Measurement

Worksheet 9

A worksheet produced by the Native Access to Engineering Programme
Concordia University, Montreal

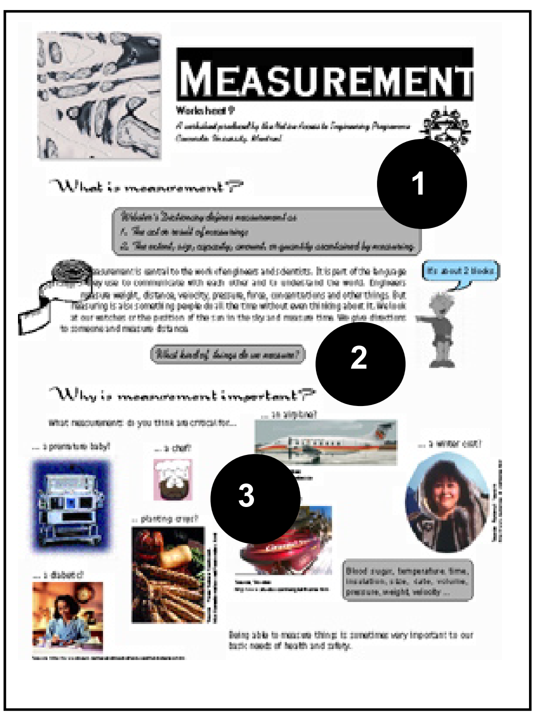
Teacher's Guide

This guide contains some suggestions for how you can work with worksheet 9, "Measurements."

1. Definition
   Do your students understand the definition? Can they identify things which are measured from it?

2. We measure all sorts of things. Here are some examples your students might suggest.
   Shoe sizes when buying running shoes.
   Police measure vehicle speeds to see if they're going to fast.
   The weight and length of a newborn.
   Store owners measure their stock by taking inventory.
   Teachers measure students' understanding by assigning grades to their work

3. Your students may be able to suggest measurements which are not listed



Airplane
Temperature: If it is very cold the wings must be de-iced before takeoff.
Time: Most municipalities do not allow flights from midnight to 6am as most people are sleeping and airplane engines are very loud.
Weight: Airplanes have a maximum load they are capable of carrying safely.
Velocity: Pilots and aircraft controllers have to know how fast planes near the airport are going and what direction they are coming from.
Wear: Airplanes are subjected to huge amounts of stress during repeated takeoffs and landings. The wear on all of their parts is very carefully monitored and measured so that engineers and technicians know when they need to be replaced.

Premature Baby
Babies who are born early are very carefully monitored. Among other things their weight, blood pressure, oxygen levels, blood sugar, temperature, fluid intake and output and respiratory rate are measured on an ongoing or frequent basis.

Concordia UNIVERSITY

Chef
Amounts in volume and weight are very important for people who cook, but more important is the temperature at which food is prepared and stored and the amount of time for which it is cooked.
Temperature: Many foods (meat, fresh fruit and vegetables, dairy products etc.) have to be stored at temperatures under 4ºC in order to ensure they maintain freshness and don't go bad. In cooking food has to be cooked at relatively high temperatures in order to ensure any bacteria are killed.
Time: Most also meats have to be cooked for a certain amount of time in order to ensure they are bacteria-free. In addition, food can only be stored for a certain amount of time before it goes off, even in a sub-zero freezer.

Snowmobile
Temperature: Anyone using a snowmobile would need to know the temperature outside. First, it would indicate just how much clothing they would need to wear. And second, some temperatures are just too cold for engines to function properly.
Volume: There should be sufficient gas to get the rider to his or her destination.

Winter coat
Insulation: A clothing manufacturer or a person making a coat must be sure that it will provide sufficient insulation from the cold.
Size: A winter coat has to fit properly in order to provide proper insulation.

Planting crops
Time: Crops have to be planted at the right time of year so that they have enough time to mature and be harvested before winter. Wild food sources have to be harvested at the right time for drying and other processing which will make them last through the winter.
Temperature: Crops also should be planted only after the last frost.

Diabetic
Blood sugar: Blood sugar levels are key to people with diabetes. By measuring blood sugar several times a day they can control their diabetes with carefully measured doses of insulin.
Blood pressure: One of the side effects of diabetes is bad circulation, especially in the extremities (hands, feet), blood pressure can indicate whether enough oxygen is getting to these areas.
Time: Another factor in controlling diabetes is eating at regular times during the day.
Weight: A person's weight also helps determine how much insulin is required.

