CHAPTER 5 - OBJECTIVE MEASUREMENTS

FIELD MEASUREMENTS AND OBJECTIVE RATING SYSTEM

The evaluation team used two methods to rate the roadway sections for dust, washboarding, raveling, rutting, and potholing. The first, discussed in Chapter 4, was a subjective and comparative method. The second method, discussed here, was an objective method with specific criteria, as presented in Appendix B, to use for the rating. Using the objective criteria, the product ratings could be compared over time, and deterioration of the roadbed over time would naturally be captured in the ratings.

This objective rating system focused on measuring rather than observing. Each monitoring location was an area 7.6 m (25 ft) long and the width of the roadbed. The depth of washboarding, raveling, rutting, and potholing occurring within the 7.6-m (25-ft) long area could all be measured. Using the appropriate Appendix B descriptive conversion table, the measurements data for each parameter were converted into a rating.

Monitoring locations were determined in advance and listed in the Monitoring Order and Mileposts Plan shown in Appendix A so that they would be uniquely located in each section and not result in a repeat monitoring of any particular location. Due to the repairs of the damage caused by rapid snow melt in the spring of 2005, the available area for monitoring in Section V was reduced and many of the planned monitoring locations in that section had to be moved. The monitoring locations in Section VI were also different from sections I through IV because Section VI was longer than the other five sections. The final monitoring locations for each event are shown in Appendix C along with all the measurement data that was collected.

During each monitoring event, four 7.6-m (25-ft) long locations were monitored in each of the six sections. To assist in finding the prescribed monitoring locations, the beginning of each treated section was semi-permanently marked with a steel fence post. The 7.6-m (25-ft) long monitoring locations were located by driving to the beginning of each section, setting the vehicle's trip counter to zero, driving to the tenth-of-the-mile point, and using a surveyor's wheel as shown in Figure 16 to find the hundredth-of-a-mile location specified in the Monitoring Order and Mileposts Plan. A 7.6-m (25-ft) long area was then measured off behind the point location to set the boundaries for the data collection.

Figure 16. Photo. Locating specified monitoring area.

To illustrate how the objective measurements system worked, Table 8, shows the measurements that were taken for raveling during the 20-month monitoring event in August 2005. According to the assessment methodology described for raveling in Appendix B, three raveling depths – right, center, and left - were recorded at each location. These depths were averaged. Once the average depths of raveling at each of four locations in a section were obtained, they were then averaged to give a section average. Referring to the descriptive table for raveling in Appendix B, the section average was converted to a rating for that section. Therefore, by way of example, at the 20-month event, the average depth of raveling for the TerraZyme section was 16 mm (0.6 in). This converts to a rating of 6, defined as loose material between 15 mm (0.6 in) and 20 mm (0.8 in) thick, for raveling in the TerraZyme section during the 20-month event.

The benefits of the objective measurement system was its success in both capturing subtle differences in performance of the sections and providing a way to compare performance over time. It was discovered through use that it also had one glaring limitation – the predetermined monitoring areas did not align with what were, in the opinion of the monitoring team, some of the poorer performing parts of a section as observed visually. Therefore the subjective judgments of the monitoring team were not necessarily reflected in the objective ratings. This difference could be minimized by taking more on-site samples.

Table 8. Raveling measurements from the 20-month event converted to objective rating.

Section	MP	Rt.	CL	Lt.	Avg. Depth (mm)	Section Avg. (mm)	Objective Rating
I - Terra-Zyme	0.05	11	13	22	15		
	0.18	18	12	11	14		
	0.33	20	16	28	21		
	0.52	13	10	23	15	16	6
II - Ligno-sulfonate	0.05	16	8	12	12		
	0.18	12	8	16	12		
	0.33	13	7	17	12		
	0.52	13	12	13	13	12	7
III - Perma-Zyme	0.05	22	7	13	14		
	0.18	22	11	26	20		
	0.33	30	15	12	19		
	0.52	8	14	13	12	16	6
IV - Soil Sement	0.05	38	22	21	27		
	0.18	18	14	27	20		
	0.33	30	21	18	23		
	0.52	25	26	19	23	23	5
V - DCA 2000 Caliber	0.05	19	30	23	24		
	0.18	17	20	17	18		
	0.35	20	15	20	18		
	0.54	10	10	12	11	18	6
VI - DMC 820 (Mag/Lig)	0.05	4	16	16	12		
	0.25	10	11	19	13		
	0.45	10	17	16	14		
	0.55	11	28	20	20	15	7

FIELD MEASUREMENTS TABLE AND OBSERVATIONS

Whereas Table 8 shows the objective raveling rating for each product at one monitoring event, Table 9 combines the ratings from four events into an overall rating for each parameter as well as an overall objective rating for each product considering all five parameters. Approximately 1300

Table 9. Objective ratings from field measurements.

