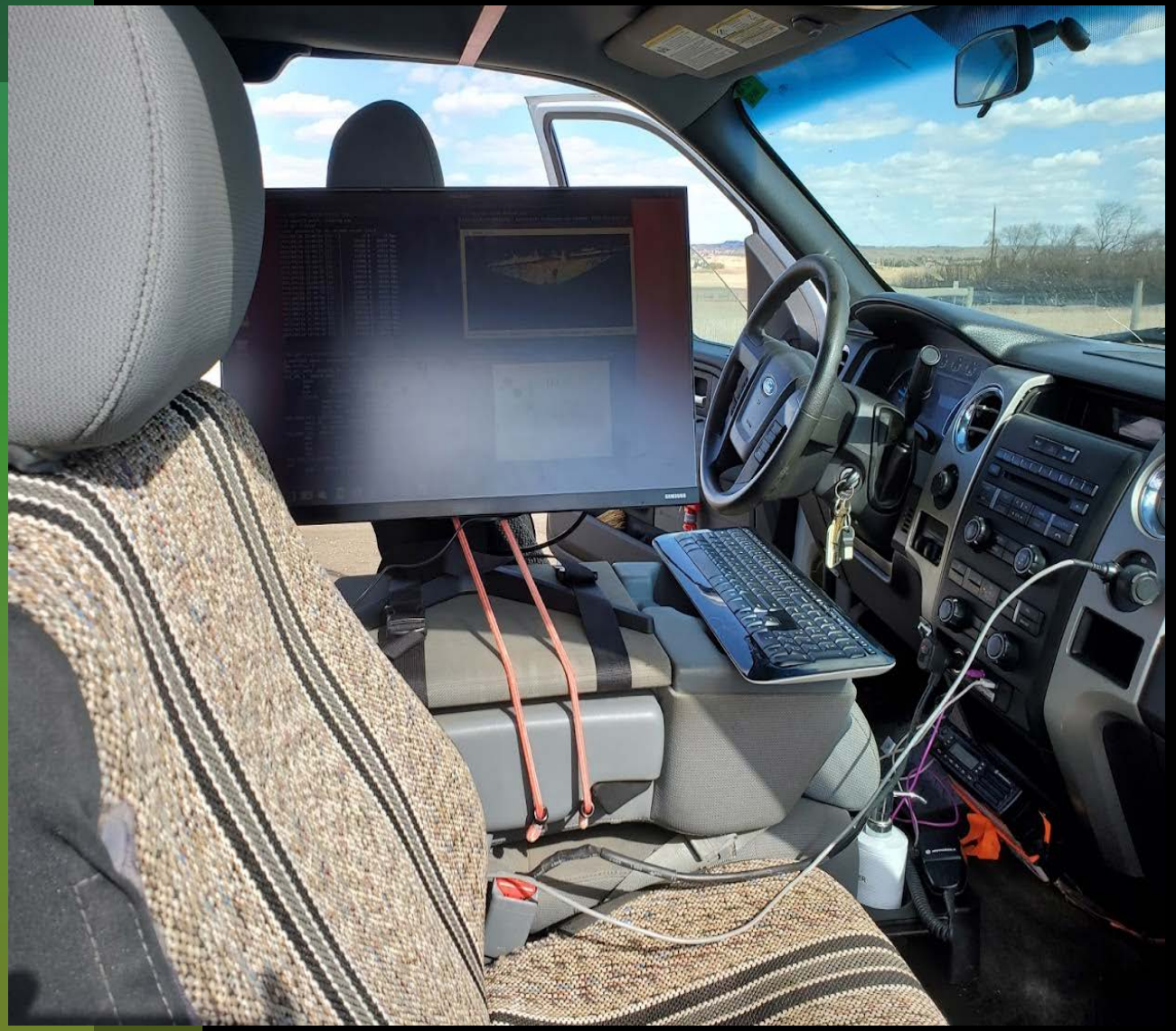
Rural Access - TYPICAL CROSS SECTION SUBGRADE

SCALE: NTS

After much experimentation, we finally chose a solid-state unit with three units to provide 180 degrees of coverage.

