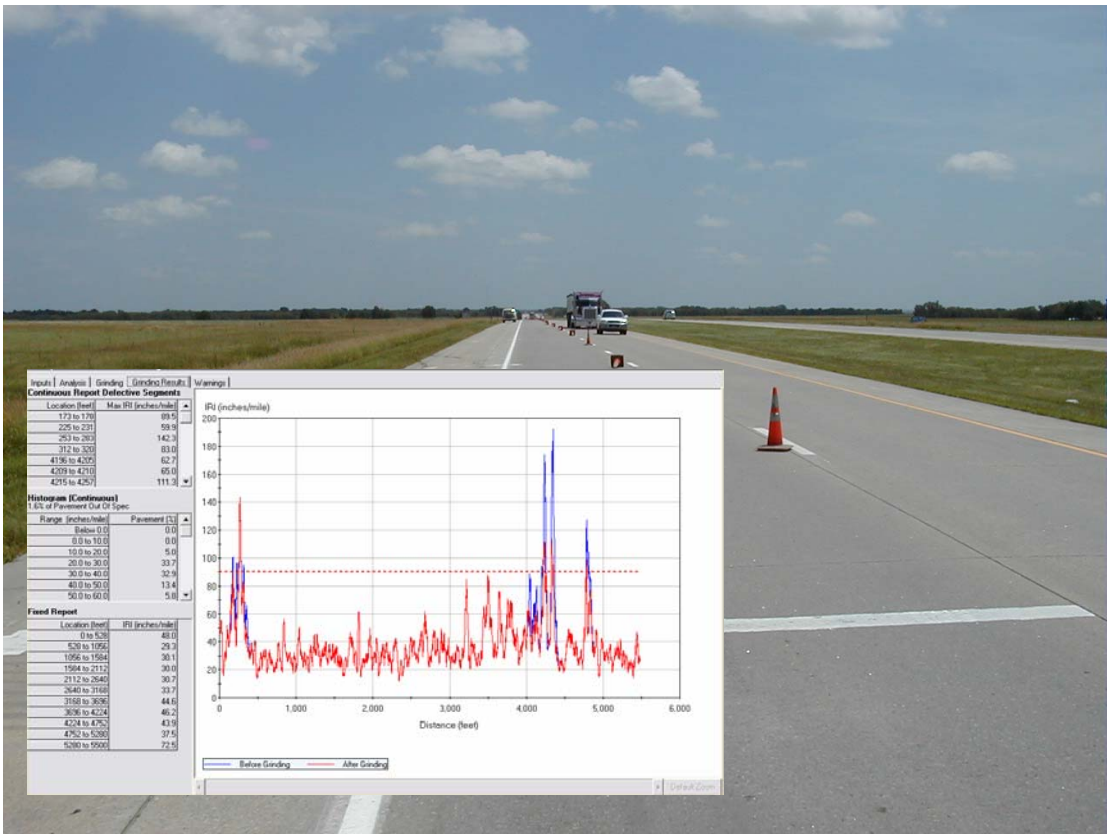
Smoothness Assurance Module

SAM

Field User's Manual



ProVAL 2.70

Smoothness Assurance Module (SAM)
Field User's Manual

Manual Revision: 1.03 (ProVAL 2.70)

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TABLE OF CONTENTS

LIST OF FIGURES

I. COLLECTING DATA

The first essential step is collecting usable data. For data to be useable the operator must be able to correlate any representative point in the profile generated by the software to the real point in the actual profile. To ensure useable data, the following checks must be completed:

Establishing a DMI Reference for Project

Once the profiler has passed its diagnostics for the profile measurement, a semi-permanent distance reference should be placed on the pavement for future use. This semi permanent reference consists of two lines that are marked on the pavement (with paint for example) that will not wear off in the time frame that any corrective action or re-measurement is anticipated.

This reference is created by marking a semi-permanent line on the pavement where profiling measurements will begin. A second line will be marked once the profiler has traveled 6000 feet. Care must be exercised to be as precise as humanly possible as these references will affect all future profile analysis and corrective actions. If the project is shorter than 6000 feet, the distance will have to be shortened to the longest length possible on the project.

The purpose of this reference is to calibrate any device that is used to find features on the pavement from the profile plot, continuous report, or tabulated data generated by the program. A common mistake is the use of stationing or survey distance measurements. These measurement systems often do not correspond the actual distance traveled over the surface of the pavement, which is what the profiler is measuring. To accurately locate features found within the electronic profile, the distance must be measured in the same fashion that was used to generate the profile. This is necessary because the relationship between stationing and the distance measured by the wheels of a profiler will not be consistent over changes in road geometry, roughness, and texture.

When the time comes for finding features in the pavement surface, a vehicle with a DMI should be used. This vehicle should first be calibrated to the profiler that took the initial measurements by starting at the same point that the profiler started at and stopping at the same point that the profiler stopped at (6000 feet as measured by the profiler). Once the vehicle has stopped at the second line on the pavement it should be “calibrated” so that it traveled 6000 feet. This calibrates the vehicle’s DMI to that of the profiler. Note that the longitudinal distance measured by the profiler may not match “true distance” with perfect accuracy, nor will it necessarily be consistent with station markers. At this stage of the process, however, it is most important that the vehicle’s DMI agrees with the profiler that took the measurements. However, if consistent tire inflation pressure is not maintained in the host vehicle, the calibration must be repeated.

It is recommended that the measurement vehicle drive for at least 15 minutes prior to calibrating and measuring so that the tires have been warmed up. This will aid in measurement reliability. Also, the user should drive the calibrated vehicle at about the same (low) speed that will be used to pinpoint features within the profile, so that no linear DMI error creeps in.

Mark Starting and Stopping Points

When the roadway is measured by the profiler, the starting and stopping points of data collection should be marked in each lane as measured. This marking should also be semi-permanent and last until all anticipated work is complete. These limits are essential for locating features on the pavement surface at any point in the future. Again, future locating efforts should be performed with a vehicle equipped with a DMI.

Reverse Runs

One forward and one reverse profiler run should be conducted on each section of pavement in the event that corrective action is required. This reverse run will enable the user to locate a point of interest in the profile using two references. The obvious check here is that the feature in question is located in the same place using either reference point.

Data Format

Save all profile data in an ERD or ASCII format, or another format that is compatible with ProVAL. Note that ProVAL does not require the profile data to be high-pass filtered before it is written to a file. The profiler may apply a high-pass filter, so long as it does not remove content that affects a ride quality index of interest.

II. PROCESSING DATA (BACKGROUND)

Once the profile has been collected it can be analyzed with the software using two distinct methods. The two methods are fixed interval reporting and continuous reporting.

Fixed interval reporting is currently the most common format for summarizing ride quality data. In fixed interval reporting a single value of a ride quality index, or perhaps one value for each wheel path, is reported for each consecutive road segment of equal length. The starting point of each successive segment begins at the first point after the previous segment. A common interval in use for this purpose is one twentieth of a mile.

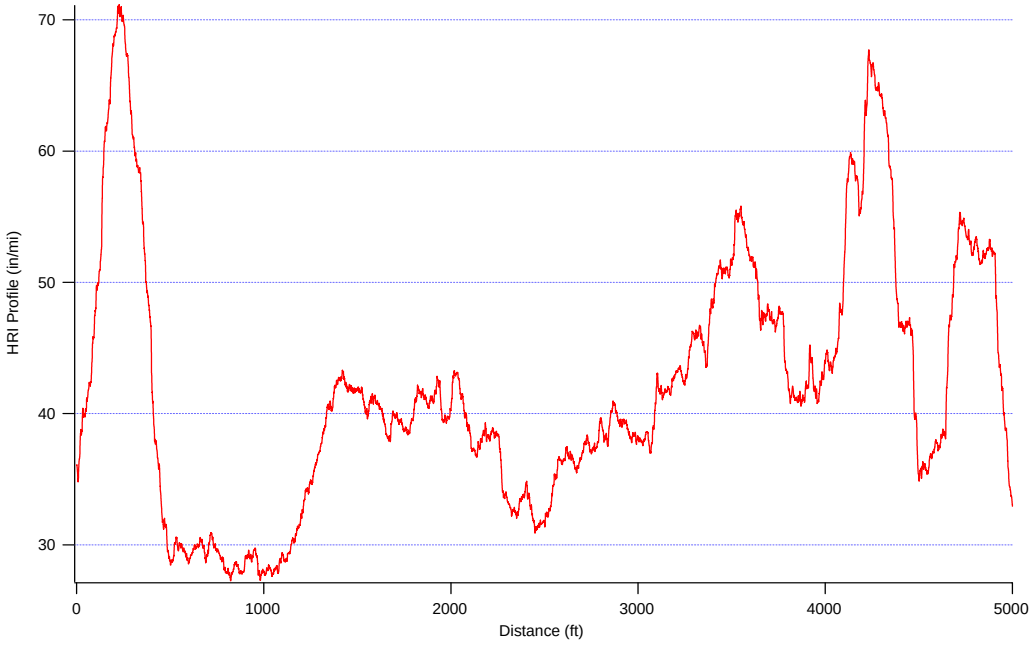
Sample Fixed Interval Summary

Although fixed interval reporting does provide a simple way to quantify pavement roughness, when used alone it greatly reduces the information available about the road condition and the location of features affecting pavement smoothness.