Test Section	Product	Event	Dust		Washboard			Raveling			Rutting			Potholing			Objective Overall Rating (x10)
			Agreed Rating	Overall Rating	Avg. Depth (mm)	Rating	Overall Rating	Avg. Depth (mm)	Rating	Overall Rating	Avg. Depth (mm)	Rating	Overall Rating	Avg. Depth (mm)	Rating	Overall Rating	
I	Terra-Zyme	8-mo.	6	5.3	0.0	10	8.8	18.6	6	6.3	0.0	10	8.5	0.0	10	9.3	76
		11-mo.	5		6.0	8		9.8	8		2.8	9		17.0	7		
		20-mo.	4		3.9	9		16.4	6		10.4	7		0.0	10		
		23-mo.	6		7.7	8		20.4	5		7.9	8		0.0	10		
II	Ligno-sulfonate	8-mo.	8	7.3	0.0	10	9.3	8.8	8	7.5	0.0	10	9.0	0.0	10	10.0	86
		11-mo.	8		0.5	9		6.6	8		1.7	9		0.0	10		
		20-mo.	4		0.5	9		12.3	7		5.0	8		0.0	10		
		23-mo.	9		4.7	9		12.7	7		1.3	9		0.0	10		
III	Perma-Zyme	8-mo.	7	6.0	0.0	10	9.3	14.8	7	6.8	12.4	7	8.3	0.0	10	10.0	81
		11-mo.	5		4.4	9		12.8	7		8.2	8		0.0	10		
		20-mo.	5		3.6	9		16.1	6		7.0	8		0.0	10		
		23-mo.	7		4.4	9		12.7	7		0.0	10		0.0	10		
IV	Soil Sement	8-mo.	5	4.3	0.0	10	7.8	16.8	6	5.8	0.0	10	8.5	0.0	10	10.0	73
		11-mo.	3		6.9	8		15.2	6		5.6	8		0.0	10		
		20-mo.	4		10.4	7		23.3	5		8.9	8		0.0	10		
		23-mo.	5		17.2	6		16.2	6		8.6	8		0.0	10		
V	DCA-2000 Caliber	8-mo.	6	6.5	0.0	10	9.5	17.8	6	6.8	0.0	10	8.0	0.0	10	10.0	82
		11-mo.	5		0.0	10		9.3	8		5.5	8		0.0	10		
		20-mo.	8		1.0	9		17.8	6		10.3	7		0.0	10		
		23-mo.	7		0.8	9		12.8	7		14.1	7		0.0	10		
VI	Mag/Lig	8-mo.	8	8.0	0.0	10	9.3	12.3	7	7.3	0.0	10	8.8	0.0	10	10.0	87
		11-mo.	8		0.0	10		7.8	8		1.9	9		0.0	10		
		20-mo.	7		3.8	9		14.8	7		5.6	8		0.0	10		
		23-mo.	9		7.0	8		10.9	7		8.6	8		0.0	10		

measurements support Table 9. For all parameters except dust, which was a rating agreed upon by the evaluators, field measurements were taken and averaged. While the averaged numbers shown in the table are a higher precision than the original measurements, the precision was maintained to capture subtle variations between the products.

For dust, no objective dust measurements were actually made. Rather, the team directly used the rating descriptions for dust in Appendix B and together agreed on the appropriate rating for each section. The evaluation team was aware that some dust measuring devices exist, but decided that transporting such a device the distance to this remote project location (which also describes most projects within CFLHD's 14-state coverage area) was not feasible.

One of the greatest strengths of the objective rating system was that performance trends over time could be plotted and reviewed. The following five subsections discuss these trends for each of the five evaluations parameters.

Dust Abatement Trends

For all of the monitoring events – at 8, 11, 20, and 23 months following the September 2004 construction completion - the weather was dry. This was fortunate as it enabled dust observations to be more comparable over time. The silt load test, discussed in the next chapter, included moisture measurements that confirmed consistent and low moisture contents.