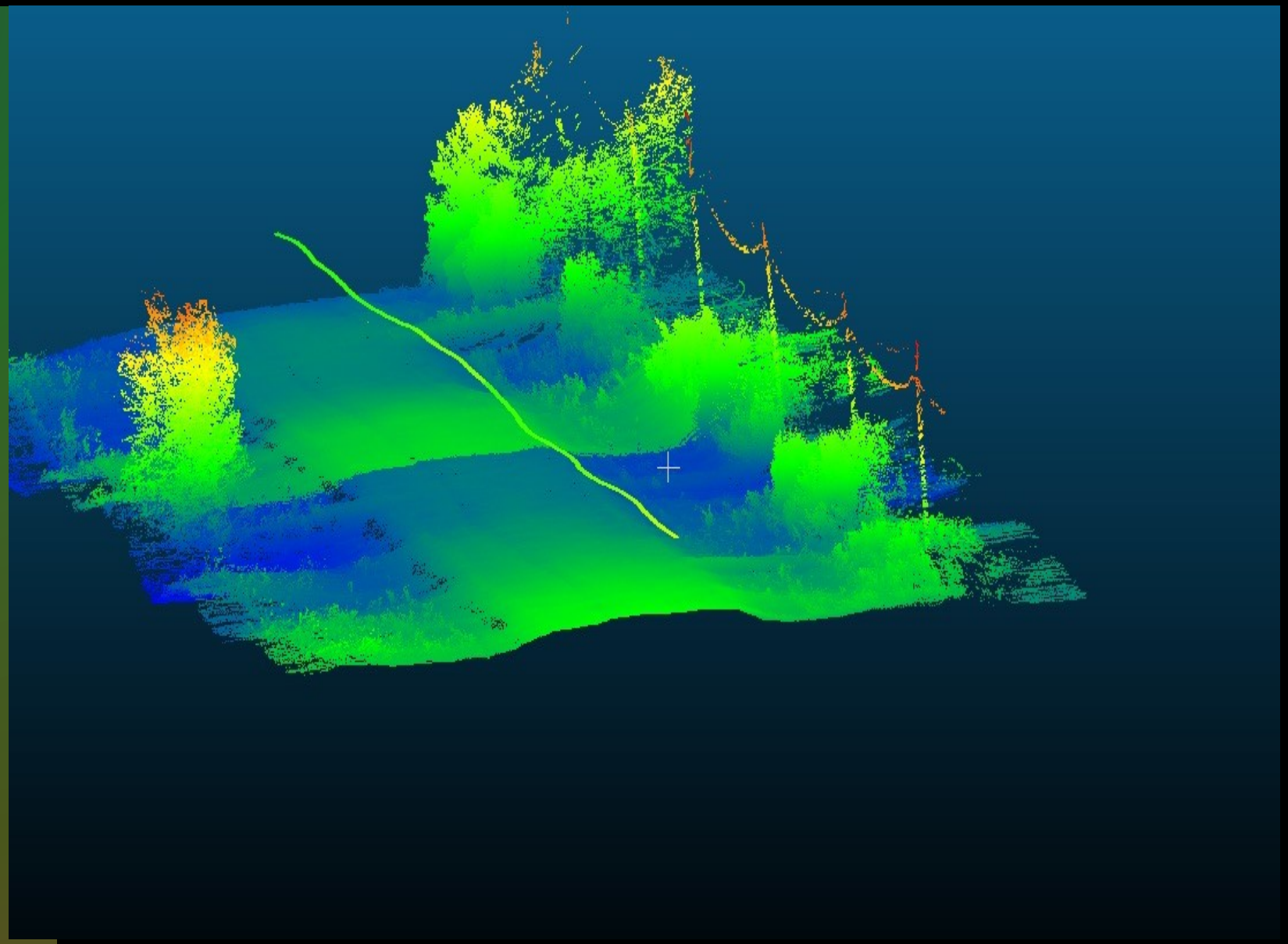

Ford
F150


SAMSUNG

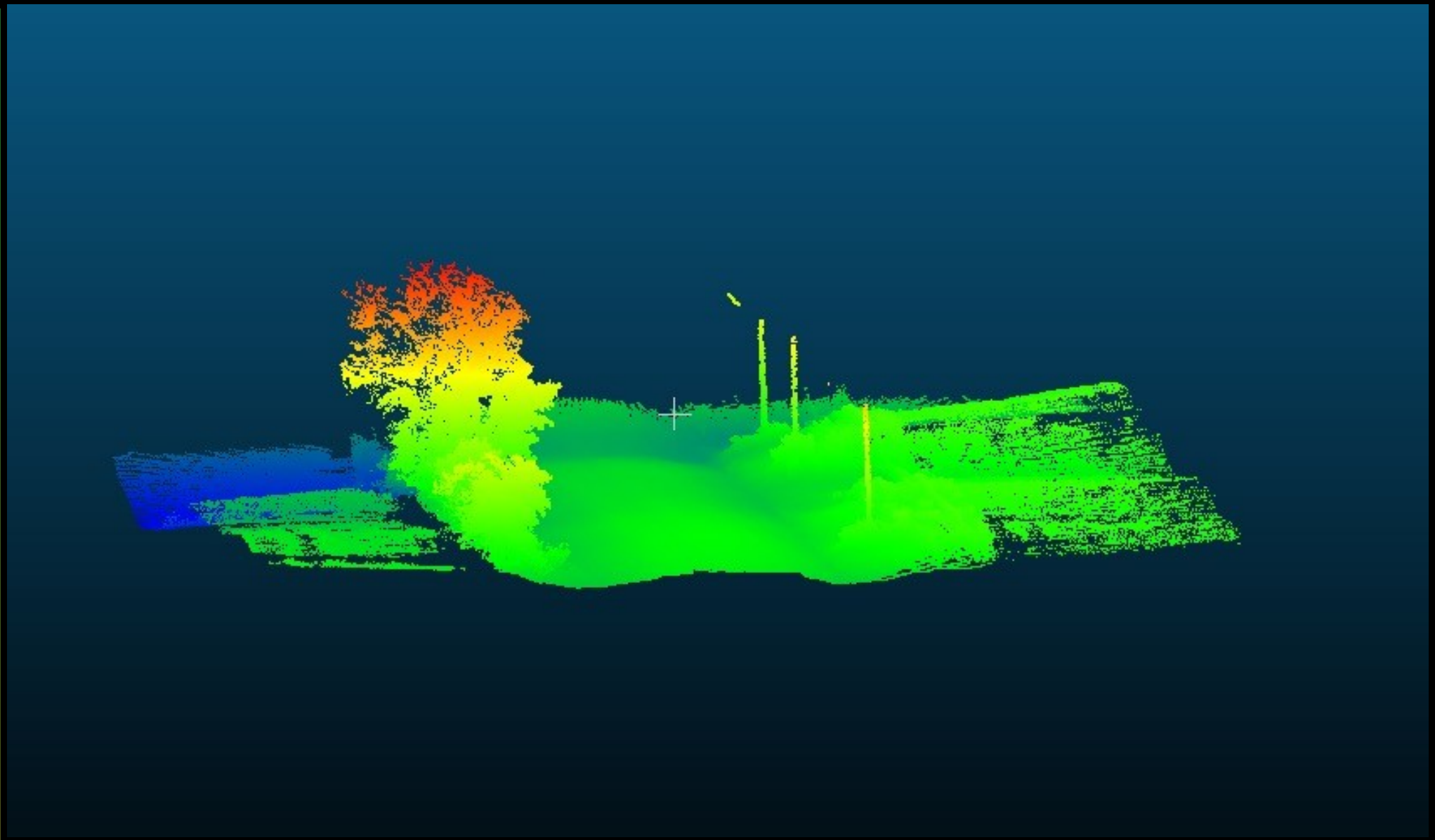


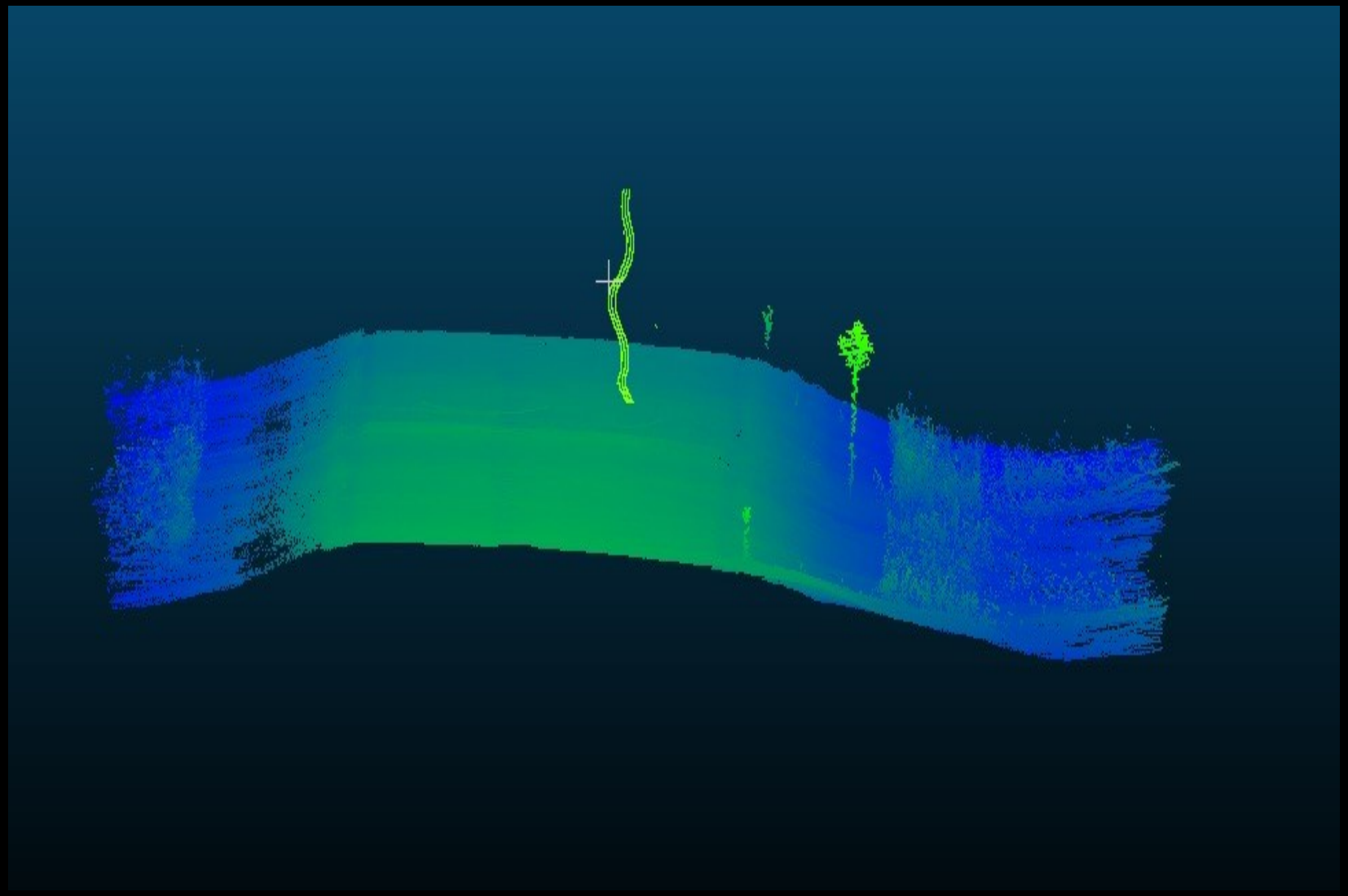
With the solid-state LiDAR and three units each data collection crew could travel at 35-40 kph to retrieve very accurate data.

The unit is affected by heavy dust and rain; this would cause an excessive amount of data points of unusable information. With the weather we had in the spring of 2021 we were able to gather data on approximately 2400 kms of gravel roads in four and half weeks.

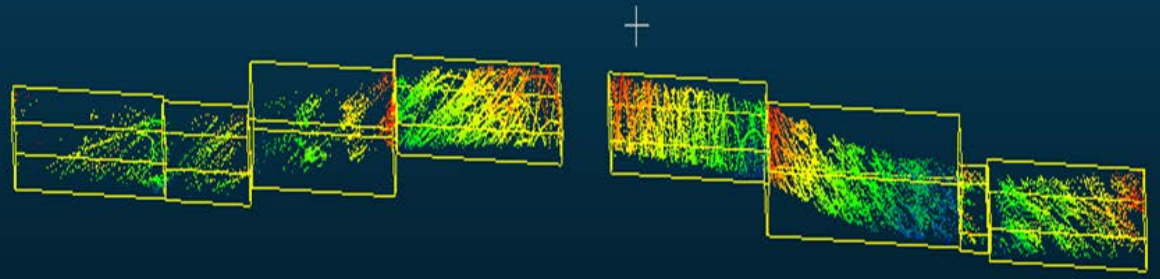


Some of the raw LiDAR data collected before removal of information not needed.