In continuous reporting, as in fixed interval reporting, a standard segment length is chosen. However, rather than starting the successive segment at the first point that falls after the first interval, the successive segment is started at the second data point in the data stream. If data are collected every inch then the second interval overlaps the first interval with the exception that an inch of the beginning is not considered and an additional inch down the stream is considered. Since this results in tens of thousand of intervals per mile, the continuous report is generated graphically.

From	To	IRI
0	264	44.6
264	528	41.8
528	792	50.5
792	1056	33.9
1056	1320	38.8
1320	1584	49.9
1584	1848	50.1
1848	2112	68.4
2112	2376	77.3
2376	2640	42.6
4488	4752	38.9
4752	5016	47.0
5016	5280	45.7
Average		47.0

Sample Continuous Summary



The information from a continuous report can be tabulated in a fixed interval report but the interval types are not the same as the traditional fixed interval report. Whereas the typical fixed interval report shows predetermined segments of roadway with independent values of roughness, this report show bands of roughness and indicates the percentage of roadway that fall within them.

Sample Tabulated Continuous Summary

IRI (in/mi)	Percentage of the Project within Band
0-20	0
25-30	0
30-35	8
35-40	12
40-45	48
45-50	13
50-55	7
55-60	5
50-65	4
65-70	1
above 70	2
TOTAL	100

III. USING PROVAL SOFTWARE

What is the Smoothness Assurance Module (SAM)?

The Smoothness Assurance Module can be used to optimize grinding strategies by analyzing measurements from profiles collected using inertial profilers. It can determine the out-of-spec locations and recommend must-grind locations. It also provides very flexible user-defined grinding strategies. A comprehensive report can then be generated to include ride quality reports before and after grinding.

How to Set Up the Analysis

The Smoothness Assurance Module consists of five screens as follows:

- **Inputs**: Inputs necessary to run the Smoothness Assurance Module analysis.
- **Analysis**: Displays the ride quality specification results and "hot-spots".
- **Grinding**: Inputs necessary to setup the grinding simulation.
- **Grinding Results**: Shows the grinding results.
- **Warnings**: Warns users about possible problems with the profile data.

The first two screens are for the ride quality report while the third and fourth screens are for the grinding simulation. The final screen, Warnings, is optional. Users may select to skip the grinding simulation and simply perform ride quality analysis. The report will only include the sections of the analysis that were used.

Inputs Window

The inputs window is shown in Figure 1.

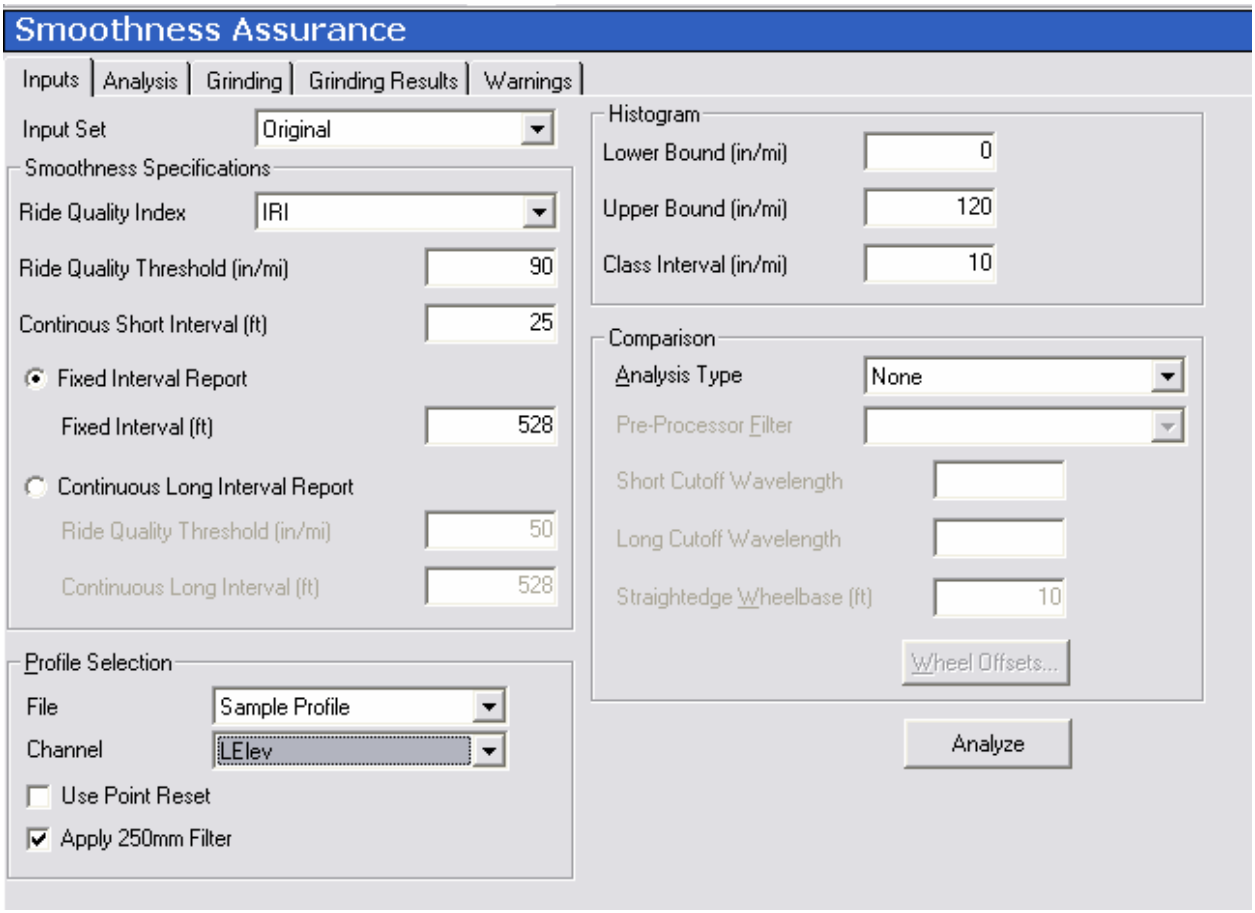


Figure 1: SAM - Input Window

Smoothness Specification Inputs – These inputs are related to ride quality specifications. Users may select a desired **Ride Quality Index** (options include **IRI**, **HRI, MRI, PTRN, RN,** and **Averaged RN**) for the analysis. The input for the **Ride Quality Threshold**, and the corresponding **Continuous Short Interval** (recommended between 25 and 50 feet), will be used to identify hot-spot or out-of-spec sections in a continuous roughness report. There is an option for producing the overall ride quality report: **Fixed Interval Report** or **Continuous Long Interval Report**. The **Fixed Interval** input (normally 528 feet or one-tenth miles) is used to produce a fixed interval roughness report. If Continuous Long Interval Report is selected, two more inputs are required – Ride Quality Threshold and its corresponding Continuous Long Interval. Caution should be taken to ensure that the profile requirements for each ride quality index are met. For IRI and HRI, it is recommended to have a profile sampling interval less than 3 inches and the profiler device to be valid in the wavelengths between 4 and 120 feet. For RN, the sampling interval should be less than 2 inches and the profiler device should be valid in the wavelengths between 1 and 50 feet.

Profile Selection and Adjustment Inputs – These inputs are related to profile selection and resetting the start and end points for the analysis. Users may use the **File** drop-down box to select a single profile data (all imported profiles from the profile viewer window are available) for the analysis. If the **Ride Quality Index** selected in the above input section is **HRI**, the **Channel** drop-down input will be disabled (i.e. both left and right channel will be used in the analysis). Otherwise, users will need to select one of the available channels for the sequent analysis. **Use Point Reset** is the same as in other analyses to enable lead-in and lead-out assignments. **Apply 250mm Filter** is used for those profiles that have not been previously filtered using a moving average technique in order to produce ride statistics. By clicking the

Adjustments button, it will display the Error! Reference source not found. screen same as that in Profile Viewer window. *Please be aware that you will need to re-run other analyses if you make any adjustments to the profile data.*

Histogram Inputs – These inputs are used to produce a **Histogram** from the fixed interval roughness report. Users will need to specify the **Upper Bound**, **Lower Bound**, and **Class Interval**. The **Upper Bound** and **Lower Bound** are used to limit the reporting range. The **Class Interval** will be used as the "step" to count frequencies of occurrence (i.e. sections). Please note that the first and the last steps are semi-infinite to include all occurrences. The **Ride Quality Threshold** value from the **Smoothness Specification Inputs** will be used to compute the percentage of pavement sections that are out-of-spec.

Comparison Inputs – There are 4 options in the **Analysis Type** drop-down box: **None, Raw Profile, Profilograph, and Rolling Straightedge.** By selecting options other than **None** in the **Analysis Type**, ProVAL will display the corresponding trace side-by-side with the roughness report. Otherwise, the simulation will not be performed and no side-by-side comparison will be produced. By selecting **Profilograph** or **Rolling Straightedge** in the **Analysis Type**, ProVAL will simulate the trace for the selected device (from the profile measured by an inertial profiler). There is a **Filter** input for **Raw Profile** that offers the following options: **None**, **Butterworth Low-pass filter, Moving Average Low-pass, Moving Average High-pass, and Moving Average Band-pass.** There is also a **Filter** input for both Profilograph and Rolling Straightedge that offers the following options: **None**, **Butterworth lowpass filter and Moving Average Low-pass.** If a filter option other than **None** is selected, users will then need to specify a **Short Cutoff Wavelength (**low-pass and band-pass**)** and **Long Cutoff Wavelength (**high-pass and band-pass**)** for the selected filter. If **Profilograph** is selected, the Profilograph wheel offsets need to be defined by clicking the **Wheel Offsets** button. A dialog screen will then pop up to aid users' input. Please refer to the standalone **Profilograph** analysis for details about the wheel offset inputs. If **Rolling Straightedge** is selected, the **Straightedge Wheelbase** needs to be specified.

