Flow Rate

Industrial Wastewater Permit, Flow Measurement, and Surcharge Statements

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ENVIRO-FLOW

IMPORTANCE OF FLOW RATE

Flow Rates

Annual Surcharge
MGY (volume) charge
MGY X COD X K=Klbs
MGY X TSS X K=Klbs
Peak Charge (gpm)
(average of 10 highest 30-minute peaks)

Capacity Units & Connection Fee
GPD
Lbs/day COD
Lbs/day TSS

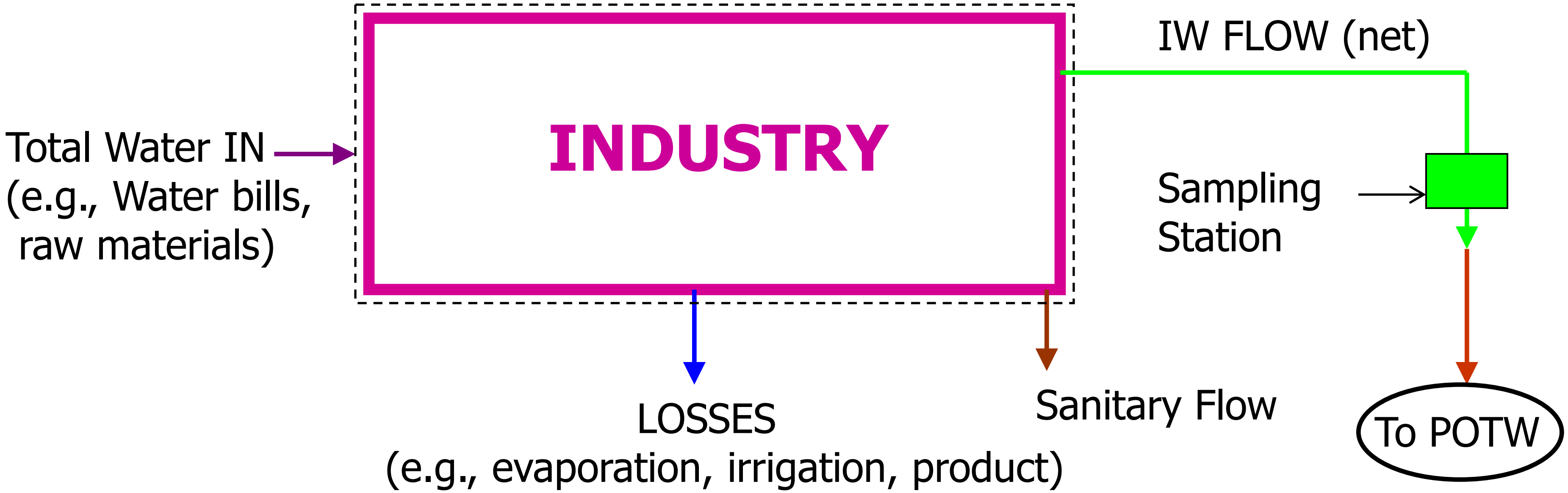
Permit Compliance
gpm
(5-minute peak peak flow rate limit-not to be exceeded at any time)

Average flow rate affects calculation of mass based limits established for 5-year permit cycle (some categorical industries)

Daily mass limit and flow rate to calculate a concentration limit.

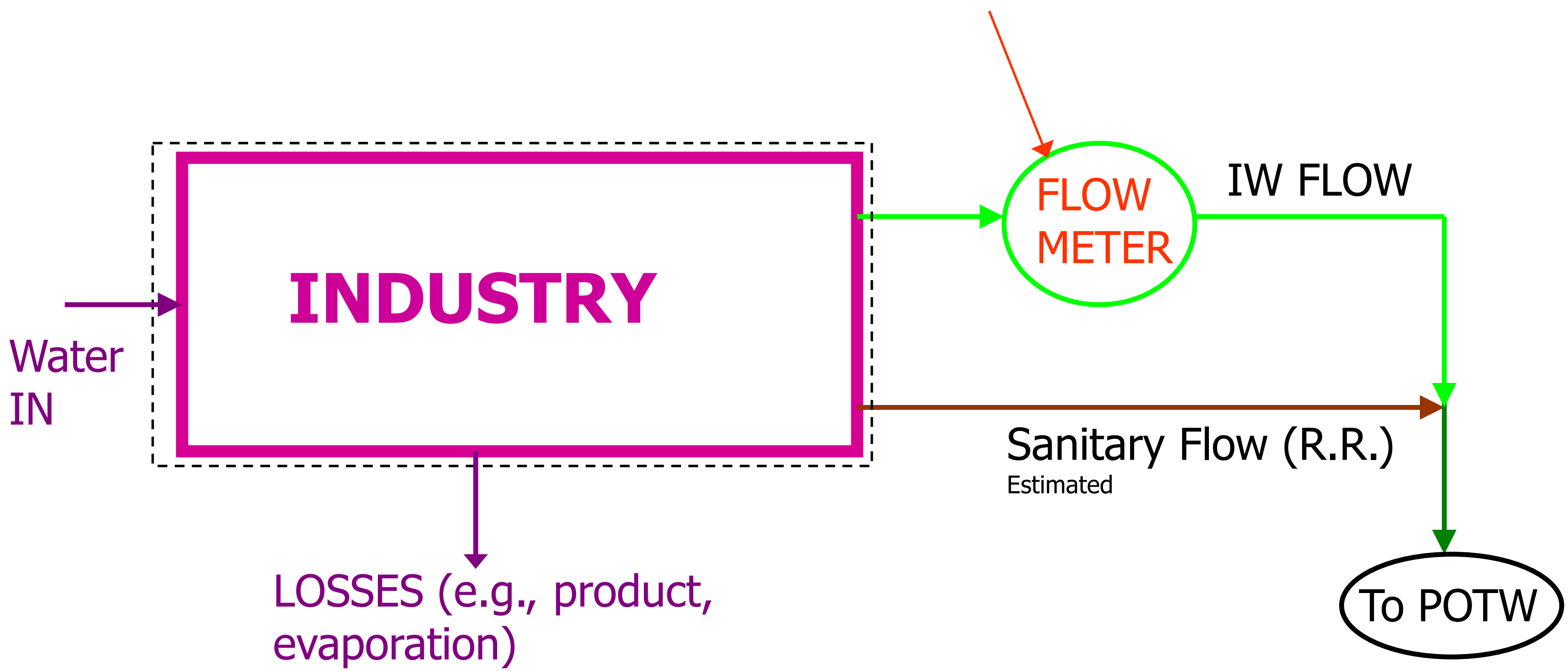
Adjusted Metered Water Supply (Water Balance)

IW FLOW (net) = WATER IN – LOSSES - SANITARY



Direct Measurement
(required above 50,000 GPD average or 100 gpm peak)