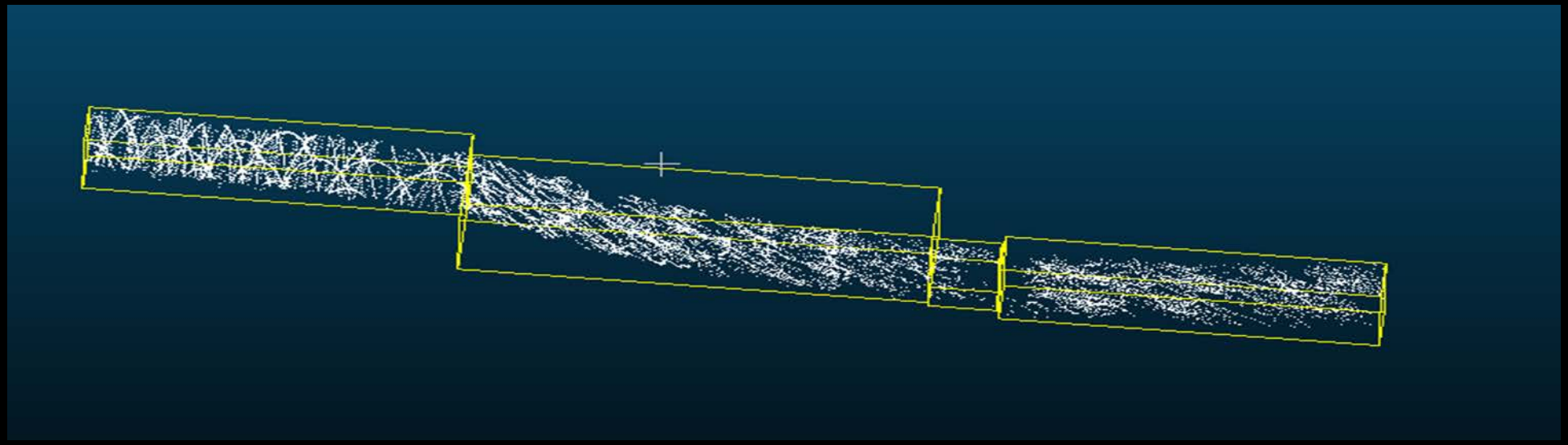


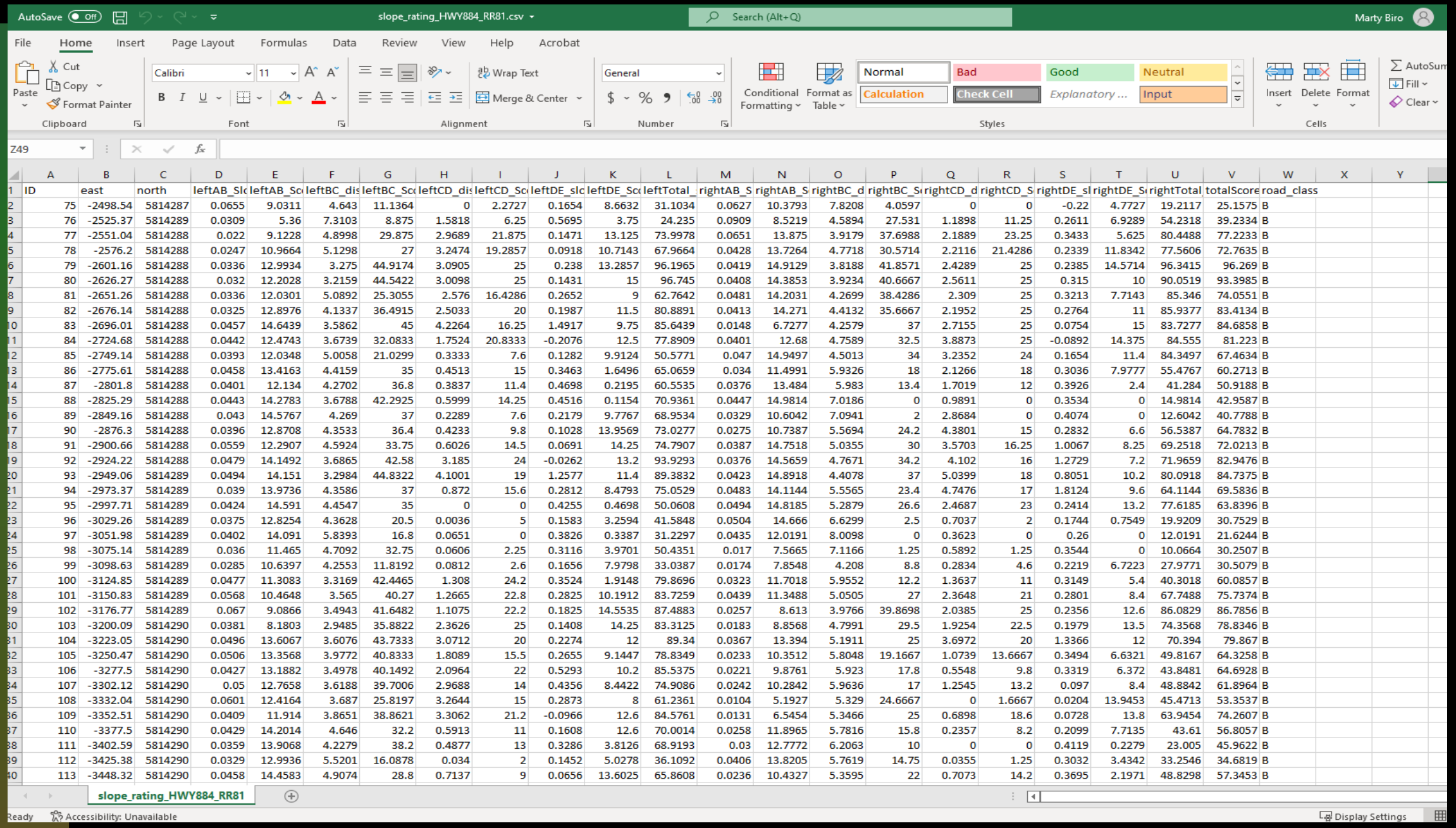


Early Spring as soon as the snow is gone and before any new growth is the best time to collect data. Later in the year mowing of the grass would be required.

