# SPILL ESTIMATION

Not Just A Guess Anymore

SCAP
SOUTHERN CALIFORNIA ALLIANCE OF PUBLICLY OWNED TREATMENT WORKS

# SPILL ESTIMATION

- Under current regulations accurate spill estimation has become critical to the operation and maintenance of a sanitary collection system
  - Reporting to State and Regional Boards
  - Reporting to local health care agency
  - Factor for determining spill category
  - Can be used in determining penalties

# SPILL ESTIMATION

- There are basically two types of systems where sewage spills occur
  - The gravity system
    - Collection pipelines, manholes, wet wells, etc.
  - The pressure system
    - Force mains, pump and lift stations, etc.

# SPILL ESTIMATION METHODS

- WAG Factor
- Flooding or ponding
- Flow velocity over time equals spill volume
- Area times depth for spills that are contained
- Charts for pick, vent and manholes
- Picture charts (San Diego and CWEA Southern Section)
- Take pictures and measurements
- Who is doing the estimating?

# SPILL ESTIMATION METHODS

- Eyeball Estimate
  - To use this method imagine the amount of water that would spill from a bucket or a barrel. A bucket contains 5 gallons and a barrel contains 50 gallons. If the spill is larger than 50 gallons, try to break the standing water into barrels and then multiply by 50 gallons. This method is useful for contained spills up to approximately 200 gallons.

# SPILL ESTIMATION METHODS

- Measured Volume
  - The volume of most spills that have been contained can be estimated using this method. The shape, dimensions, and the depth of the contained wastewater are needed. The shape and dimensions are used to calculate the area of the spills and the depth is used to calculate the volume.

# SPILL ESTIMATION METHODS

- Measured volume continued

  **Step 1** Sketch the shape of the sewage containment area.

  **Step 2** Measure or pace off the dimensions (length, width, diameter, etc.)

  **Step 3** Measure the depth at several locations and calculate an average (total of the samples by the number of samples).

  **Step 4** Convert the dimensions, including depth, to feet.

# SPILL ESTIMATION METHODS

- Measured volume continued

  **Step 5** Calculate the area in square feet using the following formulas:

  - Rectangle: Area = length (feet) x width (feet)
  - Circle: Area = diameter (feet) x diameter (feet) x 0.785
  - Triangle: Area = base (feet) x height (feet) x 0.5

  **Step 6** Multiply the area (square feet) times the depth (in feet) to obtain the volume in cubic feet.

  **Step 7** Multiply the volume in cubic feet by 7.48 (number of gallons in one cubic foot) to convert it to gallons.

# SPILL ESTIMATION METHODS

- Many times sewage spills do not pond at the site but tend to flow into the storm water system, creeks or water ways etc.  For this type of spill the flow volume or velocity must be determined and the time duration of the spill established.

# SPILL ESTIMATION METHODS

- Counting connections
  - Once the location of the spill is known, the number of upstream connections can be determined from the sewer maps.  Multiply the number of connections by 200 to 250 gallons per day per connection or 8 to 10 gallons per hour per connection.

# SPILL ESTIMATION METHODS

- For example:

  22 upstream connections x 9 gallons per hour per connection = 198 gallons per hour / 60 minutes per hour = 3.3 gallons per minute. Multiply the gallons per minute times the number of minutes the spill occurred for the total volume of the spill.

# SPILL ESTIMATION METHODS

- Pictorial Reference
  - Use a pictorial reference such as the San Diego or CWEA Southern Section picture charts to determine the flow velocity then multiply the gallons per minute times the time duration of the spill in minutes to obtain the total volume of the spill.