IW FLOW = WATER IN – LOSSES – SANITARY vs. MEASURE IW FLOW DIRECTLY



V-Notch (Triangular) Weir

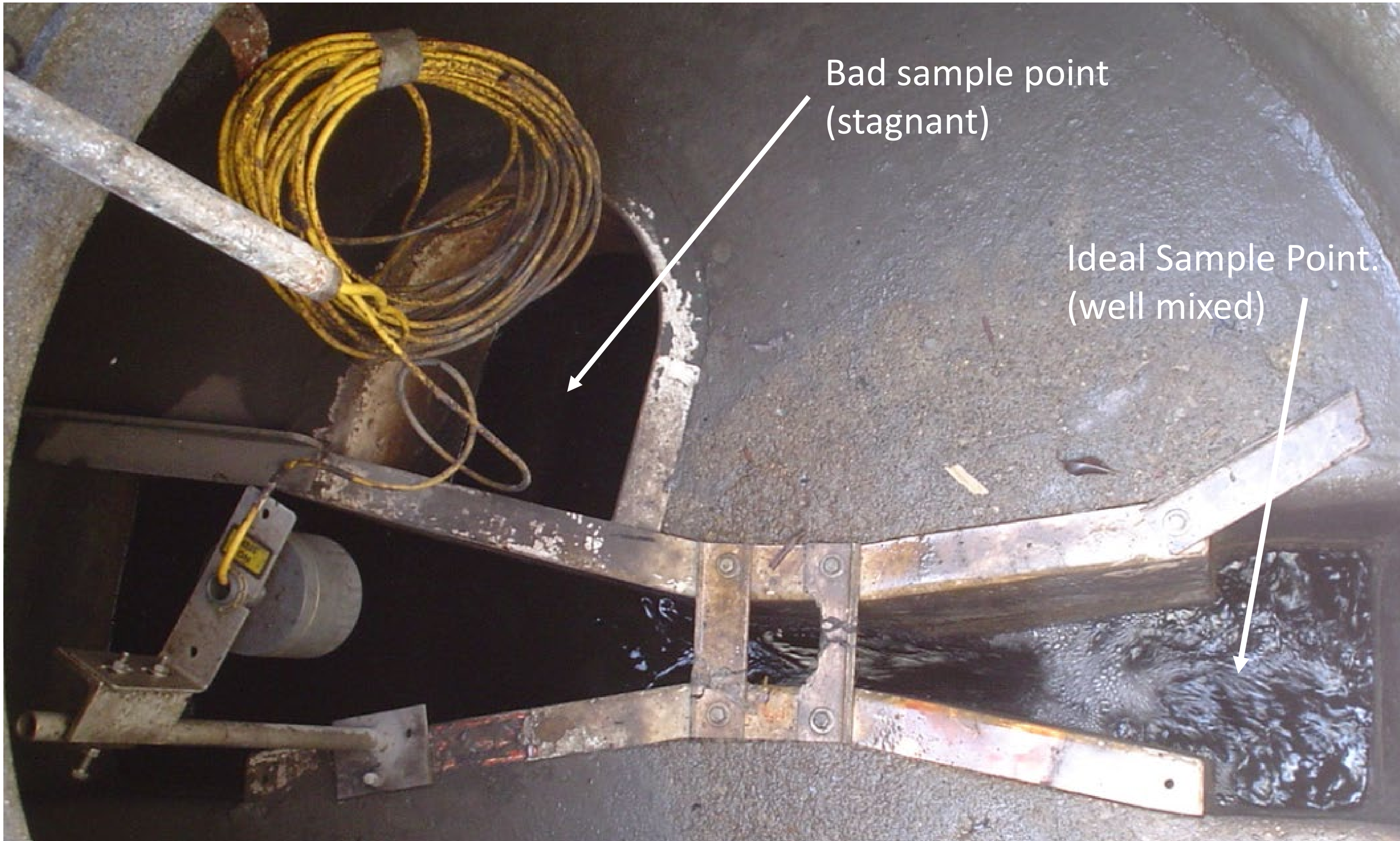
Ideal Sample Point
(well mixed)

Parshall Flume

(special fiberglass channel creates the necessary conditions for flow measurement)

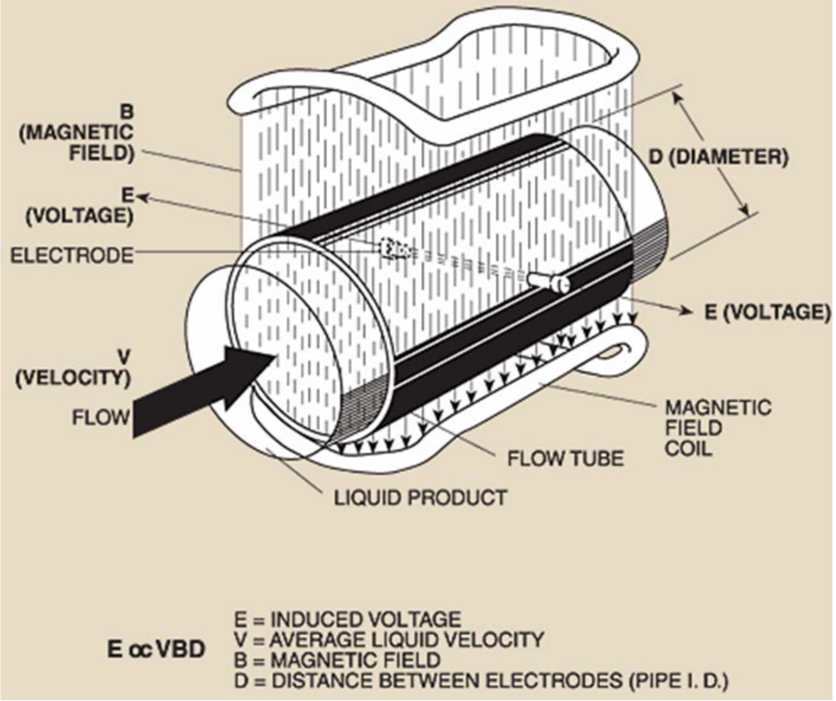
Parshall Flume & Ultrasonic Meter

(3-inch Parshall flume)



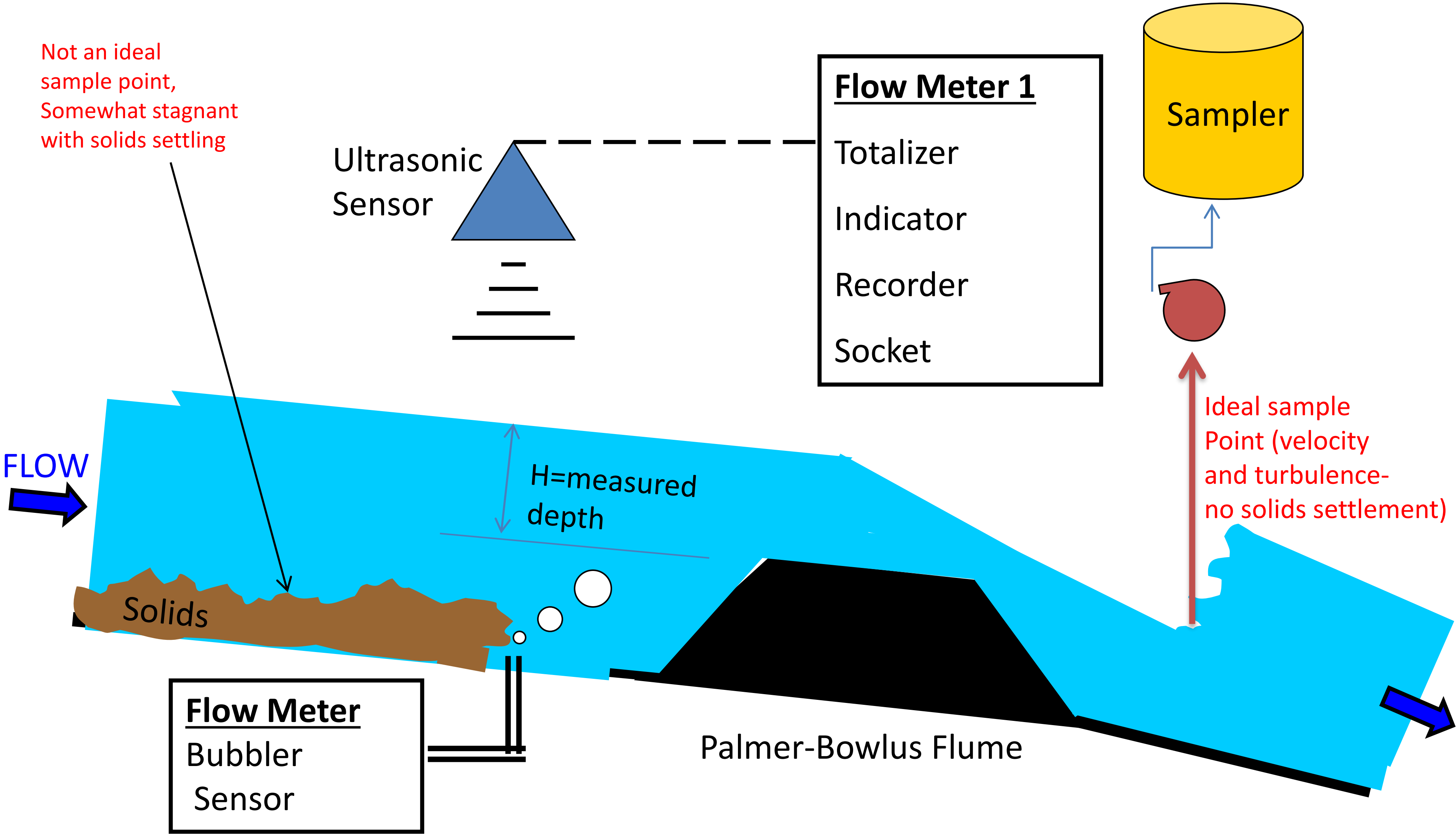
Pressure (full) Pipe Meters

(example: magnetic meters)