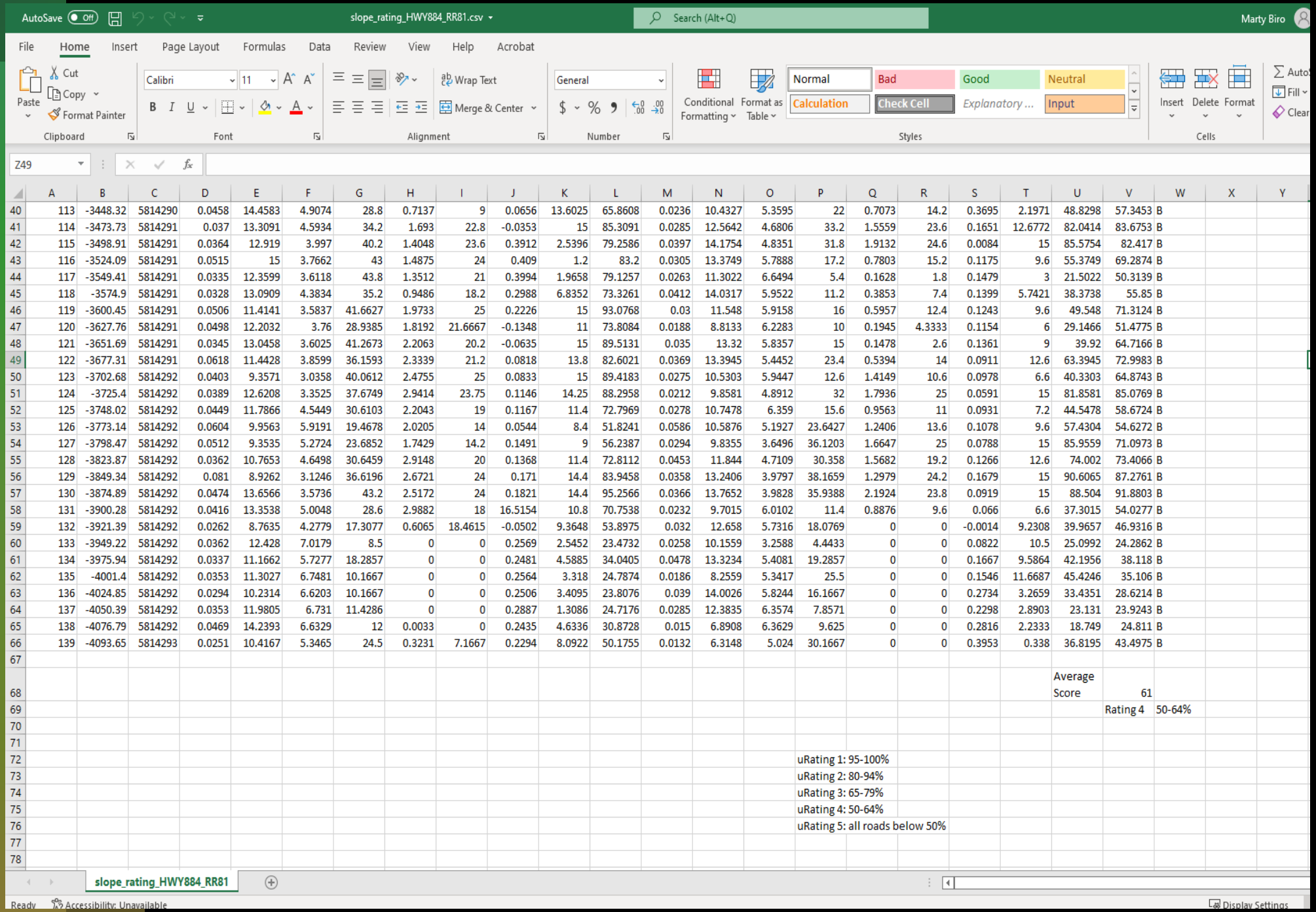


Showing the break down for calculations by section of road and one by half of road.