The plot in Figure 17 shows how the products rated over time for dust abatement. The products remained in approximately the same order of effectiveness over time except for the 20-month

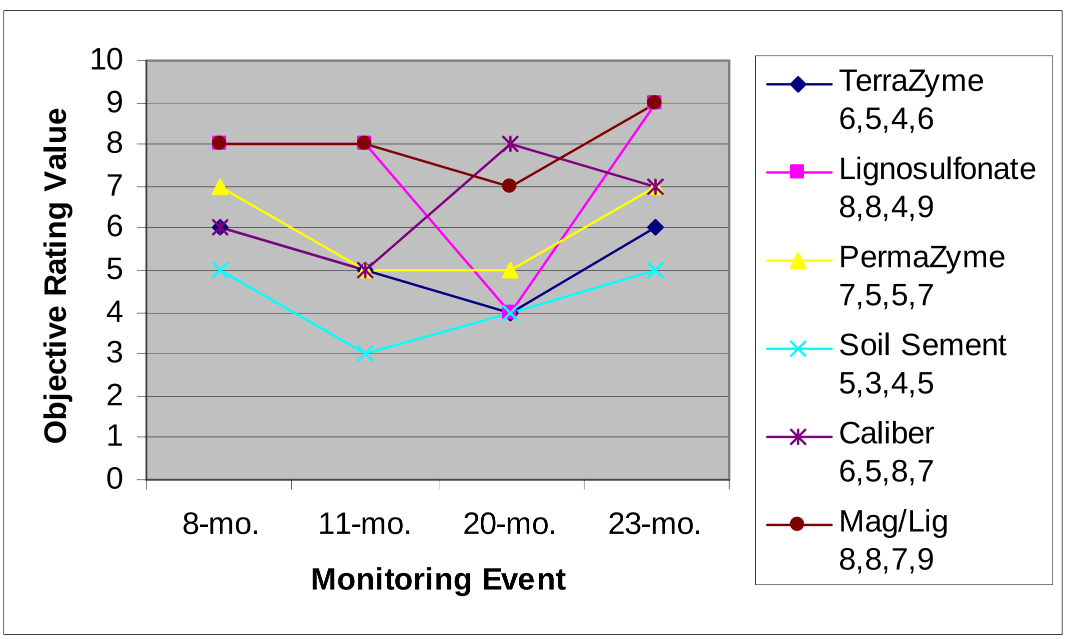

Figure 17. Plot. Dust trends.

event where the Caliber product rose three points due to less observed dust while the Lignosulfonate product dropped four points due more dust production. One explanation for this may be tied to the weather, relative humidity, and product compositions. Though it did not rain during the actual time of monitoring, 4 mm (0.16 in) of rain was recorded for the day. Lignosulfonate appeared particularly sensitive to the dry conditions at Seedskadee and received an agreed dust rating of only 4 that is described, in Appendix B, as significant loss of visibility and some uneasiness driving at 25 mph. Since Lignosulfonate does not pull moisture from the air but rather needs a moist environment, it did not perform at its best. Caliber and Mag/Lig, on the other hand, received the best scores probably because they contained magnesium chloride which absorbs moisture from the air.

It is interesting that all the products at 23 months rated equal to or higher than at 8 months. It would seem that over time, the products should have decreased in effectiveness against dusting, not become more effective. As discussed in the next chapter, silt load testing results also show that dust generation decreased over time. Also, while criteria for a threshold of acceptability under this test may be valuable, the evaluation team did not address it.

Washboarding Trends

The plot in Figure 18 shows how the six products compared over time for washboarding. As would be expected due to the low traffic volumes over the winter months, there was no measurable washboarding at 8 months. By the 20-month event, a year later, all of the sections showed some washboarding. Five products - TerraZyme, Lignosulfonate, PermaZyme, Caliber, and Mag/Lig - had an average rating of 9 and washboarding was barely visible. The four measurement locations within each of these five sections had washboard troughs that were slight