Analysis Window

The **Analysis** window shows the ride quality spec report along with one or two plots. Depending on what you select for the overall ride quality report, this window will display either (1) Continuous Short Interval report with Fixed Interval Report or (2) "Dual-Continuous reports" (i.e., Continuous Short and Long Interval Reports).

(1) Continuous Short Interval report with Fixed Interval Report

There are three tabular reports. On top left, **Continuous Report Defective Segments** shows the sections that are over the threshold value (specified in **Smoothness Specification Inputs** of the Input window) and their maximum values (or minimum, for **RN**) within these sections. Immediately beneath the previous report is the **Histogram (Continuous)** report that contains the histogram from the continuous roughness analysis. This histogram defines the percentage of the job that falls within each roughness range of interest. These percentages may be weighed against an incentive pay schedule to calculate the overall bonus or penalty. A **% Pavement Out-of-Spec** is also reported to indicate those that are over the **Ride Quality Threshold**. Finally, the last table at the bottom is the **Fixed Report** which shows roughness values for all fixed-length sections.

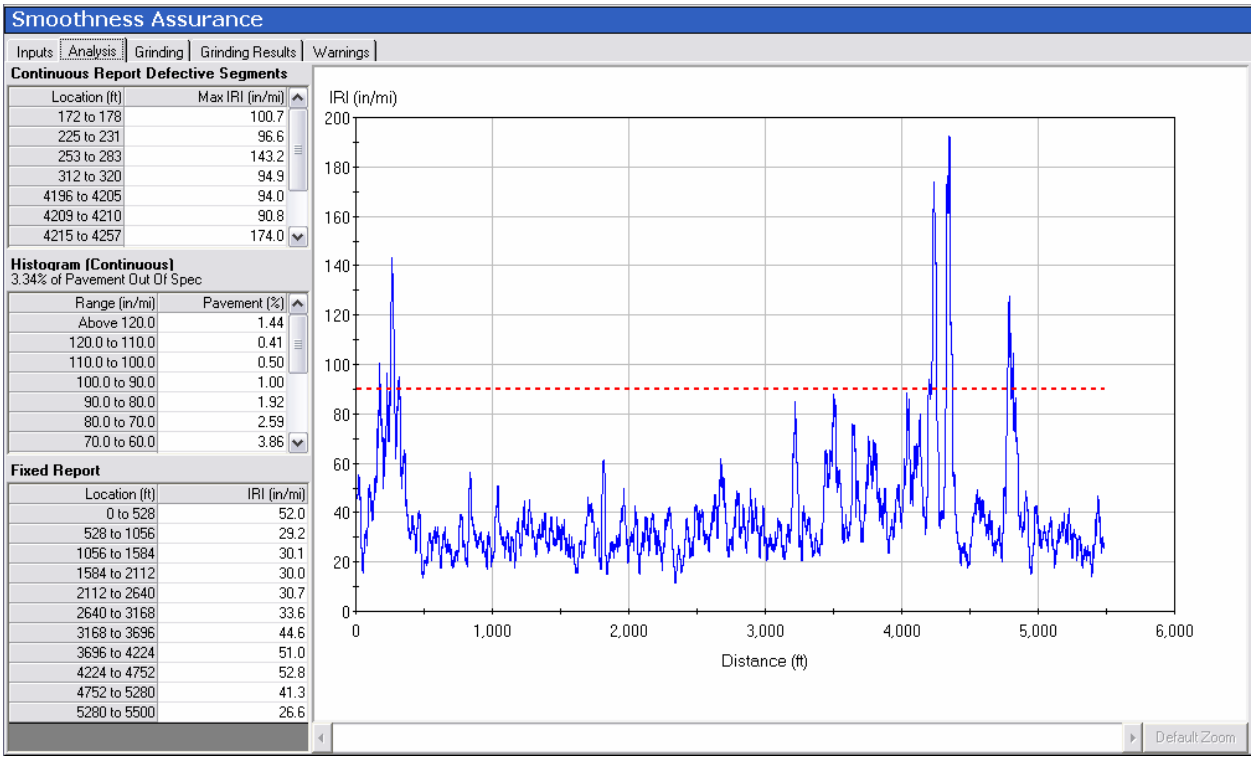


Figure 2: SAM - Ride Quality Reports (Continuous Short Interval plus Fixed Interval)

(2) “Dual-Continuous reports” (i.e., Continuous Short and Long Interval Reports)
Dual Continuous Reports are simply two continuous roughness reports based on a short and a long interval. Therefore, two sets of tables showing defective segments and the histogram are displayed for both criteria. The users have also an option to switch the continuous roughness plot between the short interval or long interval by clicking the button in the upper right corner.

