United States
Environmental Protection
Agency

Air and Radiation

EPA420-P-98-019
March 1999
M6.FLT.006

Soak Length Activity Factors for Diurnal Emissions

DRAFT

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Assessment and Modeling Division
Office of Mobile Sources
U.S. Environmental Protection Agency

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- Draft -

Soak Length Activity Factors for Diurnal Emissions

Report Number M6.FLT.006

Last Revised on March 1, 1999

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U.S.EPA Assessment and Modeling Division

1.0 INTRODUCTION

MOBILE6 will compute and report (as a user option) hourly emission factors for start, running, and evaporative emissions. These will be in addition to the standard daily emission estimates which are currently calculated by MOBILE5. The hourly emission factors will allow the MOBILE6 model to provide more precise output that accounts for the time of day that vehicle emissions occur. The temporal distribution of emissions is an important factor in the formation of diurnal evaporative emissions.

The hourly emission estimates require considerable vehicle activity information and analysis. The term "activity" refers to the vehicle's operating mode such as running, idling, parked (soaking), etc. The specific activity information includes soak durations, time of soak, trip lengths, time of trip, and other information. This document (M6.FLT.006) discusses the issue of vehicle soak time as it pertains to diurnal emissions. Other activity estimates needed to develop daily emission factors for hot soak, running loss, start and running exhaust emissions, and resting loss emissions will be documented in other MOBILE6 documents listed with the report numbers "M6.FLT.XXX". Also, for general information on evaporative emissions and their modeling in the MOBILE6 model, the reader is encouraged to review "M6.EVP.001" and "M6.EVP.002".

2.0 DATA SOURCES USED

The primary data source for this analysis is an EPA instrumented vehicle study conducted in Baltimore, Spokane and Atlanta. In these studies, instrumentation to monitor vehicle usage was installed with the motorists' permission on 168 randomly selected vehicles while they were tested at an Inspection / Maintenance (I/M) station. The motorists returned one or two weeks later to have the instrumentation removed. Information from more than 8,500 vehicle-trips was recorded. The raw data collected from the study were processed by the Radian Corporation under EPA contract to create a "trip characteristics" file. This processed file was used to develop the hourly soak time distributions. For more details regarding the instrumented vehicle study and the data processing, please refer to the document "Travel Trip Characteristics Analysis" Final Report under EPA Contract 68-C1-0079 WA 2-05 with Sierra Research.

3.0 METHODOLOGY FOR DIURNAL EMISSION ACTIVITY

This section describes the basic methodology to develop the trip length activity estimates used to calculate diurnal emissions. The process consisted of several steps. These are discussed below.

3.1 Definitions

3.1.1 Diurnal Emissions

Diurnal emissions are evaporative emissions which may escape from a non-running vehicle subsequent to its hot soak, and while it is exposed to a thermal gradient cycle of sufficient magnitude. Emissions are produced primarily during and immediately following the portion of the cycle when temperatures rise. Diurnal emissions are defined as excluding emissions that occur during vehicle running, starting, or hot soak operation. They also generally occur over a period of time of several hours, and must be apportioned to the various hourly groups.

For purposes of the MOBILE6 model, three types of diurnals can occur. The first type is the multi-day diurnal. This type occurs if a vehicle is operated, and then "soaks" (is parked) for two or more days, and experiences two or more cycles of sufficiently large thermal gradients during the multi-day soak period to raise fuel tank temperatures past a threshold value. The second type is the full or one-day diurnal. This type of diurnal needs to begin prior to the beginning of the temperature rise (i.e., prior to 6AM), and can last for up to 24 hours. The third type is the interrupted diurnal. This type is similar to the previous ones, except that the soak periods range from a minimum of one hour up to 24 hours, and they start later in the day (i.e., the vehicle is operated during the morning so that the early morning heat build (begins at 6 AM) is interrupted). The diurnals which range from 25 hours to 48 hours are a combination of a one day diurnal and an interrupted diurnal or multi-day depending on when they start.

Depending on the length of the soak, the full diurnal and the interrupted diurnal may represent only a fraction of the thermal cycle. Also, in terms of activity parameters, the MOBILE6 model diurnal activity parameters will reflect vehicles which experienced more than one interrupted diurnal during the day. Their contribution is a function of the length and timing of vehicle trips during the day. For example, a vehicle that makes a quick trip from 10:00 to 10:20 AM, and is parked until sundown will be reflected in the hourly activity parameters as part of a full diurnal (from 6 AM to 10 AM), and an interrupted diurnal from 12:20 AM until sundown. During the two hour period between 10:20 AM and 12:20 AM the vehicle is in hot soak mode.

