Ventilation and Odor Control for Sewers and Tunnels

Lawrence H. Hentz Jr, P.E., BCEE
Shahriar Eftekharzadeh, P.E., Ph.D,, PMP
Rich Atoulikian, P.E., BCEE, PMP

Do You Know My Friend?

She Changed My Life

Athens, Greece
WERF

IRC, FL
Sarasota, FL
Ypsilanti, MI
NGWRP, AZ
91st Avenue, AZ
Ocotillo, AZ
Avondale, AZ
Palm City/Tuscany
Hills, FL
Seattle, WA
Iron Bridge, FL
Dade County, FL
Sacramento, CA
Hartford, CT
East Bay MUD, CA
Rock Hill, SC
Yellowstone, WY
PG County, MD
Harford County, MD

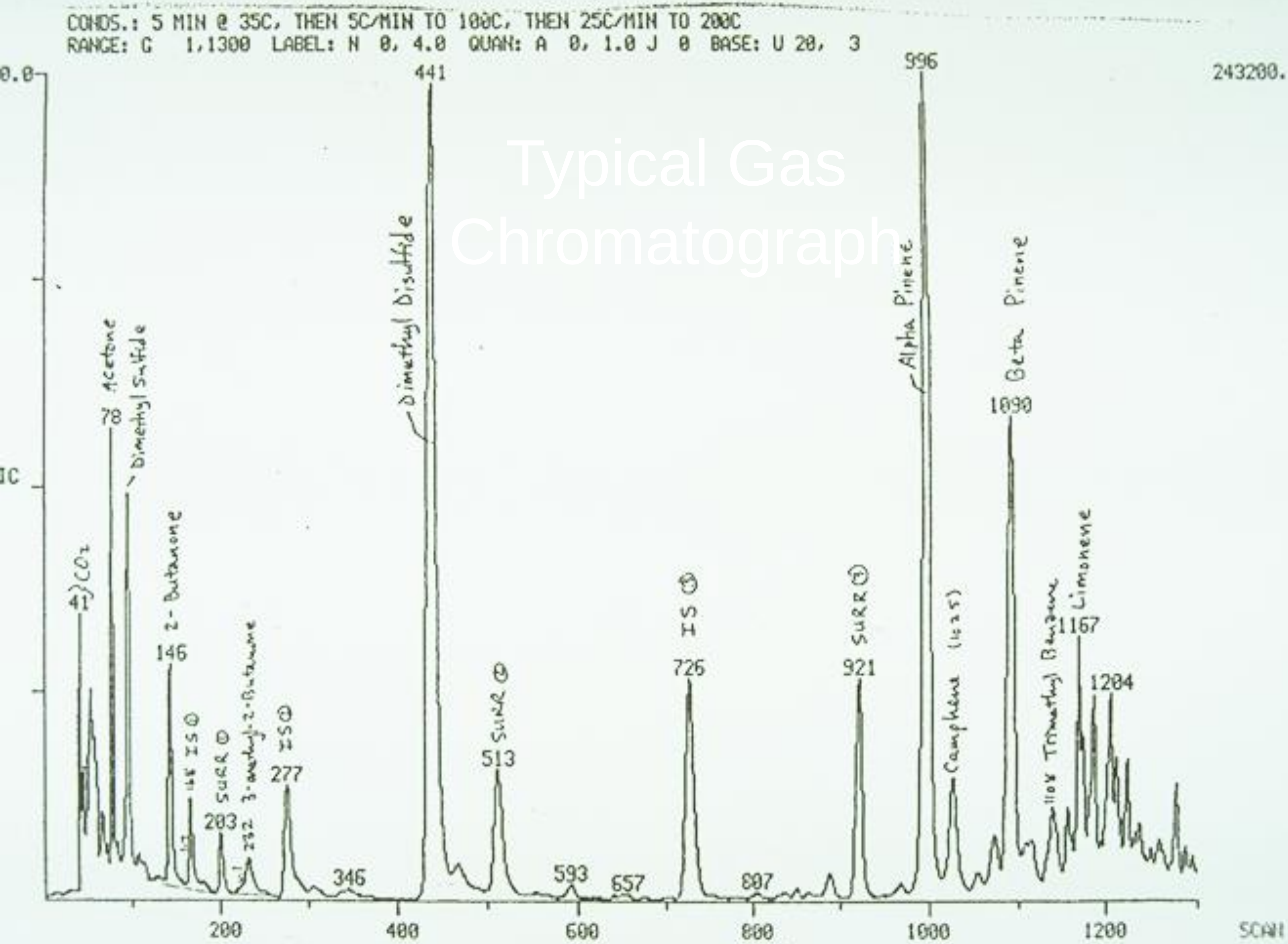
Seneca, MD
Patuxent, MD
Mill Creek, MD
Broadwater, MD
Mont. Co. RCF
Howard Co, MD
Arlington.VA
Alexandria, VA
DC WASA
Philly (x2), PA
HRSD, VA (x4)
Chez Liz, VA
Dick Creek, GA
Long Trail, VT
NBC, RI
New England Fert
MPW, SC (x4)