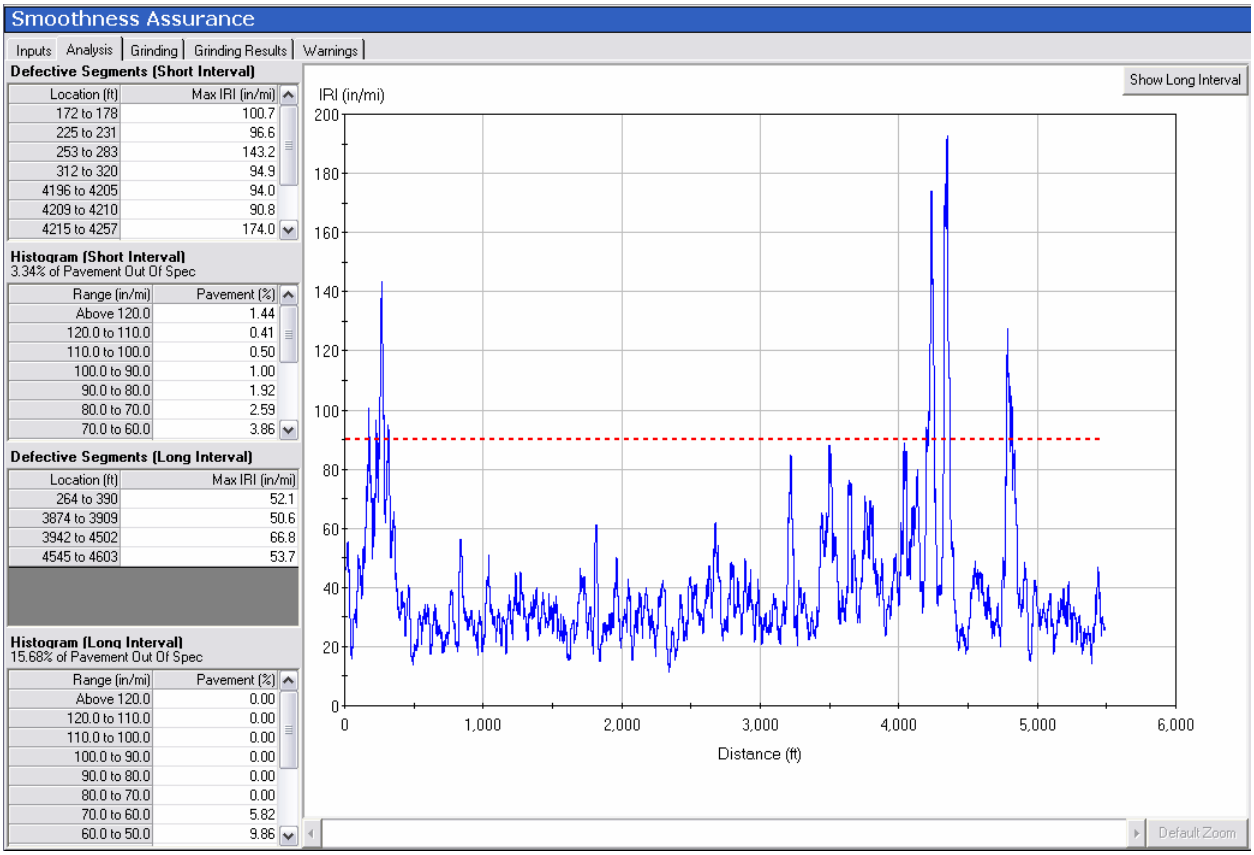


Figure 3: SAM - Ride Quality Reports (Dual Continuous) – Short Interval Plot

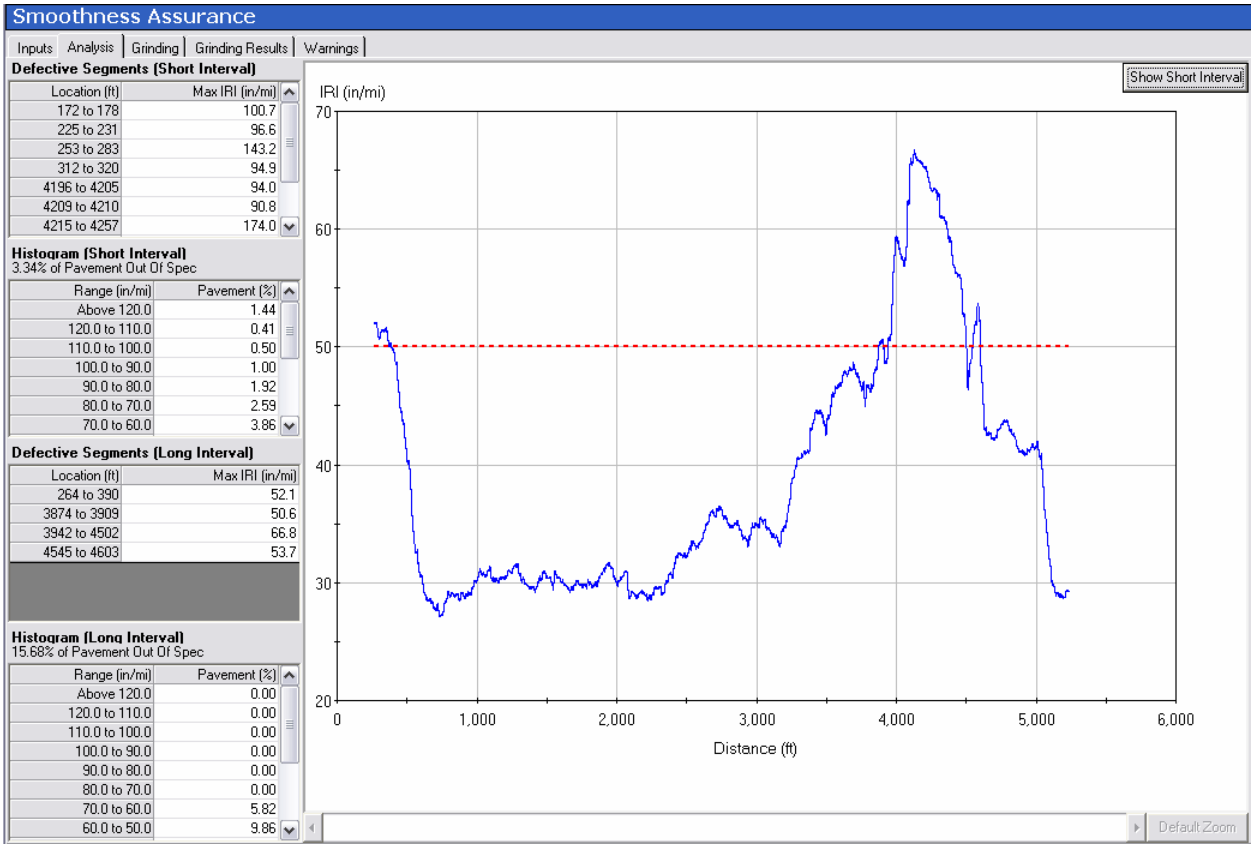


Figure 4: SAM - Ride Quality Reports (Dual Continuous) – Long Interval Plot

There may be one (e.g. Figure 2) or two plots (Figure 5) on the right of the screen depending on the option selected in the **Comparison** analysis in the **Input** window. The **Continuous Roughness** plot is displayed with the threshold value plotted as a horizontal line in red. If **Raw Profile**, **Profilograph** or **Rolling Straightedge** is selected in the **Comparison** Input window, a corresponding trace will be plotted side-by-side with the above continuous roughness plot.

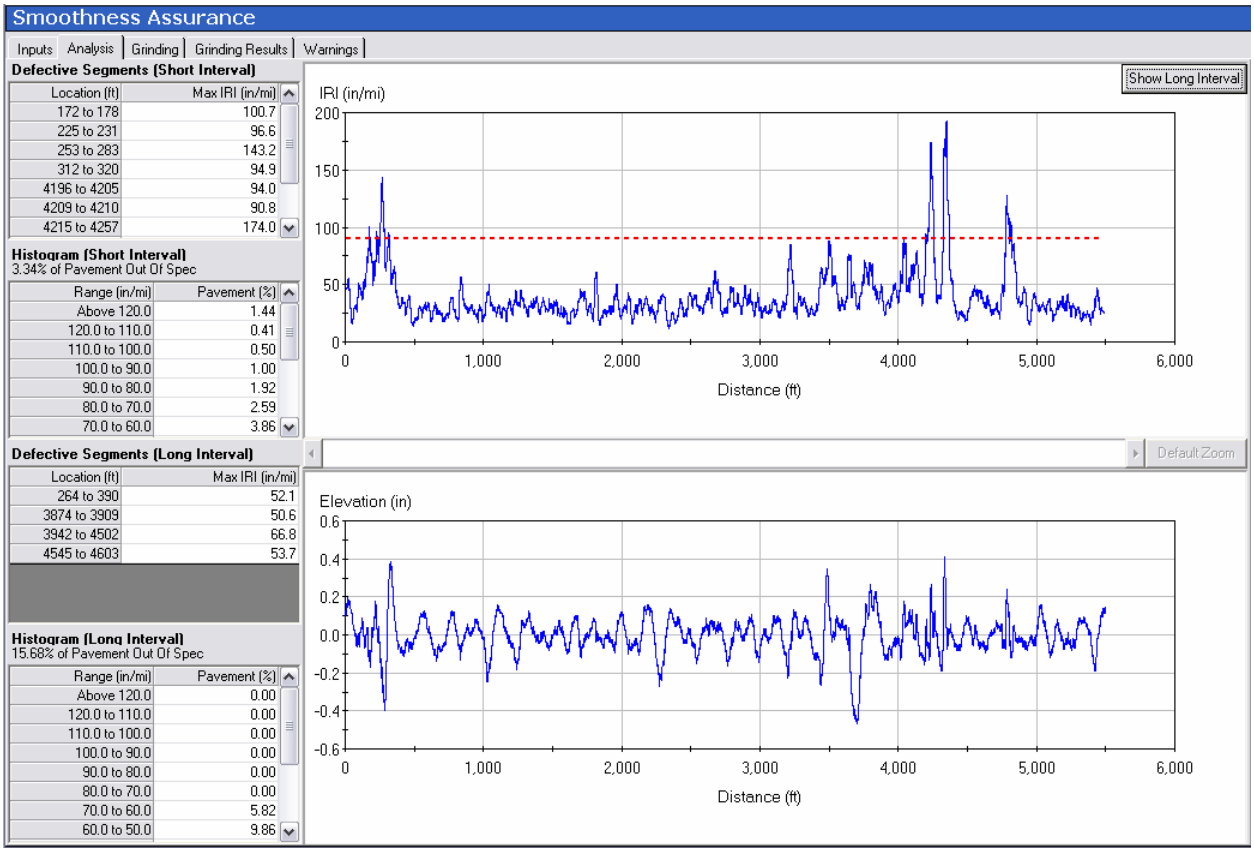


Figure 5: SAM - Ride Quality Spec Results (two plots)

Users can also take advantage of the **synchronized zooming and scrolling** when comparing the plots. Both plots will be zoomed into the same x-axis range while the y-axis range remains fixed. The scroll bar will then be activated at the bottom of the screen for users to scroll both plots horizontally and simultaneously. To zoom out to the entire trace, simply click **Default Zoom** at the right end of the scroll bar. This is particularly helpful for experienced users to fine tune the grinding locations. For example, Figure 6 is a zoomed view between 4,000 and 5,000 ft from Figure 5.