3.1.2 Hourly Diurnal Activities

For this analysis of vehicle activity, hourly diurnal activity estimates have a different basis than hourly running emission activity estimates. Where the hourly running emissions are based on the number and/or length of trips in the given hour, the hourly diurnal activity estimates are based on whether a multi-day, full day, or interrupted diurnal occurred during that hourly group. For example, a vehicle can have several trips during a

given hourly group interval; however, a vehicle is either experiencing a diurnal during a given hourly group interval, or not experiencing it during the given hourly interval. In other words the analysis assumed that each vehicle in the database could have either one or no diurnals during a given hour on a given day.

3.2 Hourly Intervals

The 24 hour day was divided into 14 different hourly groups. Thirteen of these groups have a duration of one hour. These start at 6:00AM and run through 6:59:59PM. The fourteenth group contains the remaining nighttime hours as one interval. Collapsing these hours into one group was done for three reasons: (1) the emissions contributed during the night have a relatively smaller impact on daily ozone than those contributed during the morning or day, (2) there were relatively little data for these time periods, and (3) what data were available produced results which showed very little hour to hour variance. The hourly intervals are shown in Table 1. In addition to its use for diurnal activity estimates, the same hourly group structure is used in the calculation of activity estimates for start emissions, running emissions, hot soak emissions, resting loss emissions, and running loss emissions.

Table 1 Hourly Ranges		
Group Name	**Hourly Range**	**Time**
6	6 - 7	6 am to 7 am
7	7 - 8	7 am to 8 am
8	8 - 9	8 am to 9 am
9	9 - 10	9 am to 10 am
10	10 - 11	10 am to 11 am
11	11 - 12	11 am to noon
12	12 - 13	noon to 1 pm
13	13 - 14	1 pm to 2 pm
14	14 - 15	2 pm to 3 pm
15	15 - 16	3 pm to 4 pm
16	16 - 17	4 pm to 5 pm
17	17 - 18	5 pm to 6 pm
18	18 - 19	6 pm to 7 pm
24	19 - 24 and 24 - 5	7 pm to 6 am

3.3 Identifying the Hourly Diurnals in the Database

The instrumented vehicle database consists of 'trip' type data. This means that the initial vehicle start time and stopping times were recorded while the vehicles were operating. The database was based on more than 8,500 vehicle trips, and the corresponding number of prior and subsequent soaks. For this analysis, the individual trip data were not used directly since the activity information was needed on an hourly basis rather than on a per trip basis. In essence, it was necessary to know for a given hourly group interval the number of vehicles which were experiencing a diurnal, and the number of vehicles which were in running mode or in hot soak mode.

Examination of the roughly 8,500 vehicle trips showed 168 vehicles, and 1,425 vehicle-days of data in the sample. The concept of vehicle-days was used instead of trips

because diurnals can occur over several hours, and each vehicle can experience either one or zero diurnals in a given hour of a day. For example, at 6 to 7 AM, a vehicle is either experiencing a diurnal or running / hot soaking (not experiencing a diurnal). The 1,425 vehicle-days were reduced down to 1,257 valid vehicle-days by omitting each vehicle's first day of operation in the program. The omission of each vehicle's first test day was necessary because the length of the soak prior to the installation of the instrumentation was not known. For example, if vehicle #10 were operated for 14 days in the program, it would account for 13 valid vehicle-days.

Creating the 13 hourly groups (nighttime group 14 was omitted) for diurnal activities was necessary because diurnal emissions are a function of time of day and duration of soak. For example, on a day with a typical temperature cycle, the diurnal emission effect on the 11 to 12 AM interval after an eight hour soak will likely be larger than the diurnal emissions on the 6 to 7 AM interval after an eight hour soak.

Once the database was organized into 1,257 valid vehicle-days, it was necessary to determine for each of the 13 hourly groups whether a diurnal had occurred on each of the 1,257 valid vehicle-days, and the soak duration prior to the beginning of the hourly group. By definition, a diurnal occurred if the vehicle was NOT operating, or had NOT operated in the previous two hours. In practice this will be slightly more than two hours because the data could not be analyzed on a basis any finer than by hour. For example, if a vehicle started at 7:35 AM, it was assumed to start at 7:00 AM. Also, by the definition, it was assumed that diurnal emissions would be very small in magnitude during the nighttime hours of 7 PM to 6 AM (group 14), although a vehicle's soak period could encompass part or all of this time interval. As a result, the activity distribution for the 6 PM to 7 PM group will be used for the nighttime hours.

For each hour, the duration of the preceding soaks were grouped in 12 intervals. These intervals are shown in the first column of Table 2. They range from a soak duration of 1 to 2 hours up to a multi-day soak of 72 hours or more. The 12th row (labeled "running / hot soak") contains the percentage of vehicles which were not experiencing a diurnal during a given hourly group. For example, the fifth column of the fourth row of numbers in Table 2 says that 1.67 percent of the valid vehicle-days had soaks which started between four and five hours prior to 10 AM, and did not include any vehicle operation between 10 and 11 AM.