Flow Sensors

(two most common sensors, ultrasonic and bubbler meters with advantages and disadvantages)



Open Channel Meters

- Use critical depth principles
- Simplifies flow vs. depth (head) relationship

  instead of : Q (flow)= A(area) X V(velocity), velocity hard to measure
- Primary Element (flume, weir)
  - Creates desired hydraulics
  - Follows specific known equation if conditions are met:

$$Q\ (gpm) = K\ H^n$$, H=depth, K and n constants

- Secondary Element (e.g., bubbler, ultrasonic meters)
  - Measures depth & converts to flow
  - Connected to or includes totalizer, recorder, indicator, sample pacing socket

Special hydraulic conditions must be met

(mild slope u/s, free flow d/s, critical depth achieved, etc.)

Expensive

Design and Installation

- Proper design and installation is critical
  - Slope of upstream sewer pipe and capacity of downstream sewer pipe (can not install on any sewer pipe)
  - Size of primary element
  - Type of primary element

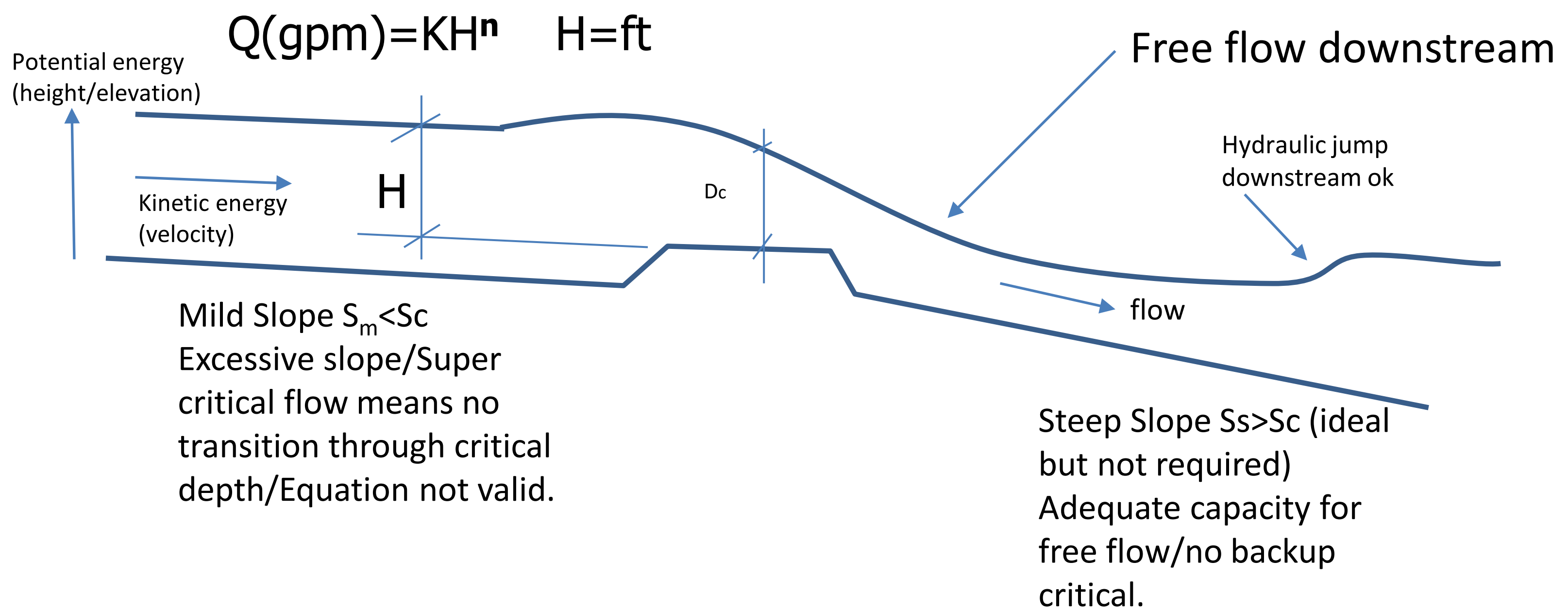
    Weir box, Parshall flume, Palmer Bowlus flume
  - Proper Instrument (sensor) selection

    Bubbler >>>>> plugging, high solids issue

    Ultrasonic >>> Affected by turbulence
  - Proper flume and pipe installation

Ideal Fume Design

Use critical depth principles
Simplifies flow vs. depth (head) relationship
Primary Element
Creates desired hydraulics
Follows specific known equation: Q (gpm)= K H^n , H=Head, measured depth



Mild slope : Kinetic energy less than Potential energy, subcritical, lower velocity, smooth surface
Steep slope : Kinetic energy greater than potential energy, supercritical, fast, turbulent
Mild slope: low velocity/higher level/higher potential energy/smooth surface

Expensive & High Maintenance

- Open Channel flow meters demand high maintenance.
  - Solids buildup and accumulation of debris. Frequent cleaning of primary element may be necessary.
  - Sewer surcharge (backed up sewer). Frequent Inspection and sewer maintenance may be necessary.
  - Bubbler tube cleaning (compressor vs. wire)
  - Regular calibration necessary and typically required annually by regulatory agencies.

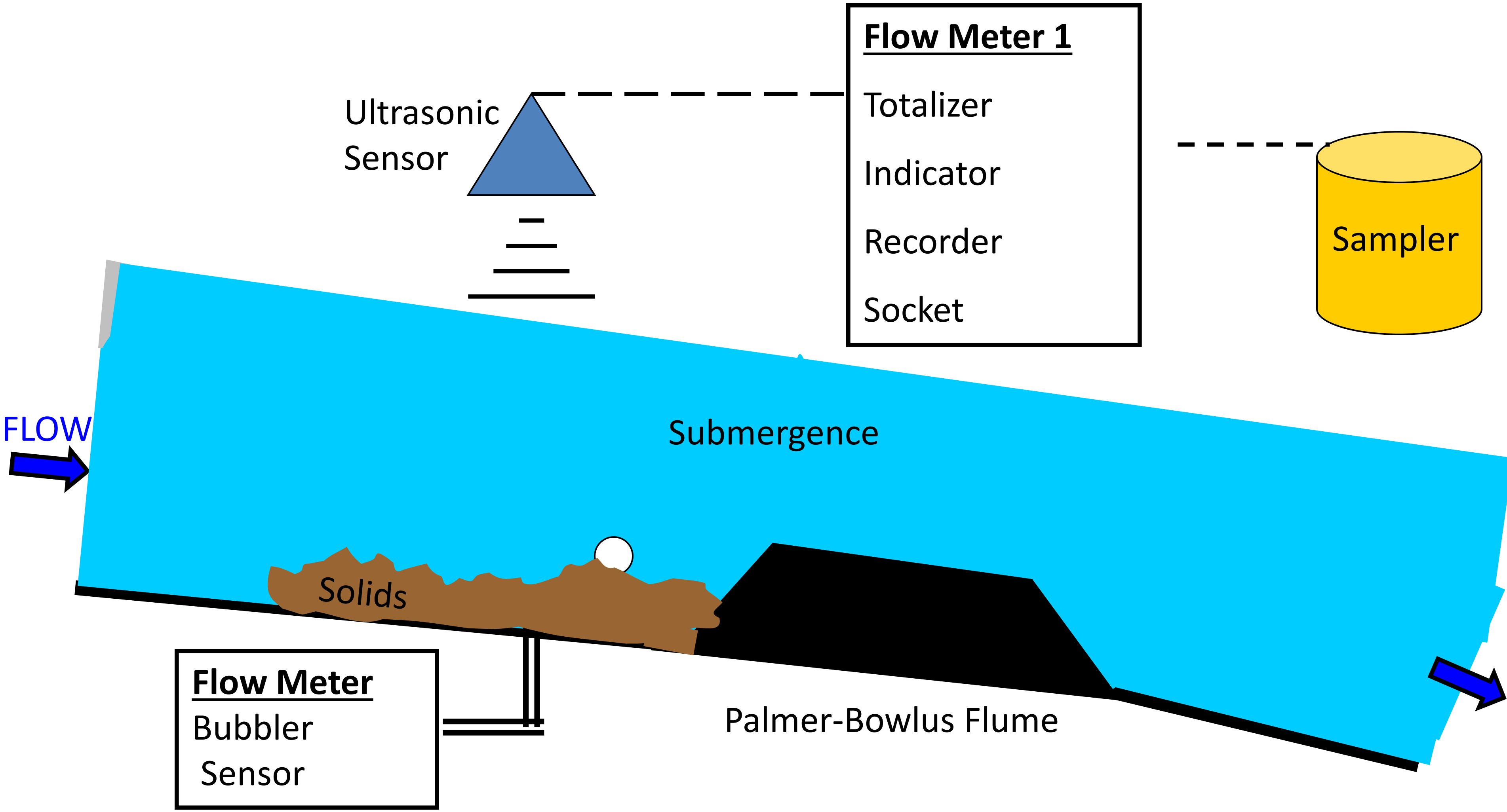
Used usually when required by LACSD. Rarely favored over the Adjusted Metered Water Supply Method.