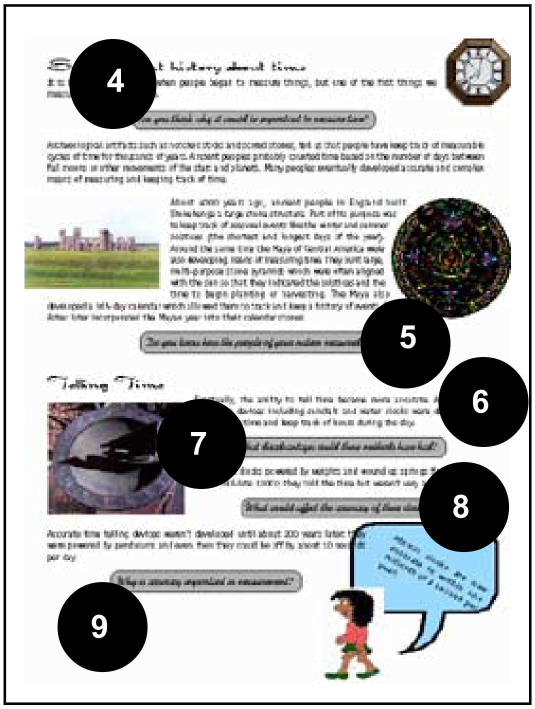
4. It would be important to measure time - or at least keep track of the seasons - for survival. People who could keep track of seasons would know when to plant crops, when to move from a summer to a winter camp or when to expect flooding or snow and when certain fish or animals would be easier to hunt.

5. The answer to this question will vary. Perhaps an elder could be invited to talk to the students about how time was measured.

6. Do your students know how each of these devices worked?

Sundial: A sundial is a device which measures the time of day through the shadow of a upright marker (called a gnomon) on a flat surface. As the sun progresses through the sky the shadow of the gnomon will move through an arc. When the shadow of the gnomon is shortest it indicates local noon.

In 1728, Jantar Mantar, an astronomical observatory, was built in the city of Jaipur, India. It has a sundial with a 30 metre high gnomon.



Water clock: There were a number of different kinds of water clocks. Some were made from containers with sloping sides. Water dripped through a small hole in the container into a second container at a constant rate. The inside of the second container would be marked to measure the passage of hours.

7. Sundials only work if there is enough light to cast a shadow, so they cannot be used to tell time at night. Water clocks really only estimate the time because it is very difficult to get the water to drip into the container at a constant rate.

8. The accuracy of these clocks was affected by friction acting on the spring as it unwound.

9. The answer to this question is contained on the page which follows in the worksheet, however, perhaps your students could brainstorm about why taking accurate measurements might be important. They might also want to think about how accurate you have to be in different situations. For instance, it is more important to be accurate in measuring ingredients for a cake or in measuring dosages of medicine.

10. Perhaps students could share recipes for their favourite meals. Here is a recipe for bannock you might try. It was found at the Luxton Museum of the Plains Indian web site at http://collections.ic.gc.ca/luxton/sect_3/bannock.htm.

You need:
4 cups flour
4 teaspoons baking powder
1 teaspoon salt
4 tablespoons oil
dried fruit, wheat germ, bran, or nuts of choice (optional)
brown sugar and cinnamon (optional)
water
A large mixing bowl
A frying pan
A spatula
A few toothpicks

Instructions:
Place the ingredients (except the water) in a bowl. You can replace a portion of the white flour with an equivalent amount of whole grain flour of choice, and include some dried fruit of choice, wheat germ, bran, and nuts of choice.

Add water, just enough to achieve a bread dough consistency. It is best to add water a tablespoon at a time starting with about 2 or 3 tablespoons.

Mix ingredients well and knead for approximately ten minutes. Grease and heat a fry pan. Form the dough into cakes about 1/2 inch thick and dust lightly with flour. The bannock can also be seasoned with brown sugar and cinnamon, dust as with flour.

Lay the bannock cakes in the frying pan and hold them over the heat. Shake the pan at intervals to prevent the bannock from sticking to the pan. Once a bottom crust has formed and the dough has hardened enough to hold together, you can turn the bannock cakes over to cook the other side.