For illustration, the hourly diurnal activity results are shown in Table 2 for all of the hourly groups and for a range of soak hours. The percentages in each column add to 100 percent and include vehicles which are not having a multi-day, full, or an interrupted diurnal (See Section 4.3 for definition of diurnal types). The percentage of vehicles in a given hourly group which are likely experiencing a multi-day diurnal are those in the rows labeled as 48 to 71 and 72+. The percentage of vehicles which are likely (there are a few exceptions depending on when the soak began) experiencing a full diurnal plus an

interrupted diurnal are those in the row labeled 24 to 47. The percentage of vehicles which are experiencing an interrupted diurnal are in the rows labeled 1 to 2 through 8 to 23. For example, the table shows that at the 6 to 7 AM interval, 61.02% of the vehicles are experiencing a soak which has lasted between 8 and 24 hours. For comparison, by 3 to 4 PM, the percentage of vehicles in this category (8 to 24) has dropped to less than 6 percent.

3.4 Hourly Diurnal Activity Results

To apply the activity distribution to all soak lengths and to smooth the distribution curve, MOBILE6 will apply activity values using a distribution curve. The actual diurnal activity distribution parameters which will be used in MOBILE6 are shown in Table 3. A set of four parameters (A, B, C, and D) is shown for each of the 13 hourly groups. The 6 - 7 group is the distribution for the 6 to 7 AM group, the 18+ group is the distribution for all the evening and nighttime hours between 7 PM and 6 AM. These parameters are the result of fitting Weibull equations (non-linear regression) to the diurnal activity results. Fitting the Weibull equations to the activity results produces a smoother activity distribution for the individual hourly groups than is shown in Table 2. The smoothness of the curve is reflected in the high r-square values (> 0.97) of the fit. Using the fitted value for the distribution was done in-order to conform to the structure of the diurnal emission factors being built into MOBILE6. These require some fairly small time intervals. If the unfitted data were used directly, some of these intervals would be represented by no data or only a very small amount of data.

The Weibull function fit is of the form:

$$Y = A - B * \exp(-C * Soaklength^{**}D) \qquad \text{Eqn 1}$$

where A, B, C, and D are regression coefficients (listed in Table 3), and soaklength in hours (1 to 72+) is the independent variable. The variable Y is the cumulative distribution in percent.

The Weibull function fit is a cumulative distribution of the soaks which are diurnals. It does not include the portion of the fleet which is in hot soak or running mode. For example, substituting the coefficients for Hourly Group 6 - 7 from Table 3 and a soak length of 72 hours into Equation 1 produces a maximum cumulative distribution of 85.0 percent. The remaining 15 percent of the fleet is in hot soak or running mode.

$$0.850 = 0.8502 - 0.8427 * \exp(-0.001616 * 72 ** 2.6440) \qquad \text{Eqn 2}$$

In the MOBILE6 model it will be necessary to calculate the percentage of soaks in a given hourly group which are X hours in duration. This is done by transforming the cumulative Weibull distribution into a non-cumulative distribution using Equation 3.

$$D(i) = Y(i) - Y(i-1) \qquad \text{Eqn 3}$$

where D(i) is the distribution for the interval from t-1 to t, Y is the Weibull function from Eqn 1.

For example, for Group 6 - 7 the percentage of soaks which are 5 - 6 hours is shown in Equations 4 and 5.

$$0.09822 = 0.8502 - 0.8427 * \exp(-0.001616 * 5 ** 2.6440) \qquad \text{Eqn 4}$$

$$0.05906 = 0.8502 - 0.8427 * \exp(-0.001616 * 4 ** 2.6440) \qquad \text{Eqn 5}$$

$$0.0392 = 0.09822 - 0.05906 \qquad \text{Eqn 6}$$

The value is 0.0392 or 3.92 percent of the fleet has a preceding 5 to 6 hour soak during the 6 to 7 AM period.

The results in Table 2 and Table 3 represent both weekdays and weekends. The combination of the two types was necessary because of a lack of data on weekends (there were insufficient numbers of weekend vehicle-days). Inclusion of these data may bias the weekday results slightly; however, no analysis was done to quantify this potential bias. To overcome this potential problem, the MOBILE6 input structure will allow for optional user input of separate weekend/weekday parameters should they become available.