Common Open Channel Flow Meter Problems *(tendency to read high)*

- Solids buildup affecting flume *(high reading)*
- Sewer Surcharge (back-up) *(high reading)*
- Plugging of bubbler tube *(high reading)*
- Turbulence with ultrasonic meters *(low reading)*
- Steam with ultrasonic meters *(high reading)*
- Foam and ultrasonic meters *(loss of signal/low, or high reading)*
- Improper or lack of calibration

Most problematic conditions result in high readings.

Common Flow Meter Problems- Illustration



CAUTION: Standard Plan (old) does not take into consideration current instrumentation technology. Based on hydraulics only. Allowed maximum slope permits hydraulic jump upstream of flume which causes turbulence/low reading with ultrasonic meters.

TABLE A

REQUIRED CONDITIONS FOR STANDARD FLOW METERING MANHOLES USING PALMER–BOWLUS FLUMES

UPSTREAM PIPE DIAMETER	MAXIMUM ALLOWABLE DISCHARGE		MINIMUM FLOW REQ'D TO OBTAIN ACCURATE READINGS	CRITICAL SLOPE AT MAXIMUM ALLOWABLE FLOW 3/	MAXIMUM SLOPE ALLOWABLE FOR UPSTREAM PIPE 4/
	MGD	GPM			
6"	0.21 mgd	150 gpm	17 gpm	0.0085	0.022
8"	0.43 mgd	300 gpm	35 gpm	0.0076	0.020
10"	0.75 mgd	520 gpm	61 gpm	0.0071	0.018
12"	1.19 mgd	825 gpm	95 gpm	0.0067	0.016
15"	2.08 mgd	1445 gpm	157 gpm	0.0062	0.015
18"	3.28 mgd	2280 gpm	263 gpm	0.0058	0.014
21"	4.82 mgd	3380 gpm	386 gpm	0.0055	0.014
24"	6.76 mgd	4700 gpm	540 gpm	0.0053	0.013

OTHER SPECIAL PROVISIONS

1/ ALL FLUME DESIGNS MUST BE PREPARED BY AN ENGINEER REGISTERED IN CALIFORNIA AND MUST BE APPROVED BY THE SANITATION DISTRICTS PRIOR TO INSTALLATION.

2/ SLOPE VALUES IN THE LAST TWO COLUMNS OF TABLE A WERE CALCULATED USING A MANNING "n" VALUE OF 0.013. THESE SLOPES SHOULD BE RECALCULATED FOR PIPES HAVING A DIFFERENT "n" VALUE.

3/ WHERE POSSIBLE, THE UPSTREAM PIPE SHOULD BE INSTALLED ON A SLOPE LESS THAN CRITICAL SLOPE. SLOPES SLIGHTLY ABOVE CRITICAL SLOPE SHOULD BE AVOIDED DUE TO RESULTING UNSTABLE AND TURBULENT FLOW PATTERNS.

4/ WHERE SPECIAL CONDITIONS REQUIRE, THE UPSTREAM PIPE SLOPE MAY BE INCREASED TO THE MAXIMUM SHOWN IN THE LAST COLUMN (CALCULATED USING A MANNING "n" VALUE OF 0.013). FOR OTHER VALUES OF "n", THE SLOPE OF THE UPSTREAM PIPE SHOULD NOT CREATE AN ENERGY GRADE LINE (E.G.L.) WHICH WOULD EXCEED THE E.G.L. AT THE FLUME ENTRANCE, WHICH CAN BE CALCULATED FROM THE RATING CURVES OF DRAWING NO. [illegible].

5/ THE PLANS FOR FLUMES TO BE INSTALLED WITH UPSTREAM PIPE SLOPES ABOVE CRITICAL SLOPE, WHEN SUBMITTED FOR DISTRICTS' APPROVAL, SHALL BE ACCOMPANIED BY ENGINEERING CALCULATIONS SUFFICIENTLY DETAILED TO ADEQUATELY INDICATE DESIGN SUITABILITY.

6/ THE MAXIMUM DEPTH OF FLOW IMMEDIATELY UPSTREAM OF THE FLUME SHOULD NOT EXCEED 0.90 THE UPSTREAM PIPE DIAMETER (D). THE DEPTH OF FLOW IN THE UPSTREAM CHANNEL BEFORE FLUME INSTALLATION (NORMAL DEPTH) SHOULD NOT EXCEED 0.75 D.

7/ THE DOWNSTREAM OUTLET PIPE SLOPE SHALL NOT BE LESS THAN THE UPSTREAM PIPE SLOPE, AND SHOULD BE GREATER IF POSSIBLE. THE DOWNSTREAM OUTLET PIPE SHOULD BE FREE OF OBSTRUCTIONS.

8/ UPSTREAM TURBULENCE SHOULD BE AVOIDED. NO BENDS, DROP M.H.'S, FLOW JUNCTIONS, GRADE CHANGES, ETC. ARE PERMITTED WITHIN 25 PIPE DIAMETERS (D) UPSTREAM OF THE METERING M.H.

TABLE B

MANHOLE DIAMETER (in)	UPSTREAM PIPE DIAMETER D (in)	$\frac{D}{2}$ (ft)	$\frac{D}{6}$ (ft)	THROAT WIDTH $\frac{D}{2}$ (in)	T (in)	STILLING WELL DIAMETER b (in)	HEIGHT OF MANHOLE BASE H (in)
48"	6"	0.250'	0.083'	3"	12"	15" I.D.	24"
	8"	0.334'	0.111'	4"	12"	15" I.D.	24"
	10"	0.417'	0.139'	5"	12"	13" I.D.	24"
	12"	0.500'	0.167'	6"	12"	13" I.D.	24"
60"	15"	0.625'	0.208'	7 1/2"	15"	13" I.D.	30"
	18"	0.750'	0.250'	9"	18"	13" I.D.	32"
72" TYPE "D"	24"	1.000'	0.333'	12"	24"		40"

NOTES

A. THE FLOW METERING M.H. BASE SHALL BE A SHOP FABRICATED MONOLITHIC STRUCTURE, REINFORCED AS SHOWN.

1. USE APPROVED STEEL FORMS FOR CASTING. SEMICIRCULAR INVERT FINISH SHALL BE FREE OF ANY UNEVENNESS GREATER THAN 1/8" WHEN CHECKED WITH A 6'-0" STEEL STRAIGHT EDGE.

