Chapter 2

2-1 *Assume*: From table 2-2 , $2.36 \frac{lb}{capita/day}$;

20,000 people x $\left(2.36 \frac{lb}{capita/day}\right) = 23.6 \frac{tons}{day}$;

landfill capacity = $\left(23.6 \frac{tons}{day}\right)$; x 365 days x 10 years = 86,140 tons

industrial waste = 1,000 tons per day, so $1023.65 \frac{tons}{day}$ is generated.

Therefore, capacity will be reached in approximately 84 days instead of 10 years.

2-3 $2\ tracks(2\ ft)(10\ ft) = 40\ ft^2;\ \frac{8 tons}{40\ ft^2} = 0.20 tons/\ ft^2 = 2.8 lb/in^2$

2-5 Moisture transfer is the movement of water from wet materials such as food waste to dry absorbent materials like paper.

2-9 *Assume*: $\frac{4.0 lb}{capita/day}$ of waste collection; 400,000 lb/day generated waste;

Assume: loose refuse (no compaction); density $= \frac{200 lb}{yd^3}$;

180,000 yd^3 capacity $\left(\frac{200 lb}{yd^3}\right) = 3.6 \times 10^7$ lb capacity;

Then, the expected life is:

$3.6 \times 10^7\ lb$ capacity $\left(\frac{1 day}{400{,}000 lb}\right) = 90$ days;

However, if it assumed that the refuse is compacted to a density of $750 \frac{lb}{yd^3}$,

$750 \frac{lb}{yd^3}(180{,}000 yd^3) = 1.35 \times 10^8\ lb$ capacity;

Then the expected life is:

$$1.35 \times 10^{8}\, lb\left(\frac{1 day}{400{,}000 lb}\right) = 388 \text{ days} \sim 1 \text{ year}$$

2-10 *As-received Heat Value* – includes organic materials, inorganic materials and water. The heat value depends on mass of the sample and the heat generated by its combustion.

Calculated by: Heat value as measured by a calorimeter (*Btu/lb*)

Moisture-Free Heat Value – the heat value of the object excluding the water component from the denominator

Calculated by: $HeatValue\left(\frac{Btu}{lb}\right) \times \left(\frac{Total\ Sample\ Mass}{Total\ Sample\ Mass - Mass\ of\ Water}\right)$

Moisture- and Ash-Free Heat Value – the heat value excluding both water and inorganic material, or ash.

Calculated by:

$$HeatValue\left(\frac{Btu}{lb}\right) \times \left(\frac{Total\ Sample\ Mass}{Total\ Sample\ Mass - Mass\ of\ Water - Mass\ of\ Ash}\right)$$

2-11 The objective of diversion is to increase the life of a landfill or to reduce the cost of disposal.

The following equation is used to attain high diversion rates:

$$\left(\frac{Solid\ waste\ not\ going\ to\ landfill}{Total\ Municiple\ solid\ waste\ generated}\right)$$

If the more honest calculation is used, we do not begin to achieve 75% diversion:

$$\left(\frac{\mathrm{Re}\,cyclables}{Mixed\ household\ and\ commercial\ waste + recyclable\,s}\right)$$

For example, suppose we assume that the purpose of the program is to recycle more. Then 1000 *lb* are either diverting or recycling it and compare the different amounts of diversion obtained by the equations above.

2-13 Using representative values for bulk density (Table 2-5);

Component	Loose Density (lb/yd^3)	Baled Density (lb/yd^3)
Newsprint	20	720
Office Paper	400	700
Cardboard	350	350
Glass	500	1800
HDPE	24	65
PETE	30	400
Steel Cans	150	850
Yard Waste	50	500
Aluminum Cans	65	250
Misc.	300	1000

Assuming: 1000 *lb* combined waste:

Loose Density = (taking weighted average of loose densities)

$$\frac{0.21(20)+0.15(400)+0.08(350)+0.12(500)+0.03(24)+0.03(30)+0.05(150)+0.18(50)+0.04(65)+0.11(300)}{1.00}=206\frac{lb}{yd^3}$$

Volume occupied by 1000 lb of loose refuse:

$$1000lb\left(\frac{1yd^3}{206lb}\right)=4.9yd^3$$

Baled Density = (taking weighted average of baled densities)

$$\frac{0.21(720)+0.15(700)+0.08(350)+0.12(1800)+0.03(65)+0.03(400)+0.05(850)+0.18(500)+0.04(250)+0.11(1000)}{1.00}=767\frac{lb}{yd^3}$$

Volume occupied by 1000 lb of baled refuse:

$$1000lb\left(\frac{1yd^3}{767lb}\right)=1.3yd^3$$

Therefore, the loose volume is approximately 3.7 times as much as the baled refuse volume.

2-14 Taking a weighted average of moisture contents, the overall moisture content is (assuming 100 *lb* of waste):

$$\frac{10lb(70\%)+33lb(6\%)+8lb(5\%)+5lb(2\%)+4lb(10\%)+3lb(2\%)+18lb(60\%)+10lb(3\%)+9lb(6\%)}{100lb}=21.6\%water$$

2-15 *On wet basis*: M = 21.6% water (calculated in 2-14)

Therefore;

$$0.216 = \frac{100-d}{100}; d = 78.42lb$$

Final dry weight of sample = 78.42 *lb*

On dry basis:

$$M_d = \frac{100lb - 78.42lb}{78.42lb}(100\%) = 27.5\%$$

Wet basis is a fraction of wet weight of the sample. Dry basis is a fraction of the dry weight of the sample. Typically, mass is expressed on a wet basis.

2-16 Composition of waste = 82% Other Waste, 18% Yard Waste

Component	% Water	% of Weight
Food	70	12.2
Paper	6	40.2
Cardboard	5	9.8
Plastics	2	6.1
Textiles	10	4.9
Rubber	2	3.7
Metals	3	12.2
Misc.	6	11.0

Moisture Content (weighted average):

$$\frac{12.2lb(70\%)+40.2lb(6\%)+9.8lb(5\%)+6.1lb(2\%)+4.9lb(10\%)+3.7lb(2\%)+12.2lb(3\%)+11lb(6\%)}{100lb} = 13.3\% \, water$$

2-17 Overall Energy Content of Waste (weighted average assuming 100 lb):

$$\frac{10lb(2000)+33lb(7200)+8lb(7000)+5lb(14000)+3lb(7500)+18lb(2800)+10lb(300)+9lb(3000)+4lb(10000)}{100\,lb} = 5265\frac{Btu}{lb}$$

2-18 Composition of Waste (assuming 100 *lb*):

Component	Weight (*lb*)	% (by Weight)
Food	10	12.8
Paper	16.5	21.0
Cardboard (wood)	7.2	9.2
Plastics	3.75	4.8
Textile	3.0	3.8
Rubber	4.0	5.1
Yard Waste	18.0	22.9
Metals	7.0	8.9
Misc.	9.0	11.5

Overall Energy Content:

$$\frac{12.8\%(2000)+21.0\%(7200)+9.2\%(7000)+4.8\%(14000)+3.8\%(7500)+5.10\%(10000)+22.9\%(2800)+8.9\%(300)+11.5\%(3000)}{100\%}=4890\frac{Btu}{lb}$$

(note: wood waste is assumed to be the cardboard)

2-19 The answer is 10 *ft.- lbs*, (see figure 2-13).

2-20 The answer to this problem depends on the current year. Students should get the current generation and diversion numbers from the USEPA website and then compare those numbers to what is shown in Chapter 2 (2012 information).