Cooking takes 12-15 minutes. Test whether or not the bannock is ready by inserting a clean toothpick into the loaf. If it comes out clean, the bannock is ready to eat.

If you don't have a fry pan you can make a thicker dough by adding less water. Roll the dough into a long ribbon, no wider than an inch. Wind this around a preheated green hardwood stick and cook over a fire, turning occasionally, until the bannock is cooked.

Another source of traditional recipes online is the Three Sisters Cookbook at http://www.oneida-nation.net/food-index.html.

11. Medicine
    Machine parts
    Radioactive exposure
    Pollution levels

12. Machined pieces which are too big or too small just won't fit where they belong. To make sure your students understand the discussion of tolerances which follows you could have them do the following exercise. Provide the students with the table which appears on page 6. The answers are provided below.

    Note that:

    Size = maximum size - tolerance = minimum Size + tolerance.

    Tolerance = ± (size - minimum size) = ± (maximum size - size).

    Maximum size = size + tolerance.

    Minimum size = size - tolerance.

Screw	Size	Tolerance	Maximum Size	Minimum size
A	25mm	± 0.25mm	25.5mm	24.5mm
B	35mm	± 0.5mm	35.5mm	34.5mm
C	18mm	± 0.1mm	18.1mm	17.9mm
D	72mm	± 3mm	75mm	69mm
E	50mm	±0.6mm	50.6mm	49.4mm

13. Coins are minted so that they fit into coin operated machines which usually judge the amount of a coin by its weight. Also coins are minted to very specific weights sizes and thickness so that they become harder to counterfeit.

14. The coins shown are the new two-dollar coins commemorating the creation of Nunavut.

15. In some ways traditional healers are very much like doctors or pharmacists. Knowing "how much" of a plant to use in a medicinal preparation, as well as how much to give to someone would be very important as some plants help healing in small amounts but can be dangerous in larger amounts.

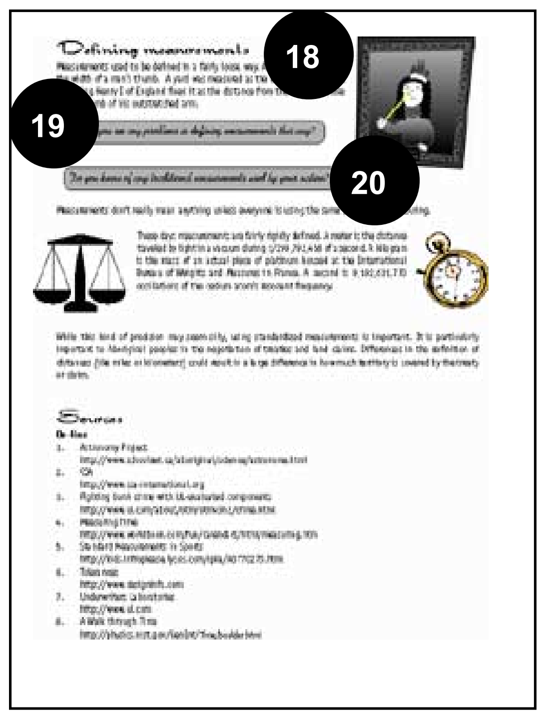
16. Safety engineers test just about every consumer product - vehicles, building materials, toys, clothing, industrial equipment etc. They can also evaluate manufacturing, industrial and medical procedures for safety. If your students are interested in safety engineering there are some great videos of tests on the web site for Underwriter's laboratories, http://www.ul.com.

17. When measurements are standardized there can be no confusion about what amounts are under discussion in business dealings or treaty negotiations. It also means that everyone is "speaking the same language" wherever measurements are used - science, engineering, business, medicine etc.

18. You can find more measurement definitions at http://kids.infoplease.lycos.com/fun/calendars/html/measuring.htm.

19. The problem of defining a measurement by the length of a person's thumb or his belt is that not everyone (not even all men) have the same sized thumb or waist. These measurements were not initially standardized.

