



Patrick Moore, P.E., IDModeling's Technical Solutions Director shares his knowledge and passion for hydraulic modeling in Pat's Corner - Tips & Techniques for Hydraulic Modeling.



## Pat's Corner - Modeling Tips & Techniques

To: Hydraulic Modeling Community  
From: IDModeling, Inc.  
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Subject: Tips & Techniques for Developing Diurnal Patterns Volume 1 Number 1

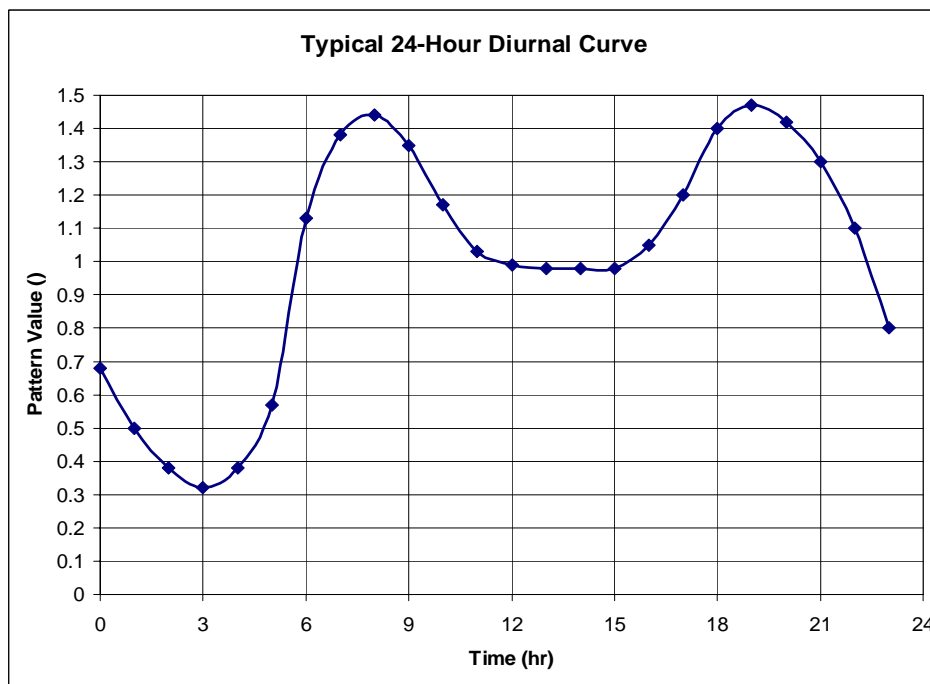
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Dear Fellow Modelers!

Below are some notes on creating **Diurnal Patterns** to keep in mind when you are developing demands for your model to help ensure that the Diurnal Patterns created are accurate and appropriate for hydraulic modeling. Let's start with a basic definition:

***Diurnal Patterns** are literally patterns that are completed in 24 hours and are repeated every 24 hours. However in general they represent temporal variations in water usage for municipal water systems that represent how water use varies from the average use over a specified time period (for example a 24-hour time period . Diurnal Patterns must be incorporated into an Extended Period Simulation (EPS) in order to accurately reflect the changing system demand of a real system over time.*

A typical diurnal curve will usually have two peaks of high water use similar to the curve shown in the figure below. One peak occurs between 6 to 8 am and the other occurs between 7 to 9 pm. This is a typical diurnal curve for a system with a significant amount of residential demand.

