WHEEL MANAGER DATA ANALYSIS

USERS MANUAL

SOF-861 User's Manual
DOC-220
Rev. 1.0

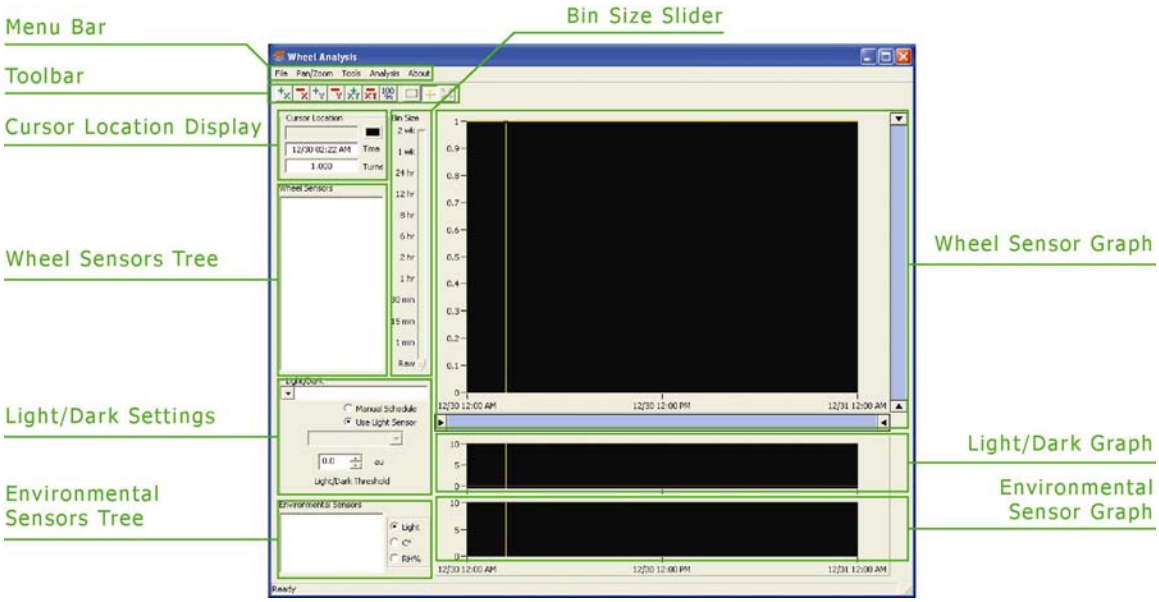
MED Associates, Inc.
P.O. Box 319
St. Albans, Vermont 05478
www.med-associates.com

TABLE OF CONTENTS

CHAPTER 1
User Interface

The Wheel Manager Data Analysis main screen appears when the application is opened. The main screen is shown below with all of the components labeled.

Figure 1.1 - Main Screen Labeled



The main screen contains three graphs, the Wheel Sensor Graph, the Light/Dark Graph and the Environmental Sensor Graph. Use the Wheel Sensors Tree, Light/Dark Settings and Environmental Sensors Tree to specify the data that appears on the graphs.

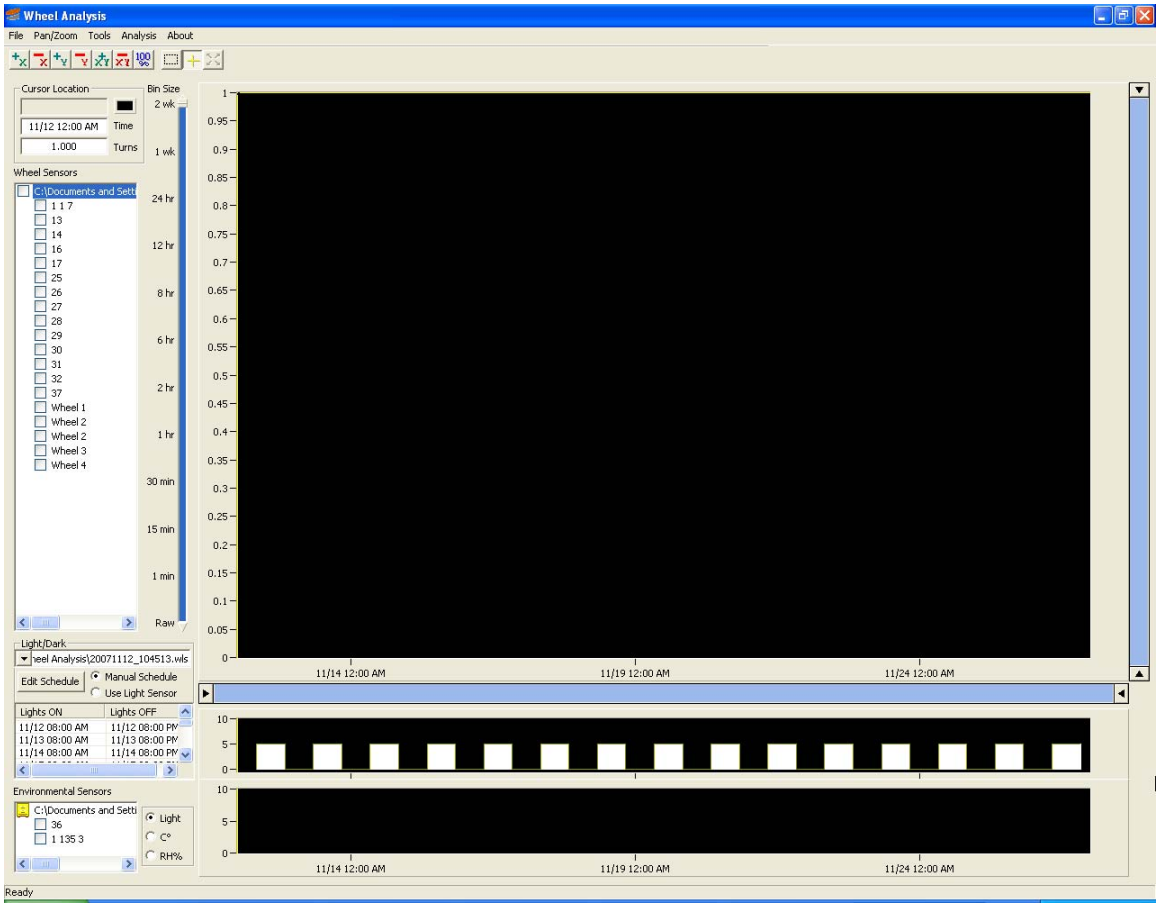
The subsequent chapters of this manual explain the main screen in much greater detail.

CHAPTER 2
Getting Started

Opening the Data File(s)

Open the Wheel Analysis application and the screen shown in Figure 1.1 will appear. Open the wheel data file(s) (.wls extension) by clicking **File** | **Open**. The data will load and the screen will resemble the one shown in Figure 2.1.

Figure 2.1 - Wheel Analysis with Data Loaded



The data file name(s) is added as a root node (leftmost) in the Wheel Sensors tree. Any wheels found in the database are listed under the database name as “children” or “leaf” nodes.

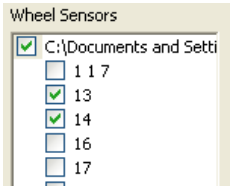
Customizing the Wheel Sensor Graph

Adding and Removing Traces from the Graph

To add a wheel sensor's trace to the wheel sensor graph, click and fill its checkbox, and to remove a wheel from the graph, clear its checkbox. All of the wheels in the data file can be added by clicking the checkbox next to the data file name.

In the example shown below data will be displayed on the Wheel Sensor Graph for wheels 13 and 14 only.