TABLE 2

Diurnal Activity Parameters by Hourly Group

SOAK Hrs	6 - 7 AM	7 - 8 AM	8 - 9 AM	9 - 10 AM	10 - 11 AM	11 - 12 AM	12 - 1 PM	1 - 2 PM	2 - 3 PM	3 - 4 PM	4 - 5 PM	5 - 6 PM	6 - 7 PM
1 to 2	1.27%	2.23%	5.25%	12.97%	14.88%	8.99%	7.48%	7.80%	11.14%	8.99%	10.18%	11.93%	13.84%
2 to 3	0.72%	1.27%	2.15%	5.09%	12.09%	13.13%	6.92%	5.41%	5.73%	8.75%	6.44%	8.27%	9.71%
3 to 4	1.27%	0.64%	1.19%	1.91%	4.93%	10.10%	11.30%	5.57%	4.30%	4.85%	6.52%	4.85%	7.08%
4 to 5	3.02%	0.95%	0.64%	1.11%	1.67%	4.77%	7.80%	10.26%	5.09%	3.98%	4.14%	5.33%	4.38%
5 to 6	3.50%	2.86%	0.95%	0.56%	0.95%	1.43%	4.30%	7.40%	9.39%	3.82%	3.58%	3.34%	4.85%
6 to 7	4.85%	2.94%	2.70%	0.72%	0.40%	0.80%	1.27%	3.90%	6.76%	8.19%	3.74%	3.34%	3.34%
7 to 8	5.81%	3.98%	2.63%	2.55%	0.56%	0.40%	0.64%	1.11%	3.26%	4.93%	6.05%	3.10%	3.10%
8 to 23	61.02%	47.81%	36.20%	29.04%	23.71%	17.90%	13.37%	9.63%	7.40%	5.89%	6.60%	7.40%	7.72%
24 to 47	4.93%	4.06%	3.26%	2.39%	2.07%	1.91%	1.27%	1.27%	0.95%	1.03%	0.72%	0.48%	0.48%
48 to 71	0.88%	0.72%	0.64%	0.56%	0.48%	0.48%	0.48%	0.40%	0.32%	0.24%	0.24%	0.16%	0.16%
72+	0.48%	0.32%	0.32%	0.16%	0.08%	0.08%	0.08%	0.08%	0.08%	0.08%	0.08%	0.08%	0.08%
running / hot soak	12.25%	32.22%	44.07%	42.96%	38.19%	40.02%	45.11%	47.18%	45.58%	49.24%	51.71%	51.71%	45.27%
TOTAL	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Table 3
Weibull Distribution Coefficients for Diurnal Activities

Hourly Group	Coefficient A	Coefficient B	Coefficient C	Coefficient D	Regression R^2 Value
6 - 7	0.8502	.8427	0.001616	2.6440	0.995
7 - 8	0.6559	0.6342	0.001473	2.5928	0.996
8 - 9	0.5418	0.4793	0.001880	2.4486	0.995
9 - 10	0.5525	0.3867	0.002715	2.2846	0.994
10 - 11	0.5987	0.3971	0.038477	1.3344	0.973
11 - 12	0.5950	0.8389	0.5479	0.5086	0.974
12 - 13	0.5313	0.9246	0.6797	0.4943	0.981
13 - 14	0.4995	0.6927	0.4367	0.6834	0.979
14 - 15	0.5039	0.5180	0.2147	1.0038	0.976
15 - 16	0.4630	0.4793	0.2227	1.0182	0.981
16 - 17	0.4361	0.3870	0.1233	1.3237	0.989
17 - 18	0.4400	0.3881	0.1723	1.1886	0.996
18 +	0.5025	0.4509	0.1967	1.1494	0.998

4.0 USING THE HOURLY DIURNAL ACTIVITY INFORMATION

4.1 Overview

To use the diurnal activity information in the MOBILE6 model requires that the activity information be integrated with the diurnal emission parameters. This is not a trivial task since both the activity information and the diurnal emission information are both functions of time of day and soak length. Also, the task is made more difficult since several types of diurnal emissions exist, and some of these are a function of both the time of day being evaluated and the time that the soak began.

4.2 Diurnal Types

Four different diurnal types are present in MOBILE6. These are Interrupted, Full, Two-day, and Three-day. In addition, there are periods where there is no diurnal because the vehicle is running or under a hot soak. More complete information on diurnal types and diurnal emissions can be found in EPA documents EPA-420-P-98-011 "Modeling Hourly Diurnal Emissions and Interrupted Diurnal Emissions Based on Real-Time Diurnal Data" -M6.EVP.001, and M6.EVP.003 "Evaluating Multiple Day Diurnal Evaporative Emissions Using RTD Tests".

The emission effects of the Null diurnal (a running or non diurnal mode), Interrupted diurnal, Full diurnal, and two and three day diurnals are all assumed to start prior to 6 am. The interrupted diurnals are a function of the time of day at which the diurnal started, ranging from 7am to 2pm. Each has a different emission effect as explained in M6.EVP.002. These are labeled: "I - 7 am", "I - 8am", "I - 9am", "I - 10am", "I - 11am", "I - 12 am", "I - 1pm", and "I - 2pm". Several of these are illustrated in the sample calculation.