City of San Diego
Metropolitan Wastewater Department

# Reference Sheet for Estimating Sewer Spills from Overflowing Sewer Manholes

*All estimates are calculated in gallons per minute (gpm)*

Wastewater Collection Division
(619) 654-4160

5 gpm

25 gpm

50 gpm

100 gpm

150 gpm

200 gpm

225 gpm

250 gpm

275 gpm

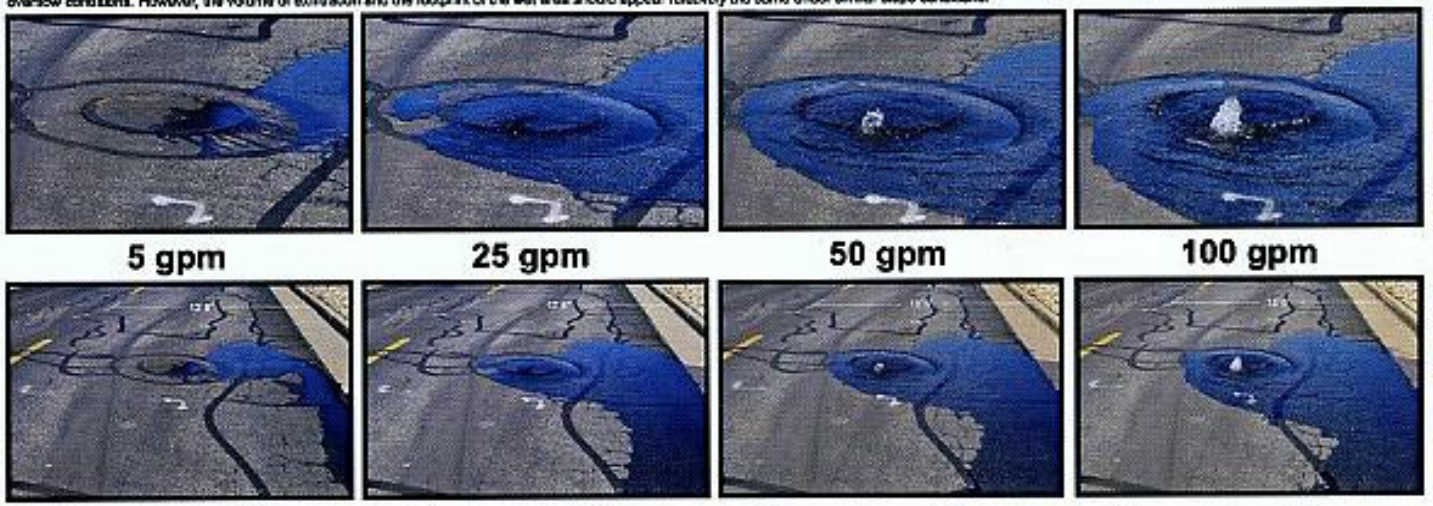
All photos were taken during a demonstration using metered water from a hydrant in cooperation with the City of San Diego's Water Department.

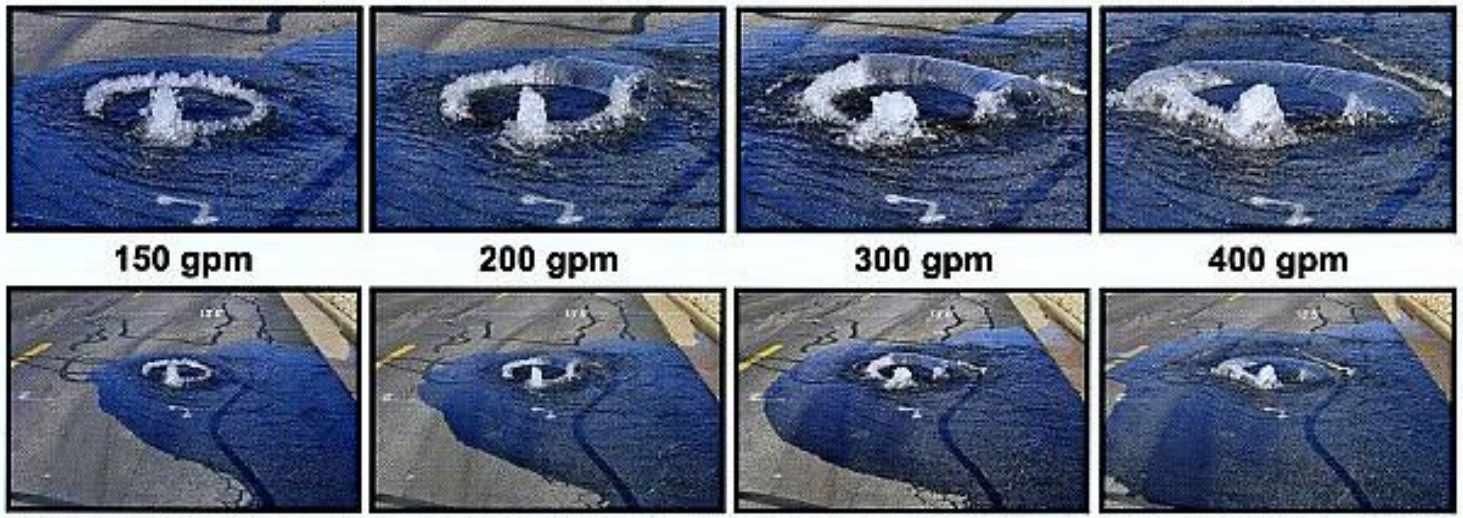
rev. 4/99

# SSCSC MANHOLE OVERFLOW GAUGE

Overflow Simulation courtesy of Eastern Municipal Water District

DISCLAIMER: This overflow simulation may appear differently from those in other systems because of the manhole lid pick hole configuration. Manhole lids with single or multiple pick holes may appear differently during overflow conditions. However, the volume of exfiltration and the footprint of the wet area should appear relatively the same under similar slope conditions.