Figure 2.2 - Wheels 13 and 14 Selected

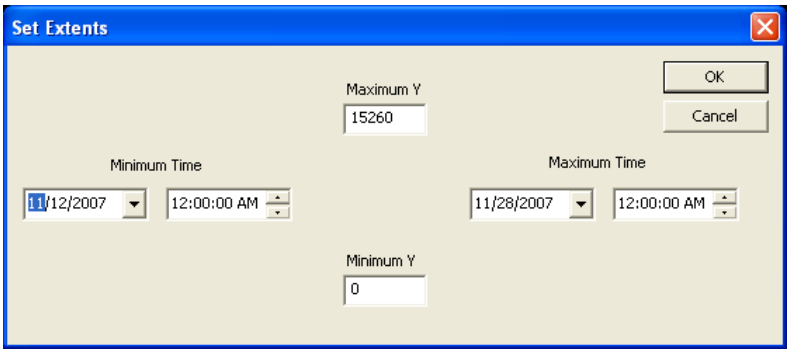


Sensors are listed by the name assigned in Wheel Manager. If no name was given, the column label is used. The column label is generated using the Hub ID, Sensor Type and Sensor ID numbers. The sensor type is indicated using a numeric value. A Wheel Sensor (ENV-044 Low Profile Running Wheel) is indicated with a '1', Light Sensor with a '2', Temperature Sensor with a '3', Humidity Sensor with a '4' and Wheel Sensor (ENV-044-V Vertical Running Wheel with a '5'. Refer to **Appendix B** of this manual for further information regarding column labels.

Adjusting the X- and Y-Axis Ranges

To set the wheel graph axis ranges manually, select **Tools | Set Graph Extents**. Set the min and max x-axis (time) values and the min and max y-axis (turn or km) values in the field provided. Click **OK** to return to the main screen with the axis extents altered. Click **Cancel** to return without changes.

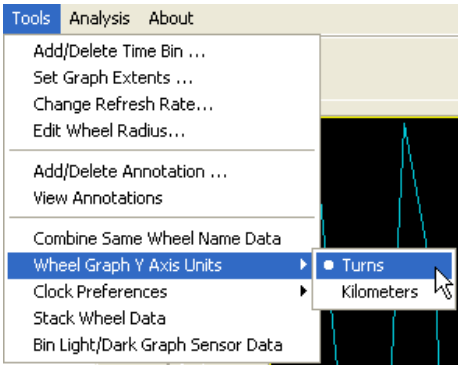
Figure 2.3 - Set Graph Extents Dialog



Adjusting the Y- Axis Units

To change the Y-Axis units select **Tools** | **Wheel Graph Y Axis Units** | **Turns** or **Kilometers**.

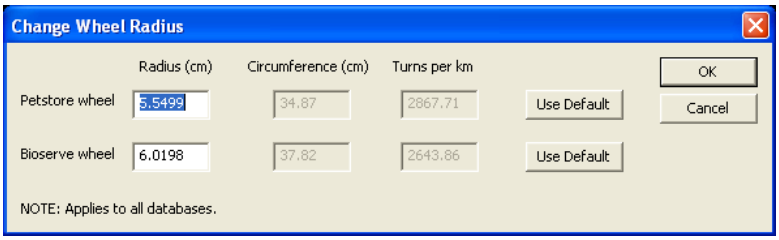
Figure 2.4 – Tools | Wheel Graph Y Axis Units



Adjusting the Wheel Radius

To adjust the ratio of wheel revolutions per kilometer, select **Tools** | **Edit Wheel Radius** and enter the wheel radius in centimeters. Click the **Use Default** button to restore the default wheel radius.

Figure 2.5 - Tools | Edit Wheel Radius



Viewing Multiple Traces

When viewing multiple traces in the graph, the data may be overlaid or stacked. To switch how the traces are viewed select **Tools** | **Stack Wheel Data**.

Figure 2.6 - Wheel Data Stacked

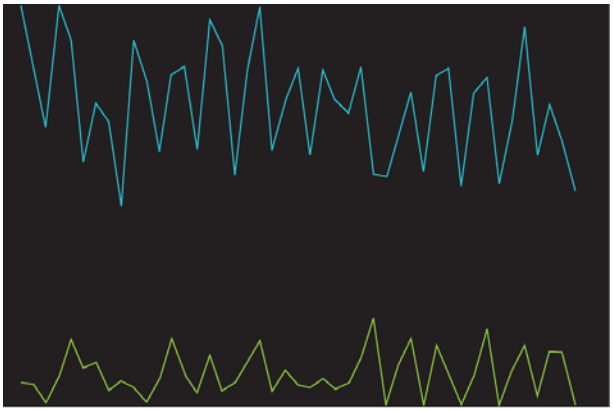
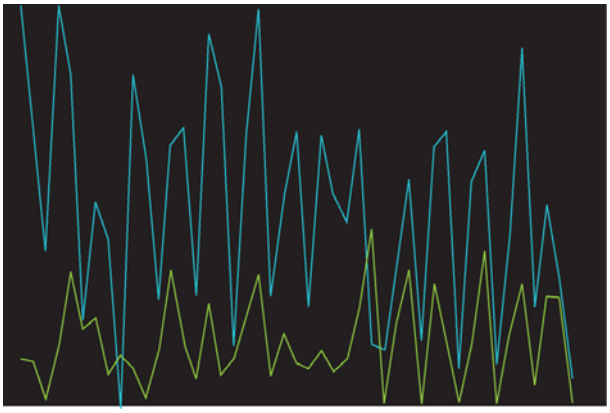


Figure 2.7 - Wheel Data Overlaid



Adjusting the Bin Size

The wheel data resolution can be adjusted using the Bin Size slider on the main screen. Drag the pointer up or down the slider to change the graph data bin size. The light/dark graph will be unaffected by changing bin size if the **Tools** | **Bin Light Sensor Data** menu item is unchecked.

To add or remove a bin size from the slider, select **Tools**| **Add/Delete Time Bin** and the screen shown in Figure 2.8 will appear. Refer to Table 2.1 to add or delete time bins.

Figure 2.8 - Add/Delete Time Bin Dialog

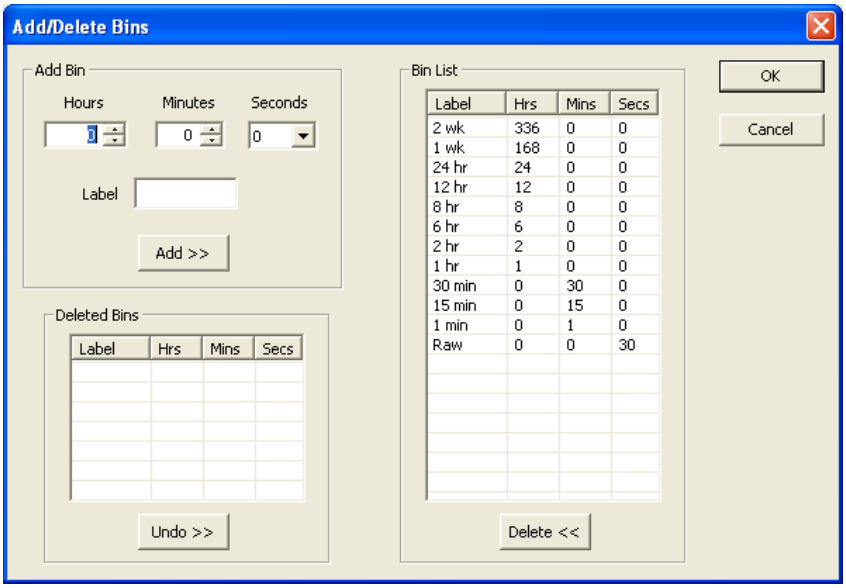


Table 2.1 - Add/Delete Time Bin Dialog Information

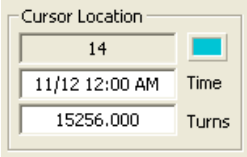
Add>>	Enter the time in Hours, Minutes and Seconds and enter a unique Label that is less than 10 characters. The time must also be unique to the list of existing bins in the **Bin List**. Click the **Add>>** button and the new bin will appear on the **Bin List**.
Bin List	Displays all of the current time bins.
Delete<<	To delete a time bin, select it on the **Bin List** and click the **Delete<<** button. This time bin will now appear on the **Deleted Bins** list.
Deleted Bins	Displays all of the deleted time bins.
Undo>>	To undelete a bin, select it on the **Deleted Bins** list and click the **Undo>>** button.