20. Again, the answers to this question will vary.

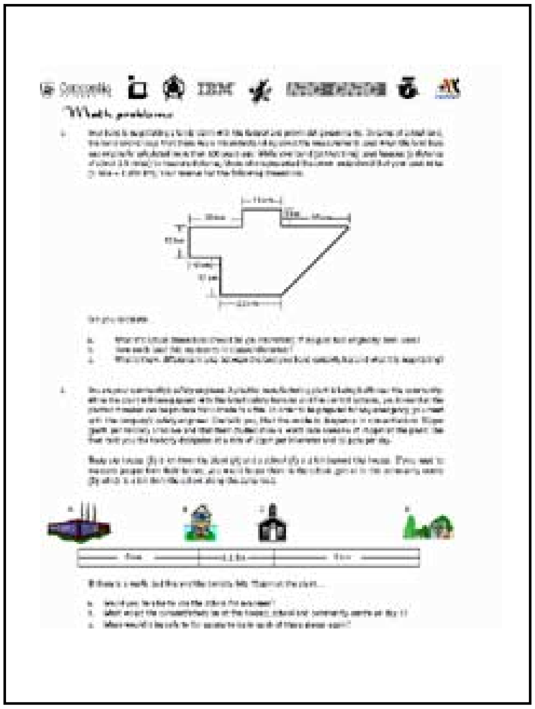


Tolerances

Screws, nuts and bolts have to fit together properly so they are designed to be within certain tolerances. For instance, a screw might be designed to have a 75mm diameter ± 0.1mm. These specifications mean that the screw's diameter will be no smaller than 74.9mm and no bigger than 75.1mm.

Can you fill in the blanks in the table below?

Screw	Size	Tolerance	Maximum Size	Minimum size
A	25mm	± 0.25mm		
B	35mm		35.5mm	34.5mm
C		± 0.1mm		17.9mm
D			75mm	69mm
E	50mm			49.4mm



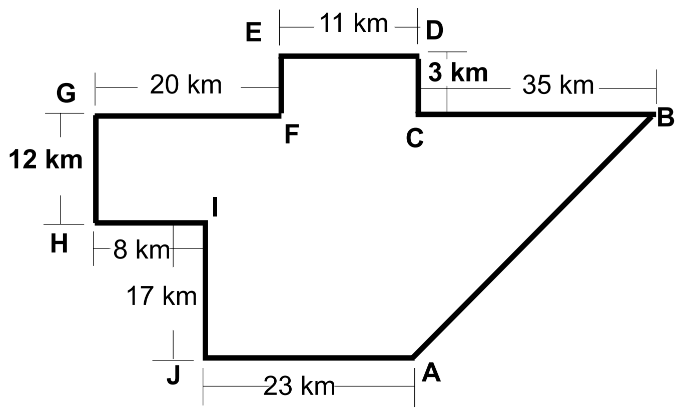
Question 1a

I. What do we know?

- The dimensions of the community boundaries except one.
- All boundaries, except the unknown, run either directly north-south or east-west.
- 1 league = 2.5 miles
- 1 mile = 1.609 km

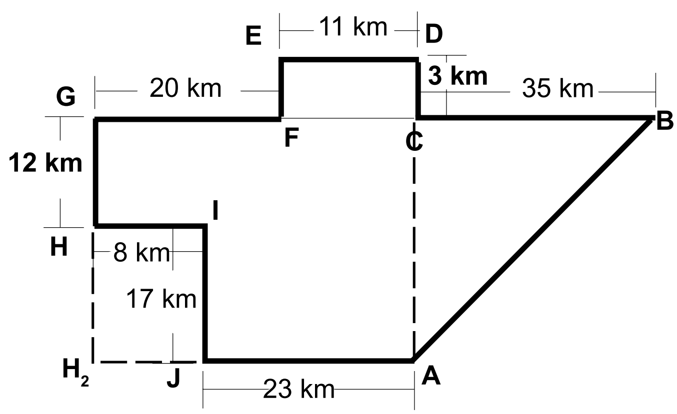
II. Determine the length of the unknown boundary.

Determining the length of the unknown boundary may seem a bit confusing at first. It might help to begin by labeling the diagram as shown.



The students should also be reminded that the community's boundaries run in straight line north-south and east-west. This means the northern boundaries are parallel to the southern ones. It also means that where north-south boundaries meet east-west boundaries they form a right angle.

If they look at the diagram carefully, the students should be able to break it into rectangles which will help them, as shown below.



They should then realize that the straight line distance $\overline{GC}$, is the same length as $\overline{H_2A}$, which means that the imaginary line $\overline{AC}$ runs directly north-south and makes a right angle with line $\overline{CB}$.