2. THE CURING OF THE PRECAST UNITS SHALL CONFORM TO SECTION 207-2.7 OF THE STANDARD SPECIFICATIONS FOR PUBLIC WORKS CONSTRUCTION, 1988 EDITION. AS AN ALTERNATIVE, THE UNITS MAY BE CURED USING SATURATED STEAM FOR A MINIMUM OF 12 HOURS FOLLOWED BY 6 DAYS OF WATER CURING OR MEMBRANE CURING. IF THE UNITS ARE CURED BY THE ALTERNATE METHOD, THEY SHALL NOT BE SHIPPED PRIOR TO 8 DAYS AFTER CASTING NOR UNTIL THE CONCRETE HAS ATTAINED A STRENGTH OF 3600 PSI.

B. THE NOTES AND SPECIFICATIONS CONTAINED ON THIS DRAWING ARE SUPPLEMENTAL TO THE STANDARD SPECIFICATIONS FOR PUBLIC WORKS CONSTRUCTION, 1988 EDITION, AND AMENDMENTS AS ADOPTED BY THE COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY. IN ALL MATTERS WHERE CONFLICT EXISTS BETWEEN THE NOTES AND SPECIFICATIONS ON THE DRAWINGS AND THE STANDARD SPECIFICATIONS, THE NOTES AND SPECIFICATIONS ON THE DRAWING SHALL GOVERN.

C. ALL ELECTRICAL EQUIPMENT AND WIRING INSTALLED WITHIN THE MANHOLE MUST BE SUITABLE FOR CLASS I, GROUP D, DIVISION 1 HAZARDOUS LOCATIONS AS SPECIFIED IN ARTICLES 500-517 OF THE NATIONAL ELECTRICAL CODE. ALL ELECTRICAL EQUIPMENT AND WIRING MUST BE ACCEPTED, OR CERTIFIED, OR LISTED, OR LABELED, OR OTHERWISE DETERMINED TO BE SAFE BY A NATIONALLY RECOGNIZED TESTING LABORATORY, SUCH AS UNDERWRITERS' LABORATORIES, INC. OR FACTORY MUTUAL ENGINEERING CORP. PURGING OF ELECTRICAL EQUIPMENT IS ALLOWABLE IF IN CONFORMANCE WITH THE TYPE X AND Y REQUIREMENTS OF THE NATIONAL FIRE PROTECTION ASSOCIATION PAMPHLET NO. 496, "STANDARD FOR PURGED AND PRESSURIZED EQUIPMENT IN HAZARDOUS LOCATIONS."

OFFICE OF ... ENGINEER

STANDARD FLOW METERING MANHOLE BASE

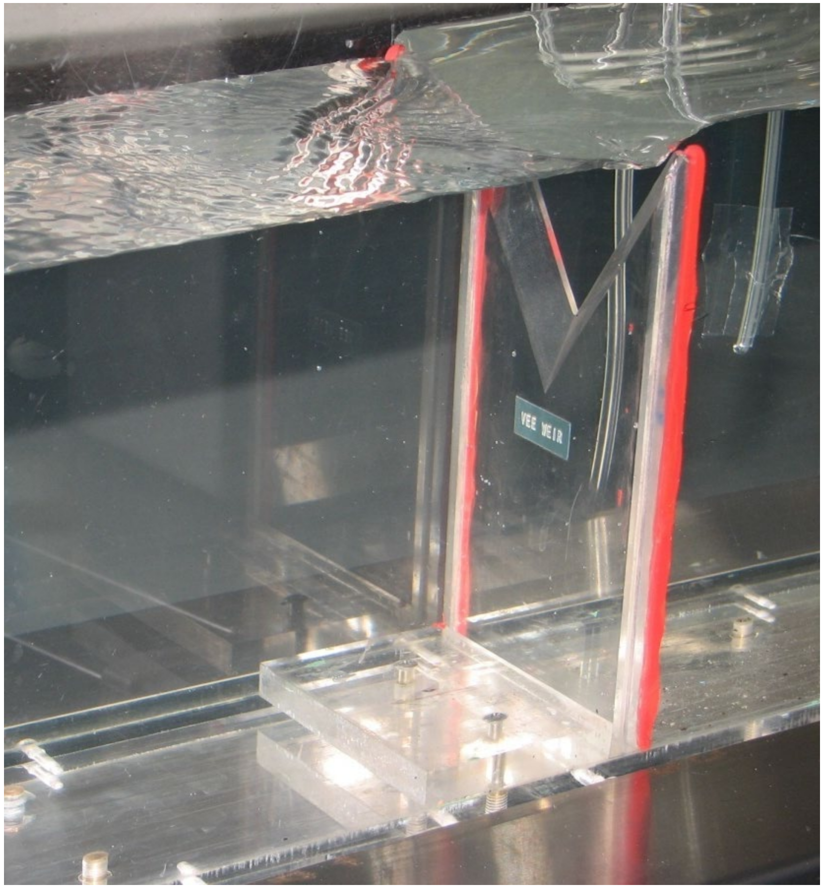
PB flume at Slope 0.16% (left) and 1.2 % (right) [Flow = 92 gpm, H = 0.29 ft for both]

Avelar, J., Saez, J., Laskowska, M. and E. Laskowska. Effect of Turbulence on Open Channel Meters. Presentation at CWEA Conference, Ontario, CA., April 15, 2011.

Saez, J.A., Laskowska, M., Laskowska., E., Tsipena, F., Garza., A, Aiu. M, and K. Yong. Effect of Surface Turbulence on Palmer-Bowlus Flume and Open Channel Monitoring Sensors. Paper at EWRI/ASCE Conference, Lake Placid, 2007.

Non-submerged vs. Submerged Weir

(LMU Hydraulics Laboratory)



Recommendations

- Develop correlation between effluent discharge and water consumption or other relevant parameter. Discharge to consumption ratio typically 0.8-0.95. Review monthly and take corrective action if ratio not consistent with expectations.
- Do not delay data review until a final report is due.
- Inspect flow meter regularly and perform necessary maintenance and calibration.

Correcting Flow Meter Data

Annually, about 5% of facilities experience some problematic flow meter data.

[redacted]

WASTEWATER TREATMENT SURCHARGE STATEMENT 2020 / 2021

[redacted]

ATTACHMENT - WATER BALANCE (Discharge to Consumption Ratio)

WATER CONSUMPTION				WATER DISCHARGE		D/C	
DATE	MTR# 3640		TOTAL	TOTALIZER	TOTAL		
	READING	VOLUME	(GAL)	READINGS	(GAL)		
06/17/20	340,613			109,066,456			
07/20/20	**342,981**	**2,368**	**1,771,264**	**110,650,555**	**1,584,099**	***89.40%***	
08/18/20	344,899	1,918	1,434,664	112,181,497	1,530,942	*106.7%*	
09/17/20	346,799	1,900	1,421,200	114,103,658	1,922,161	*135.2%*	
10/20/20	348,335	1,536	1,148,928	115,397,124	1,293,466	*112.6%*	
11/19/20	349,574	1,239	926,772	116,411,133	1,014,009	*109.4%*	
12/21/20	350,617	1,043	780,164	117,239,796	828,663	*106.2%*	
			5,711,728		**6,589,241**	***115.4%***	
01/20/21	351,425	808	604,384	117,795,445	555,649	*91.9%*	
02/18/21	352,280	855	639,540	118,348,475	553,030	*86.5%*	
03/18/21	353,334	1,054	788,392	118,999,703	651,228	*82.6%*	
04/19/21	355,014	1,680	1,256,640	120,149,269	1,149,566	*91.5%*	1,759,907
05/18/21	356,494	1,480	1,107,040	120,961,798	812,529	*73.4%*	
06/16/21	357,923	1,429	1,068,892	121,879,941	918,143	*85.9%*	2,880,238
			5,464,888		**4,640,145**	***84.9%***	4,640,145
				12,813,485	**12,813,485**		

Date	Water Meter Read	CCF	Consumption (Gallons)	Estimated Discharge (Gallons)	Days
06/17/20	340,613			**84.9%**	
12/21/20	350,617	10,004	7,482,992	6,353,060	187
7/1/2020				**5,877,430**	**173**
12/21/2020					