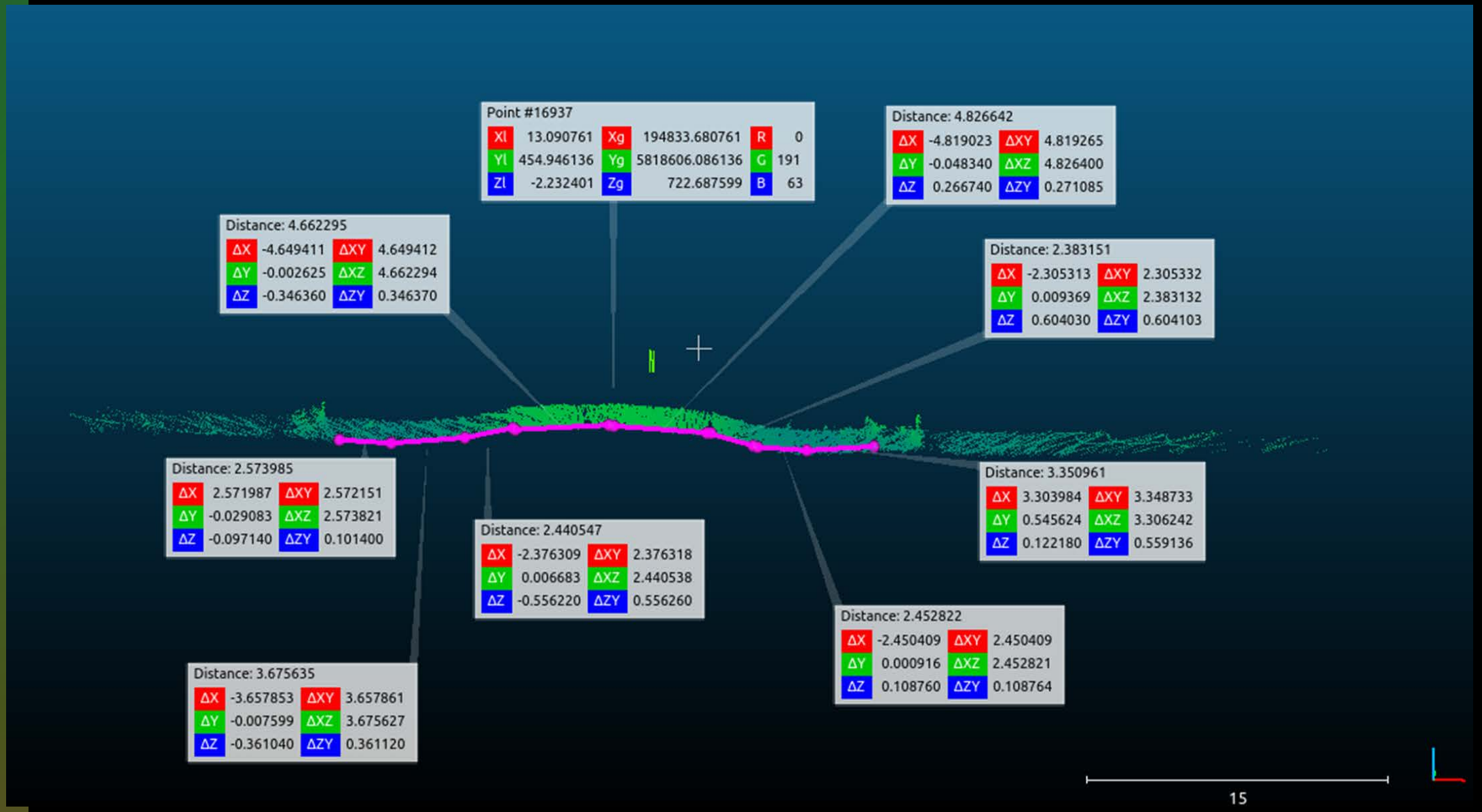


	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1	ID	east	north	leftAB_Slc	leftAB_Sc	leftBC_dis	leftBC_Sc	leftCD_dis	leftCD_Sc	leftDE_slc	leftDE_Sc	leftTotal_	rightAB_S	rightAB_S	rightBC_d	rightBC_S	rightCD_d	rightCD_S	rightDE_sl	rightDE_S	rightTotal	totalScore	road_class
2	75	-2498.54	5814287	0.0655	9.0311	4.643	11.1364	0	2.2727	0.1654	8.6632	31.1034	0.0627	10.3793	7.8208	4.0597	0	0	-0.22	4.7727	19.2117	25.1575	B
3	76	-2525.37	5814289	0.0309	5.36	7.3103	8.875	1.5818	6.25	0.5695	3.75	24.235	0.0909	8.5219	4.5894	27.531	1.1898	11.25	0.2611	6.9289	54.2318	39.2334	B
4	77	-2551.04	5814288	0.022	9.1228	4.8998	29.875	2.9689	21.875	0.1471	13.125	73.9978	0.0651	13.875	3.9179	37.6988	2.1889	23.25	0.3433	5.625	80.4488	77.2233	B
5	78	-2576.2	5814288	0.0247	10.9664	5.1298	27	3.2474	19.2857	0.0918	10.7143	67.9664	0.0428	13.7264	4.7718	30.5714	2.2116	21.4286	0.2339	11.8342	77.5606	72.7635	B
6	79	-2601.16	5814288	0.0336	12.9934	3.275	44.9174	3.0905	25	0.238	13.2857	96.1965	0.0419	14.9129	3.8188	41.8571	2.4289	25	0.2385	14.5714	96.3415	96.269	B
7	80	-2626.27	5814288	0.032	12.2028	3.2159	44.5422	3.0098	25	0.1431	15	96.745	0.0408	14.3853	3.9234	40.6667	2.5611	25	0.315	10	90.0519	93.3985	B
8	81	-2651.26	5814288	0.0336	12.0301	5.0892	25.3055	2.576	16.4286	0.2652	9	62.7642	0.0481	14.2031	4.2699	38.4286	2.309	25	0.3213	7.7143	85.346	74.0551	B
9	82	-2676.14	5814288	0.0325	12.8976	4.1337	36.4915	2.5033	20	0.1987	11.5	80.8891	0.0413	14.271	4.4132	35.6667	2.1952	25	0.2764	11	85.9377	83.4134	B
10	83	-2696.01	5814288	0.0457	14.6439	3.5862	45	4.2264	16.25	1.4917	9.75	85.6439	0.0148	6.7277	4.2579	37	2.7155	25	0.0754	15	83.7277	84.6858	B
11	84	-2724.68	5814288	0.0442	12.4743	3.6739	32.0833	1.7524	20.8333	-0.2076	12.5	77.8909	0.0401	12.68	4.7589	32.5	3.8873	25	-0.0892	14.375	84.555	81.223	B
12	85	-2749.14	5814288	0.0393	12.0348	5.0058	21.0299	0.3333	7.6	0.1282	9.9124	50.5771	0.047	14.9497	4.5013	34	3.2352	24	0.1654	11.4	84.3497	67.4634	B
13	86	-2775.61	5814288	0.0458	13.4163	4.4159	35	0.4513	15	0.3463	1.6496	65.0659	0.034	11.4991	5.9326	18	2.1266	18	0.3036	7.9777	55.4767	60.2713	B
14	87	-2801.8	5814288	0.0401	12.134	4.2702	36.8	0.3837	11.4	0.4698	0.2195	60.5535	0.0376	13.484	5.983	13.4	1.7019	12	0.3926	2.4	41.284	50.9188	B
15	88	-2825.29	5814288	0.0443	14.2783	3.6788	42.2925	0.5999	14.25	0.4516	0.1154	70.9361	0.0447	14.9814	7.0186	0	0.9891	0	0.3534	0	14.9814	42.9587	B
16	89	-2849.16	5814288	0.043	14.5767	4.269	37	0.2289	7.6	0.2179	9.7767	68.9534	0.0329	10.6042	7.0941	2	2.8684	0	0.4074	0	12.6042	40.7788	B
17	90	-2876.3	5814288	0.0396	12.8708	4.3533	36.4	0.4233	9.8	0.1028	13.9569	73.0277	0.0275	10.7387	5.5694	24.2	4.3801	15	0.2832	6.6	56.5387	64.7832	B
18	91	-2900.66	5814288	0.0559	12.2907	4.5924	33.75	0.6026	14.5	0.0691	14.25	74.7907	0.0387	14.7518	5.0355	30	3.5703	16.25	1.0067	8.25	69.2518	72.0213	B
19	92	-2924.22	5814288	0.0479	14.1492	3.6865	42.58	3.185	24	-0.0262	13.2	93.9293	0.0376	14.5659	4.7671	34.2	4.102	16	1.2729	7.2	71.9659	82.9476	B