HDR

H_2S and Olfactory Science

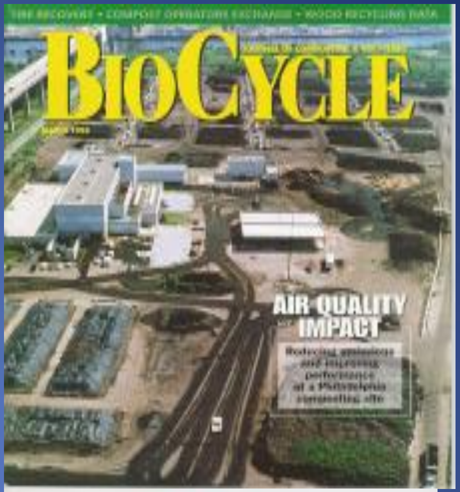
Analytical Chemistry And Chemical Engineering

Typical Gas Chromatograph



Publications and Patents

…More Than 30 Articles on
Odor Control



…Contributing Author to the
WEF / ASCE
Manuals of Practice
ODOR CONTROL
IN WASTEWATER
TREATMENT PLANTS

…U.S. Patent Holder
For Scrubber Technology

neighbors NORTH

The Herald

www.herald.com SUNDAY, JANUARY 14, 2001 6 NORTH

CITY WINNING ODOR WAR

New system gets best results yet

Page 3

City seems to have solved odor problem at lift station

BY JUDY ODIERNA

jodierna@herald.com

North Miami residents living along Northwest 125th Street and 11th Avenue can open their windows again.

Their neighbor, a city sewage lift station, has finally cleaned up its act.

NORTH MIAMI

After years of trying to neutralize the lift station's foul odor with chemical deodorants and renovations, the city hired a company that created a $90,000 biofiltration system.

The treatment center sucks all the air in the space above the wet well in the pump and puts it through cubes that take away the odor.

"It's been up for three weeks, and the smell has gone away," said City Manager Lee Feldman.

The sewage pumping station is a busy one. It collects sewage from the city's residential area and 20 other private pump stations, including the one from North Shore Medical Center in unincorporated Miami-Dade.

"Residents have expressed their gratitude," said Councilman Ossmann Desir, who represents the Sunkist Grove district. "We have to wait a bit and observe and see if it will stay that way in the long term."

Feldman agrees and says the real test for the system will be the summer months.

"In the summer, there's high humidity, the air becomes saturated and the odor doesn't disappear so quickly," he said.