Effluent flow meter calibrated 12/21/21

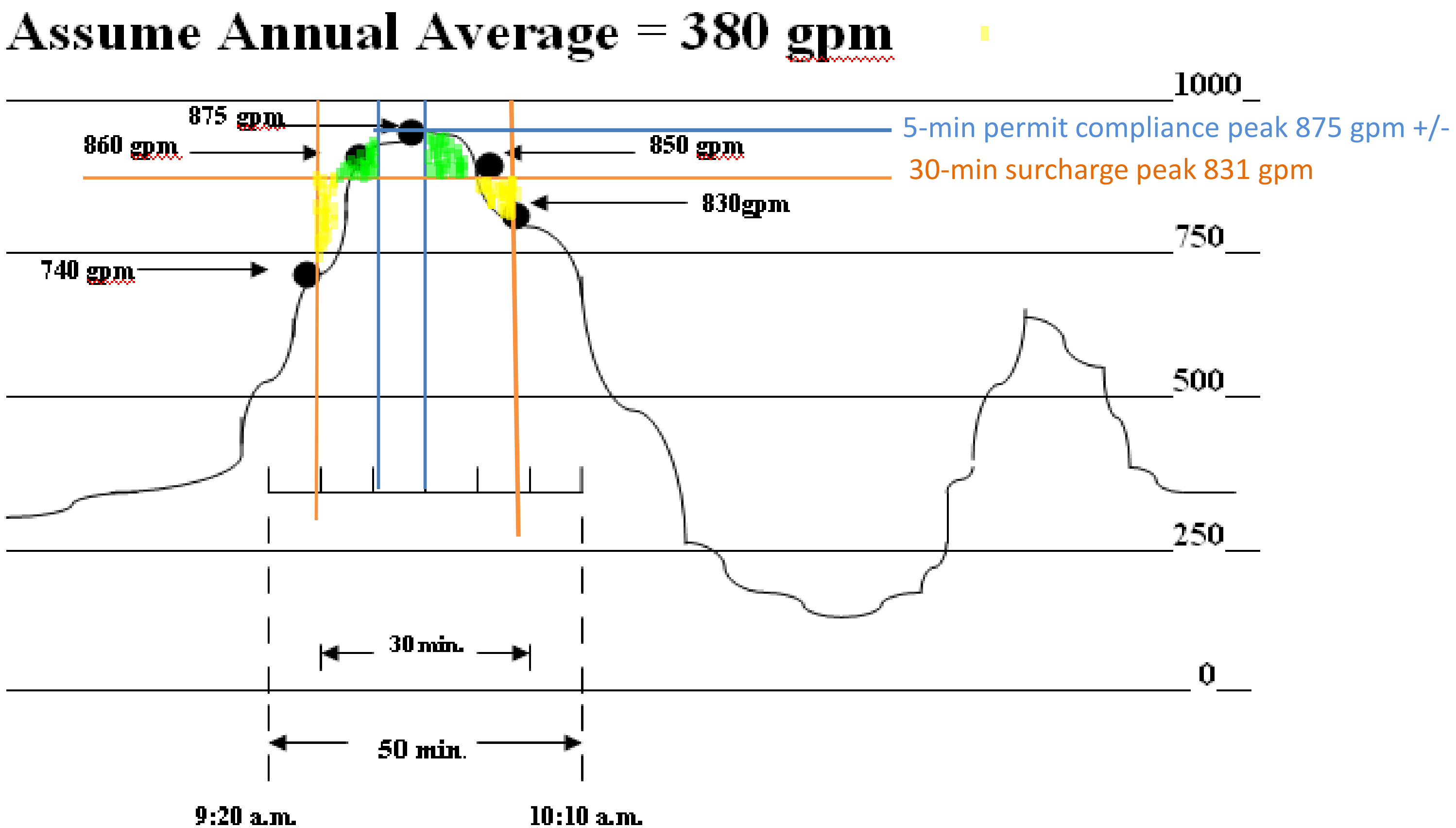
Effluent flow meter readings erratically high before calibration.

*** Estimated based on Water Consumption X D/C Average**

LACSD may accept corrected/adjusted erratic data for surcharge statement if well documented, and supported with technical analysis. Evaluated on case-by-case basis.

Discharger filed and paid surcharge based on erratic high data for many years due to lack of maintenance and data analysis (problematic meter).

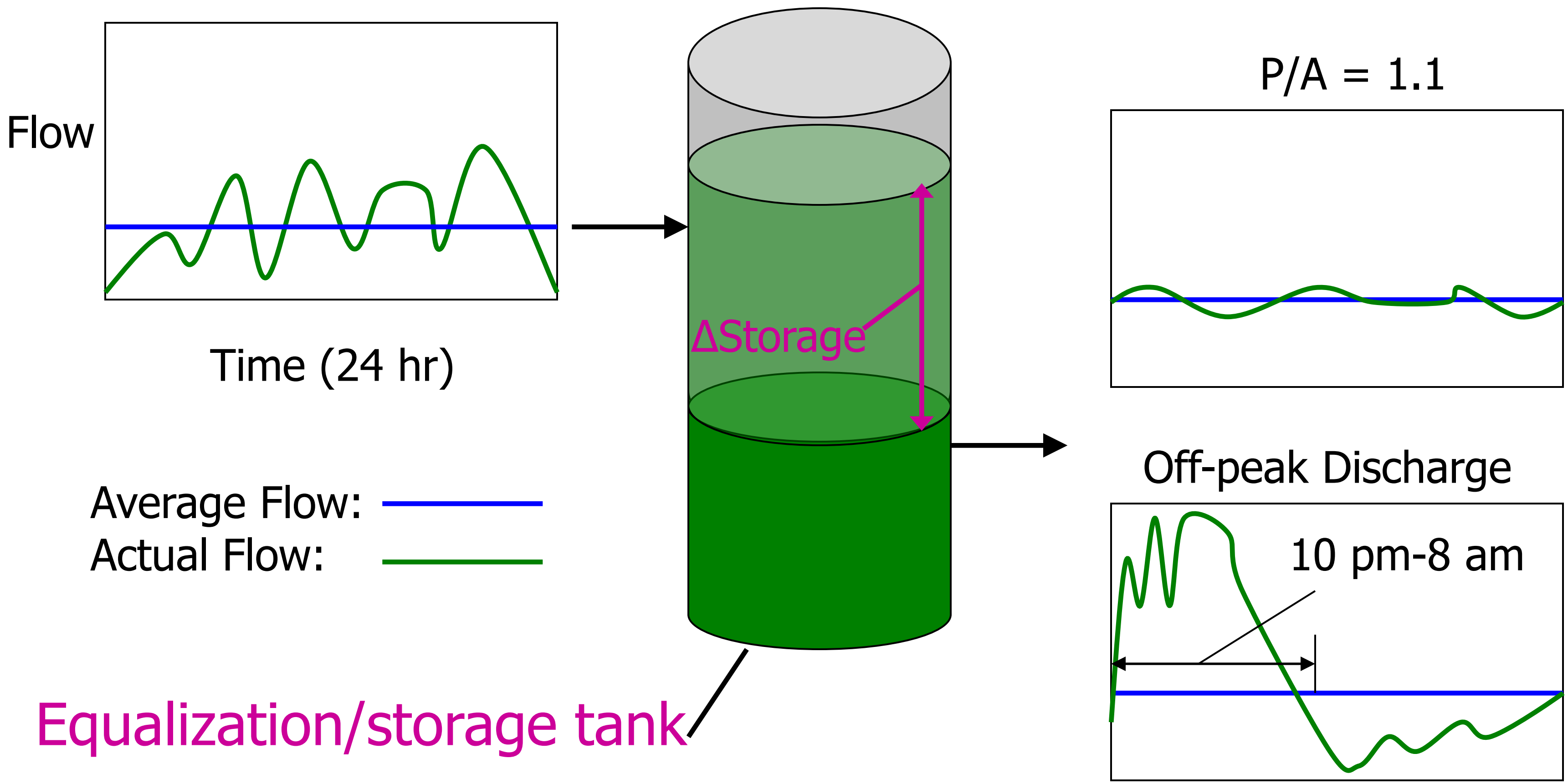
30-minute Surcharge Peak Flow Rate vs 5-min Permit Compliance Peak Flow Rate