4.3 Rules for Determining Diurnal Type

The MOBILE6 model uses rules in the hourly diurnal emissions calculation to determine how to allocate vehicle activity to each diurnal emission type. The rules are based on which hour of the day is being modeled, the soak duration, and in the case of interrupted diurnals, the time of day the soak began. For example, for Hour X, the activity data will indicate what percentage of the fleet has been soaking for what period of time. The model must allocate these activity fractions to the appropriate type of diurnal. Knowing how much activity data to allocate to interrupted, full, two-day, and three-day diurnal types allows MOBILE6 to properly weight each type together for each hour of the day.

Rules One through Four point to a case where there is no diurnal. These are the Null diurnal cases. The vehicle is either in hot soak mode or resting loss mode. Rule Five applies to an interrupted diurnal, and rules Six through Eight apply to full or multi-day diurnals. Soak time refers to the length of the soak in hours, and hour refers to the hour of the day on a 24 hour clock (i.e., 5 = 5 AM).

Table 4
Determining the Type of Diurnal

Rule #	Rule	Diurnal Type	Explanation
Rule 1	Soaktime < 1	Hot Soak	Hot Soak Period - No diurnal
Rule 2	Soaktime >= 1 and Soaktime < 2	Resting Loss	Vehicle Equilibrating to Ambient - No diurnal
Rule 3	Hour <= 5 (5 AM)	Resting Loss	Assume no diurnal emission from midnight to 5 am
Rule 4	Soaktime <= Hour - 13	Resting Loss	No diurnal beginning in Afternoon assume no temp rise after 3 pm.
Rule 5	Soaktime > Hour - 13 and Soaktime <= Hour - 5	Interrupted	Hot Soak ended after 6 am causes interrupted diurnal.
Rule 6	Soaktime > Hour - 5 and Soaktime <= Hour + 17	Full	Diurnal begins at 6 am. No significant diurnal on previous day.
Rule 7	Soaktime > Hour + 17 and Soaktime <= Hour + 41	Two-Day	Diurnal begins at 6 am. Significant diurnal previous day.
Rule 8	Soaktime > Hour + 41	Three-Day	Diurnal begins at 6 am. Significant diurnal previous two or more days.

Application of the "diurnal rules" is shown graphically in the attached Excel spreadsheet "Diur_Rule.xls". It requires Excel 97, and should be viewed in color. The overall spreadsheet contains two worksheets (Tables A-1 and A-2). The first worksheet is a matrix with hour of the day as columns and Soaktime as rows. It shows the entire range. The second worksheet shows only the interrupted diurnals. The reader should note that there are several different types of interrupted diurnals based on the time of day the soak period started. The overall worksheet matrix is color coded to represent each type of diurnal / no diurnal. The color pink represents the periods of the day / soak combinations when no diurnal occurs (hotsoak periods). The yellow color also represents the periods when a diurnal does not occur. This is typically during the nighttime hours when only

resting loss emissions occur. The darker blue periods near the top of the figure represent the interrupted diurnal periods. The green portion the figure indicates when a full day diurnal can occur. The lighter blue section of the figure with white letters represents the two day diurnal, and the red section at the bottom represents the three day diurnal periods.

4.4 Example Calculation

An example calculation is provided in the accompanying linked (attached) spreadsheet. This calculation is fairly lengthy and involves three separate spreadsheets linked as document EVP_DIU2.XLS. It is attached and discussed in this section to provide a sample calculation of the method of combining the activities with the diurnal emissions. The sample calculation provides an estimate for diurnal emissions in grams per hour per vehicle and grams per hour per day per vehicle for the case of 1990-93 PFI vehicles which did not fail the purge or pressure I/M test. Other 1981 and later model year groups and evaporative I/M test status cases would use similar calculations.

The calculations in the spreadsheet are based on incorporating the methodology described in document EPA420-P-98-011 (or M6.EVP.002) "Modeling Hourly Diurnal Emissions and Interrupted Diurnal Emissions Based on Real-Time Diurnal Data", and the diurnal activity estimates described in the current document.

The text of this example calculation is written to coincide with the Excel spreadsheet EVP_DIU2.XLS. This spreadsheet consists of three tables. These are: FDD "Non Gross", "Gross Temps", and "Hourly". The "Non Gross" table provides an example calculation of the average daily diurnal emission estimate for a vehicle which is not a gross liquid leaker. The "Gross Temps" table is a calculation of the daily temperature distribution used to calculate the diurnal emissions of the gross liquid leakers. The "Hourly" table is the primary table. It calculates the individual hourly diurnal emissions for each soak length of non-gross liquid leakers and gross liquid leakers, and sums them into a daily total. The gross liquid leakers and the non-gross liquid leakers are discussed separately in document EPA420-P-98-011 (or M6.EVP.002), and in the MOBILE6 model because gross liquid leakers are a small portion of the vehicle fleet, but nevertheless have a large impact on the total diurnal emissions because of their tremendous emission rates.