**PROVIDING QUALITY TRAINING FOR COLLECTION SYSTEM PERSONNEL SINCE 1991**

**Mission Statement:** To continuously increase the level of professionalism of Collection Systems personnel involved in the operation, maintenance, design and construction of Wastewater Collection Systems, by providing education and training, taking an active role in promoting certification, and Recognizing proficiency in our field.

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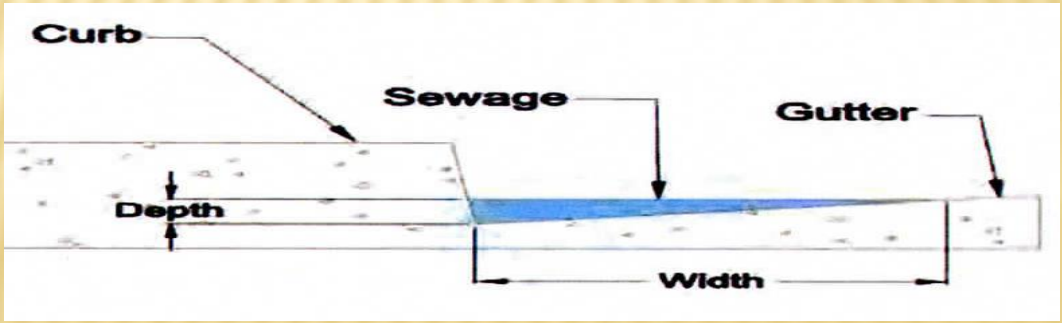
# SPILL ESTIMATION METHODS

- Open Channel Spill Estimation
  - For ditches, channels, gutters, etc.
  - Measure the cross sectional dimensions of the channel and determine the velocity of the flow
  - Measure the velocity by dropping a floating object into the flow and time over a measured distance
  - Flow (Q), $ft^3/sec$ = Velocity (V), ft/sec X Area (A),$ft^2$
  - Flow times duration equals amount of spill



# SPILL ESTIMATION METHODS

- Drop Bucket Method
  - Can be used for small spills where entire flow stream can be captured in a bucket
  - Time how long it takes to fill the bucket
  - Dividing the volume of the bucket (in gallons) by the elapsed time to fill the bucket (in minutes) equals the flow rate in gallons per minute (gpm)
  - Example:  If it takes 30 seconds to fill a 5-gallon bucket and the spill has occurred for 20 minutes the total spill volume would be 200 gallons (5gal/.5min = 10gpm X20min = 200gal.)

# SPILL ESTIMATION METHODS

- Calculating a spill based upon pipe size
  - Need to know the size of the pipe
  - Need a flow calculation chart
  - Measure the depth of the flow down stream of the blockage
  - Measure the depth of flow again after the blockage has been cleared and flow stabilized

| Flow Depth Inches | 8 " PIPE | 10" PIPE | 12" PIPE | 15" PIPE | 18" PIPE | 21" PIPE | 24" PIPE |
|---|---|---|---|---|---|---|---|
| 1 | 20 GPM | 25 GPM | 30 GPM | 35 GPM | 40 GPM | 45 GPM | 50 GPM |
| 2 | 60 | 70 | 80 | 85 | 95 | 105 | 125 |
| 3 | 110 | 125 | 135 | 150 | 175 | 185 | 210 |
| 4 | 160 | 180 | 200 | 235 | 260 | 285 | 320 |
| 5 | 190 | 240 | 280 | 315 | 360 | 380 | 445 |
| 6 | 260 | 310 | 355 | 415 | 455 | 500 | 555 |
| 7 | 290 | 370 | 425 | 495 | 570 | 620 | 695 |
| 8 | 320 | 430 | 500 | 600 | 680 | 760 | 815 |
| 9 | | 465 | 575 | 690 | 800 | 890 | 965 |
| 10 | | 490 | 625 | 775 | 905 | 1005 | 1120 |
| 11 | | | 685 | 870 | 1020 | 1135 | 1275 |
| 12 | | | 715 | 935 | 1130 | 1260 | 1410 |
| 13 | | | | 1020 | 1240 | 1415 | 1580 |
| 14 | | | | 1070 | 1345 | 1520 | 1690 |
| 15 | | | | 1105 | 1425 | 1650 | 1850 |
| 16 | | | | | 1495 | 1760 | 1990 |
| 17 | | | | | 1550 | 1880 | 2110 |
| 18 | | | | | 1595 | 1980 | 2285 |
| 19 | | | | | | 2050 | 2410 |
| 20 | | | | | | 2115 | 2530 |
| 21 | | | | | | 2160 | 2630 |
| 22 | | | | | | | 2700 |
| 23 | | | | | | | 2765 |
| 24 | | | | | | | 2820 |