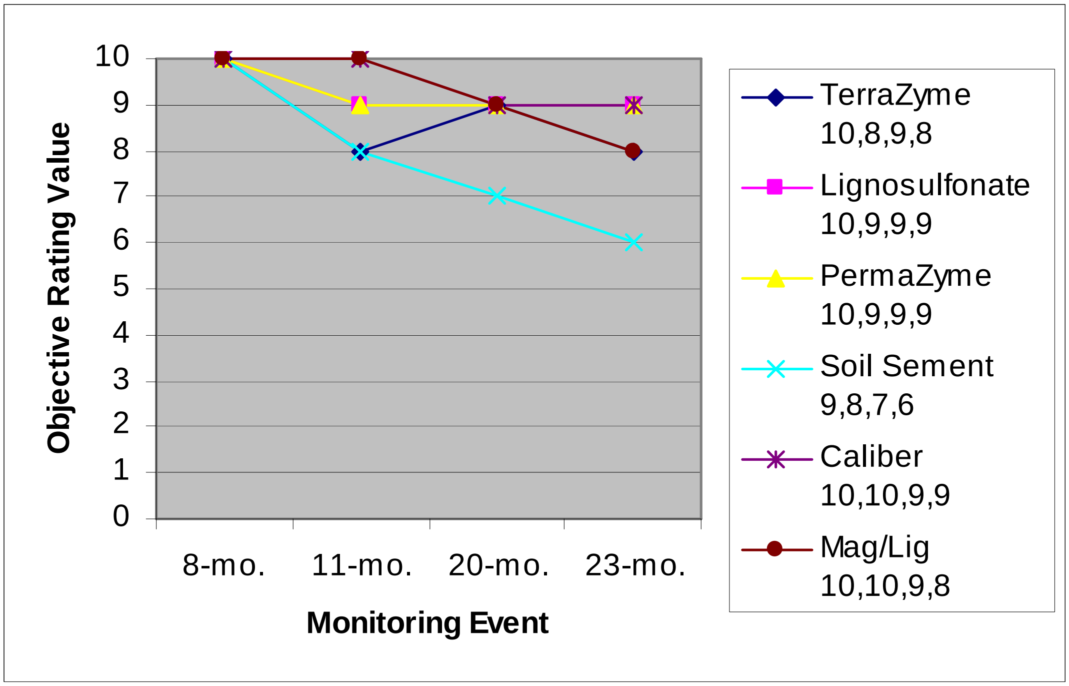

Figure 18. Plot. Washboarding trends.

(less than 13 mm (0.5 in)) or non-existent. This produced an average measured depth of less than 5 mm (0.2 in). The rating descriptions in Appendix B for washboarding convert washboarding troughs less than 5 mm (0.2 in) deep into a rating of 9.

In the final monitoring event at 23 months, washboarding was more prevalent and pronounced than previously measured. The Soil Sement section received the lowest scores over time for washboarding which was observed to be consistent and significant throughout the entire section. The average measured depth of washboarding troughs, which is illustrated in Figure 19, from the four monitoring locations in this section was 17 mm (0.7 in) that converts to a rating of 6. It is notable that both the Soil Sement section and also Caliber section are only 3.7 m (12 ft) wide and therefore typically experience traffic concentrated to only two tracks, yet the Caliber section's average measured depth of washboarding troughs was less than 1 mm (0.04 in) which gave it a rating of 9.

Figure 19. Photo. Measuring washboarding depths.

All the sections had some washboarding by the final monitoring event, but not necessarily throughout their entire lengths. The evaluation team naturally felt some frustration that the predetermined monitoring locations often fell outside of what appeared to be significant washboard areas, but adhered to the predetermined plan so as not to interject bias into the study. The specific monitoring locations were planned without reference to known field conditions and with the objectives of spreading the locations out fairly evenly across the available monitoring area and not repeating any locations.

Raveling Trends

The plot in Figure 20 shows how the products rated over time for raveling. In general, the scores for raveling were lower than for washboarding, though most motorists would probably complain about washboarding long before they complained about raveling. As shown in Figure 20, the amount of raveled material generally increased over time resulting in lower scores over time. Raveling of roadway material appeared to be significant as the average depth of raveled material in a section, as shown in Table 9, ranged from 7 to 23 mm (0.3 to 0.9 in). Again the scores that each section received were dependent on the specific locations of the four 7.6-m (25-ft) long measurement areas within each section. It also should be noted that both curves and travel speeds are important factors in kicking loose material to one side or the other, and there was