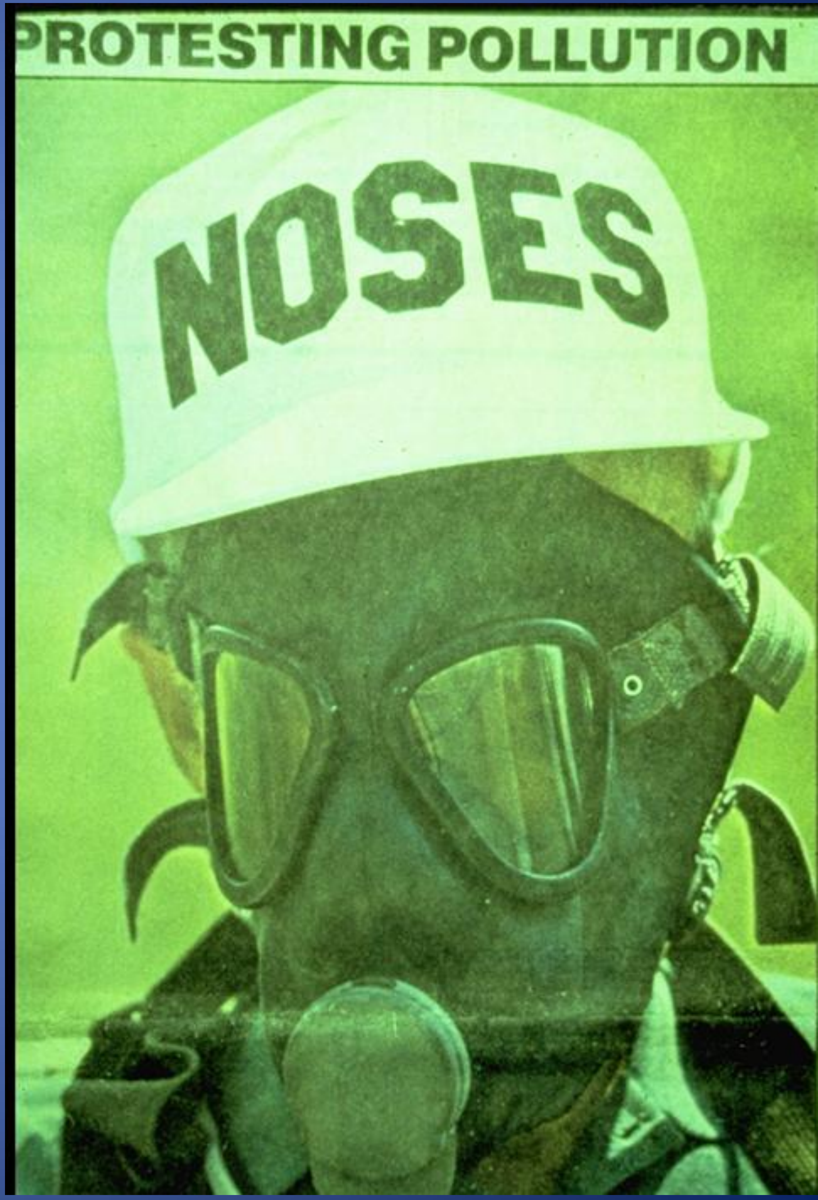
I Am Forever Grateful

Lessons Learned

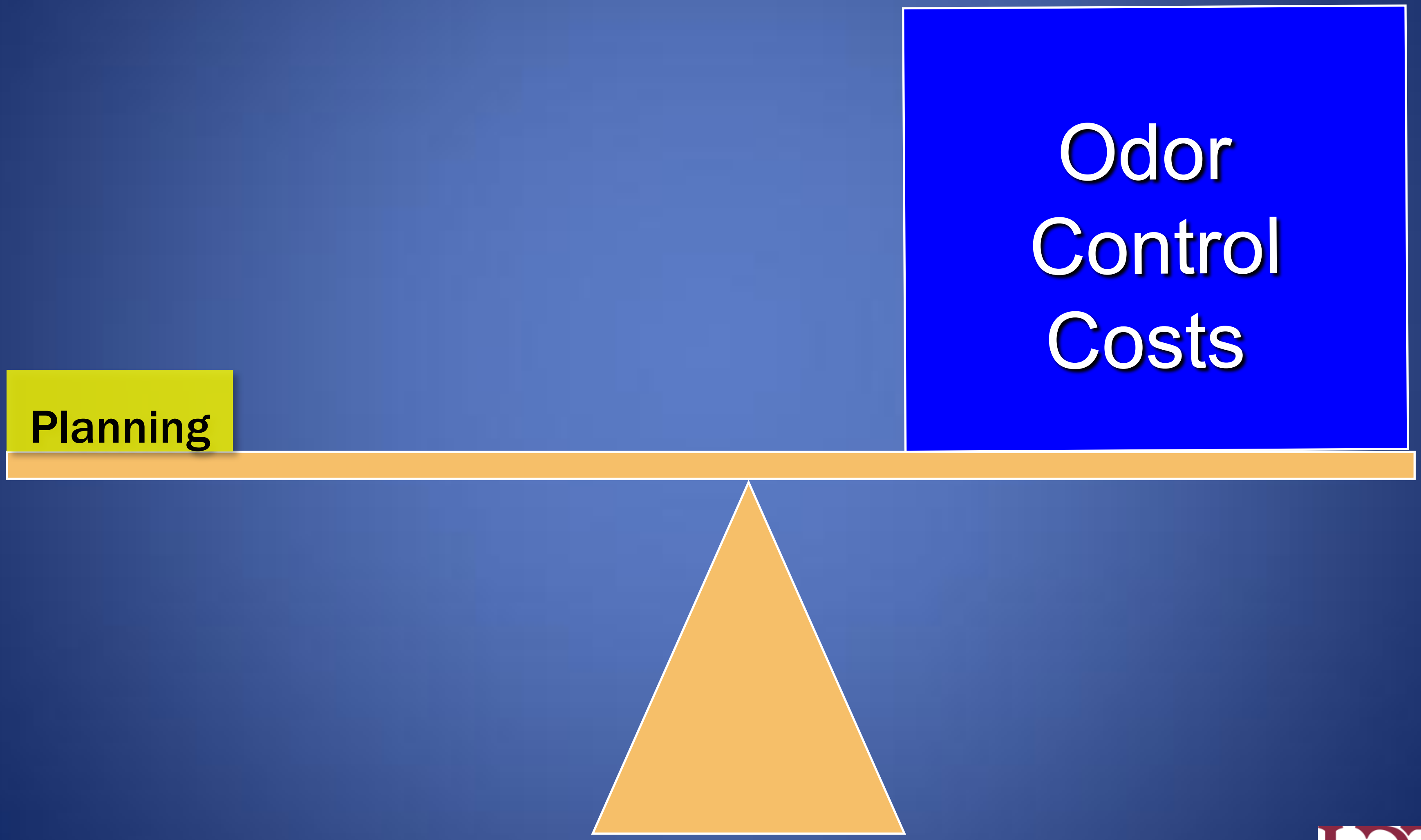
Use Fundamental Scientific Principals

Use Best Available Information and Best Available Technology

Develop An Odor Control Plan That Can Adapt To Actual Conditions