Using the Cursor

The Cursor Location section of the main screen (see Figure 2.9) displays information about the wheel graph cursor's current location. The cursor is a pair of yellow intersecting lines with a horizontal and a vertical component. The topmost fields show the name of the wheel trace and the trace color. If the text field is blank and the wheel trace color box is black, the cursor is currently not associated with any particular trace. Below the current graph field the location of the cursors is shown. Time is the X-axis component and turns (or kilometers) is the Y-axis component of the cursor location. To change the units displayed for the Y-axis component select **Tools | Wheel Graph Y Axis Units**.

Double click the left mouse button in the wheel graph to move the cursor to a plot, or click a selected wheel name in the wheel sensor tree to move the cursor to it's trace. For more information on cursor control refer to the **Chapter 3** of this manual.

Figure 2.9 - Cursor Location Section of Main Screen



Combining Data for Wheels with the Same Name

Wheels may be listed as unique items, or combined together into wheel groups of the same name. This allows wheel data for a particular cage to appear contiguous, even if multiple physical wheels are used to acquire the data. As an example, lets assume that a wheel is named in Wheel Manager to match its cage identifier e.g. B57A3. After acquisition has begun, wheel B57A3 goes out of service, and is replaced by another wheel. This replacement wheel needs to be named in Wheel Manager with the same name as the out of service wheel – B57A3. Now in Wheel Analysis, select **Tools | Combine Same Wheel Name Data**, and only one wheel in the Wheel Sensors list will have the name B57A3. When selected and shown in the graph, the data from the two physical wheels will be combined to appear as one contiguous data stream, named B57A3.

Customizing the Light/Dark Graph

The light/dark graph displays data from a light sensor or from a manually entered day/night schedule. The Light/Dark settings control the information shown on the Light/Dark graph.

The data in the light/dark graph can be binned like that in the wheel graph, or displayed as "unbinned" (raw) data. To switch between binned or raw data in the light/dark graph, select **Tools** | **Bin Light Sensor Data**.

Select a Database

If multiple databases are open, the light sensor or manual schedule must be picked from one of the open databases. Select the database in this pull down control.

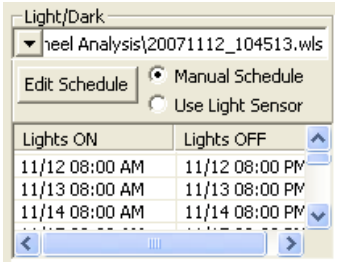
Select Manual Schedule or Use Light Sensor

Use the radio buttons to specify using either the manual schedule or light sensor as the light/dark graph source.

Creating a Manual Schedule

When the **Manual Schedule** radio button is selected, a schedule showing **lights on** and **lights off** times appear. Double click the schedule or click the **Edit Schedule** button to show the **Manual Light/Dark Scheduler** dialog.

Figure 2.10 – Light/Dark Controls with Manual Schedule Radio Button Selected



The Manual Light/Dark Scheduler dialog (Figure 2.11) provides a way to use the light/dark features of the Wheel Analysis software without using an environmental light sensor.

Refer to Table 2.2 and enter the desired information. The schedule is represented in graphical form on the screen.

Figure 2.11 – Manual Light/Dark Scheduler Dialog

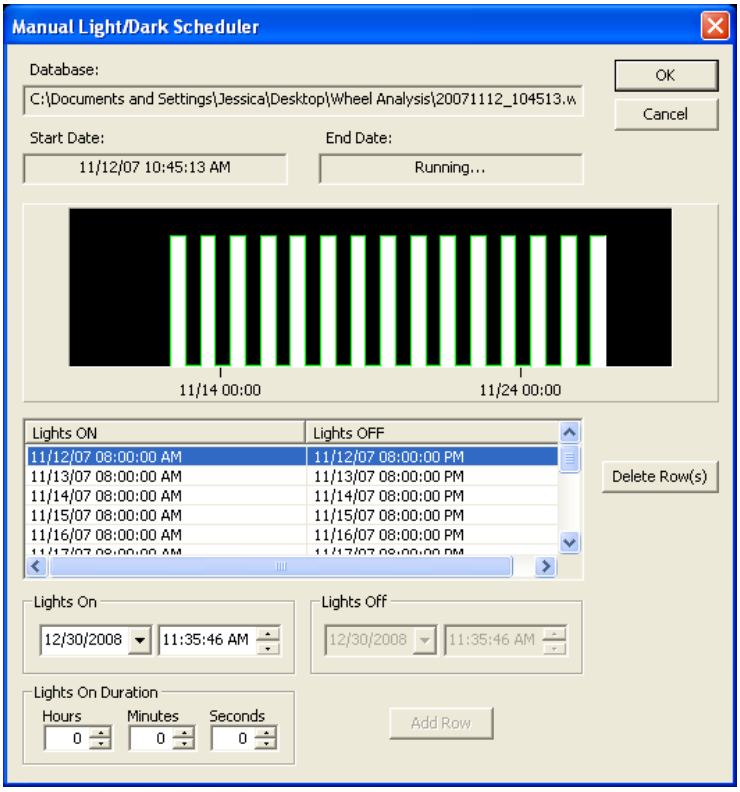


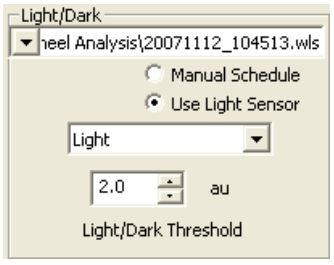
Table 2.2 – Manual Light/Dark Schedule Information

Lights On	Enter the time that the lights will turn on
Lights On Duration	Enter the duration of time that the lights will stay on
Add Row	Click to add this row to the schedule
Lights Off	Displays the time that the lights will turn off (this is a read only field)
Delete Rows	Deletes the selected row(s) from the schedule
OK	Click to save changes and close dialog
Cancel	Click to ignore changes and close dialog

Using the Light Sensor

When the **Use Light Sensor** radio button is selected, a dropdown selector to pick the desired light sensor appears. Select the sensor to use as the light/dark graph data source.

Figure 2.12 - Light/Dark Controls with Use Light Sensor Radio Button Selected



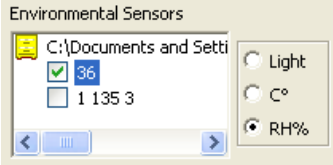
Setting the Light/Dark Threshold

When using a light sensor as the light/dark graph source, a level of brightness must be chosen to delineate between dark and light. The Light/Dark Threshold value is in arbitrary units (au). Each light sensor in each database has an associated Threshold value. The Threshold value is indicated in the light/dark graph by a pink horizontal line. The Light/Dark Threshold can be adjusted by entering a value in the field, using the up and down arrow keys to the right of the field or by clicking and dragging the pink indicator line on the light/dark graph.

Customizing the Environmental Sensor Graph

The environmental graph displays the light, temperature, or humidity data from the environmental sensors.

Figure 2.13 - Environmental Sensor Data



Adding and Removing Traces from the Graph

To add an environmental sensor's trace to the environmental sensor graph, click and fill its checkbox, and to remove a sensor from the graph, clear its checkbox.

Selecting Data to Display on the Graph

Use the radio buttons to specify which data to display on the Environmental Sensor Graph, Light, Temperature (°C) or Relative Humidity (RH%).

Add/Delete/Edit Annotations

Annotations are notes associated with a particular wheel or an entire database. An annotation has a time component, and a message. The annotations can be shown on the wheel graph from the **Tools** menu, **View Annotations** option. Use the Tools menu, Add/Delete Annotation option to show the annotations in the open database(s).

Click **Tools** | **Add/Delete Annotation** and the screen shown in Figure 2.14 will appear. Refer to Table 2.3 to add, edit or delete an annotation.