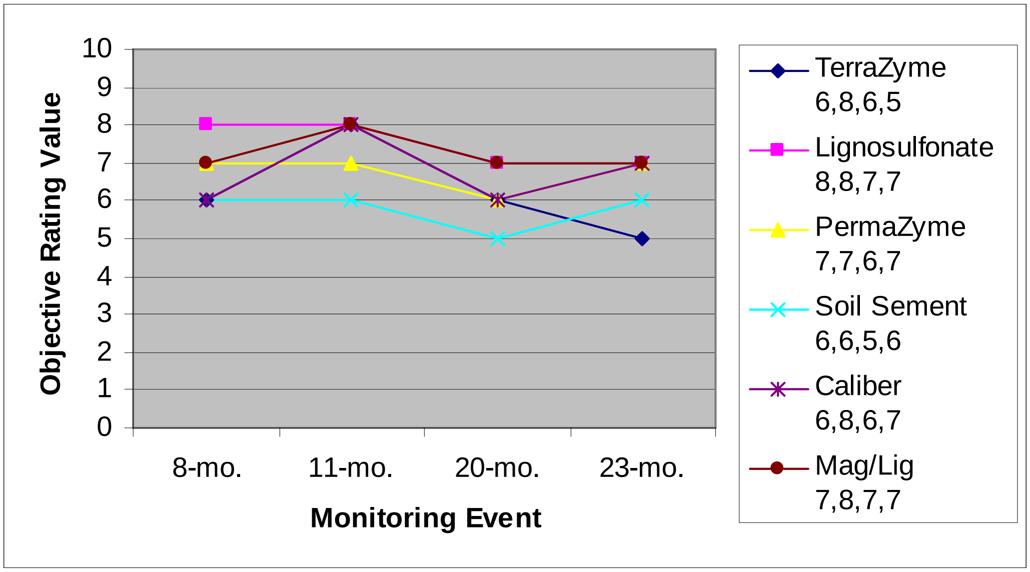

Figure 20. Plot. Raveling trends.

consistently more raveling on the outside of curves throughout all the sections. All measurement data is provided in Appendix C, and comments on road geometry are provided as well.

Rutting Trends

The plot in Figure 21 shows how the products rated over time for rutting. Generally, some rutting developed over time in all the sections. Rutting was measured multiple times in each wheel path within a 7.6-m (25-ft) long location, and an average depth reported for each wheel path. Final rutting depths for any of the products were not over 15 mm (0.6 in), and since traffic volumes were so low at the Seedskadee Refuge, it may not have been sufficient to cause extensive rutting. The only really significant rutting seemed to be on the Bureau of Land

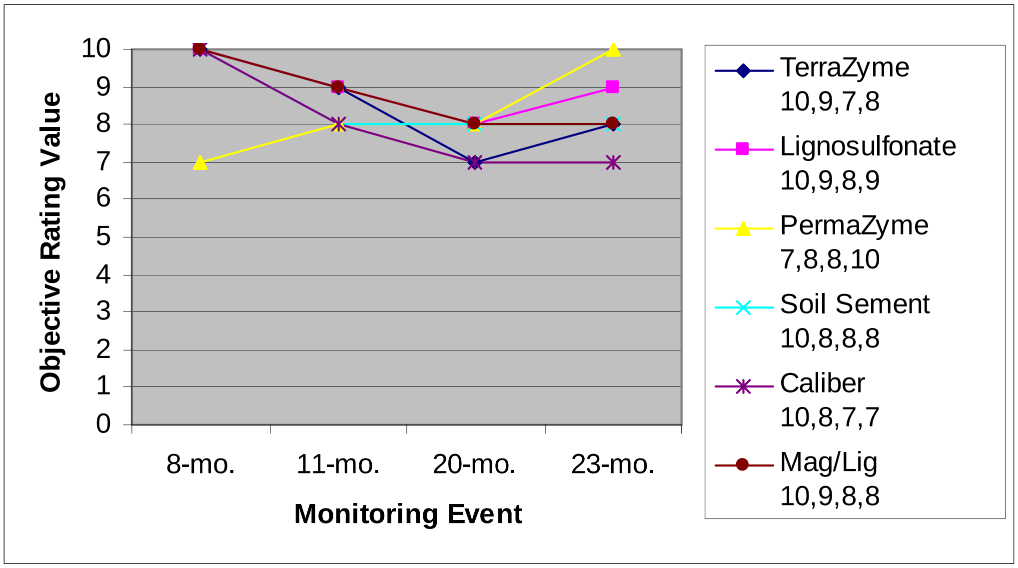

Figure 21. Plot. Rutting trends.

Management (BLM) access roads between the highway and the Refuge boundaries. But since these roads were not reconstructed as part of the Seedskadee project, these BLM access road ruts were not physically measured.