Avg. Peak = (740+860+875+850+830)gpm÷5 = 831 gpm
30-min. Peak Flow Charge = $100.10x(2.5 log[831÷380])x831 gpm = **$70,705.64**

Instantaneous highest Peak = 875 gpm (incorrect, not based on 30-minute peak flow)
Incorrect Peak Flow Charge = $100.10x(2.5 log[875÷380])x875 gpm = $**78,828.75**

Flow Equalization/Control



Example: Average Flow 201 gpm (290,000 GPD, 24 hr)

- Original case: Peak flow = 350 gpm (P/A = 1.74)
  - Peak charge = **$21,021.00/year**
- Improved case: Peak flow = 255 gpm (P/A = 1.27)
  - Peak charge = **$6,636.63/year**
- What if Peak flow = 201 gpm?
  - Charge = **$0** (P/A = 1.00)

Capacity Units & Connection Fee

Connection Fee Program

- One-time Fee
  - New users
  - Increase by 25% over baseline credit
- Capacity unit (CU): equivalent to discharge from single-family residence
- Capacity Units depend on quantity (flow) and quality (COD & TSS)

Capacity Unit Formula

Equation:

$$CU = X\,\frac{(GPD)}{260} + Y\,\frac{(PPD\ COD)}{1.22} + Z\,\frac{(PPD\ TSS)}{0.59}$$

260 GPD, 1.22 PPD COD & 0.59 PPD TSS from single family home (Results in 1 CU for single family, 2.5 people)

Understand number of discharge days

- In some cases: Discharge Days ≠ Production days
- Examples:
  - Cooling tower operation on weekend, even if production down
  - Clean-up or other IW producing activity on weekend, even if production down

GPD (flow rate) = Gallons/Days

TIPS, COMMON MISTAKES & EXAMPLES

(If time allows)

1. Regular Review of Data

- Review/analyze on a regular basis (Flow, IN/OUT, Production, Gas)
- Decide & take action
- How frequently?
- Don’t wait until August!

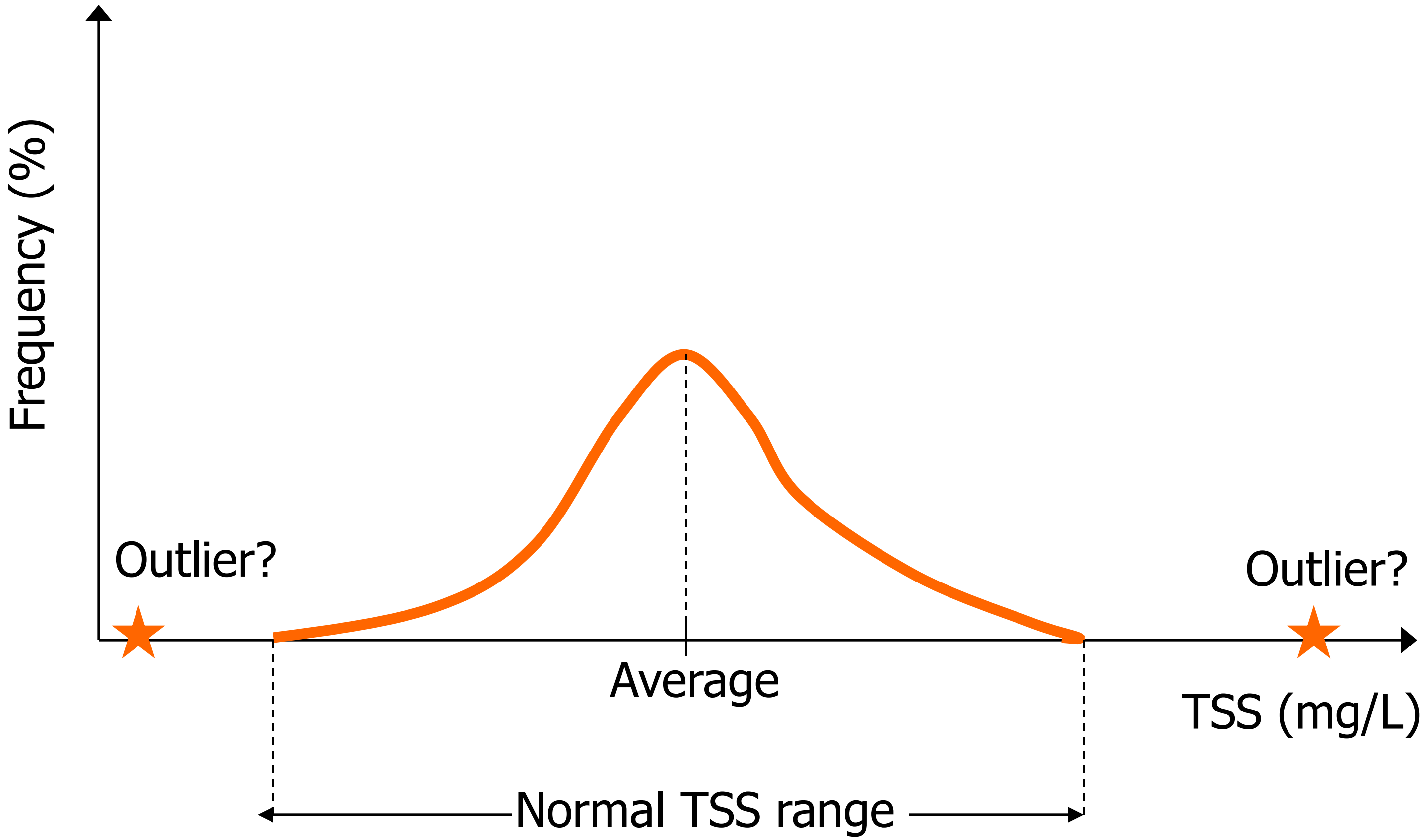
2. Accuracy of Flow Meter Data

- Check meter at least monthly
- D = Discharge, C = Consumption
  - D/C < 1.00 (0.85 – 0.95 for most facilities- EXAMPLES)
  - Know D/C range for your facility (e.g., 0.90-0.96)
  - Stay within D/C range (except day to day)
  - If out of range, check & correct (calibrate/maintain effluent meter)
- Apply corrections for erroneous period (D/C Ratio, adjusted metered water supply, etc.)
- City water meter may be inaccurate

3. Insufficient Sampling Frequency

- Minimum required sampling frequency may not be sufficient
- IW strength (high variability, low-level technology, reliability, wastewater matrix, sampling/analysis techniques)
- Counter/control with more frequent sampling

TSS Variability



3. Example (Tortilla Mfg.): TSS Costs @ 15 MGY

Scenario A (4 samples)

3500 mg/L
4500 mg/L
4000 mg/L
8000 mg/L
5000 mg/L = AVG.

TSS cost = 15 MGY x 5000 mg/L x 0.00834 x $377.40 = **$236,063.70**

No extra samples

Scenario B (6 samples)