4.4.1 Hourly Diurnal Emissions of Non-Gross Liquid Leakers

The "FDD Non Gross" table calculates the full day diurnal (FDD) for a vehicle that is not a gross liquid leaker (NGLL). The formulas are shown at the top of the sheet and the result (FDD) is given at the bottom of the sheet. The value is 2.6832 grams of HC for this example.

The value of FDD is used in the "Hourly" spreadsheet in the columns Non Gross -

Diurnal grams (Worksheet "Hourly" Cells CC through CU) to calculate the hourly diurnal emissions for each hourly group (i) at each soaktime (j). The formula which is used in each cell of the matrix is:

$$\text{Hourly Diurnal}(i,j) = \text{FDD} * \text{Diurnal Fract}(i,j) * \text{Activity Fract}(i,j) \qquad \text{Eqn 7}$$

where hourly group i ranges from 6-7am to 11-12pm (18 groups)
where soaktime = j ranges from 1 to 72 hours
where Hourly Diurnal is the average g/vehicle for that hour, including both soaking and non-soaking vehicles.

The 'Diurnal Fract(i,j)' parameter is shown in worksheet "Hourly" Cells BI-CA for each hourly group and soaklength. The 'rules' used to develop the Diurnal Fract parameter are shown in worksheet "Hourly" Cells AO-BG. The value in each of the Diurnal Fract cells is the fraction of a daily diurnal that cell or hourly group / soak length represents. As reported in M6.EVP.002.

The "Activity Fract(i,j)" parameter used in Eqn 7 is shown in worksheet "Hourly" Cells U-AM. These are the fraction of an hourly group's activity represented by one of the soaklengths. Each column normalizes to unity (i.e., Column V sums to 1.0). The activity values shown in worksheet "Hourly" Cells U-AM were calculated from the cumulative activity values shown in worksheet "Hourly" Cells A-S.

The final average daily diurnal for a non-gross liquid leaker is shown in worksheet "Hourly" cell CU. This reflects the impact of the activity distribution and the interrupted diurnals. The value for this example of vehicles that pass both purge and pressure tests is 1.271 grams / day - non-gross liquid leaker. In comparison, the value would be 2.6832 grams /day - nongross liquid leaker if all of the fleet received a full day diurnal.

4.4.2 Hourly Diurnals of Gross Liquid Leakers

Equation 8 was used to calculate the hourly diurnal emissions of gross liquid leakers (HDGLL). It is a function of the hourly temperature difference (difference within an hour), and the daily temperature difference (difference between the current hour and the temperature prior to 6:00AM). It is weighted by the activity distribution in Table 2.

$$\text{HDGLL} = 100.29*(0.008958 + (0.007383*\text{Hourly DTemp}) + (0.003053*\text{Daily DTemp})) * \text{Activity} \qquad \text{Eqn 8}$$

The hourly and daily temperature differences are shown in worksheet "Hourly" (Cells CX-DP). The calculation in Equation 8 excluding the activity weighting was done in worksheet "Hourly" (Cells DR-EJ), and the activity weighting was done in worksheet

"Hourly" (Cells EL-FD).

The daily temperature difference for each hourly group and soak time is based on the daily temperature profile found in the spreadsheet table "Gross Temps". This table takes the standardized temperature profile found in the Code of Federal Regulations - 40CFR86, and creates a new standardized temperature profile based on the daily minimum and maximum temperatures. In this case, the daily minimum and maximum temperatures were 82 F to 106 F.

For comparison, the final average diurnal emission result for liquid leakers for this example is shown in Cell CU. It is 63.326 grams / day- gross liquid leaker. This is a very large emission result, especially in comparison to the value of 1.271 grams / day - nongross liquid leaker. However, the high value for the gross liquid leaker is an extreme (not close to the average vehicle diurnal emission). Gross liquid leakers are (fortunately) relatively rare in the fleet, and typically make up less than 1 percent. They reflect vehicles with serious fuel system problems where liquid fuel/vapor (not just vapor) is escaping from the system.

5.0 COMMENTS

Comments on this report and its proposed use in MOBILE6 should be sent to the attention of the author, and submitted electronically to mobile@epa.gov, or by fax to (734) 214-4939, or by mail to MOBILE6 Review Comments, US EPA Assessment and Modeling Division, 2000 Traverwood Drive, Ann Arbor MI 48105. Electronic submission of comments is preferred, since we will make any comments available on our web site. In your comments, please note clearly the document that you are commenting on including the report title and the code number listed. Please be sure to include your name, address, affiliation, and any other pertinent information.