Though the objective measurements in the PermaZyme section show decreased rutting (higher scores) over time, this result is likely due to the variability of the distress within the section's four monitoring areas at any given event. For example, at the 8-month event, rutting was measured at three locations in PermaZyme section, and no other rutting was measured in any other section on the entire project. Thus PermaZyme received the lowest score at the 8-month event. But in the final 23-month monitoring event, no rutting was measured in any of the four monitoring locations in PermaZyme section, and all of the other sections' measurements showed some rutting.

Potholing Trends

The plot in Figure 22 shows how the products rated over time for potholing. It was not known at the beginning of the study whether there would be potholing or not. Potholes on this project were few and far between, and a score of 10 indicated that potholes were not evident at any of the four monitoring locations within a section. At the 11-month event, the TerraZyme section received a score of 7 because a pothole, measured to be 48 mm (1.9 in) deep, was found within one of the 7.6-m (25-ft) long measurement areas. There was no rating criterion that actually fit this occurrence of one pothole, but the fact that it occurred within a monitoring area was recognized with a score of 7.

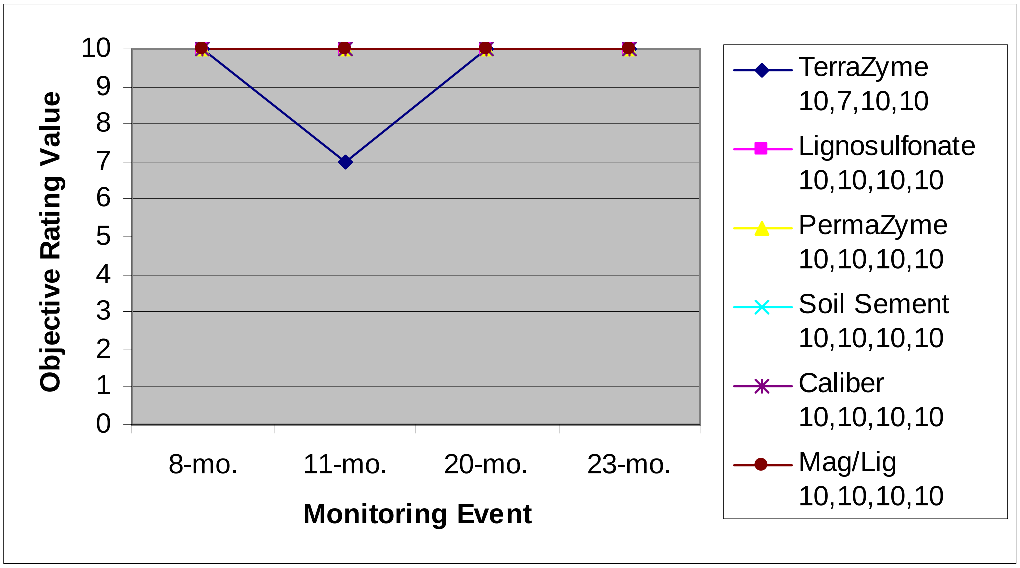

Figure 22. Plot. Potholing trends.

The objective rating criteria had been set up to rate areas of potholing where numerous potholes were developing. Thus, if one pothole occurred within a 7.6-m (25-ft) monitoring area, that area was likely to receive a low score. In another monitoring event, when that area was missed and no potholes were found, the section would receive a higher score. For this project, the monitoring team decided to track the few occurring potholes individually by measuring their diameter and depth at each subsequent event after they were discovered as shown in Figure 23. The pothole rating criteria may need to be revised later on for other monitoring projects.

Figure 23. Photo. Measuring Pothole Depth.

A total of three potholes were found on the entire project and their measurements through time are shown on Table 10. Their depths were measured both to the loose surface material and to the hard surface beneath. After measuring to the hard surface, the team then filled the pothole in to the original loose material depth. This practice continued throughout the two-year monitoring period, but it should be noted that a vehicle tire drops only to the loose surface, not to the hard surface beneath, and this surface can change over time. In fact, observing the depth to the loose surface of each pothole over time suggested that the potholes were repairing themselves.

In PermaZyme Section III, a pothole measuring 50 mm (2 in) deep was found during the first monitoring event. By the 11-month event this pothole had filled in some, and by the final event it appeared to be correcting itself measuring only 30 mm (1.2 in) deep. The first pothole in TerraZyme Section I at milepost 0.48 was discovered at the 11-month event in August 2005. It too became a little more shallow and wider over time. A second pothole in Section I had appeared at the May 2006 20-month event. This pothole only minimally changed in the three months leading up to the final 23-month monitoring event.