Note: the chart assumes V = 2.0 feet per second and n = 0.013

1. Record the time that spill was reported.
2. Record the flow, in inches, downstream of the spill or blockage. Record the pipe size in inches. Determine flow rate in gallons per minute (GPM) using chart above.
3. Re-establish flow and allow stabilizing. Record the time that flow stabilizes and the depth of flow, in inches. Determine flow rate using chart above.
4. Subtract the flow rate calculated in #2 from the flow rate calculated in #3.
5. Multiply the result of 4 by the minutes elapsed from notification to stopping overflow.
6. Report total amount in gallons on the SSO Report.

# SPILL ESTIMATION METHODS

- Example:
  - A Spill was reported at 3:50 pm and was corrected at 6:25 pm on the same day. Calculate the volume of the spill for a 10 inch pipeline with 1 inch of downstream flow before correction and 5 inches of flow after correction and stabilization of flow.

# SPILL ESTIMATION METHODS

- Time reported – 3:50 pm
- Time Corrected – 6:25 pm
- Duration of spill – 2:35 or **155 minutes**
- Depth of flow before – 1 inch
- Depth of flow after – 5 inches

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| 3 | 110 | 125 | 135 | 150 | 175 | 185 | 210 |
| 4 | 160 | 180 | 200 | 235 | 260 | 285 | 320 |
| 5 | 190 | 240 | 280 | 315 | 360 | 380 | 445 |
| 6 | 260 | 310 | 355 | 415 | 455 | 500 | 555 |
| 7 | 290 | 370 | 425 | 495 | 570 | 620 | 695 |
| 8 | 320 | 430 | 500 | 600 | 680 | 760 | 815 |
| 9 | | 465 | 575 | 690 | 800 | 890 | 965 |
| 10 | | 490 | 625 | 775 | 905 | 1005 | 1120 |
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| 19 | | | | | | 2050 | 2410 |
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# SPILL ESTIMATION METHODS

- From Chart

  Flow after stabilization = 240 gpm

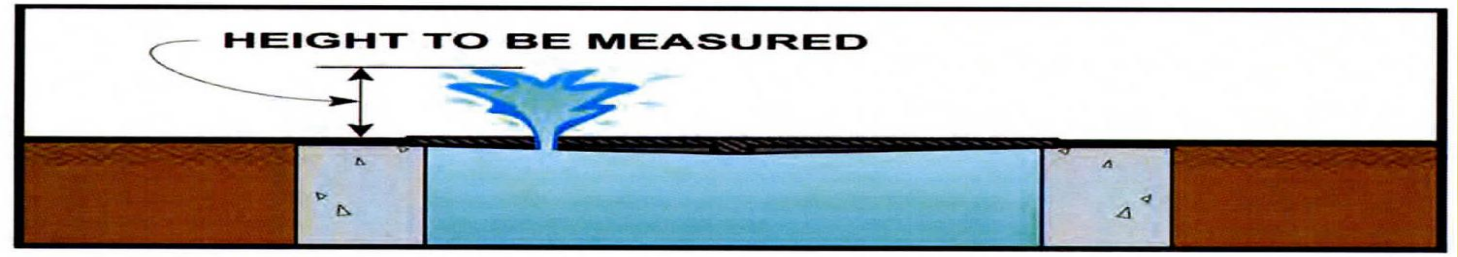
  Flow downstream before = 25 gpm

  Net Flow = 240 -25 = 215 gpm

  **SPILL VOLUME = 215 (gpm) X 155 (m) = 33,325 gallons**

# SPILL ESTIMATION METHODS

- To determine spill volume from vent or pick holes
  - Count the number of holes
  - Measure the height of the water exiting from the holes




  - Refer to pick hole chart to determine the volume from each hole
  - Multiply the number of holes times the flow rate times the duration of the spill to determine spill volume