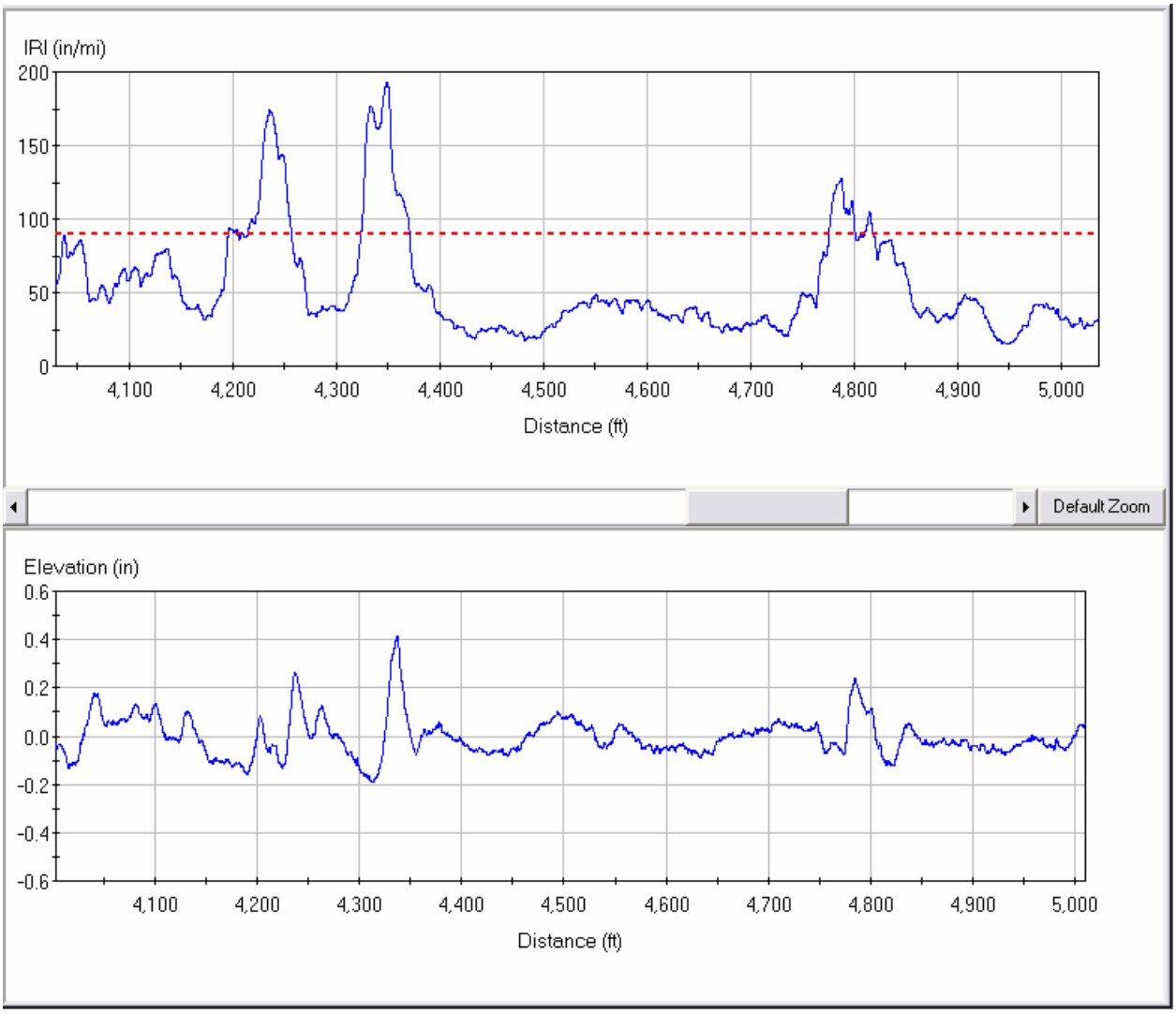


Figure 6: Zooming and Scrolling for Plot Comparison

Grinding Window

The **Grinding** input window is shown in Figure 7.

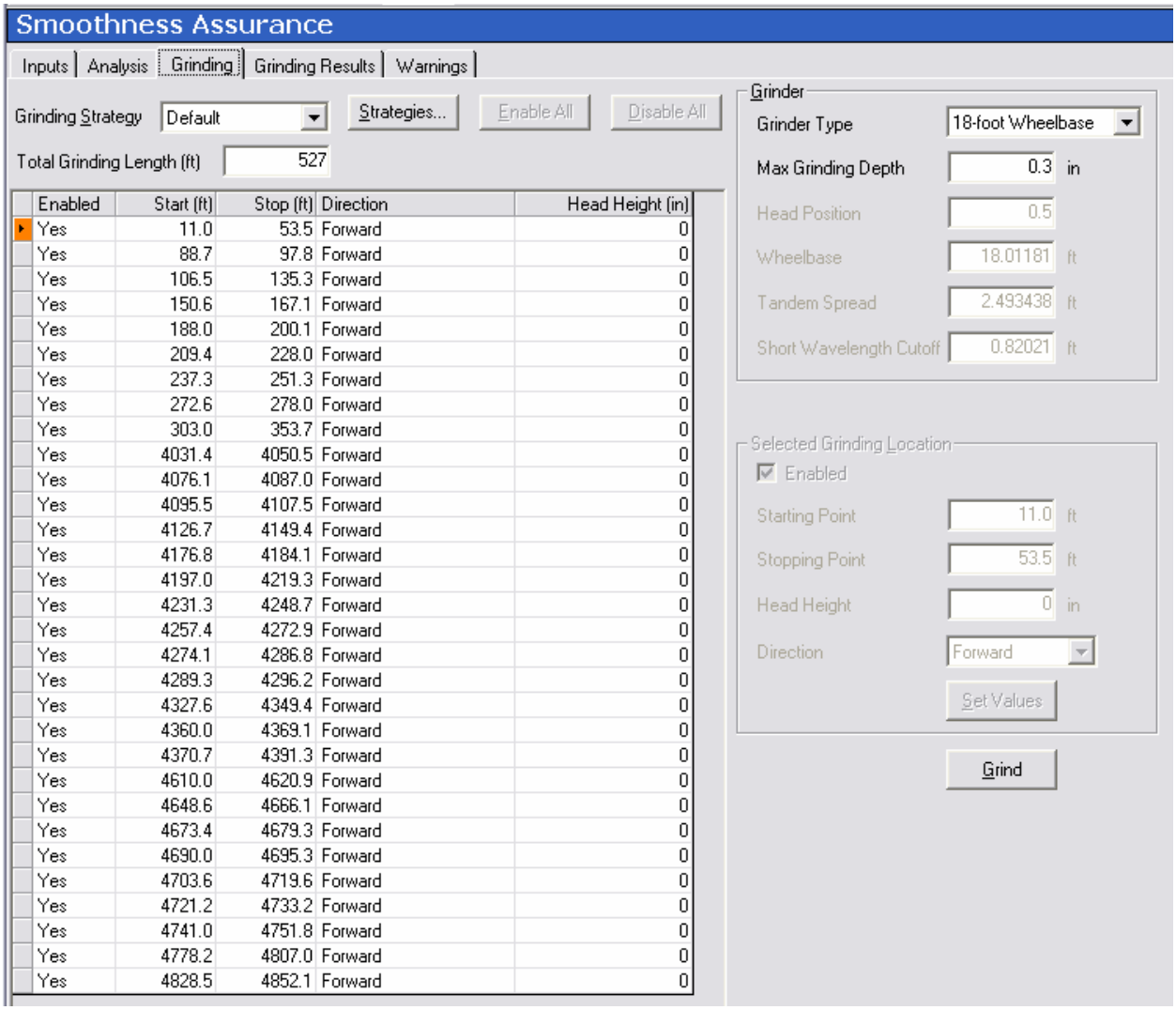


Figure 7: SAM – Grinding Inputs

First, users may define the grinder parameters to be simulated in the **Grinder** frame at the upper right. You may select a grinder mode from the **Grinder Type** drop down box: **User-defined, 18-foot Wheelbase**, **25-foot Wheelbase** are available. For **User-defined** grinder, additional inputs will be needed: **Head Position**, **Wheelbase**, **Tandem Spread**, and **Short Wavelength Cutoff**. For **18-foot Wheelbase** and **25-foot Wheelbase**, the above inputs are fixed and not editable. The **Head Position** is defined as the front tandem center to the grinding head divided by the wheelbase. The **Wheelbase** is distance between tandem centers. The **Tandem Spread** is the distance between tandem wheel centers. The **Short Wavelength Cutoff** is used in a low-pass filter (currently, moving average) during grinding simulation to emulate tire-enveloping. For any grinder selection, the **Maximum Grinding Depth** is currently used only to issue '**deep grinding**' in the **Warnings** window where this value is exceeded in the grinding simulation.

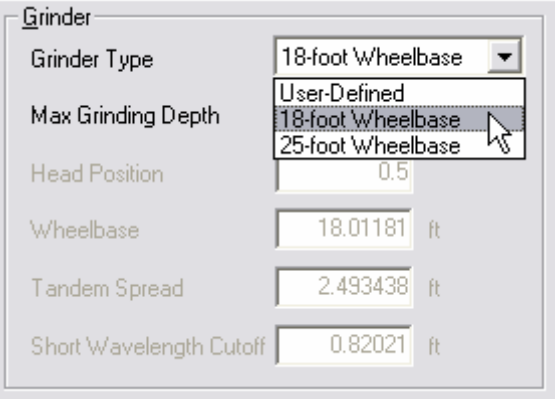
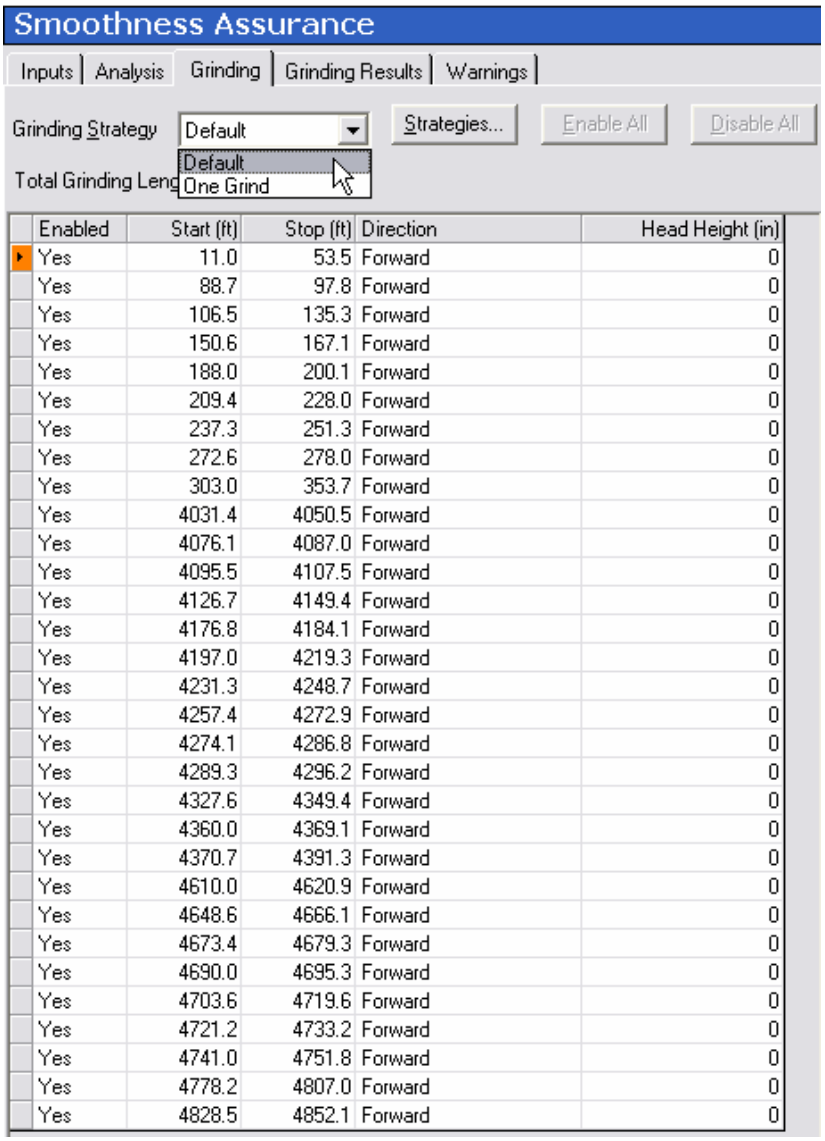


Figure 8: Grinder Setup

The **Grinding Strategies** (Figure 9), the associated speed buttons, and the **Selected Grinding Location (**Figure 11**)** can be used to define any grinding sections and grinding setups (starting and end points, head height, and directions). The users can either select **Default** or **One Grind** from the drop down box. If **Default** is selected, the program will provide users a list of optimal grinding locations determined by the software. However, it is recommended that users fine-tune the list manually to suit their needs. **One Grind** is used to define a single grind location to cover the entire length. While it sounds unrealistic, it is a powerful tool for experienced users to determine must-grind locations.