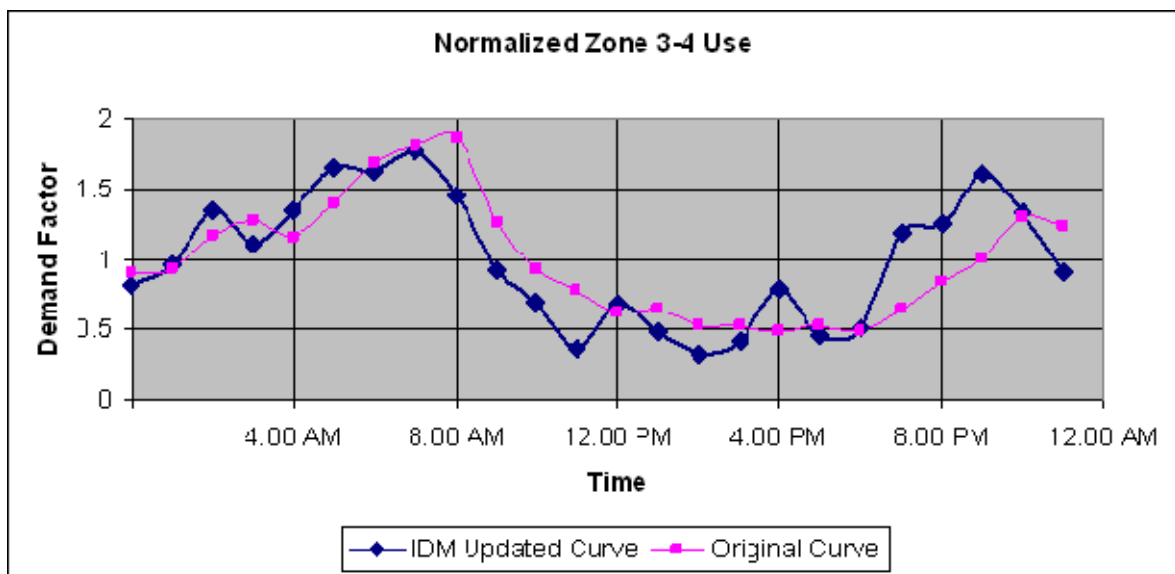


**Proper calculation of a diurnal curve is essential for accurate modeling and to get good calibration results for EPS calibration runs.** Some of the points noted below highlight simple but important mistakes often made when creating diurnal curves that can lead to misleading model results. We have listed some key tips to help avoid these mistakes and help ensure better modeling results!

**Here are some key points to remember when developing Diurnal Patterns:**

- 1) Diurnal Patterns represent how water use varies from the average water use of the period in question. If the period looked at is a 24 hour period the average water use is over the entire 24 hour period. If the period is a week the average water use is over the entire seven day period. The average period demand is represented in the model as the base model demand. Make sure that all water use values calculated are normalized to the average period demand that is under investigation.
- 2) Diurnal patterns are often represented as water use from midnight to midnight in a 24 hour period. **Make sure the water usage data used starting time reflects the desired model start time.** If the time frame of the data is not from midnight to midnight but includes a full 24 hours, this data can still be used to calculate the diurnal just make sure the final patterns reflect the start time expected. In the model.
- 3) Diurnal curves separate water use over a specified period into distinct time steps. Many modelers typically use a one hour time step for most models because these represent a reasonable balance between model accuracy and model calculation time. The higher the number of calculation points can result in longer model run times. **Select a time step that is compatible with the available data while being aware of the model calculation time.**
- 4) Calculation of Diurnal curves is typically done using mass balance methods to calculate the water use for each time step in the period. Make sure that all calculations are completed using the same time period. If the first time step is from midnight to 1 am (assuming a midnight start and a one hour time step) then the first mass balance will relate to the total water use between midnight and 1 am. . It is very easy to mistakenly use one time frame for tanks and another time frame for well and pump station flows accidentally. **The best way to remember this is to think that each time frame is a mass balance of all water use during that specific period.**
- 5) System mass balances can be calculated for the entire system or for specific pressure zones as long as the flows in and out of the zone are known. If significant flows between zones occur at unmetered PRV's, the diurnal curves will not effectively represent water use in either zone. Combine the water zone mass balances together to get a more accurate mass balance.
- 6) How to complete a Mass balance of water use for a specific time period:
  - a. **Mass balance equation: Demand = Flow in – Flow out + water supply from Tanks**
  - b. To do a mass balance you need
    - i. the flows **in** and **out** of the system for that period
      1. Water supply from flows in and out should be translated to **total volume of water**. Do not translate volume change in tanks to rates of water flow. This is a mass balance of total water used (i.e. a volume) for a given period.
      2. Convert flow rates to volumes by multiplying water rate of flow by the length of time the water flowed. For example: 60 minutes of flow at 1000 gpm = 60,000 gallons
        - a. **Adjust the time factor as necessary if a pump is shut off during the hour.**
      3. Flow in is the sum of all sources of water supply into the zone or system. This may include wells, pump station and turnouts, and PRVs from higher zones that **feed the zone or system** in question
      4. Flow out of the zone includes all sources of water supply out of the zone or system. This may include wells, pump station and turnouts, and PRVs from higher zones that **are fed by zone or system** in question
      5. If flows vary try to get the best average flow value for the period
    - ii. The Water supply from the system Tanks can be calculated as follows:
      1. Obtain the starting and ending tank levels for the period for each tank in the zone in question.
      2. Water supplied by tanks is calculated from the tank level change.
        - a. Make sure to use this formula: **Water supply from the tanks = Volume at start of period – Volume at the end of the period.**