Figure 2.14 - Add/Delete/Edit Annotation Dialog

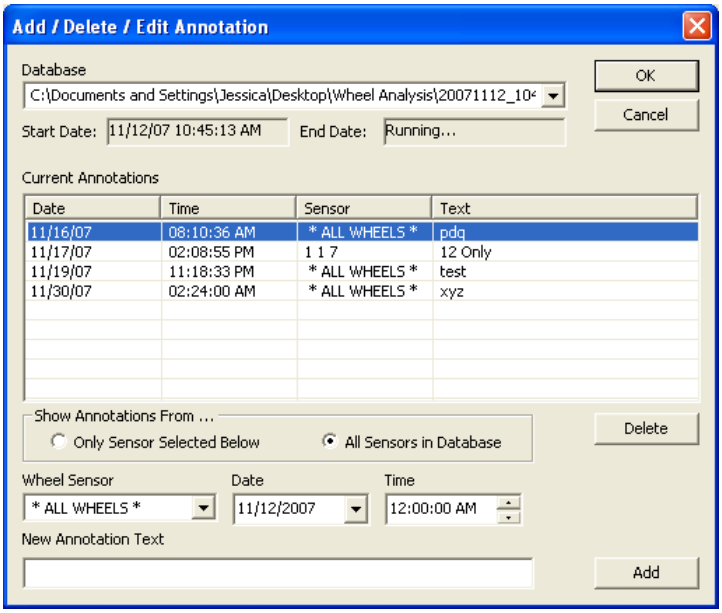


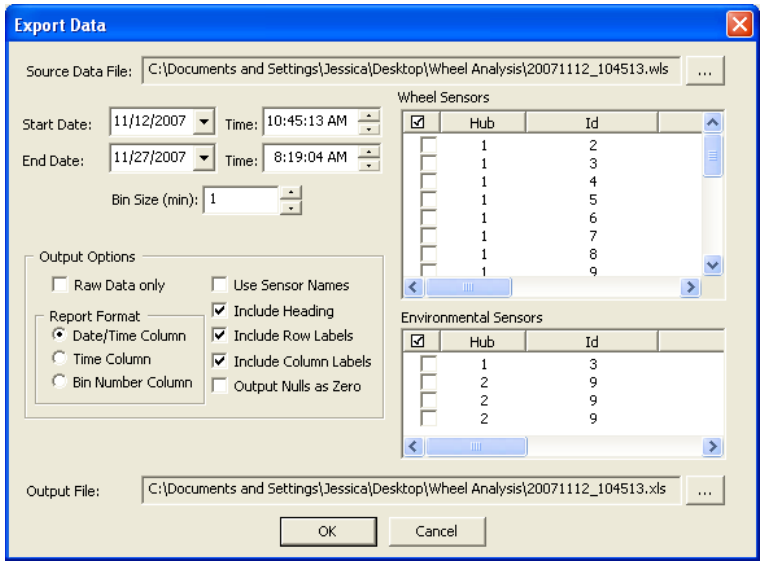
Table 2.3 – Add/Delete/Edit Annotation Dialog Information

Database	Select the database to work with from the Database dropdown selector
Start Date	Displays the time that the acquisition started for the selected database
End Date	Displays the time that the acquisition ended for the selected database. If the database is still acquiring data or was not closed properly this field will display "Running…"
Current Annotations Table	Lists the Date, Time, Sensor and Text for each annotation in the selected database. Click a column header to sort by that field
Delete	Deletes the selected row in the **Current Annotations** table
Add	Use the **Wheel Sensor**, **Date** and **Time** dropdown selectors to enter the desired information. Next add the desired text to the **New Annotation Text** field. Click **Add** to add this annotation to the **Current Annotations** table.
OK	Click to save changes and close dialog
Cancel	Click to ignore changes and close dialog

Exporting Data

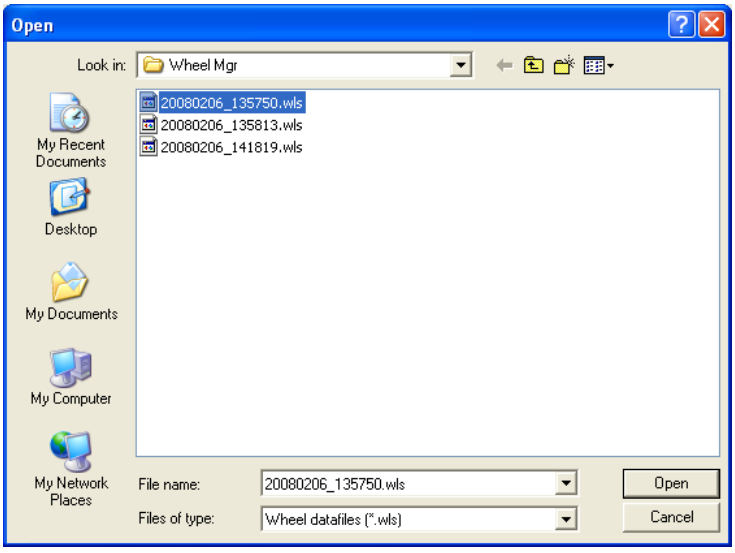
To export data to a Microsoft® Excel® spreadsheet file, a comma delimited or tab delimited file, select **File | Export**. The screen shown in Figure 2.15 will appear. Click on the "**...**" button in the upper right corner to browse to the desired source data file. The screen shown in Figure 2.16 will appear.

Figure 2.15 - Export Data Screen



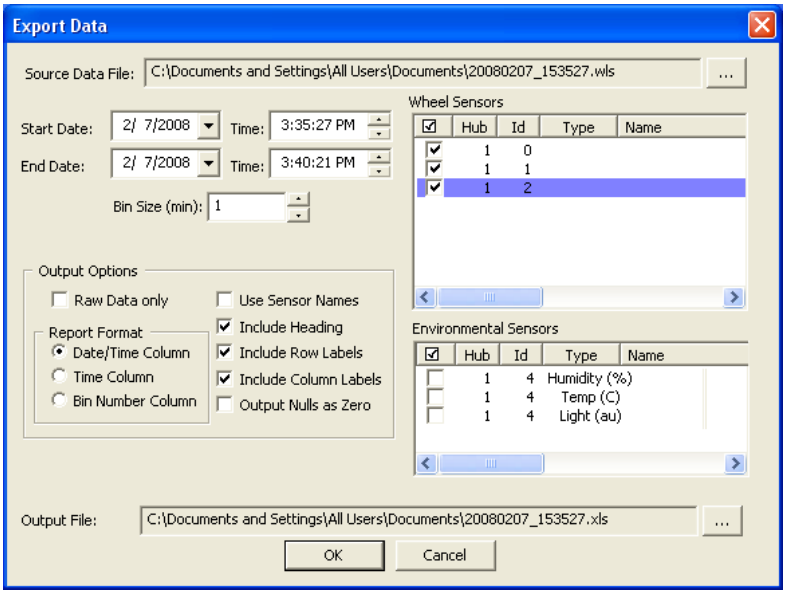
Select the desired source data file and click **Open**. The screen shown in Figure 2.17 will appear.

Figure 2.16 – Select the Source Data File



Select the desired source data file and click **Open**. The screen shown in Figure 2.17 will appear.

Figure 2.17 – Export Data Screen with Source Data File Selected



The Export Data screen will now contain the file name of the source data file. The following Output Options are available:

Table 2.4 – Export Data Screen Information

Start Date and Time	By default, the date and time that the data acquisition was started. Can be adjusted to a later date and time if desired.
End Date and Time	By default, the date and time that the data acquisition was ended. Can be adjusted to an earlier date or time if desired.
Bin Size (min)	Set the desired bin size in minutes. **NOTE:** The recommended minimum bin size is one minute if wheel data only are being exported and two minutes if environmental sensor data are being exported. This will prevent "holes" in the data.
Raw Data Only	Disables all report Output Options and Bin Size. Only one Wheel or Environmental Sensor can be selected.