Enable All and **Disable All** buttons are simply utilities to turn on or turn off the "Enable" field for all grinding locations that listed in the **Grinding Locations** table. Within the **Grinding Locations** table, the users can navigate to any grinding location and an indicator (a triangle with highlighted background) will point to the active location. The user may then use the **Selected Grinding Location** frame to edit the grinding setup for the active grinding location.

The **Default** and **One Grind** strategies are not directly editable. However, the user may make editable copies of these strategies using the Grinding Strategies Manager discussed below.



Enabled	Start (ft)	Stop (ft)	Direction	Head Height (in)
Yes	11.0	53.5	Forward	0
Yes	88.7	97.8	Forward	0
Yes	106.5	135.3	Forward	0
Yes	150.6	167.1	Forward	0
Yes	188.0	200.1	Forward	0
Yes	209.4	228.0	Forward	0
Yes	237.3	251.3	Forward	0
Yes	272.6	278.0	Forward	0
Yes	303.0	353.7	Forward	0
Yes	4031.4	4050.5	Forward	0
Yes	4076.1	4087.0	Forward	0
Yes	4095.5	4107.5	Forward	0
Yes	4126.7	4149.4	Forward	0
Yes	4176.8	4184.1	Forward	0
Yes	4197.0	4219.3	Forward	0
Yes	4231.3	4248.7	Forward	0
Yes	4257.4	4272.9	Forward	0
Yes	4274.1	4286.8	Forward	0
Yes	4289.3	4296.2	Forward	0
Yes	4327.6	4349.4	Forward	0
Yes	4360.0	4369.1	Forward	0
Yes	4370.7	4391.3	Forward	0
Yes	4610.0	4620.9	Forward	0
Yes	4648.6	4666.1	Forward	0
Yes	4673.4	4679.3	Forward	0
Yes	4690.0	4695.3	Forward	0
Yes	4703.6	4719.6	Forward	0
Yes	4721.2	4733.2	Forward	0
Yes	4741.0	4751.8	Forward	0
Yes	4778.2	4807.0	Forward	0
Yes	4828.5	4852.1	Forward	0

Figure 9: SAM – Grinding Locations

The users can use the Grinding Strategies Manager to manage multiple grinding strategies. By clicking the Strategies button, a window such as in the following screenshot will pop-up to allow users to copy, rename, and remove strategies. Therefore, multiple strategies can be stored. Please note that only the active strategy will be used for analysis and reporting.

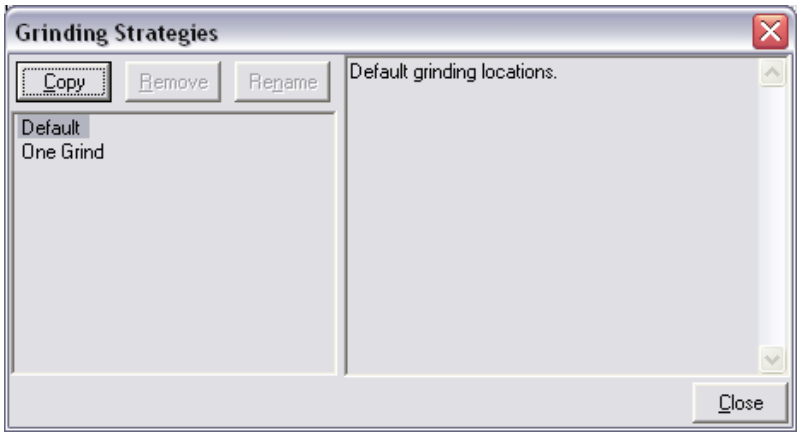


Figure 10: SAM – Grinding Strategies Manager

For each **Selected Grinding Location**, users may decide whether to grind it or not by selecting or unselecting the **Enable** checkbox. Users can also define the **Start and End Points**, **Head Height** of the grinder, and **Direction**. The Head Height of the grinder is relative to the datum formed by the mid-points of the front wheel set and rear wheel set. There are several options for the **Direction** definition: **forward, reverse, forward-forward, reverse-reverse, forward-then-reverse, and reverse-then-forward** (the first two are for one-pass grinding and rest are for two-pass grinding). Users may cycle through those options to achieve the best grinding effects.

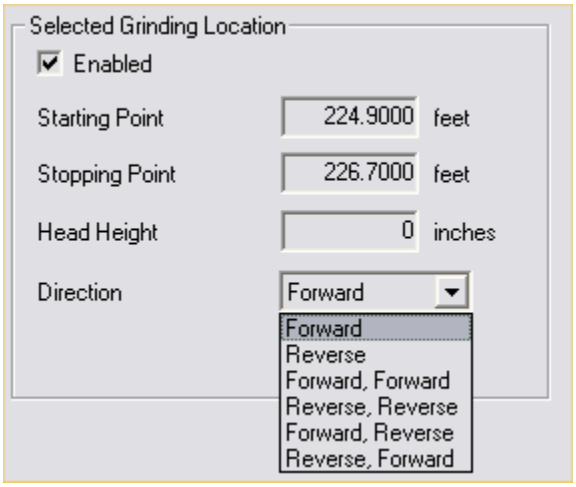


Figure 11: SAM – Selected Grinding Location

Grinding Results Window

As seen in the following figure, a typical grinding result includes 3 tables and at least one plot.

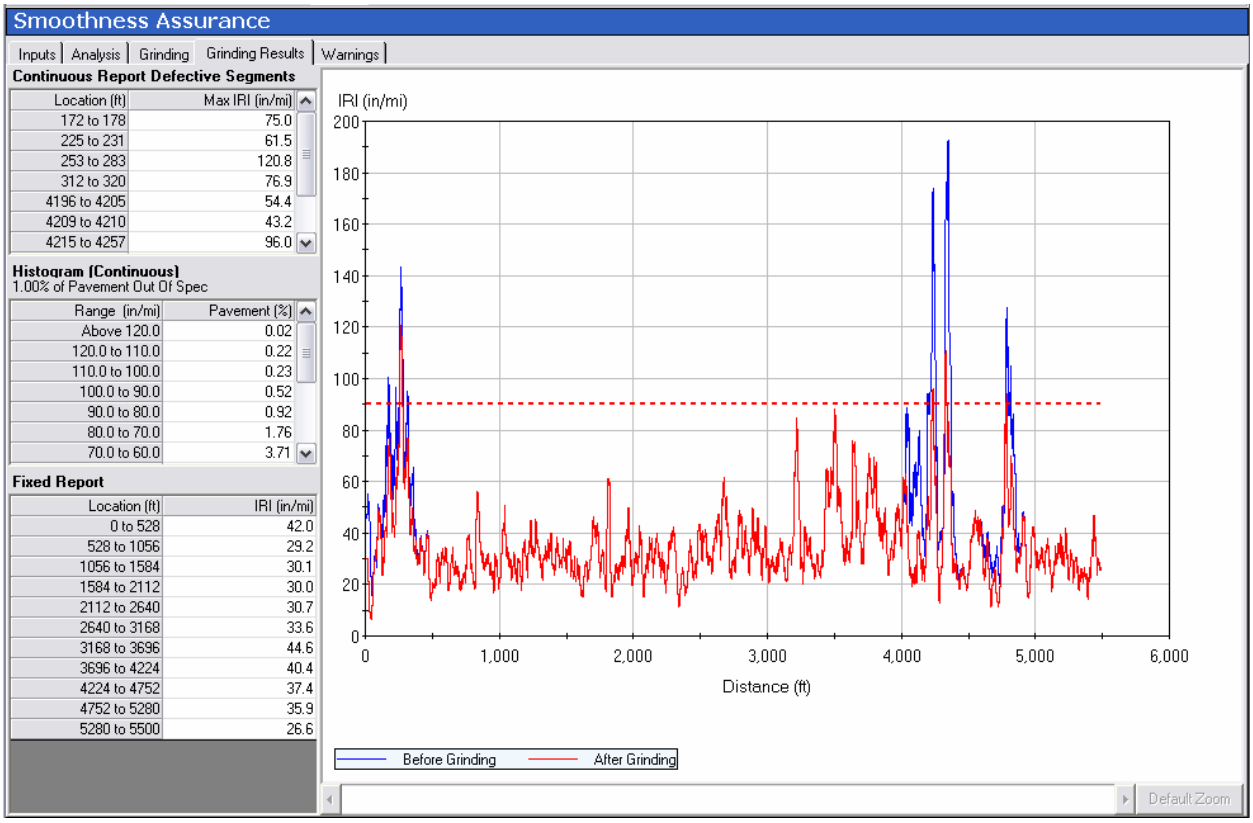


Figure 12: SAM – Grinding Results (one plot)