# Estimated Flows thru Manhole Cover Vent Holes and Pick Holes for SSO estimating

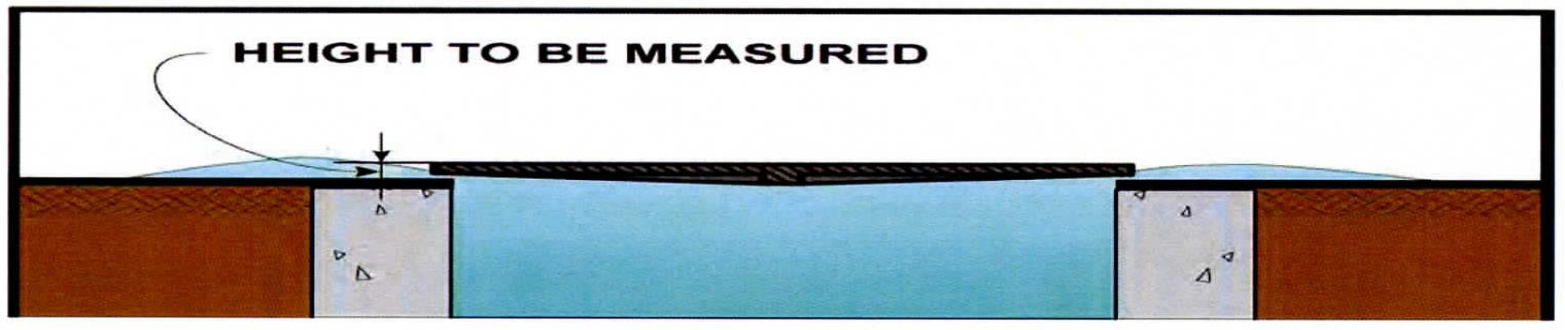
| Hole Dia. inches | Area sq. ft. | Coeff.of Vel. Cv | Coeff. Of Cont. Cc | C Cv x Cc | Water Ht inches | Water Ht inches | Water Ht feet | Q cfs | Q gpm | Q gph |
|---|---|---|---|---|---|---|---|---|---|---|
| **Vent Hole** | | | | | | | | | | |
| 0.50 | 0.00136 | 0.945 | 0.70 | 0.662 | 1/16 th | 0.063 | 0.005 | 0.0005 | 0.23 | 14 |
| 0.50 | 0.00136 | 0.945 | 0.70 | 0.662 | 1/8 th | 0.125 | 0.010 | 0.0007 | 0.33 | 20 |
| 0.50 | 0.00136 | 0.945 | 0.70 | 0.662 | 1/4 th | 0.250 | 0.021 | 0.0010 | 0.47 | 28 |
| 0.50 | 0.00136 | 0.945 | 0.70 | 0.662 | one half | 0.500 | 0.042 | 0.0015 | 0.66 | 40 |
| 0.50 | 0.00136 | 0.945 | 0.70 | 0.662 | 3/4 ths | 0.750 | 0.063 | 0.0018 | 0.81 | 49 |
| 0.50 | 0.00136 | 0.945 | 0.70 | 0.662 | 1 inch | 1.000 | 0.083 | 0.0021 | 0.94 | 56 |
| **Vent Hole** | | | | | | | | | | |
| 0.75 | 0.00307 | 0.955 | 0.67 | 0.640 | 1/16 th | 0.063 | 0.005 | 0.0011 | 0.51 | 31 |
| 0.75 | 0.00307 | 0.955 | 0.67 | 0.640 | 1/8 th | 0.125 | 0.010 | 0.0016 | 0.72 | 43 |
| 0.75 | 0.00307 | 0.955 | 0.67 | 0.640 | 1/4 th | 0.250 | 0.021 | 0.0023 | 1.02 | 61 |
| 0.75 | 0.00307 | 0.955 | 0.67 | 0.640 | one half | 0.500 | 0.042 | 0.0032 | 1.44 | 87 |
| 0.75 | 0.00307 | 0.955 | 0.67 | 0.640 | 3/4 ths | 0.750 | 0.063 | 0.0039 | 1.77 | 106 |
| 0.75 | 0.00307 | 0.955 | 0.67 | 0.640 | 1 inch | 1.000 | 0.083 | 0.0045 | 2.04 | 122 |
| **Vent Hole** | | | | | | | | | | |
| 1.00 | 0.00545 | 0.960 | 0.65 | 0.624 | 1/16 th | 0.063 | 0.005 | 0.0020 | 0.88 | 53 |
| 1.00 | 0.00545 | 0.960 | 0.65 | 0.624 | 1/8 th | 0.125 | 0.010 | 0.0028 | 1.25 | 75 |
| 1.00 | 0.00545 | 0.960 | 0.65 | 0.624 | 1/4 th | 0.250 | 0.021 | 0.0039 | 1.77 | 106 |
| 1.00 | 0.00545 | 0.960 | 0.65 | 0.624 | one half | 0.500 | 0.042 | 0.0056 | 2.50 | 150 |
| 1.00 | 0.00545 | 0.960 | 0.65 | 0.624 | 3/4 ths | 0.750 | 0.063 | 0.0068 | 3.06 | 184 |
| 1.00 | 0.00545 | 0.960 | 0.65 | 0.624 | 1 inch | 1.000 | 0.083 | 0.0079 | 3.54 | 212 |
| | | | | | | | | | | |
| **Pick Hole semicircular area** | | | | | | | | | | |
| 1.00 | 0.00273 | 0.960 | 0.65 | 0.624 | 1/16 th | 0.063 | 0.005 | 0.0010 | 0.44 | 27 |
| 1.00 | 0.00273 | 0.960 | 0.65 | 0.624 | 1/8 th | 0.125 | 0.010 | 0.0014 | 0.63 | 38 |
| 1.00 | 0.00273 | 0.960 | 0.65 | 0.624 | 1/4 th | 0.250 | 0.021 | 0.0020 | 0.89 | 53 |
| 1.00 | 0.00273 | 0.960 | 0.65 | 0.624 | one half | 0.500 | 0.042 | 0.0028 | 1.25 | 75 |
| 1.00 | 0.00273 | 0.960 | 0.65 | 0.624 | 3/4 ths | 0.750 | 0.063 | 0.0034 | 1.53 | 92 |
| 1.00 | 0.00273 | 0.960 | 0.65 | 0.624 | 1 inch | 1.000 | 0.083 | 0.0039 | 1.77 | 106 |
| 1.00 | 0.00273 | 0.960 | 0.65 | 0.624 | 1-1/2 inch | 1.500 | 0.125 | 0.0048 | 2.17 | 130 |
| 1.00 | 0.00273 | 0.960 | 0.65 | 0.624 | 2 inches | 2.000 | 0.167 | 0.0056 | 2.51 | 150 |