<table>
<tr><td>Use Sensor Names</td><td>Enable this option in order to have Sensor Names appear in the exported data file. Refer to Figure B-4.
NOTE: If two different wheels are given the same name and the Use Sensor Names option is selected during data export, the data collected from these wheels will be merged in the data file. This can be useful if hardware problems occur and a wheel needs to be replaced during a study.
NOTE: Leave Use Sensor Names unchecked if Names were not assigned to the sensors.</td></tr>
<tr><td>Report Format</td><td>Allows the user to select the format of the bin labels in the exported data file.
o Date/Time Column: Each bin will be labeled using the date and time of the corresponding bin.
o Time Column: Each bin will be labeled using the time of the corresponding bin (in minutes).
o Bin Number Column: Each bin will be labeled using the bin number.</td></tr>
<tr><td>Include Heading</td><td>If checked, a heading will appear in the exported data file. This heading includes the date and time that the data was exported, the data file name, data acquisition start and stop times and the number of hubs and wheels. Refer to Figure B-1.</td></tr>
<tr><td>Include Row Labels</td><td>If checked, each row (or bin) will be labeled according to the “Report Format” selected. Refer to Figure B-1.</td></tr>
<tr><td>Include Column Labels</td><td>If checked, each column of data will be labeled with the Hub ID, Sensor Type and Sensor ID numbers, or names if “Use Sensor Names” is selected. Refer to Figure B-1.
o Sensor Type: The sensor type is indicated in the Column Label using a numeric value.
<table>
<tr><th>Sensor Type</th><th>Column Label</th></tr>
<tr><td>Wheel Sensor (ENV-044 Low Profile Running Wheel)</td><td>1</td></tr>
<tr><td>Light Sensor</td><td>2</td></tr>
<tr><td>Temperature Sensor</td><td>3</td></tr>
<tr><td>Humidity Sensor</td><td>4</td></tr>
<tr><td>Wheel Sensor (ENV-044-V Vertical Running Wheel)</td><td>5</td></tr>
</table></td></tr>
<tr><td>Output Nulls as Zero</td><td>If checked, the export will output zeroes, rather than nulls, for blank records/values. Refer to Figure B-3.</td></tr>
<tr><td>Wheel Sensors</td><td>Select the wheel sensors to include in the exported data file. Click the ☑ to select all of the wheel sensors.</td></tr>
<tr><td>Environmental Sensors</td><td>Select the environmental sensor data to include in the exported data file. Click the ☑ to select all of the environmental sensors.</td></tr>
<tr><td>Output File</td><td>Displays the destination folder of the exported data file. Click the “...” button in the lower right corner to browse to a different destination folder.</td></tr>
</table>

When all of the correct information has been entered, click **OK** to export the data file to the destination folder. Exported files may be saved as *.xls (Microsoft® Excel®) files. Many other spreadsheet programs can also read these files. Open the desired spreadsheet software application and open the file. Exported files may also be saved in tab delimited (*.tsv) or comma delimited (*.csv) formats. To select the desired output format, click the "**...**" button next to the **Output File** and select the desired type in the **Save as Type** field.

Exporting to Metafile…

To save an image of the wheel graph as an enhanced metafile (*.emf), select **File** | **Export to Metafile**.

Changing the Refresh Rate…

Wheel Analysis can display data from a database being written to by Wheel Manager. The data displayed in the graphs will be updated according to the schedule set in the Change Refresh Rate dialog. To display the dialog, select **Tools** | **Change Refresh Rate**.

Since the average sample rate is 30 seconds, a minimum of 1 minute is allowed for the Wheel Analysis refresh rate. To stop the refreshing of an open database, close the database in Wheel Manager. Alternatively, simply set the refresh to a very high value to limit any inconvenience of refreshing data.

Setting Clock Preferences

Times can be represented using a 12-hour or 24-hour clock. As an example: "1:15 pm" in 12-hour representation would be "13:15" in 24-hour notation. To change the time format select **Tools** | **Clock Preferences**.

CHAPTER 3
Viewing the Graphs

Using the Wheel Sensor Graph Cursor

The Wheel Graph has one cursor consisting of horizontal and vertical yellow lines. The value at the point of intersection is shown at the main screen upper left corner in the "Cursor Location" box (see Figure 2.9). The first line indicates the wheel name, and the box to the right indicates the trace color of the current active trace.

All cursor actions below will move the cursor on the current active trace. To change the current active trace, select a wheel in the wheel tree (wheel must be "on" – checkbox filled).

Be sure that the cursor control button  on the toolbar is selected in order to manipulate the cursor.

Figure 3.1 – Wheel Graph with Cursor

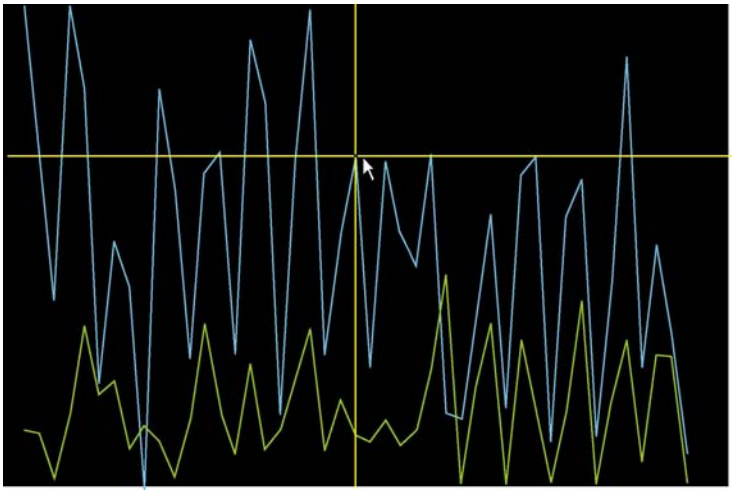


Table 3.1 – Wheel Graph Cursor Control Actions

Double Click	Moves the cursor to the nearest time position on the current active trace.
Left and Right Arrow Keyboard Keys	Moves the cursor's time (x-axis) position.
Click and Drag the Vertical Position of the Cursor	Moves the cursor's time (x-axis) position. The Cursor control toolbar button must be depressed. (Ctrl+K)
Click and Drag Horizontal Portion of the Cursor	Moves the cursor to the earliest time point with the desired Y-axis value (km or turns). The Cursor Control toolbar button must be depressed (Ctrl+K)

Using the Light/Dark Graph Cursor

The Light Graph has two cursors – yellow and pink. The vertical yellow time (x-axis) cursor is locked in sync with the wheel sensor and environmental sensor graph time cursors. The pink horizontal line cursor indicates the light/dark threshold and appears only if the Use Light Sensor radio button is selected. Light sensor readings above this line are considered to be daytime for circadian rhythm research. The light/dark threshold line may be dragged with the mouse, or set with the edit box to the left of the light/dark graph.

Figure 3.2 - Light/Dark Graph with Cursors

Using the Environmental Sensor Graph Cursor

The Environmental graph has one cursor – a yellow time (x-axis) cursor that is locked in sync with the wheel sensor and environmental sensor graph time cursors. This cursor may not always be precisely aligned vertically with the cursors in the Wheel Sensor Graph Cursor and the Light/Dark Graph Cursor. This is due to the fact that data is sampled less frequently from the Environmental Sensor than the Wheel Sensor, and consequently there are fewer data points.

Zooming in on the Graphs

To "zoom" is to change the extents of a graph's axes. "Zoom In" to show less data, in finer detail and "Zoom Out" to show more data, with less detail. There are several ways to change the zoom level.

Zoom Using the Lasso Zoom

Lasso Zoom control uses the mouse to "draw" a rectangular zoom region.

To turn on Lasso Zoom using any of the following methods:

Table 3.2 - Lasso Zoom Methods

Keyboard	Ctrl + L
Toolbar	
Pan/Zoom Menu	Pan/Zoom | Lasso Zoom

Once in Lasso Zoom mode (indicated by lasso toolbar button down):

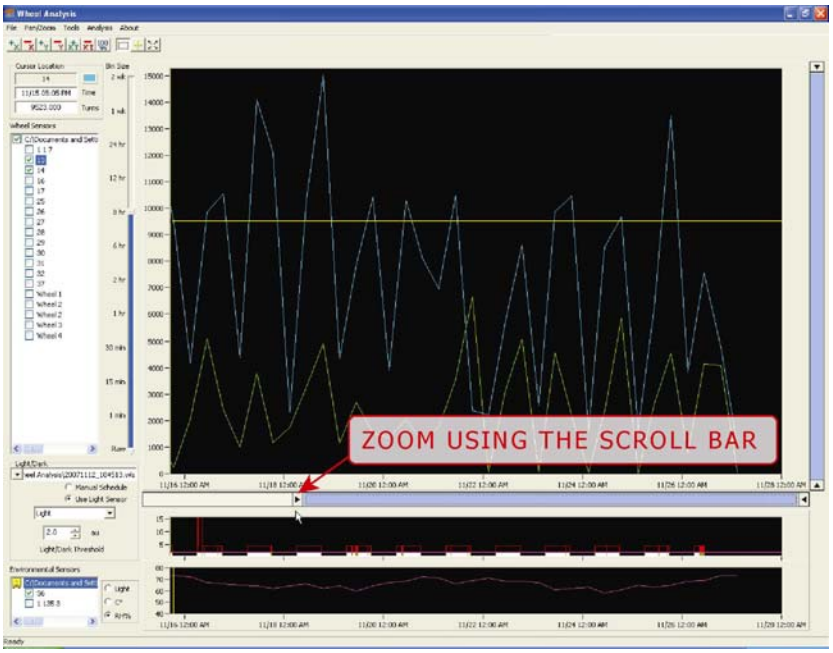
- Click and drag to enlarge that area of the graph
- Hold down Shift key and click inside graph to zoom out to the previous range

Zoom Using the Scroll Bar

The scroll bars below and to the right of the wheel graph indicate the current visible range, as a subset of the data's full extents. The arrow boxes at the scroll bar ends indicate the current range setting. The arrows may also be dragged with the mouse to change the visible range (zoom level). To show less time (zoom "in"), drag the left end of the horizontal scroll bar to the right and/or the right end of the horizontal scroll bar to the left.