20	93	-2949.06	5814289	0.0494	14.151	3.2984	44.8322	4.1001	19	1.2577	11.4	89.3832	0.0423	14.8918	4.4078	37	5.0399	18	0.8051	10.2	80.0918	84.7375	B
21	94	-2973.37	5814289	0.039	13.9736	4.3586	37	0.872	15.6	0.2812	8.4793	75.0529	0.0483	14.1144	5.5565	23.4	4.7476	17	1.8124	9.6	64.1144	69.5836	B
22	95	-2997.71	5814289	0.0424	14.591	4.4547	35	0	0	0.4255	0.4698	50.0608	0.0494	14.8185	5.2879	26.6	2.4687	23	0.2414	13.2	77.6185	63.8396	B
23	96	-3029.26	5814289	0.0375	12.8254	4.3628	20.5	0.0036	5	0.1583	3.2594	41.5848	0.0504	14.666	6.6299	2.5	0.7037	2	0.1744	0.7549	19.9209	30.7529	B
24	97	-3051.98	5814289	0.0402	14.091	5.8393	16.8	0.0651	0	0.3826	0.3387	31.2297	0.0435	12.0191	8.0098	0	0.3623	0	0.26	0	12.0191	21.6244	B
25	98	-3075.14	5814289	0.036	11.465	4.7092	32.75	0.0606	2.25	0.3116	3.9701	50.4351	0.017	7.5665	7.1166	1.25	0.5892	1.25	0.3544	0	10.0664	30.2507	B
26	99	-3098.63	5814289	0.0285	10.6397	4.2553	11.8192	0.0812	2.6	0.1656	7.9798	33.0387	0.0174	7.8548	4.208	8.8	0.2834	4.6	0.2219	6.7223	27.9771	30.5079	B
27	100	-3124.85	5814289	0.0477	11.3083	3.3169	42.4465	1.308	24.2	0.3524	1.9148	79.8696	0.0323	11.7018	5.9552	12.2	1.3637	11	0.3149	5.4	40.3018	60.0857	B
28	101	-3150.83	5814289	0.0568	10.4648	3.565	40.27	1.2665	22.8	0.2825	10.1912	83.7259	0.0439	11.3488	5.0505	27	2.3648	21	0.2801	8.4	67.7488	75.7374	B
29	102	-3176.77	5814289	0.067	9.0866	3.4943	41.6482	1.1075	22.2	0.1825	14.5535	87.4883	0.0257	8.613	3.9766	39.8698	2.0385	25	0.2356	12.6	86.0829	86.7856	B
30	103	-3200.09	5814290	0.0381	8.1803	2.9485	35.8822	2.3626	25	0.1408	14.25	83.3125	0.0183	8.8568	4.7991	29.5	1.9254	22.5	0.1979	13.5	74.3568	78.8346	B
31	104	-3223.05	5814290	0.0496	13.6067	3.6076	43.7333	3.0712	20	0.2274	12	89.34	0.0367	13.394	5.1911	25	3.6972	20	1.3366	12	70.394	79.867	B
32	105	-3250.47	5814290	0.0506	13.3568	3.9772	40.8333	1.8089	15.5	0.2655	9.1447	78.8349	0.0233	10.3512	5.8048	19.1667	1.0739	13.6667	0.3494	6.6321	49.8167	64.3258	B
33	106	-3277.5	5814290	0.0427	13.1882	3.4978	40.1492	2.0964	22	0.5293	10.2	85.5375	0.0221	9.8761	5.923	17.8	0.5548	9.8	0.3319	6.372	43.8481	64.6928	B
34	107	-3302.12	5814290	0.05	12.7658	3.6188	39.7006	2.9688	14	0.4356	8.4422	74.9086	0.0242	10.2842	5.9636	17	1.2545	13.2	0.097	8.4	48.8842	61.8964	B
35	108	-3332.04	5814290	0.0601	12.4164	3.687	25.8197	3.2644	15	0.2873	8	61.2361	0.0104	5.1927	5.329	24.6667	0	1.6667	0.0204	13.9453	45.4713	53.3537	B
36	109	-3352.51	5814290	0.0409	11.914	3.8651	38.8621	3.3062	21.2	-0.0966	12.6	84.5761	0.0131	6.5454	5.3466	25	0.6898	18.6	0.0728	13.8	63.9454	74.2607	B
37	110	-3377.5	5814290	0.0429	14.2014	4.646	32.2	0.5913	11	0.1608	12.6	70.0014	0.0258	11.8965	5.7816	15.8	0.2357	8.2	0.2099	7.7135	43.61	56.8057	B
38	111	-3402.59	5814290	0.0359	13.9068	4.2279	38.2	0.4877	13	0.3286	3.8126	68.9193	0.03	12.7772	6.2063	10	0	0	0.4119	0.2279	23.005	45.9622	B
39	112	-3425.38	5814290	0.0329	12.9936	5.5201	16.0878	0.034	2	0.1452	5.0278	36.1092	0.0406	13.8205	5.7619	14.75	0.0355	1.25	0.3032	3.4342	33.2546	34.6819	B
40	113	-3448.32	5814290	0.0458	14.4583	4.9074	28.8	0.7137	9	0.0656	13.6025	65.8608	0.0236	10.4327	5.3595	22	0.7073	14.2	0.3695	2.1971	48.8298	57.3453	B