# SPILL ESTIMATION METHODS

- To determine the spill volume of a spill from around the rim of the manhole cover
  - Find the area of the gap (diameter of the cover from the diameter of the inside of the ring)
  - Find the velocity (ft/sec) of the spill by measuring the height of the sewage plume
  - Area times the velocity (ft/sec) times the duration of the spill times (448.8 for gpm/cfs) equals the total spill volume in gallons

# SPILL ESTIMATION METHODS

- One inch vertical plume = 2ft/sec
- Two inch vertical plume = 3.3 ft/sec
- Three inch vertical plume = 4.0 ft/sec
- Four inch vertical plume = 4.6 ft/sec
- Five inch vertical plume = 5.2 ft/sec
- Six inch vertical plume = 5.7 ft/sec



# TABLE 'A'

## ESTIMATED SSO FLOW OUT OF M/H WITH COVER IN PLACE

### 24" COVER

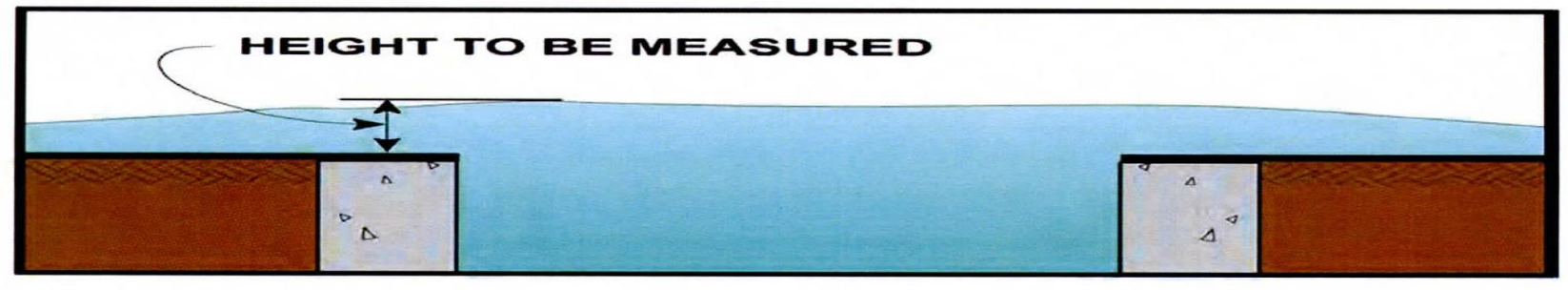
| Height of spout above M/H rim H in inches | S S O FLOW Q | | Min. Sewer size in which these flows are possible |
|---|---|---|---|
| | in gpm | in MGD | |
| 1/4 | 1 | 0.001 | |
| 1/2 | 3 | 0.004 | |
| 3/4 | 6 | 0.008 | |
| 1 | 9 | 0.013 | |
| 1 1/4 | 12 | 0.018 | |
| 1 1/2 | 16 | 0.024 | |
| 1 3/4 | 21 | 0.030 | |
| 2 | 25 | 0.037 | |
| 2 1/4 | 31 | 0.045 | |
| 2 1/2 | 38 | 0.054 | |
| 2 3/4 | 45 | 0.065 | |
| 3 | 54 | 0.077 | |
| 3 1/4 | 64 | 0.092 | |
| 3 1/2 | 75 | 0.107 | |
| 3 3/4 | 87 | 0.125 | |
| 4 | 100 | 0.145 | |
| 4 1/4 | 115 | 0.166 | |
| 4 1/2 | 131 | 0.189 | |
| 4 3/4 | 148 | 0.214 | |
| 5 | 166 | 0.240 | |
| 5 1/4 | 185 | 0.266 | |
| 5 1/2 | 204 | 0.294 | |
| 5 3/4 | 224 | 0.322 | 6" |
| 6 | 244 | 0.352 | |
| 6 1/4 | 265 | 0.382 | |
| 6 1/2 | 286 | 0.412 | |
| 6 3/4 | 308 | 0.444 | |
| 7 | 331 | 0.476 | |