The visible range bars may be dragged to "pan" the graph. Also, a click inside the scroll bar, outside the visible range, will move the visible range toward the click position. Click and hold to move continuously.

Figure 3.3 - Zooming in Using the Scroll Bar



Zoom Using the Zoom Around Cursor

To zoom in or out around the cursor use any of the following methods:

Table 3.3 - Zoom Using the Zoom Around Cursor

	X (time)		Y (turns, km, C, etc)		Both X and Y	
	In	Out	In	Out	In	Out
Keyboard	Ctrl + +	Ctrl + Shift + +	Ctrl + -	Ctrl + Shift + -	Ctrl + B	Ctrl + Shift + B
Toolbar						
Pan/Zoom menu	Zoom In X	Zoom Out X	Zoom In Y	Zoom Out Y	Zoom In Both	Zoom Out Both

Zooming Out to the Full Extents

To zoom out to full extents use any of the following methods:

Table 3.4 - Zooming Out to the Full Extents

Keyboard	Ctrl + 1
Toolbar	
Pan/Zoom Menu	Pan/Zoom | Zoom Out Full

Zoom Using the Center Mouse Wheel

Roll the center mouse wheel down (towards your hand) to zoom in around the cursor. Roll the wheel up (away) to zoom out. To zoom in quickly, double click near the area of interest to move the cursor, then roll the mouse wheel down to zoom in.

Zoom Using the Set Graph Extents Dialog

Set the zoom levels by entering the minimum and maximum axes values in the Set Graph Extents dialog. Refer to the Adjusting the X- and Y-Axis Ranges section of this manual for further information.

Panning

To “pan” is to move the visible region, without affecting the zoom level. It is only possible to pan a graph that is shown at less than full extents (zoomed “in”).

To enter Pan mode and pan with the mouse use any of the following methods:

Table 3.5 - Panning

Keyboard	Ctrl + H
Toolbar	
Pan/Zoom Menu	Pan/Zoom | Pan Control

Once in Pan mode (indicated by toolbar pan button down), click and drag the mouse inside a graph to pan.

Alternatively, use the left/right arrow keyboard keys to move the cursor “off the edge” of the graph. Graph will pan in that direction.

Also, the scroll bars may be used to pan. Click and drag the visible region portion of the scroll bar. Or, click inside the scroll bar but outside the visible region to move the visible region in the direction of the click.

CHAPTER 4
Viewing the Actogram

The actogram is a useful tool for determining circadian locomotor activity rhythms. The actogram plots a wheel's activity versus time. Each horizontal line represents one day in single plot mode, or two days in double plot mode. The actogram can display activity in several graph styles: line, bar, or flat. The different graph styles show the activity (alpha) periods and resting (rho) phases using different line styles.

View the actogram for a specific wheel by right-clicking on the wheel name displayed on the Wheel Sensor Tree or by highlighting the desired wheel on the Wheel Sensor Tree and selecting **Analysis | Actogram…**. It will take a few moments for the actogram to be created. An example actogram is shown below.

The actogram can be customized using the controls on the screen. A description of each control is included in Table 4.1.

Figure 4.1 – Example Actogram

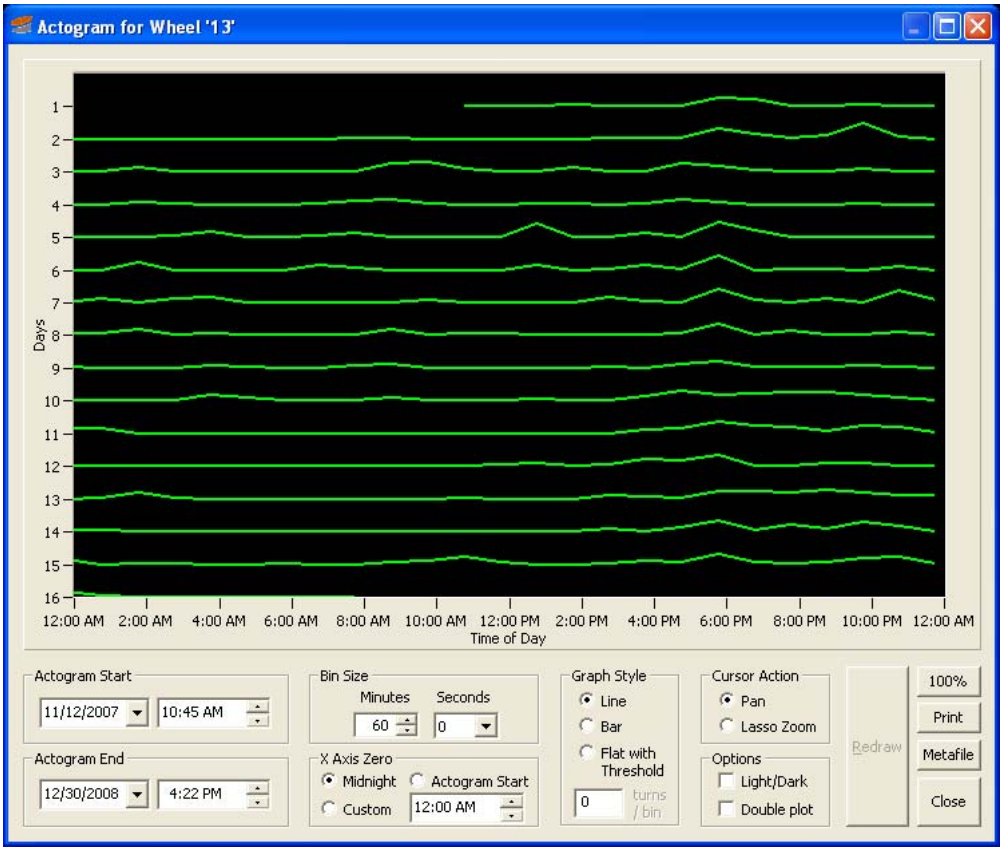


Table 4.1 – Actogram Dialog Information

Actogram Start	Actogram start time
Actogram End	Actogram end time
Bin Size	A smaller bin size (30 second minimum) will show data in greater detail, but may appear too "jagged". A larger bin size will show data in less detail, but may appear "smoother".
X-Axis Zero	Controls the time at the x-axis origin. • If the **Midnight** radio button is selected, the x-axis origin will be 00:00 (12 AM). • If the **Actogram Start** radio button is selected, the x-axis origin will be the time indicated in the **Actogram Start** field. • If the **Custom** radio button is selected, a time must be entered as the x-axis origin. Custom is helpful for aligning light on (or off) time with the beginning of the graph.
Graph Style	Select the method to display the data, Line, Bar or Flat graph.
Cursor Action	Select the function of the cursor on the graph. • **Pan** allows the user to place the cursor on the graph area and by clicking and holding the left mouse button, then dragging to move the graph contents. • **Lasso Zoom** allows the user to select a rectangular area of the graph to zoom in on by clicking and holding the left mouse button over the desired graph area. Hold down the Shift key and click the left mouse button in the graph to undo a lasso zoom.
Options	• If the **Light/Dar**k checkbox is selected the light/dark periods will be displayed. Clear the checkbox to show on wheel turn data versus time. The source of the light/dark data depends on the Light/Dark setting on the main screen. • If the **Double Plot** checkbox is selected data from two consecutive days will be plotted on the same horizontal row. The second day will be repeated on the left side on the line below.
Redraw	Replots data using the current Actogram settings.
100%	Performs a full zoom out. May be helpful after using the lasso zoom.
Print	Sends the actogram to a printer.
Metafile	Saves a picture of the actogram as an enhanced metafile (*.emf).
Close	Closes the actogram dialog and returns to the main screen.