Table A-1
Diurnal "Rules"

Prior Diurnal Time hours	Soak Time hours	6:00 AM 600	700	800	900	1000	1100	noon 1200	1300	1400	1500	1600	6 PM to 7 pm 1700	1800	1900	2000	2100	2200	midnight to 1 am) 2300	2400	100	200	300	400	5:00 AM 500
	0	hot soak	hot soak	hot soak	hot soak	hot soak	hot soak	hot soak	hot soak	hot soak	hot soak	hot soak	hot soak	hot soak	hot soak	hot soak	hot soak	hot soak	hot soak	hot soak	hot soak	hot soak	hot soak	hot soak	hot soak
	1	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting
0	2	F (6 am)	I (7 am)	I (8 am)	I (9 am)	I (10 am)	I (11 am)	I (noon)	I (1 pm)	I (2 pm)	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting
1	3	F (6 am)	F (6 am)	I (7 am)	I (8 am)	I (9 am)	I (10 am)	I (11 am)	I (noon)	I (1 pm)	I (2 pm)	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting
2	4	F (6 am)	F (6 am)	F (6 am)	I (7 am)	I (8 am)	I (9 am)	I (10 am)	I (11 am)	I (noon)	I (1 am)	I (2 pm)	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting
3	5	F (6 am)	F (6 am)	F (6 am)	F (6 am)	I (7 am)	I (8 am)	I (9 am)	I (10 am)	I (11 am)	I (noon)	I (1 pm)	I (2 pm)	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting
4	6	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	I (7 am)	I (8 am)	I (9 am)	I (10 am)	I (11 am)	I (noon)	I (1 pm)	I (2 pm)	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting
5	7	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	I (7 am)	I (8 am)	I (9 am)	I (10 am)	I (11 am)	I (noon)	I (1 pm)	I (2 pm)	resting	resting	resting	resting	resting	resting	resting	resting	resting	resting
6	8	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	I (7 am)	I (8 am)	I (9 am)	I (10 am)	I (11 am)	I (noon)	I (1 pm)	I (2 pm)	resting	resting	resting	resting	resting	resting	resting	resting	resting
7	9	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	I (7 am)	I (8 am)	I (9 am)	I (10 am)	I (11 am)	I (noon)	I (1 pm)	I (2 pm)	resting	resting	resting	resting	resting	resting	resting	resting
8	10	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	I (7 am)	I (8 am)	I (9 am)	I (10 am)	I (11 am)	I (noon)	I (1 pm)	I (2 pm)	resting	resting	resting	resting	resting	resting	resting
9	11	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	I (7 am)	I (8 am)	I (9 am)	I (10 am)	I (11 am)	I (noon)	I (1 pm)	I (2 pm)	resting	resting	resting	resting	resting	resting
10	12	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	I (7 am)	I (8 am)	I (9 am)	I (10 am)	I (11 am)	I (noon)	I (1 pm)	resting	resting	resting	resting	resting	resting
11	13	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	I (7 am)	I (8 am)	I (9 am)	I (10 am)	I (11 am)	I (noon)	resting	resting	resting	resting	resting	resting
12	14	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	I (7 am)	I (8 am)	I (9 am)	I (10 am)	I (11 am)	resting	resting	resting	resting	resting	resting
13	15	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	I (7 am)	I (8 am)	I (9 am)	I (10 am)	resting	resting	resting	resting	resting	resting
14	16	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	I (7 am)	I (8 am)	I (9 am)	resting	resting	resting	resting	resting	resting
15	17	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	I (7 am)	I (8 am)	resting	resting	resting	resting	resting	resting
16	18	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	I (7 am)	resting	resting	resting	resting	resting	resting
17	19	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	resting	resting	resting	resting	resting	resting
18	20	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	resting	resting	resting	resting	resting	resting
19	21	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	resting	resting	resting	resting	resting	resting
20	22	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	resting	resting	resting	resting	resting	resting
21	23	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	resting	resting	resting	resting	resting	resting
22	24	2 day (6am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	resting	resting	resting	resting	resting	resting
23	25	2 day (6am)	2 day (6am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	resting	resting	resting	resting	resting	resting
24	26	2 day (6am)	2 day (6am)	2 day (6am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	resting	resting	resting	resting	resting	resting
25	27	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	resting	resting	resting	resting	resting	resting
26	28	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	resting	resting	resting	resting	resting	resting
27	29	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	resting	resting	resting	resting	resting	resting
28	30	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	resting	resting	resting	resting	resting	resting
29	31	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	resting	resting	resting	resting	resting	resting
30	32	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	resting	resting	resting	resting	resting	resting
31	33	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	resting	resting	resting	resting	resting	resting
32	34	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	resting	resting	resting	resting	resting	resting
33	35	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	resting	resting	resting	resting	resting	resting
34	36	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	resting	resting	resting	resting	resting	resting
35	37	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	F (6 am)	F (6 am)	F (6 am)	F (6 am)	resting	resting	resting	resting	resting	resting
36	38	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	F (6 am)	F (6 am)	F (6 am)	resting	resting	resting	resting	resting	resting
37	39	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	F (6 am)	F (6 am)	resting	resting	resting	resting	resting	resting
38	40	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	F (6 am)	resting	resting	resting	resting	resting	resting
39	41	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	resting	resting	resting	resting	resting	resting
40	42	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	resting	resting	resting	resting	resting	resting
41	43	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	resting	resting	resting	resting	resting	resting
42	44	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	resting	resting	resting	resting	resting	resting
43	45	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	resting	resting	resting	resting	resting	resting
44	46	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	resting	resting	resting	resting	resting	resting
45	47	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	resting	resting	resting	resting	resting	resting
46	48	3 day (6 am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	resting	resting	resting	resting	resting	resting
47	49	3 day (6 am)	3 day (6 am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	resting	resting	resting	resting	resting	resting
48	50	3 day (6 am)	3 day (6 am)	3 day (6 am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	resting	resting	resting	resting	resting	resting
49	51	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	resting	resting	resting	resting	resting	resting
50	52	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	resting	resting	resting	resting	resting	resting
51	53	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	resting	resting	resting	resting	resting	resting
52	54	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	resting	resting	resting	resting	resting	resting
53	55	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	resting	resting	resting	resting	resting	resting
54	56	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	resting	resting	resting	resting	resting	resting
55	57	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	resting	resting	resting	resting	resting	resting
56	58	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	resting	resting	resting	resting	resting	resting
57	59	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	resting	resting	resting	resting	resting	resting
58	60	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	resting	resting	resting	resting	resting	resting
59	61	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	2 day (6am)	2 day (6am)	2 day (6am)	2 day (6am)	resting	resting	resting	resting	resting	resting
60	62	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	2 day (6am)	2 day (6am)	2 day (6am)	resting	resting	resting	resting	resting	resting
61	63	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	2 day (6am)	2 day (6am)	resting	resting	resting	resting	resting	resting
62	64	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	2 day (6am)	resting	resting	resting	resting	resting	resting
63	65	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	resting	resting	resting	resting	resting	resting
64	66	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	resting	resting	resting	resting	resting	resting
65	67	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	resting	resting	resting	resting	resting	resting
66	68	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	resting	resting	resting	resting	resting	resting
67	69	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	resting	resting	resting	resting	resting	resting
68	70	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	resting	resting	resting	resting	resting	resting
69	71	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	resting	resting	resting	resting	resting	resting
70	72	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	3 day (6 am)	resting	resting	resting	resting	resting	resting