| 7 1/4 | 354 | 0.509 | |
| 7 1/2 | 377 | 0.543 | |
| 7 3/4 | 401 | 0.578 | 8" |
| 8 | 426 | 0.613 | |
| 8 1/4 | 451 | 0.649 | |
| 8 1/2 | 476 | 0.686 | |
| 8 3/4 | 502 | 0.723 | |
| 9 | 529 | 0.761 | |

### 36" COVER

| Height of spout above M/H rim H in inches | S S O FLOW Q | | Min. Sewer size in which these flows are possible |
|---|---|---|---|
| | in gpm | in MGD | |
| 1/4 | 1 | 0.002 | |
| 1/2 | 4 | 0.006 | |
| 3/4 | 8 | 0.012 | |
| 1 | 13 | 0.019 | |
| 1 1/4 | 18 | 0.026 | |
| 1 1/2 | 24 | 0.035 | |
| 1 3/4 | 31 | 0.044 | |
| 2 | 37 | 0.054 | |
| 2 1/4 | 45 | 0.065 | |
| 2 1/2 | 55 | 0.079 | |
| 2 3/4 | 66 | 0.095 | |
| 3 | 78 | 0.113 | |
| 3 1/4 | 93 | 0.134 | |
| 3 1/2 | 109 | 0.157 | |
| 3 3/4 | 127 | 0.183 | |
| 4 | 147 | 0.211 | |
| 4 1/4 | 169 | 0.243 | |
| 4 1/2 | 192 | 0.276 | |
| 4 3/4 | 217 | 0.312 | 6" |
| 5 | 243 | 0.350 | |
| 5 1/4 | 270 | 0.389 | |
| 5 1/2 | 299 | 0.430 | |
| 5 3/4 | 327 | 0.471 | |
| 6 | 357 | 0.514 | |
| 6 1/4 | 387 | 0.558 | 8" |
| 6 1/2 | 419 | 0.603 | |
| 6 3/4 | 451 | 0.649 | |
| 7 | 483 | 0.696 | |
| 7 1/4 | 517 | 0.744 | |
| 7 1/2 | 551 | 0.794 | |
| 7 3/4 | 587 | 0.845 | 10" |
| 8 | 622 | 0.896 | |
| 8 1/4 | 659 | 0.949 | |
| 8 1/2 | 697 | 1.003 | |
| 8 3/4 | 734 | 1.057 | |
| 9 | 773 | 1.113 | |

# SPILL ESTIMATION METHODS

- To determine the spill volume of a spill from a manhole without a cover
  - Find the area of the manhole opening (Area = 3.14 $R^2$)
  - Find the velocity (ft/sec) of the spill by measuring the height of the sewage plume




  - Area times the velocity (ft/sec) times the duration of the spill times (448.8 gpm/cfs) equals the total spill volume in gallons.