The above screen is for the report when Fixed Interval Report is selected. If Continuous Long Interval report is selected, the screen should look like the following:

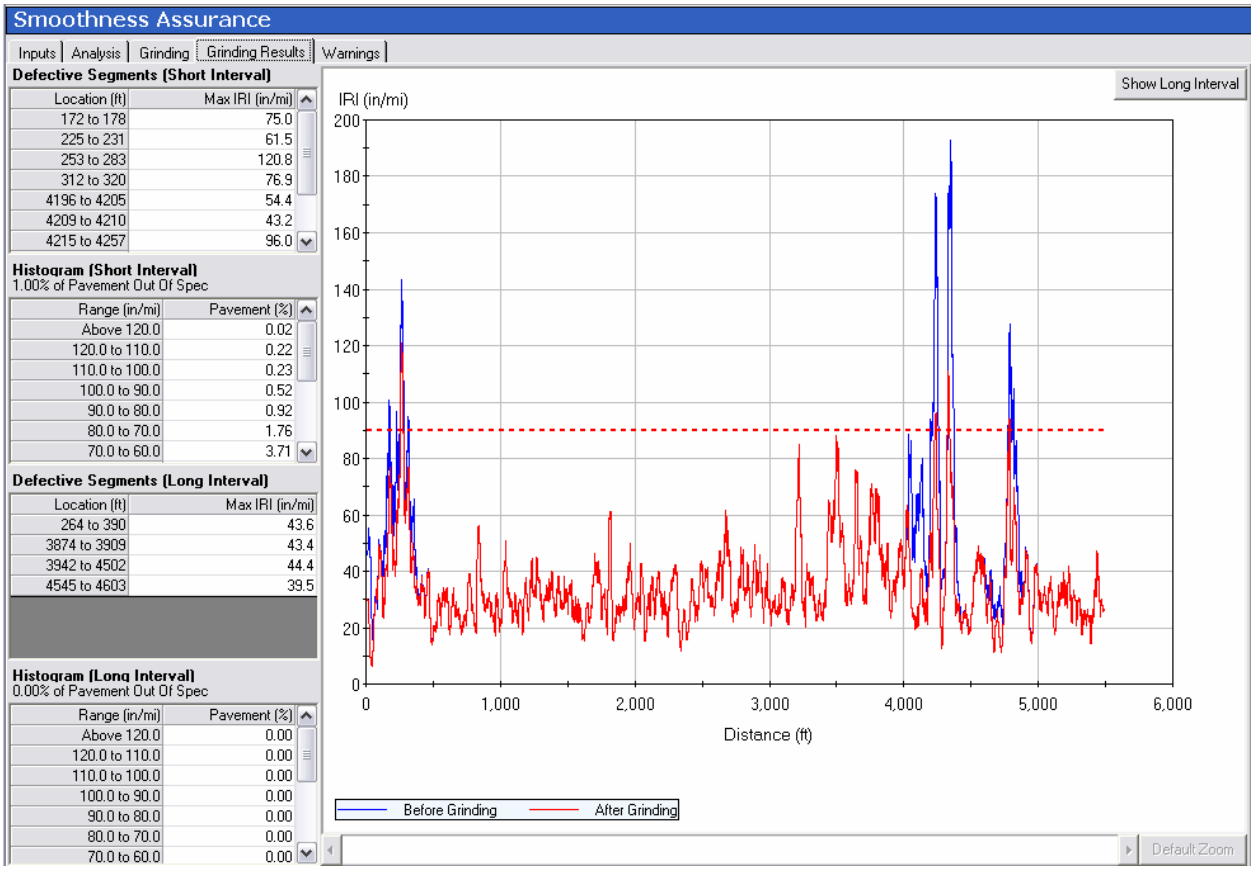


Figure 13: SAM – Grinding Results (one plot) – Dual Continuous reports

Uses may switch between Continuous Short Interval plot and Long Interval plot by clicking the button at the upper right corner.

The top continuous roughness profile plot is the default while the bottom plot is optional. If users select **None**, only one plot will be displayed for the continuous roughness profiles before and after grinding (e.g. Figure 12). If users select **Profilograph** or **Rolling Straightedge** in **Comparison/Analysis Type** of the **Input** screen, the bottom plot will display the corresponding simulated trace (e.g. Figure 14); if **Raw Profile** is selected, both the raw profile (before grinding) and simulated profile (after grinding) will be displayed. Please note that the "raw profile" may be filtered if the corresponding filter option is selected.

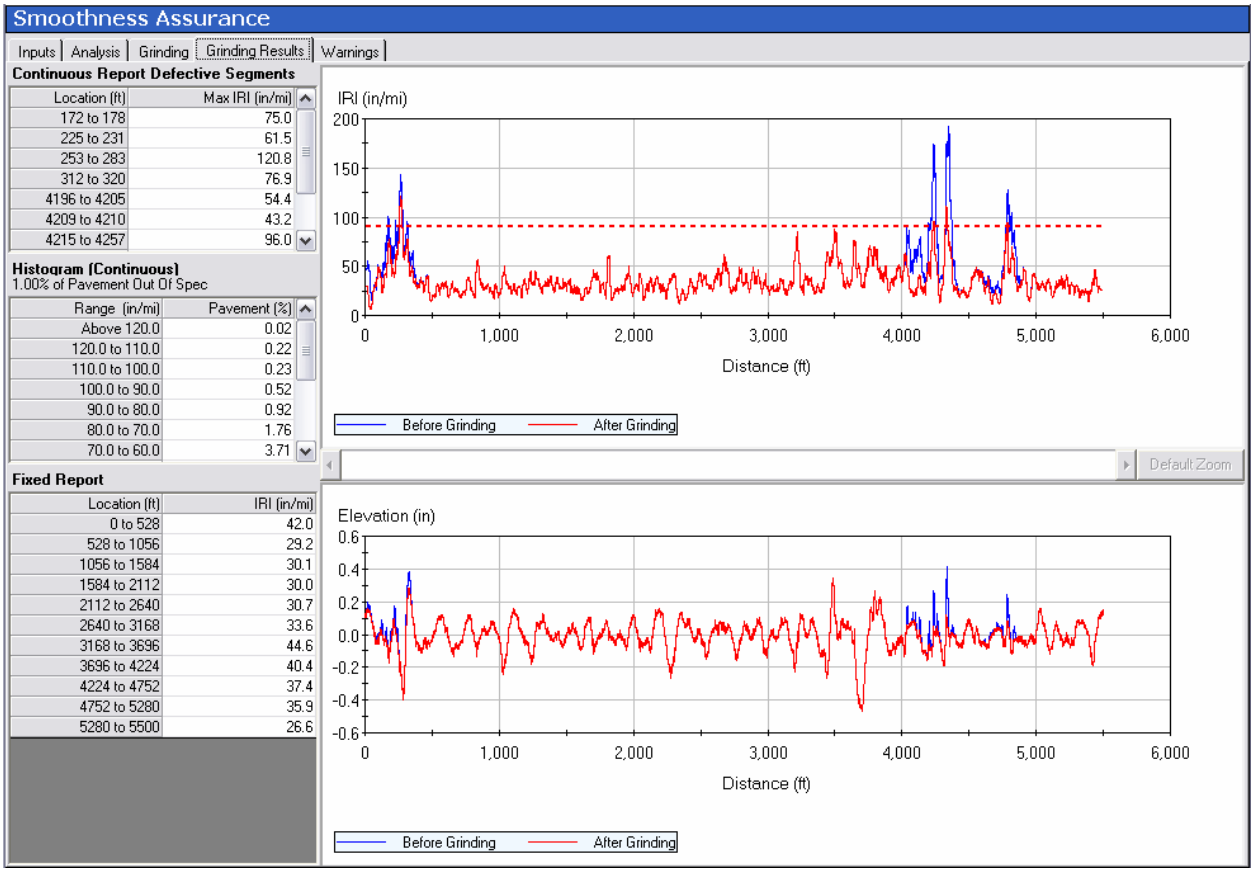


Figure 14: SAM – Grinding Results (two plots)

The **Continuous Report Defective Segment Report, Histogram Report, and Fixed Report** are similar to those in the **Ride Quality Specification Analysis** except the results here are for those after grinding**.** Comparing the example of before vs. after grinding results in Figure 2 and Figure 12, it can be seen that the percentage of **Pavement Out-of-Spec** has improved from 3.3% to 1.6% by using the default grinding locations. A more detailed side-by-side comparison is provided in the **Report** section.

The users can also take advantage of the **synchronized zooming and scrolling** when comparing the plots. Both plots will be zoomed into the same x-axis range while the y-axis range remains fixed. The scroll bar will then be activated at the bottom of the screen for users to scroll both plots horizontally and simultaneously. To zoom out to the entire trace, simply click **Default Zoom** at the right end of the scroll bar. It will be helpful for experienced users to fine tune the grinding locations. Figure 15 is a zoomed section (4,000 to 5,000 feet) from Figure 15.