- i.  $Volume = \pi/4 * D^2 * Tank\ Height$ . Since only the level changes the **volume change =  $\pi/4 * D^2 * (L_{start} - L_{end})$ , where D = the tank diameter in feet and L is the tank level in feet.**
  - ii. For our current example this would use Level\_12 am – Level at 1 am.
  - iii. **NOTE:** using this formula ensures that the mass balance equation reflect the proper mathematical sign. Water from the tank (tank level is lower at the end of the period) is a “flow in” (the result is positive) and water stored (tank level is higher at the end of the period) is a “flow out” (the result is negative). Calculating the volume change this way will ensure the mass balance is accurate and lessens the chance of a miscalculation.
- b. **NOTE:** you **do NOT** use the tank level at 11 am for the water stored for this period. **This is the most common error people make and can introduce a significant error in the diurnals.** Only use the starting and ending tank levels for the period in question.
- c. See the example below for how different the patterns can be. The original curve used the wrong tank levels, the IDM updated curve used the correct tank levels  
**Note: this will require tank levels for one hour past the ending period**



- 7) Once you calculate the system demand at each hour you need to **normalize the demand** to create diurnal multipliers.
- a. A diurnal multiplier is how the water flow varies from the average flow for the day.
  - b. This is why the “base” demand put into the model DEMAND01 category is equal to the average demand flow at that location.
    - i. i.e. on Max Day node 1000 has a demand of 100 gpm. This is the average Max Day demand for this node for the simulation period. To get the demand at a given hour you multiply the “base” demand by the pattern multiplier for that hour.
  - c. First calculate the average demand for all period values. If you have 24 demand periods you average all of them to get this value. Now divide each hourly demand by the average demand to get the diurnal multiplier.
  - d. **Don't forget the simple QA/QC check:**
    - i. Diurnal multipliers must average to 1 for all values used in the period or sum to equal to 1 times the number of pattern values. Thus if 1 hour patterns are used then summing all diurnal patterns will equal 24.00 ( 24 patterns x 1 = 24.00) and averaging all diurnal patterns will equal 1.00. Summing is a better check as it is easier to find small errors using this method that averaging.
    - ii. Completing this check will ensure that no simple math errors were made.

- iii. **Watch out for rounding** the pattern values to 2 decimal places. If you round the pattern values make sure to check the sum again to make sure you are not high or short due to rounding.

Keeping these things in mind should help you whenever you are asked to make diurnal curves. Just remember the key ids the pattern multiplier is based on a mass balance of all water use from the start of the period until the start of the next period. This will help you use the right values.

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