CHAPTER 5
Viewing the Periodogram

The periodogram developed by Enright (1965) is a useful method for identifying the presence and robustness of periodicity in time-series data (Refinetti, 1993; 2004). The X^2 (chi-square) designation refers to subsequent contribution to Enright's periodogram by Sokolove and Bushell (1978) that provides a test of significance using the chi-square distribution. The Periodogram dialog in the Wheel Analysis software performs an implementation of their chi-square periodogram. The results of these computations are graphically displayed, as is the most probable circadian period detected.

To view the periodogram for a specific wheel, highlight the wheel on the Wheel Sensor Tree and select **Analysis** | **Periodogram**, or right click on the wheel, and choose **Periodogram** from the pop-up menu. An example periodogram is shown in Figure 5.1.

The y-axis of the periodogram graph displays the "robustness" for each period in a range of test periods laid out along the x-axis (see Figure 5.1). The peak "robustness" value indicates the dominant period in the data.

The **Bin Size** setting defines the size, in minutes, of the time bins used to group running wheel counts. This setting is also a primary determinant of the number of periods tested and, by extension, the resolution of the periodogram.

The algorithm breaks the wheel data into sections of time period *P*, where $19 \leq P \leq 27$ hours, and *P* increments by the time bin size. Using the example of 6-minute bins (10 bins per hour), the time periods tested would be 19.0 hours, 19.1 hours, 19.2 hours, etc. up to 27.0 hours. The wheel activity in each time period will be most similar to each other when the segment lengths have the same length as the subject's actual circadian period.

The periodogram calculation is an iterative process where the "robustness" of the period (designated Q_P) is calculated for each period *P*. The wheel's time-series data are split into consecutive segments of *P* duration, and mathematically superimposed on each other so that the first time bin of each segment is aligned. The data are stored in a 2-dimensional array, with each segment of *P* duration comprising a row, and aligned time bins form the columns. Therefore the number of rows equals the number of *P* length segments, and the number of columns equals the number of time bins contained in each *P* length segment. Column means are calculated, and then the variance of these means is computed. Q_P is a ratio of the variance of time bin means for period *P* and the overall variance for the data set. As *P* approaches the dominant period in the data, the variance for the column means will increase, and consequently the Q_P for that period *P*.

The test of significance for the peak Q_P value uses the Wilson and Hilferty transformation (1931), a technique allowing the conversion between chi-square and z-score statistics. α is corrected for multiple tests using Bonferroni correction.

The test of significance assumes at least 10 days of data. With fewer days, the computed value will still be accurate, but the significance test will be less sensitive.

The periodogram can be customized using the controls on the screen. A description of each control is included in Table 5.1.

Figure 5.1 - Example Periodogram

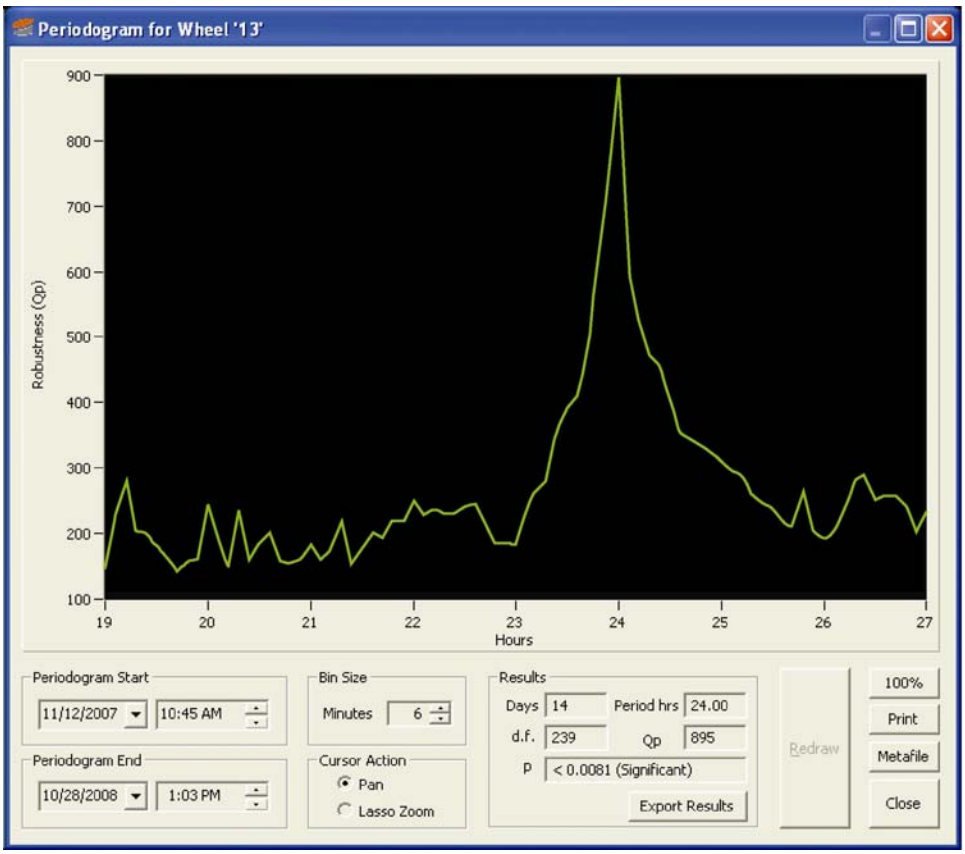


Table 5.1 – Periodogram Dialog Information

Periodogram Start	Periodogram start time
Periodogram End	Periodogram end time
Bin Size	A smaller bin size (1 minute minimum) will show data in greater detail, but may appear too "jagged". A larger bin size will show data in less detail, but may appear "smoother". Six-minute bins will yield results to a 0.1-hour resolution. One-minute bins will yield finer resolution circadian period – down to 0.0167-hour resolution.
Cursor Action	Select the function of the cursor on the graph. • **Pan** allows the user to place the cursor on the graph area and by clicking and holding the left mouse button, move the graph contents. • **Lasso Zoom** allows the user to select a rectangular area of the graph to zoom in on by clicking and holding the left mouse button over the desired graph area. Hold down the Shift key and click the left mouse button to undo a lasso zoom.

Results	• **Days**: the number of whole days in the data set. • **Period Hours**: the calculated circadian period. • **d.f.:** degrees of freedom = (Period Hours * bins per hour) - 1. • **Q_P:** robustness of "Period Hour's" calculation. • **p:** probability that the maximum Qp calculated is a false peak. A p of 0.05% or less is a "significant" finding. • **See Note:** button appears when a warning exists. The message will warn of insufficient data. A minimum of ten days of data is suggested to achieve statistical significance. • **Export Results:** Button will save the periodogram analysis results and graph to a text file.
Redraw	Replots data using the current periodogram settings.
100%	Performs a full zoom out. May be helpful after using the lasso zoom.
Print	Sends the periodogram to a printer.
Metafile	Saves a picture of the periodogram as an enhanced metafile (*.emf).
Close	Closes the periodogram dialog and returns to the main screen.

References

Enright, J. T. (1965). The search for rhythmicity in biological time-series. *Journal of Theoretical Biology* **8**: 426-468.

Sokolove, P. G. and Bushell, W. N. (1978). The chi square periodogram: its utility for analysis of circadian rhythms. *Journal of Theoretical Biology* **72**: 131-160.

Refinetti, R. (1993). Comparison of six methods for the determination of the period of circadian rhythms. *Physiology and Behavior* **54**: 869-875.

Refinetti, R. (2004). Non-stationary time series and the robustness of circadian rhythms. *Journal of Theoretical Biology* **227**: 571-581.