Table 10. Individual pothole measurements.

Location	Measurements	8-mo.	11-mo.	20-mo.	23-mo.
Section I TerraZyme, MP 0.47	Diameter (mm)			275	280
	Depth to Loose Surface (mm)			35	30
	Depth to Hard Surface (mm)			45	50
Section I TerraZyme, MP 0.48	Diameter (mm)		270	435	310
	Depth to Loose Surface (mm)		48	40	20
	Depth to Hard Surface (mm)		68	127	25
Section III PermaZyme, MP 0.43	Diameter (mm)	445	420	420	550
	Depth to Loose Surface (mm)	50	27	39	30
	Depth to Hard Surface (mm)	70	47	55	44

OBJECTIVE MEASUREMENTS SUMMARY AND EVALUATION

In Table 9, there is an overall rating covering the entire monitoring period for each product and parameter. These parameter ratings are plotted in Figure 24 along with an objective overall rating showing an averaged value of all of the parameters. From objective measurements, four groups of product performance are evident. In the first group were Lignosulfonate and Mag/Lig

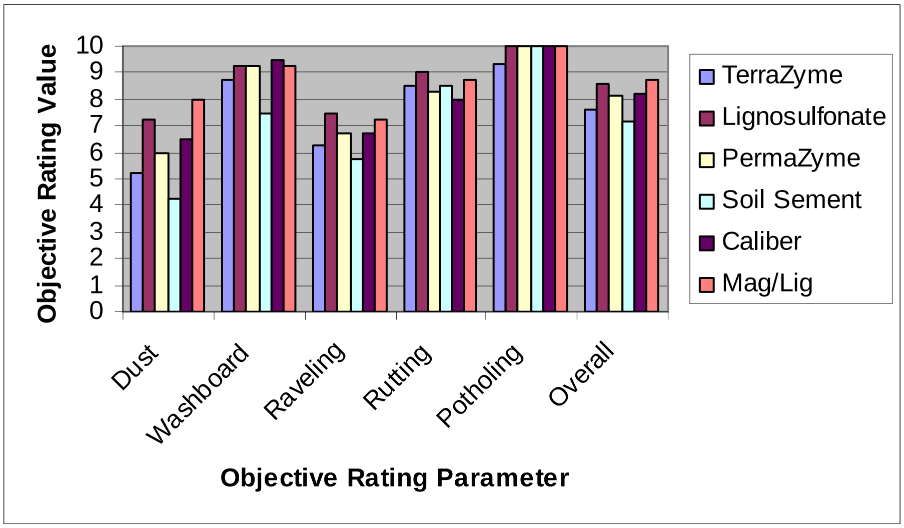

Figure 24. Plot. Relative product standings from objective rating system.

performing the best. In the second were Caliber and PermaZyme. TerraZyme was in the third group, and Soil Sement fell into a fourth group with the lowest overall average score.

The strength of the objective rating system lies in its descriptive criteria. If the descriptive criteria are meaningful, then the analysis provides 1) relative standings of the products just as the subjective method provided relative standings, 2) trends over time discussed in this chapter, and 3) a view of which parameters have the lowest ratings and therefore may be of greatest concern. The relative standings of the products for each parameter evaluated are clearly shown in Figure 24 and can be compared to the relative standings from the subjective comparative method covered in Chapter 4.

The third benefit of revealing which parameters have the lowest ratings and may be of greatest concern is a little more complicated than it first appears. From the point of view of road users or maintenance personnel, assuming that the parameters with the lowest values are the parameters needing the most attention and correction could be a mistake. According to Figure 24, dust generation and raveling were the parameters of greatest concern because they received the lowest values, while washboarding and rutting were of less concern, and potholing of very little concern. This observation is entirely dependent on the meaningfulness, defined as rooted in the experience of those who use the road, of the Appendix B descriptive criteria. These criteria were developed with a view of probable best case to worst case conditions expected to be encountered on a native material or gravel surface roadway. But someone driving the road may not agree that dust and raveling were the biggest problems even though Figure 24 indicates they were. Normally drivers are more concerned about washboarding, rutting, and potholing because of the damage that can be done to their vehicle. Dust and raveling are typically just irritants, though dust also may affect plant life in the area. Despite this possible confusion, the evaluation team felt that the objective rating system was one they would use again and recommend for use by others.