$\overline{GC}$ = $\overline{GF}$ + $\overline{FC}$
= 20 km + 11 km
= 31 km

$\overline{H_2A}$ = $\overline{H_2J}$ + $\overline{JA}$
= 8 km + 23 km
= 31 km

Now the problem can be solved using Pythagorean theorum, provided the distance AC can be determined.

$\overline{AC}$ = $\overline{GH}$ + $\overline{IJ}$
= 12 km + 17 km
= 29 km

Using Pythagorean' theorem

$\overline{AB}^2$ = $\overline{BC}^2$ + $\overline{AC}^2$
= $(35\text{ km})^2$ + $(29\text{ km})^2$
= 1225 km^2 + 841 km^2
= 2066 km^2

$\overline{AB}$ = $\sqrt{2066\text{km}^2}$
= 45.5 km

III. Convert each boundary
The current dimensions of the territory are given in kilometers. They are the metric equivalent of the dimensions originally negotiated in miles. We know that a league is 2.5 times longer than a mile. In order to determine what the length of each boundary would have been if leagues had been used mulitply by 2.5. $\overline{AB}$ is used as an example.

$\overline{AB}_{new}$ = $\overline{AB}_{actual}$ x conversion factor
= 45.5 km x 4.022
= 183 km

Answer
The dimensions of the community should be as follows:

$\overline{AB}$	**=**	**114 km**	**$\overline{BC}$**	**=**	**87.5 km**
$\overline{CD}$	**=**	**7.5 km**	**$\overline{DE}$**	**=**	**27.5 km**
$\overline{EF}$	**=**	**7.5 km**	**$\overline{FG}$**	**=**	**50 km**
$\overline{GH}$	**=**	**30 km**	**$\overline{HI}$**	**=**	**20 km**
$\overline{IJ}$	**=**	**42.5 km**	**$\overline{JA}$**	**=**	**57.5 km**

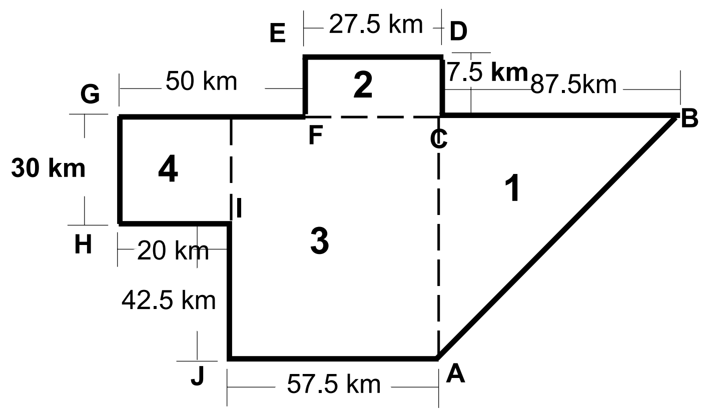
Question 1b

I. What do we know?

- The new dimensions of the community boundaries.
- All boundaries, except the $\overline{AB}$, run either directly north-south or east-west.
- ΔABC is a right angled triangle.

II. Break the community diagram into smaller areas which are easy to calculate.

The students should break the diagram up into rectangles and triangles and label the lengths of each side. There are a number of ways to do this only one is shown as an example.



III. Calculate the areas in each component of the diagram.

Area1 is a triangle:

$$\text{Area1} = \frac{\text{base} \times \text{height}}{2}$$

$$= \frac{87.5 \text{ km} \times 72.5 \text{ km}}{2}$$

$$= \frac{6343.75 \text{ km}^2}{2}$$

$$= 3172 \text{ km}^2$$

Areas 2,3, and 4 are rectangle. They are all calculated using the same formula. Area 3 is given as an example.