Table A-2
Rules for Interrupted Diurnals

Prior Diurnal Time hours	Soak Time hours	6:00 AM 600	700	800	900	1000	1100	noon 1200	1300	1400	1500	1600	1700	6 PM to 7 pm 1800	1900	2000	2100	2200	2300	midnight to 1 2400
	0																			
	1																			
0	2		l (7 am)	l (8 am)	l (9 am)	l (10 am)	l (11 am)	l (noon)	l (1 pm)	l (2 pm)										
1	3			l (7 am)	l (8 am)	l (9 am)	l (10 am)	l (11 am)	l (noon)	l (1 pm)	l (2 pm)									
2	4				l (7 am)	l (8 am)	l (9 am)	l (10 am)	l (11 am)	l (noon)	l (1 am)	l (2 pm)								
3	5					l (7 am)	l (8 am)	l (9 am)	l (10 am)	l (11 am)	l (noon)	l (1 pm)	l (2 pm)							
4	6						l (7 am)	l (8 am)	l (9 am)	l (10 am)	l (11 am)	l (noon)	l (1 pm)	l (2 pm)						
5	7							l (7 am)	l (8 am)	l (9 am)	l (10 am)	l (11 am)	l (noon)	l (1 pm)	l (2 pm)					
6	8								l (7 am)	l (8 am)	l (9 am)	l (10 am)	l (11 am)	l (noon)	l (1 pm)	l (2 pm)				
7	9									l (7 am)	l (8 am)	l (9 am)	l (10 am)	l (11 am)	l (noon)	l (1 pm)	l (2 pm)			
8	10										l (7 am)	l (8 am)	l (9 am)	l (10 am)	l (11 am)	l (noon)	l (1 pm)	l (2 pm)		
9	11											l (7 am)	l (8 am)	l (9 am)	l (10 am)	l (11 am)	l (noon)	l (1 pm)	l (2 pm)	
10	12												l (7 am)	l (8 am)	l (9 am)	l (10 am)	l (11 am)	l (noon)	l (1 pm)	
11	13													l (7 am)	l (8 am)	l (9 am)	l (10 am)	l (11 am)	l (noon)	
12	14														l (7 am)	l (8 am)	l (9 am)	l (10 am)	l (11 am)	
13	15															l (7 am)	l (8 am)	l (9 am)	l (10 am)	
14	16																l (7 am)	l (8 am)	l (9 am)	
15	17																	l (7 am)	l (8 am)	
16	18																		l (7 am)	
17	19																			