# TABLE 'B'

## ESTIMATED SSO FLOW OUT OF M/H WITH COVER REMOVED

### 24" FRAME

| Water Height above M/H frame H in inches | S S O FLOW Q in gpm | in MGD | Min. Sewer size in which these flows are possible |
|---|---|---|---|
| 1/8 | 28 | 0.04 | |
| 1/4 | 62 | 0.09 | |
| 3/8 | 111 | 0.16 | |
| 1/2 | 160 | 0.23 | |
| 5/8 | 215 | 0.31 | 6" |
| 3/4 | 354 | 0.51 | 8" |
| 7/8 | 569 | 0.82 | 10" |
| 1 | 799 | 1.15 | 12" |
| 1 1/8 | 1,035 | 1.49 | |
| 1 1/4 | 1,340 | 1.93 | 15" |
| 1 3/8 | 1,660 | 2.39 | |
| 1 1/2 | 1,986 | 2.86 | |
| 1 5/8 | 2,396 | 3.45 | 18" |
| 1 3/4 | 2,799 | 4.03 | |
| 1 7/8 | 3,132 | 4.51 | |
| 2 | 3,444 | 4.96 | 21" |
| 2 1/8 | 3,750 | 5.4 | |
| 2 1/4 | 3,986 | 5.74 | |
| 2 3/8 | 4,215 | 6.07 | |
| 2 1/2 | 4,437 | 6.39 | |
| 2 5/8 | 4,569 | 6.58 | 24" |
| 2 3/4 | 4,687 | 6.75 | |
| 2 7/8 | 4,799 | 6.91 | |
| 3 | 4,910 | 7.07 | |

### 36" FRAME

| Water Height above M/H frame H in inches | S S O FLOW Q in gpm | in MGD | Min. Sewer size in which these flows are possible |
|---|---|---|---|
| 1/8 | 49 | 0.07 | |
| 1/4 | 111 | 0.16 | |
| 3/8 | 187 | 0.27 | 6" |
| 1/2 | 271 | 0.39 | |
| 5/8 | 361 | 0.52 | 8" |
| 3/4 | 458 | 0.66 | |
| 7/8 | 556 | 0.8 | 10" |
| 1 | 660 | 0.95 | 12" |
| 1 1/8 | 1,035 | 1.49 | |
| 1 1/4 | 1,486 | 2.14 | 15" |
| 1 3/8 | 1,951 | 2.81 | |
| 1 1/2 | 2,424 | 3.49 | 18" |
| 1 5/8 | 2,903 | 4.18 | |
| 1 3/4 | 3,382 | 4.87 | |
| 1 7/8 | 3,917 | 5.64 | 21" |
| 2 | 4,458 | 6.42 | |
| 2 1/8 | 5,000 | 7.2 | 24" |
| 2 1/4 | 5,556 | 8 | |
| 2 3/8 | 6,118 | 8.81 | |
| 2 1/2 | 6,764 | 9.74 | |
| 2 5/8 | 7,403 | 10.66 | |
| 2 3/4 | 7,972 | 11.48 | 30" |
| 2 7/8 | 8,521 | 12.27 | |
| 3 | 9,062 | 13.05 | |
| 3 1/8 | 9,604 | 13.83 | |
| 3 1/4 | 10,139 | 14.6 | |
| 3 3/8 | 10,625 | 15.3 | 36" |
| 3 1/2 | 11,097 | 15.98 | |
| 3 5/8 | 11,569 | 16.66 | |
| 3 3/4 | 12,035 | 17.33 | |
| 3 7/8 | 12,486 | 17.98 | |
| 4 | 12,861 | 18.52 | |
| 4 1/8 | 13,076 | 18.83 | |
| 4 1/4 | 13,285 | 19.13 | |
| 4 3/8 | 13,486 | 19.42 | |

# SPILL ESTIMATION METHODS

- To calculate spills in a pressure system (force main)
  - Flow meter
  - Pump capacity over time (constant run)
  - Volume pumped from wet well times number of pump cycles (fill and draw)
  - Minus flow that reached destination if known

# SPILL ESTIMATION METHODS

- Start time can be the most difficult to determine
  - Time of initial notification
  - Witness statements
    - Knock on doors
  - Telemetry alarms
- Stop time should be accurately recorded by field staff on site

# SPILL ESTIMATION METHODS

- Conclusion
  - Accurate spill estimation is more important now than ever before (most spills are under estimated)
  - Field personnel gather the data
    - Measurements
    - photos
    - Time
  - Engineer or supervisor makes the estimate

# TEST