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
40	113	-3448.32	5814290	0.0458	14.4583	4.9074	28.8	0.7137	9	0.0656	13.6025	65.8608	0.0236	10.4327	5.3595	22	0.7073	14.2	0.3695	2.1971	48.8298	57.3453	B
41	114	-3473.73	5814291	0.037	13.3091	4.5934	34.2	1.693	22.8	-0.0353	15	85.3091	0.0285	12.5642	4.6806	33.2	1.5559	23.6	0.1651	12.6772	82.0414	83.6753	B
42	115	-3498.91	5814291	0.0364	12.919	3.997	40.2	1.4048	23.6	0.3912	2.5396	79.2586	0.0397	14.1754	4.8351	31.8	1.9132	24.6	0.0084	15	85.5754	82.417	B
43	116	-3524.09	5814291	0.0515	15	3.7662	43	1.4875	24	0.409	1.2	83.2	0.0305	13.3749	5.7888	17.2	0.7803	15.2	0.1175	9.6	55.3749	69.2874	B
44	117	-3549.41	5814291	0.0335	12.3599	3.6118	43.8	1.3512	21	0.3994	1.9658	79.1257	0.0263	11.3022	6.6494	5.4	0.1628	1.8	0.1479	3	21.5022	50.3139	B
45	118	-3574.9	5814291	0.0328	13.0909	4.3834	35.2	0.9486	18.2	0.2988	6.8352	73.3261	0.0412	14.0317	5.9522	11.2	0.3853	7.4	0.1399	5.7421	38.3738	55.85	B
46	119	-3600.45	5814291	0.0506	11.4141	3.5837	41.6627	1.9733	25	0.2226	15	93.0768	0.03	11.548	5.9158	16	0.5957	12.4	0.1243	9.6	49.548	71.3124	B
47	120	-3627.76	5814291	0.0498	12.2032	3.76	28.9385	1.8192	21.6667	-0.1348	11	73.8084	0.0188	8.8133	6.2283	10	0.1945	4.3333	0.1154	6	29.1466	51.4775	B
48	121	-3651.69	5814291	0.0345	13.0458	3.6025	41.2673	2.2063	20.2	-0.0635	15	89.5131	0.035	13.32	5.8357	15	0.1478	2.6	0.1361	9	39.92	64.7166	B
49	122	-3677.31	5814291	0.0618	11.4428	3.8599	36.1593	2.3339	21.2	0.0818	13.8	82.6021	0.0369	13.3945	5.4452	23.4	0.5394	14	0.0911	12.6	63.3945	72.9983	B
50	123	-3702.68	5814292	0.0403	9.3571	3.0358	40.0612	2.4755	25	0.0833	15	89.4183	0.0275	10.5303	5.9447	12.6	1.4149	10.6	0.0978	6.6	40.3303	64.8743	B
51	124	-3725.4	5814292	0.0389	12.6208	3.3525	37.6749	2.9414	23.75	0.1146	14.25	88.2958	0.0212	9.8581	4.8912	32	1.7936	25	0.0591	15	81.8581	85.0769	B
52	125	-3748.02	5814292	0.0449	11.7866	4.5449	30.6103	2.2043	19	0.1167	11.4	72.7969	0.0278	10.7478	6.359	15.6	0.9563	11	0.0931	7.2	44.5478	58.6724	B
53	126	-3773.14	5814292	0.0604	9.9563	5.9191	19.4678	2.0205	14	0.0544	8.4	51.8241	0.0586	10.5876	5.1927	23.6427	1.2406	13.6	0.1078	9.6	57.4304	54.6272	B
54	127	-3798.47	5814292	0.0512	9.3535	5.2724	23.6852	1.7429	14.2	0.1491	9	56.2387	0.0294	9.8355	3.6496	36.1203	1.6647	25	0.0788	15	85.9559	71.0973	B
55	128	-3823.87	5814292	0.0362	10.7653	4.6498	30.6459	2.9148	20	0.1368	11.4	72.8112	0.0453	11.844	4.7109	30.358	1.5682	19.2	0.1266	12.6	74.002	73.4066	B
56	129	-3849.34	5814292	0.081	8.9262	3.1246	36.6196	2.6721	24	0.171	14.4	83.9458	0.0358	13.2406	3.9797	38.1659	1.2979	24.2	0.1679	15	90.6065	87.2761	B
57	130	-3874.89	5814292	0.0474	13.6566	3.5736	43.2	2.5172	24	0.1821	14.4	95.2566	0.0366	13.7652	3.9828	35.9388	2.1924	23.8	0.0919	15	88.504	91.8803	B
58	131	-3900.28	5814292	0.0416	13.3538	5.0048	28.6	2.9882	18	16.5154	10.8	70.7538	0.0232	9.7015	6.0102	11.4	0.8876	9.6	0.066	6.6	37.3015	54.0277	B
59	132	-3921.39	5814292	0.0262	8.7635	4.2779	17.3077	0.6065	18.4615	-0.0502	9.3648	53.8975	0.032	12.658	5.7316	18.0769	0	0	-0.0014	9.2308	39.9657	46.9316	B
60	133	-3949.22	5814292	0.0362	12.428	7.0179	8.5	0	0	0.2569	2.5452	23.4732	0.0258	10.1559	3.2588	4.4433	0	0	0.0822	10.5	25.0992	24.2862	B
61	134	-3975.94	5814292	0.0337	11.1662	5.7277	18.2857	0	0	0.2481	4.5885	34.0405	0.0478	13.3234	5.4081	19.2857	0	0	0.1667	9.5864	42.1956	38.118	B
62	135	-4001.4	5814292	0.0353	11.3027	6.7481	10.1667	0	0	0.2564	3.318	24.7874	0.0186	8.2559	5.3417	25.5	0	0	0.1546	11.6687	45.4246	35.106	B
63	136	-4024.85	5814292	0.0294	10.2314	6.6203	10.1667	0	0	0.2506	3.4095	23.8076	0.039	14.0026	5.8244	16.1667	0	0	0.2734	3.2659	33.4351	28.6214	B
64	137	-4050.39	5814292	0.0353	11.9805	6.731	11.4286	0	0	0.2887	1.3086	24.7176	0.0285	12.3835	6.3574	7.8571	0	0	0.2298	2.8903	23.131	23.9243	B
65	138	-4076.79	5814292	0.0469	14.2393	6.6329	12	0.0033	0	0.2435	4.6336	30.8728	0.015	6.8908	6.3629	9.625	0	0	0.2816	2.2333	18.749	24.811	B
66	139	-4093.65	5814293	0.0251	10.4167	5.3465	24.5	0.3231	7.1667	0.2294	8.0922	50.1755	0.0132	6.3148	5.024	30.1667	0	0	0.3953	0.338	36.8195	43.4975	B
67																							
68																					Average Score	61	
69																						Rating 4	50-64%
70																							
71																							
72																uRating 1: 95-100%							
73																uRating 2: 80-94%							
74																uRating 3: 65-79%							
75																uRating 4: 50-64%							
76																uRating 5: all roads below 50%							
77																							
78																							

