HW Problem 11: **SOLUTION** **2005**

Design a transfer station for MSW for scenario A

Given: 20 yr design life

MSW collected per capita in the design year is:

Scen A 5.5 lb/person/day

current population is 95000

Growth rate = 1 %

Population in design year = 114770.4

Peak day = 2 x average day amount

Peak hour = 0.15 x Peak day amount

Transfer mode is 105 cu-yd open top trailers, with some compaction

Assume that 95 % of the MSW is brought to the transfer station in compaction vehicles of capacity as determined in the MSW coll. problem for 8 hour working day.

Scen A 29 cu-yd

The remaining 5 % is brought by private vehicles, with capacity 1 cu-yd.

Specific weight of MSW on compaction vehicle and transfer container is

Scen A 521 lb/cu-yd

Specific weight of MSW on private vehicles is

Scen A 202 lb/cu-yd

Average service rate at scalehouse is 1.3 vehicles/minute

Average service rate at tipping stalls is 0.21 vehicles/minute

SCENARIO A

a. Estimate average and Peak day, and Peak hour throughput in design year, asuming the TS operates
6 days per week. Give answer in tons.

Average day 7 d/wk tons	6 d/wk tons	Peak day tons	Peak hour tons
316	368	737	111

col 1 Pop x MSW coll per person per day / 2000

col 2 col 1 x 7 / 6

col 3 col 2 x peak factor

col 4 col 3 x peak factor

b. Determine the number of transfer containers required to handle design year peak day. The TS operates 8 hours / working day. Assume a transfer container can be placed, filled, and removed in 0.25 hours. Use as many containers as required. The container holds 105 cu-yd. The specific weight is 521 lb/cu-yd

Number of containers	Loads / day	TS capacity
1	32	875.888
2	64	1751.776

1 Container is acceptable

c. Estimate the area required to store the peak hour MSW amount in a cubical pile 8 ft high, with specific weight 450 lb/cu-yd. give answer in cu-yd.

Area = peak hr Amount / (SW x pile height)
= 111 tons x 2000lb/ton / (450 x 8 ft / 3 ft/yd)
= 184 sq-yd

d. Estimate the number of compaction and private vehicles using the landfill (separate and together) in the design year during the peak day. Also estimate the corresponding peak day arrival times and utilization factors at the scalehouse.

COMPACTION VEHICLES

number of compaction vehicles = fraction brought x peak day amnt / compaction vehicle capacity
0.95 x 737 tns x 2000lb/tn / 521 lb/cu-yd / 29 cu-yd
= 92
arrival rate = number / minute
= 92 / (8 x 60) = 0.19 vehicles / minute
utilization factor = arrival rate / service rate
= 0.19 / 1.3 = 0.15

PRIVATE VEHICLES

number of private vehicles = fraction brought x peak day amnt / private vehicle capacity
0.05 x 737 tns x 2000lb/tn / 202 lb/cu-yd / 1.00 cu-yd
= 365
arrival rate = number / minute
= 365 / (8 x 60) = 0.76 vehicles / minute
utilization factor = arrival rate / service rate
= 0.76 / 1.3 = 0.59

TOTAL VEHICLES

number = 457
arrival rate = 0.95
utilization factor = arrival rate / service rate
= 0.95 / 1.3 = 0.73

e. Estimate the average number of vehicles in the scalehouse system, their average wait time, and the 95 % probability of having n or fewer vehicles in the system during peak day.

Use total vehicles.

Assuming 1 scalehouse

Average # of vehicles waiting to be served = utilization factor squared / (1- utilization factor)

= square (0.73) / (1 - 0.73)

= 2.0 vehicles

Average waiting time = arrival rate / (service rate x (service rate - arrival rate))

= 0.95 / (1.3 x (1.3 - 0.95))

= 2.1 minutes

Probability of n or less vehicles in system?

n	P(n)	P(<= n)	
0	0.27	0.27	
1	0.196	0.46	
2	0.1435	0.61	
3	0.1051	0.71	
4	0.077	0.79	
5	0.0564	0.85	
6	0.0413	0.89	
7	0.0302	0.92	
8	0.0222	0.94	
9	0.0162	0.96	Answer

P(n) = 1 - utilization factor, if n = 0

P(n) = (utilization factor ^ n) x P(0), if n > 0

P(<= n) = sum of P(n)'s up to n

f. For the compaction and private vehicles combined, determine the average number of vehicles in the tipping system, their average wait time, and the probability of having n or fewer vehicles in the system (up to 0.95 probability), for fewest tipping stalls that result in a 95 % probability of having 5 or fewer vehicles waiting to tip, during peak day.

Try 6 7 8 9 tipping stalls (try four different numbers, e.g., 6 through 9

arrival rate = 0.95 vehicles/minute
service time = 0.21 vehicles/minute
utilization factor = 4.53

P(n) PROBABILITY TABLE

	Probabily, given K and n			
number of tipping stalls, K	6	7	8	9
# of vehicles in tipping sys. if 5 are waiting	11	12	13	14
facility utilization factor	0.755625	0.648	0.566719	0.504
n				
0	0.008751	0.01	0.010526	0.011
1	0.039676	0.046	0.047723	0.048
2	0.089942	0.104	0.108181	0.11
3	0.135924	0.157	0.163489	0.166
4	0.154062	0.178	0.185304	0.188
5	0.139696	0.161	0.168025	0.17
6	0.105557	0.122	0.126964	0.129
7	0.079762	0.079	0.082232	0.083
8	0.06027	0.051	0.046602	0.047
9	0.045542	0.033	0.02641	0.024
10	0.034412	0.021	0.014967	0.012
11	0.026003	0.014	0.008482	0.006
12	0.019648	0.009	0.004807	0.003
13	0.014847	0.006	0.002724	0.002
14	0.011219	0.004	0.001544	8E-04

CUMULATIVE PROBABILITY TABLE

	Cum Probability, given K and n			
number of tipping stalls, K	6	7	8	9
# of vehicles in tipping sys. if 5 are waiting	11	12	13	14
n				
0	0.008751	0.01	0.010526	0.011
1	0.048428	0.056	0.058249	0.059
2	0.138369	0.159	0.16643	0.169
3	0.274294	0.316	0.329919	0.334
4	0.428355	0.494	0.515223	0.522
5	0.568051	0.655	0.683248	0.693
6	0.673608	0.776	0.810212	0.821
7	0.75337	0.855	0.892443	0.905
8	0.81364	0.906	0.939046	0.952
9	0.859182	0.939	0.965456	0.976
10	0.893594	0.961	0.980423	0.988
11	0.919597	0.975	0.988905	0.994
12	0.939246	0.983	0.993713	0.997
13	0.954092	0.989	0.996437	0.998
14	0.965311	0.993	0.997981	0.999

From inspection of the table above, it is apparent that 7 tipping stalls are required.

g. How would the transfer station design for Scenario's B and C differ? How would it be similar?