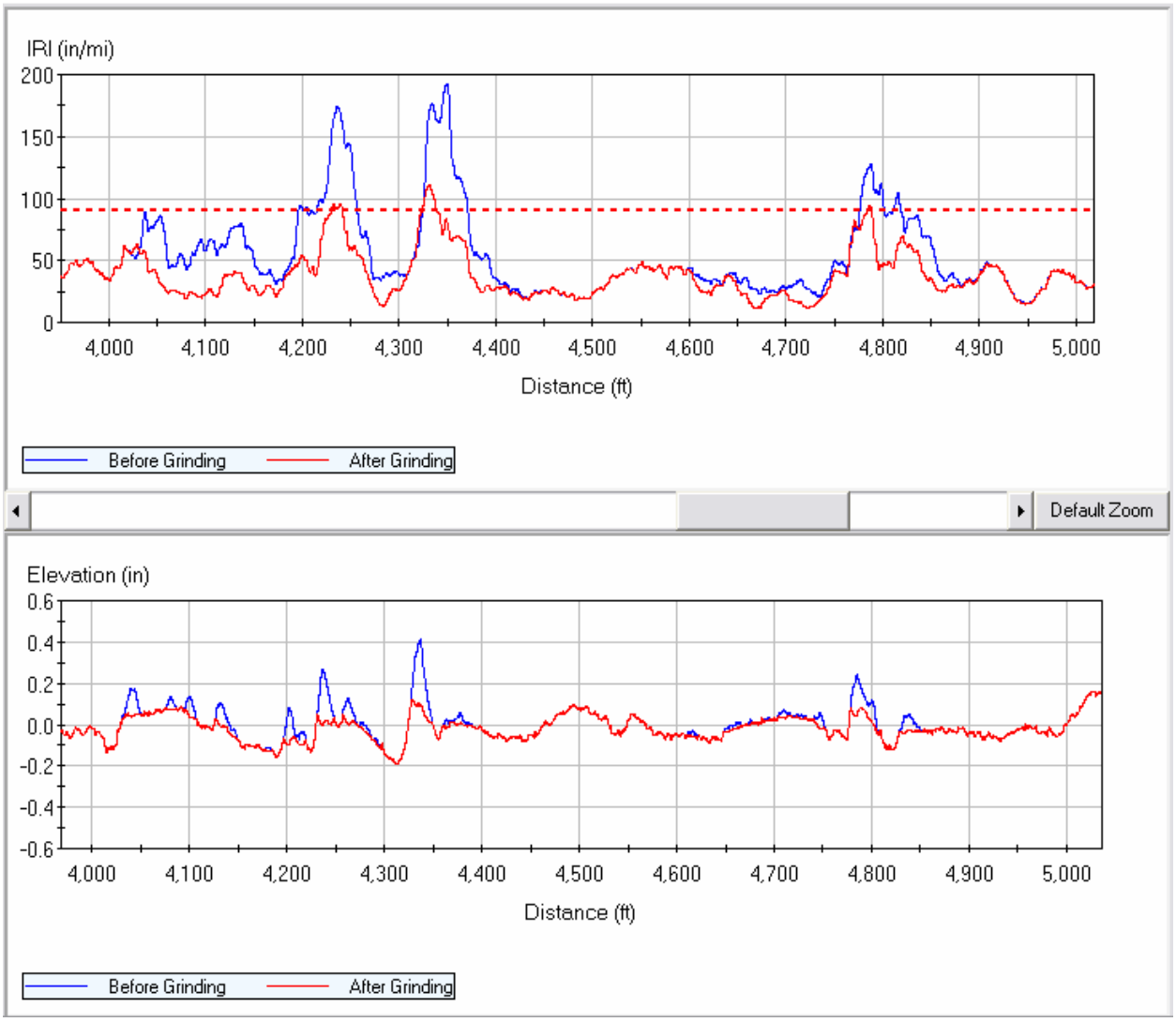


Figure 15: Grinding Result - Zooming and Scrolling in Comparison Plots

Warnings Window

The Warnings window is used to check whether there are any potential errors in the profile data or during analysis. After clicking the "Check for Warnings" button, ProVAL will check for several possible problems and display the results in a table. The table shows the channel of profile data, the locations, and the warning types (see below).

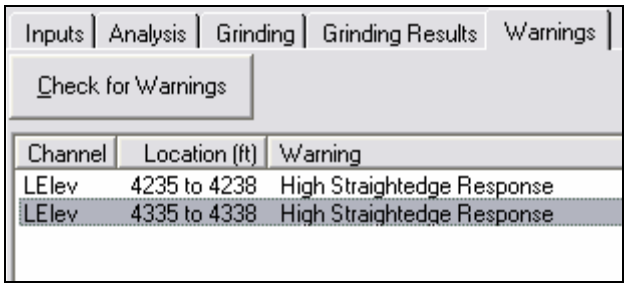


Figure 16: SAM – Warnings

The warning types consist of the following:

- **Spikes** : Possible problems identified by anti-smoothing technique – the baselength for the anti-smoothing is set to be the greater of 0.3 meters or 5 times the sampling interval and the threshold is set to be 5 mm,
- **High Straightedge Response**: possible problems associated with high Rolling Straightedge responses – a 3 meter (9.8 feet) wheelbase is used with high and low response thresholds (for detecting Bumps and Dips) are set to be 3 mm and -5 mm, respectively,
- **Extreme Roughness**: possible problems with extremely high roughness values – the threshold is set to be 5 times the average roughness value,
- **Deep Grinding**: when grinding depth exceeds the **maximum grinding depth** value specified in the **Grinder** setup frame of the **Grinding** screen.

IV. CORRECTING THE PROFILE

Once it has been determined that corrective action is necessary the pavement must be marked with a semi-permanent marking for the diamond grinding operator. Great care must be taken to ensure that the areas identified by the software are accurately transferred to the pavement surface. For this reason all locations should be identified using the same references and measurement types that were used during the initial data collection. The following steps should be followed:

Begin with a vehicle that has a DMI that is easy to calibrate

Begin with a vehicle that has a DMI that is easy to calibrate. To locate the "hot spots" on the pavement surface the device used to locate these areas must measure distance in the exact same manner as the profiler. At this point in the project, it is irrelevant if the profiler had a poorly calibrated DMI, however, the user attempting to locate disturbances shown by the software needs to be unaffected by any such problem. By calibrating the DMI of the locating device to that of the profiler, the possibility of this type of error has been eliminated. If the DMI is not easy to calibrate, the operator may elect not to calibrate the locating device before marking the pavement in situations where time is short.

Calibrate this vehicle to the Profiler using the 6000'section

Calibrate this vehicle to the Profiler using the 6000 foot section identified in part I. Take extra care to be as precise as possible as this will affect the results.

Layout the sections of pavement using the strategic grinding report

- Do not use location data from the profiler analysis that has been converted to be displayed in project stationing format. Numerous errors can result from using stationing because stationing does not agree with lineal feet traversed in a lane (unless the entire project is on a surface with no vertical/horizontal curves or station equations). Use location information that references how many feet the "hot spot" is from the starting point of the profiler run.
- Using the DMI that has been calibrated to the profiler, measure the distance from the beginning of the profiler run to the beginning of the first grind area. Stop and mark this location. Be sure to drive at the same speed that the DMI was calibrated.
- Drive the vehicle until it has traveled to the end of the first grind area and mark this location. Be sure to drive at the same speed that the DMI was calibrated.
- Continue this until all grind locations have been marked on the pavement.
- If there are several grind spots and thus a multitude of start and stopping points the DMI measurements may start to drift due to the low speeds at each starting and stopping point (depending on the quality of the DMI). It is recommended that some grind areas in the middle and end of the project be spot checked by measuring their distance from the beginning of the

profiler run independently without stopping. This will ensure that no error has been included from the starting and stopping of the DMI vehicle. Please note, some DMIs handle the starting and stopping better than others.

Cross check the pavement grind locations using the reverse profile

Cross check the pavement grind locations using a strategic grinding report from the reverse profile (optional).

- ❑ Using the reverse profiler run, check a small sample of the measurements made in section 3. Perform the same steps described in section 3, only use the starting point of the reverse run and measure distances in the opposite direction. Be sure to drive at the same speed that the DMI was calibrated.
- ❑ It is recommended that at least one grind section in the beginning, middle, and end of the project be checked to ensure grind location accuracy.
- ❑ As another check, take an obvious and easy to find feature from the ten foot straightedge response plot. Measure the location on the pavement as described earlier. Use a ten foot straightedge to locate the feature in the profile. This feature should be in the location as indicated in the ten foot straightedge simulation.
- ❑ If locations do not line up then there is a problem with the data. Stop, find the source of the error, and re-locate the grind areas before grinding the pavement.

Perform diamond grinding

- ❑ Setup the grinder so that the grinding head is in the plane of the bottom of the support wheels.
- ❑ Measure the maximum depth of the grinding and compare this to the depth that is indicated on the grinding report. If the depths are not close, then there are several issues to investigate.
  - Is the grinding head setup in the plane of the bottom of the support wheels?
  - Is the correct location being ground?
  - Is the operator changing the depth control during grinding?
  - Are there errors in the profile caused by a faulty profilometer?
- ❑ Profile the corrected pavement and check results.

More Information

The Official ProVAL website is: http://www.roadprofile.com.

Sayers, M.W., and S.M. Karamihas, The Little Book of Profiling, The University of Michigan Transportation Research Institute (UMTRI), October 1997.

The Road Profile User's Group: http://www.rpug.org

An extensive bibliography on profiling can be found at the UMTRI website: http://www.umtri.umich.edu/erd/roughness/rr_bib.html