This slide and previous slide shows the data collected from one mile with a total of 139 cross section measurements in that mile.


Point #16937
Xl 13.090761 Xg 194833.680761 R 0
Yl 454.946136 Yg 5818606.086136 G 191
Zl -2.232401 Zg 722.687599 B 63
Distance: 4.826642
ΔX -4.819023 ΔXY 4.819265
ΔY -0.048340 ΔXZ 4.826400
ΔZ 0.266740 ΔZY 0.271085
Distance: 4.662295
ΔX -4.649411 ΔXY 4.649412
ΔY -0.002625 ΔXZ 4.662294
ΔZ -0.346360 ΔZY 0.346370
Distance: 2.383151
ΔX -2.305313 ΔXY 2.305332
ΔY 0.009369 ΔXZ 2.383132
ΔZ 0.604030 ΔZY 0.604103
Distance: 2.573985
ΔX 2.571987 ΔXY 2.572151
ΔY -0.029083 ΔXZ 2.573821
ΔZ -0.097140 ΔZY 0.101400
Distance: 2.440547
ΔX -2.376309 ΔXY 2.376318
ΔY 0.006683 ΔXZ 2.440538
ΔZ -0.556220 ΔZY 0.556260
Distance: 3.350961
ΔX 3.303984 ΔXY 3.348733
ΔY 0.545624 ΔXZ 3.306242
ΔZ 0.122180 ΔZY 0.559136
Distance: 2.452822
ΔX -2.450409 ΔXY 2.450409
ΔY 0.000916 ΔXZ 2.452821
ΔZ 0.108760 ΔZY 0.108764
Distance: 3.675635
ΔX -3.657853 ΔXY 3.657861
ΔY -0.007599 ΔXZ 3.675627
ΔZ -0.361040 ΔZY 0.361120
15

Challenges to Implementation

- Translating technology-driven evaluations to real-world outcomes takes dedication, work and culture change.
- Politics thrives on ignorance, while governance thrives on data : the former is fun, the latter is hard.
- Overcoming cynicism and resistance to technology is difficult.
- Crafting and utilizing asset management solutions such as this as a means to an end, and not an end in and of themselves.

In Conclusion – LiDAR Lessons Learned

- Provides an objective, consistent baseline for condition evaluation of gravel roads.
- Removes semantics by eliminating human interpretation and replacing it with standardized, objective evaluation using technology.
- Removes politics from infrastructure management and planning.
- Provides an easy to understand, easy to digest representation of quality for non-expert decision makers.
- Is quick, efficient, accurate and uses minimal human resources.
- Validates outcomes and provides a common, centralized record upon which to build institutional knowledge.