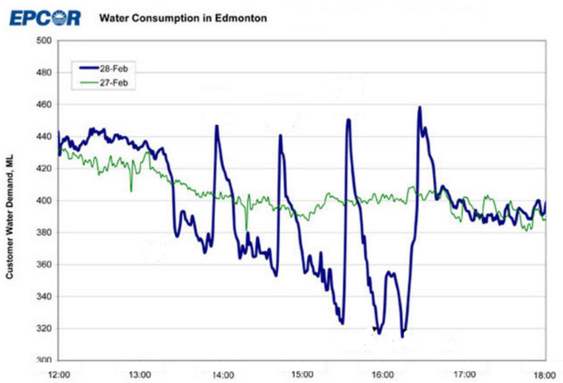
Providing Clean Water

1. What could go wrong in a city if its demand for water can't be met?

2. How can a city ensure that it can meet its demand for water all the time?

3. The graph shows the use of water in Edmonton on two days in February 2010.



   (a) What is different about the way water was used on Feb. 27 and Feb. 28?

   (b) Approximate the total water used on Feb. 27 between 12:00 and 16:00.

   (c) By visual estimate, how does the **total** water used on Feb. 28 compare to Feb. 27?

   (d) In the graph, the vertical axis begins at 300 ML/min, rather than at 0 ML/min. How do you think the look of the graph would change if its scale went from 0 to 500 ML/min rather than from 300 ML/min? Why do you think it was presented this way?

   (e) What might be the reason that the use of water was so unusual on February 28?

Connection to the Real World
A citys water provider is responsible for anticipating and meeting the demand for clean water. To do this they monitor water levels, and study water-use patterns. To ensure the demand can be met, they need to predict what the demand will be, even in unusual circumstances.

For more Real-World Problems Being Solved by Mathematics, visit http://www.cemc.uwaterloo.ca/resources/real-world.html.

Solution:

1. If a city's demand for water can't be met, problems could include
   - Doctors and surgeons couldn't wash their hands
   - No water to put out fires
   - Crops and gardens affected
   - Personal inconveniences: laundry, showers, swiming, etc.

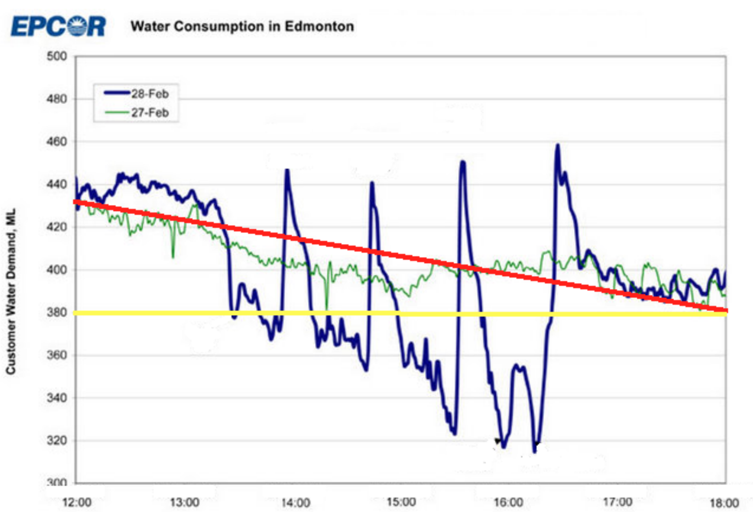
2. To ensure that a city's demand for water will be met, the water provider should
   - Measure the amount of water available
   - Measure the amount of water used
   - Analyze the patterns in water consumption

   This requires scientists, mathematicians and computer scientists. It also uses special measuring devices that interface with computers to record the data.

3. (a) The water use was much more varied on Feb. 28 than on Feb. 27.

   (b) The total water use between 12:00 and 16:00 is represented by the area under the green "curve". It is not trivial to find the area under such a strangely-shaped curve. Calculus gives techniques for determining the area under some familiar curves if we can recognize their shape or equation, but in this case we have neither a familiar shape nor an equation.

   One way to approximate the water use on Feb. 27 between 12:00 and 16:00 is to draw a straight line that is close to the shape of the graph. That line could start at 430 ML at 12:00 and end at 380 ML at 16:00. It appears as if the curve is both above and below the line in equal proportions. The total water use is approximated by the area under the red line. That area consists of two regions: a right-angled triangle between the red (upper, "diagonal") line and the yellow (horizontal) line, and a rectangle below the yellow line.



   We must also consider the units of the graph. The vertical axis of the graph as published by Epcor is labelled as ML. Interpreting the graph this way would mean that at any particular instant we can measure the volume of water used. In fact, we must measure the water used at regular units of time. Epcor clarified that the points on this graph represent the volume of water used in each one-minute interval. The unit for the vertical axis should actually read ML/min.

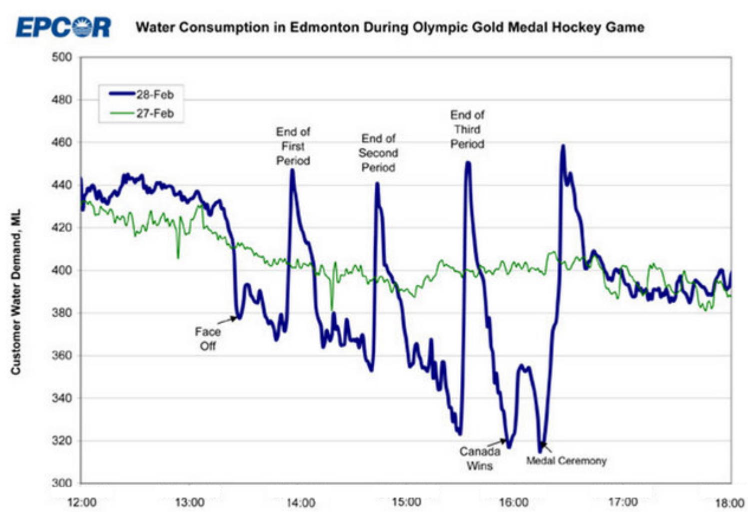
The base of the triangle has a length of 4 hours = 240 minutes, while the height of the triangle is 50 ML/min. The area of the triangle is thus
$\frac{1}{2}(240 \text{ min}) \times 50 \text{ ML/min} = 6,000$ ML.
The rectangle has a width of 240 min and a height of 380 ML/min, for an area of
240 min $\times 380$ ML/min $= 91,200$ ML.
The total water use on Feb. 27 from 12:00 to 16:00 is thus $6,000 + 91,200 = 97,200$ ML.

Note that if we had left the vertical axis unit as ML, our calculation would give as a unit the ML $\times$ hour, when what we actually want is a volume of water, measured in ML. This is a good lesson in careful interpretation of data presented in the media.

(c) The total water use appears similar, or perhaps slightly lower, on Feb. 28 than on Feb. 27. To know for sure, we'd need the water readings.

(d) If the vertical axis ranged from 0 to 500 ML/min, the ups and downs of the graph would not look as extreme, since they would only span one quarter of the vertical space of the graph. By showing a vertical range from 300 to 500 ML, the graph exaggerates the variations in water use during the hockey game.
This technique of "selective scale" is often used with graphs in the media, in order to focus on trends and changes. By studying the scale of a graph carefully, you can interpret it more accurately.

(e) On Sunday, Feb 28, 2010, Canada won a gold medal in Olympic men's hockey. Epcor, Edmonton's water provider, noticed a significant change in water use patterns during the game than on a typical weekend. The following graph correlates the water use patterns to the key points of the game.



If an event like the Olympics can cause an uneven demand for water, what other events might affect water consumption?