Wilson, E. B. and Hilferty, M. M. (1931). The Distribution of Chi-Square. Proceedings of the National Academy of Sciences of the United States of America **17**: 684-688.

APPENDIX A
Software Installation

If the computer being used with the Wheel Manager Data Analysis software was purchased as part of the system from MED Associates, the software installation was completed at the factory. If the computer was not purchased from MED Associates, follow the instructions to install the software.

Before beginning the installation, phone, fax or e-mail Med Associates with the registration information in order to receive the software installation password. This password will be necessary during the installation process.

Begin software installation by inserting the Wheel Manager Data Analysis CD into the CD-ROM drive. The screen shown in Figure A.1 will appear. Click **Install the Wheel Manager software** and the screen shown in Figure A.2 will appear.

Figure A.1 – Wheel Manager Installation Main Screen

Begin installing the software by clicking **Install**. Complete the steps to install the software, entering the desired User Name and Company as well as the password when prompted.

Successful installation will be indicated by a green check mark, and a red X will indicate an unsuccessful installation. Once the software has successfully been installed, the screen shown in Figure A.3 will appear.

Figure A.2 – Click Install to Begin

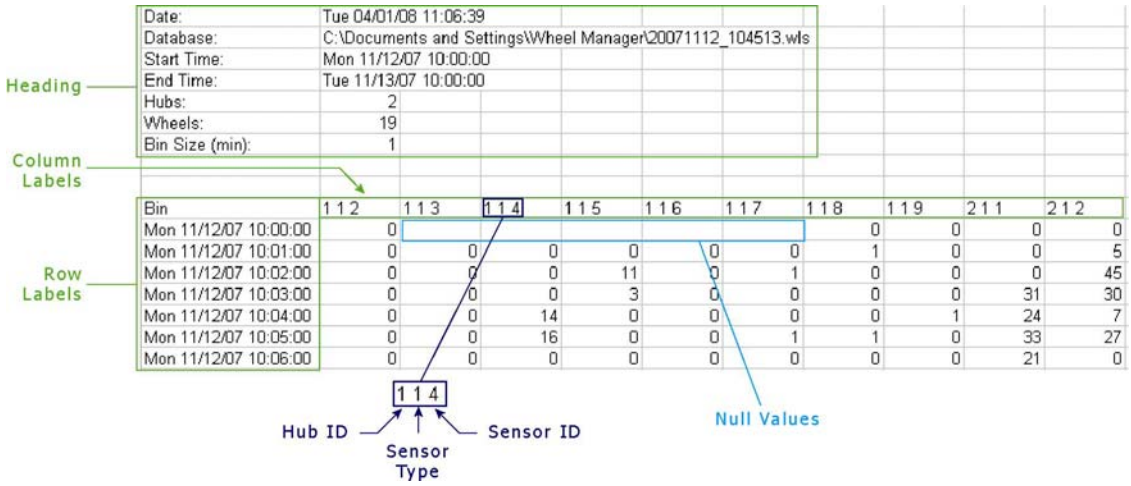
Software installation is now complete. Click **Finish** to close this window.

Figure A.3 – Customer Information Screen

APPENDIX B
Sample Exported Data Files

The sample data file shown in Figure B-1 was generated using the Output Options shown in Figure B-2. The sample data file shown in Figure B-3 was generated using the same Output Options, but with the **Output Nulls as Zero** option enabled.

Figure B-1 - Sample Exported Data File with Labels Identified



Date:	Tue 04/01/08 11:06:39
Database:	C:\Documents and Settings\Wheel Manager\20071112_104513.wls
Start Time:	Mon 11/12/07 10:00:00
End Time:	Tue 11/13/07 10:00:00
Hubs:	2
Wheels:	19
Bin Size (min):	1

Bin	112	113	114	115	116	117	118	119	211	212
Mon 11/12/07 10:00:00	0						0	0	0	0
Mon 11/12/07 10:01:00	0	0	0	0	0	0	1	0	0	5
Mon 11/12/07 10:02:00	0	0	0	11	0	1	0	0	0	45
Mon 11/12/07 10:03:00	0	0	0	3	0	0	0	0	31	30
Mon 11/12/07 10:04:00	0	0	14	0	0	0	0	1	24	7
Mon 11/12/07 10:05:00	0	0	16	0	0	1	1	0	33	27
Mon 11/12/07 10:06:00	0	0	0	0	0	0	0	0	21	0

Figure B-2 - Output Options Used to Generate Exported Data Shown Above

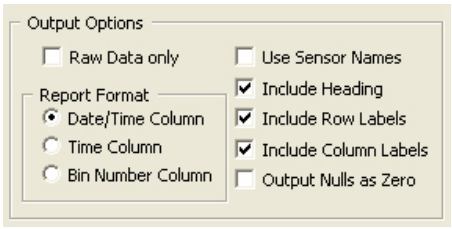


*Figure B-3 – Sample Exported Data File with **Output Nulls as Zero** Enabled*

Date:	Tue 04/01/08 11:06:39
Database:	C:\Documents and Settings\Wheel Manager\20071112_104513.wls
Start Time:	Mon 11/12/07 10:00:00
End Time:	Tue 11/13/07 10:00:00
Hubs:	2
Wheels:	19
Bin Size (min):	1

Bin	112	113	114	115	116	117	118	119	211	212
Mon 11/12/07 10:00:00	0	0	0	0	0	0	0	0	0	0
Mon 11/12/07 10:01:00	0	0	0	0	0	0	1	0	0	5
Mon 11/12/07 10:02:00	0	0	0	11	0	1	0	0	0	45
Mon 11/12/07 10:03:00	0	0	0	3	0	0	0	0	31	30
Mon 11/12/07 10:04:00	0	0	14	0	0	0	0	1	24	7
Mon 11/12/07 10:05:00	0	0	16	0	0	1	1	0	33	27
Mon 11/12/07 10:06:00	0	0	0	0	0	0	0	0	21	0

Null Values Output as Zeros

The sample exported data file shown in Figure B-4 was generated with the **Use Sensor Names** option enabled.

*Figure B-4 – Sample Exported Data File with **Use Sensor Names** Enabled*

	Date:	Tue 04/01/08 11:06:39						
	Database:	C:\Documents and Settings\Wheel Manager\20071112_104513.wls						
	Start Time:	Mon 11/12/07 10:00:00						
	End Time:	Tue 11/13/07 10:00:00						
	Hubs:	2						
	Wheels:	19						
	Bin Size (min):	1						
Sensor Names →	Bin	Humid	Light	Temp	Wheel 1	Wheel 2	Wheel 3	Wheel 4
	Mon 11/12/07 10:00:00		0		0			
	Mon 11/12/07 10:01:00	47.16		22.59	0	0	0	0
	Mon 11/12/07 10:02:00		0	22.56	0	0	0	11
	Mon 11/12/07 10:03:00	47.69	0		0	0	0	3
	Mon 11/12/07 10:04:00	47.82		22.52	0	0	14	0
	Mon 11/12/07 10:05:00		0	22.55	0	0	16	0
	Mon 11/12/07 10:06:00	47.95	0		0	0	0	0

The sample exported data file shown in Figure B-5 was generated with the **Raw Data Only** option enabled. The message time (MsgTime) is shown in milliseconds. The message type (MsgType) is indicated using a numeric value. A message reading '131' indicates a Sensor Reset and a message reading '134' indicates a Sensor Message. The battery voltage (Battery) is in volts DC.

*Figure B-5 – Sample Exported Data File with **Raw Data Only** Enabled*

Date:	Tue 04/01/08 11:12:35		
Database:	C:\Documents and Settings\Wheel Manager\20071112_104513.wls		
Start Time:	Mon 11/12/07 10:00:00		
End Time:	Tue 11/13/07 10:00:00		
Hub:	1		
Sensor:	3		
MsgTime	MsgType	Battery	Count
30346	134	4.493	0
59749	134	4.493	0
89821	134	4.493	0
119223	134	4.493	0
149294	134	4.493	0
178695	134	4.514	0
208473	134	4.514	0
238125	134	4.493	0
267903	134	4.493	0
297554	134	4.493	0
327331	134	4.493	0