$$\text{Area3} = \text{base} \times \text{height}$$

$$= 57.5 \text{ km} \times 72.5 \text{ km}$$

$$= 3806 \text{ km}^2$$

$$\text{Area2} = 206 \text{ km}^2$$

$$\text{Area4} = 600 \text{ km}^2$$

IV. Total the areas.

Total area = area1 + area2 + area3 + area4

= $3172\ km^2 + 206\ km^2 + 3806\ km^2 + 600\ km^2$

= $7784\ km^2$

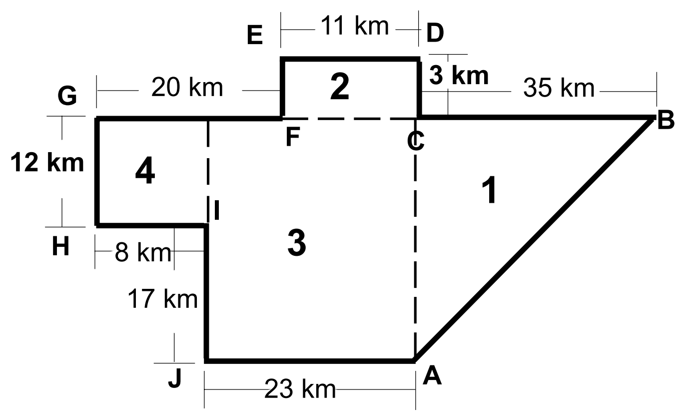
Answer
Total area = $7784\ km^2$

Question 1c

I. What do we know?

- The actual dimensions of the community boundaries.
- All boundaries, except the $\overline{AB}$, run either directly north-south or east-west.
- ΔABC is a right angled triangle.
- Total $area_{new}$ = $7784\ km^2$ (from 1b)

II. Calculate the total area as in 1b. but using actual dimension.



Area1 = $507.5\ km^2$
Area2 = $33\ km^2$
Area3 = $667\ km^2$
Area4 = $96\ km^2$

Total $area_{actual}$ = $1304\ km^2$

III. Calculate how many times more

$$= \frac{\text{total area}_{new}}{\text{total area}_{actual}} = \frac{7784\ km^2}{1304\ km^2} = 5.96$$

Answer
The band council is trying to negotiate approximately 6 times more land.

Question 2a

I. What do we know?
- Dangerous concentration = 50ppm
- Maximum concentration at plant = 75 ppm
- Plant - houses ($\overline{AB}$) = 5 km
- houses - school ($\overline{BC}$) = 3.2 km
- school - community centre ($\overline{CD}$) = 8 km
- concentration dissipates at 2ppm/km and 10ppm/day

II. Calculate distance from plant to school, AC.

$\overline{AC}$ = $\overline{AB}$ + $\overline{BC}$
= 5 km + 3.2 km
= 8.2 km

III. Calculate concentration at school (C)

Concentration_C = Concentration_A - (AC x dissipation rate)
= 75ppm - (8.2 km x 2ppm/km)
= 75ppm - 16.4ppm
= 58.6ppm

IV. Compare concentration with safe levels.

58.6ppm is greater than the safe level of 50ppm.

Answer
The school could not be used because the concentration of smoke would be too great.

Question 2b.

I. What do we know?
- Dangerous concentration = 50ppm
- Maximum concentration at plant = 75 ppm
- Plant - houses ($\overline{AB}$) = 5 km
- houses - school ($\overline{BC}$) = 3.2 km
- school - community centre ($\overline{CD}$) = 8 km
- concentration dissipates at 2ppm/km and 10ppm/day
- concentration at school is 58.6ppm (from 2a)

II. Calculate concentration at houses, B

Concentration_B = Concentration_A - ($\overline{AB}$ x dissipation rate)
= 75ppm - (5km x 2ppm/km)
= 75ppm - 10ppm
= 65 ppm

III. Calculate concentration at community centre, D

$$Concentration_D = Concentration_C - (CD \times \text{dissipation rate})$$
$$= 58.6ppm - (8\text{ km} \times 2ppm/km)$$
$$= 58.6 - 16ppm$$
$$= 42.6ppm$$

Answer
The concentrations are
Houses: 65ppm
School: 58.6ppm
Community centre: 42.6ppm

Question 2c

I. What do we know?

- Day 1 concentrations at all points.
- concentration dissipates 10ppm/day
- concentrations under 50ppm are safe.

II. Calculate concentrations on subsequent days

The easiest way to determine when each place is safe is to create a graph which list the concentration at each place on each day. The concentration decreases by 10 ppm at each site each day and is safe when it is lower than 50ppm

	Plant	Houses	School	Community Centre
Day1	75ppm	65ppm	58.6ppm	42.6ppm
Day2	65ppm	55ppm	48.6ppm	
Day3	55ppm	45ppm		
Day4	45ppm			

Answer
The community centre is safe the day of the fire.
The school is safe the day after the fire.
The houses are safe 2 days after the fire.
The plant is safe 3 days after the fire.