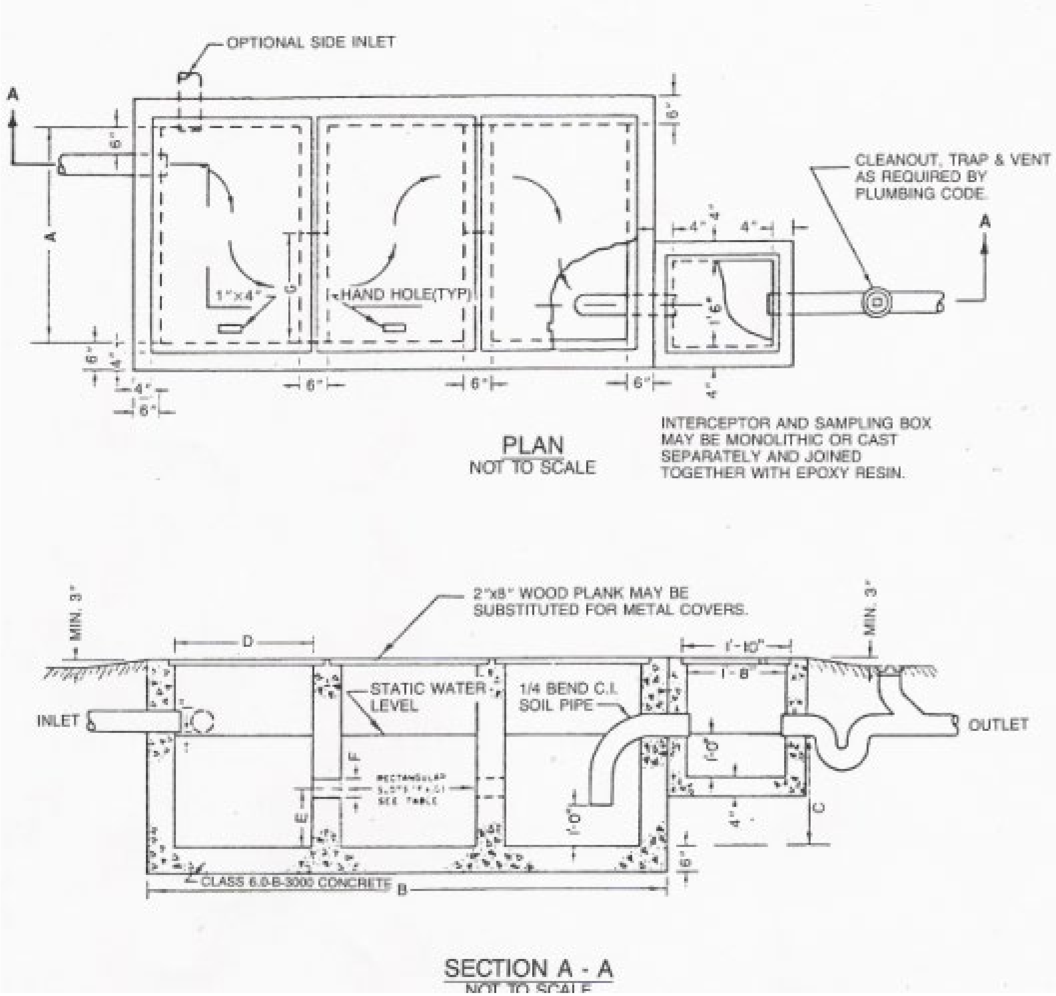
3500 mg/L
4500 mg/L
4000 mg/L
8000 mg/l
3200 mg/L
4800 mg/L
4667 mg/L = AVG.

TSS cost = 15 MGY x 4667 mg/L x 0.00834 x $377.40 = **$220,341.86**

Two Extra samples = **$300**

NET SAVINGS = $15,421.84

3-stage Clarifier & Sample Box



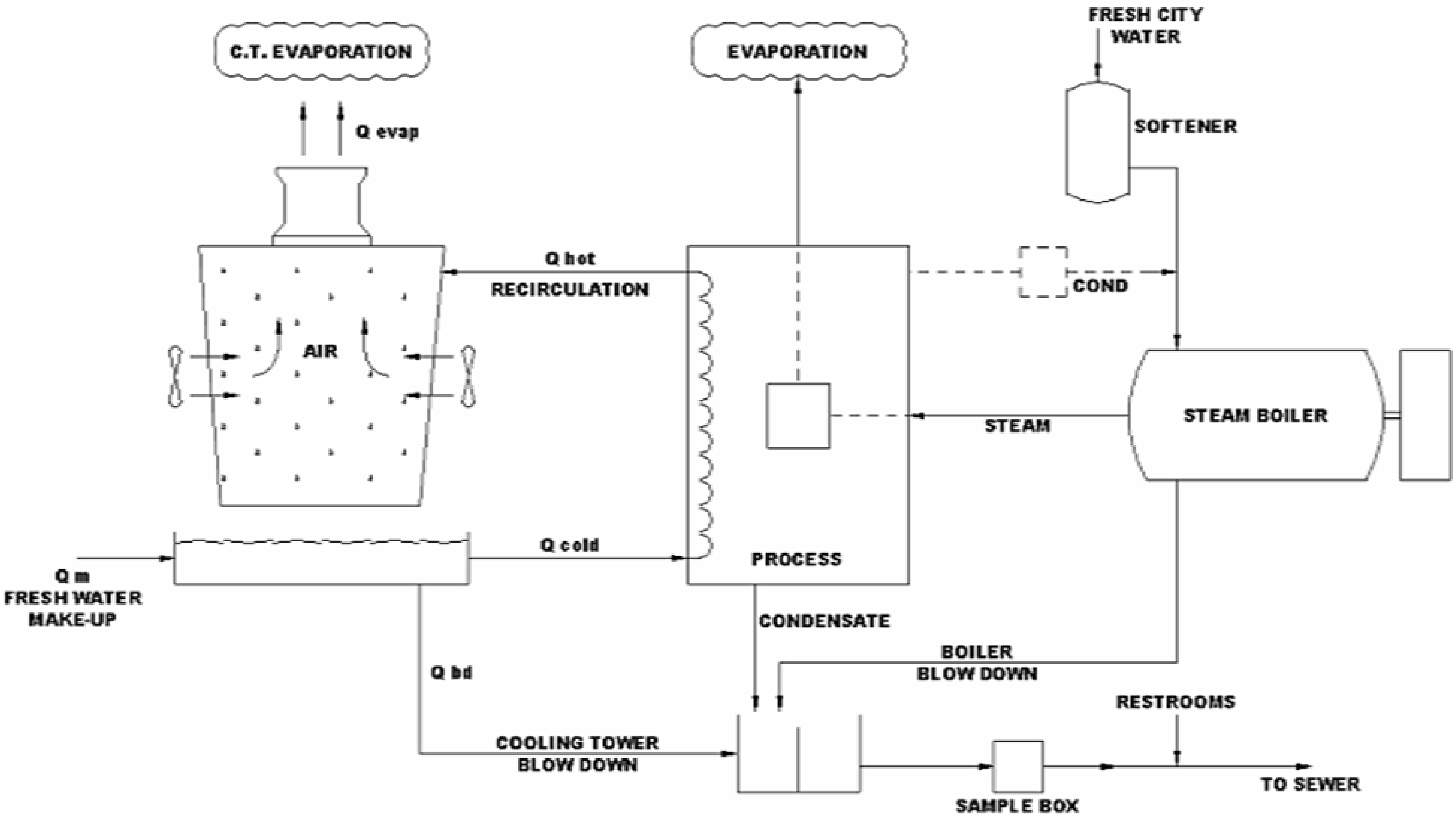
Sample Box

4. Inadequate Evaluation of Capacity Units Usage

- Know in advance & keep track (at least quarterly)
- Take early action to reduce/eliminate connection fee
- Determine cause (Flow, COD, TSS)
- Common Actions:
  - Extra samples (e.g., to deal with statistical outliers)
  - Improved sampling (e.g., clean sample point)
  - Water conservation/reuse
  - Operational changes
  - Repair leaks, equipment
  - Pretreatment

5. Avoid Exaggerated Water Losses

- Use reasonable/defensible/documented calculations, and data to avoid audits/revisions
- Audit -> Reduced losses -> Connection fee



EXAMPLE - PROCESS EVAPORATION LOSSES
COOLING TOWER / BOILER STEAM

5. Exaggerated Cooling Tower Evaporation

- Cycles of concentration = Ratio of Tower TDS to Fresh water TDS
- Blowdown related to evaporation
- Excessive losses may violate water balance
  - Excessive evaporative losses may result in blowdown > total discharge

5. Example: Boiler Losses

- Energy balance
  - Gas bills -> Maximum possible evaporation
- Example:
  - Gas Bill = 300,000 Therms/YR
  - Energy purchase = $3x10^5$ Therm $x10^5$ BTU/Therm
  - Latent heat of evaporation = 1030 BTU/lb of H_2O
  - Maximum evaporation = $[3x10^{10}$ x 0.8 eff.] ÷ 1030 = 23,300,970 lb/YR = **2.79 MGY**
  - Total Energy-related Losses < **2.79 MGY**

6. Inadequate cleaning and maintenance of sampling and pretreatment facilities

- Clean sampling point
- Pump clarifier frequently
- Maintain pretreatment system

THANK YOU!