An Ounce of Prevention



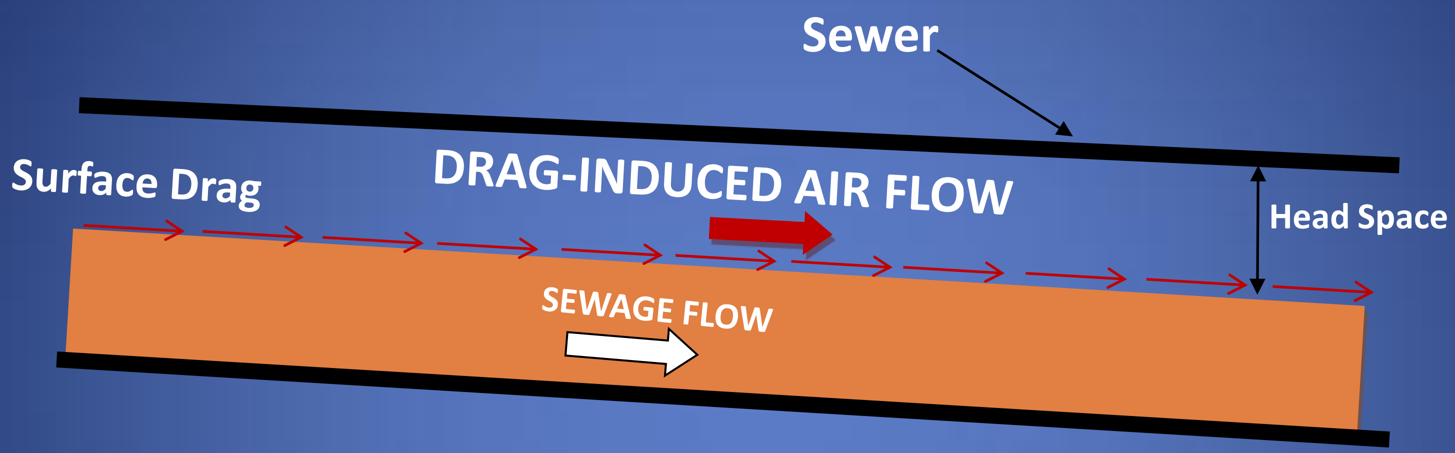
Ventilation and Odor Control in Sewers and Tunnels

- Forces Causing Airflow and Ventilation
- Tools for Estimating Airflow and Pressurization
- Technologies for Controlling Emissions of Odorous Compounds

Sewer Ventilation

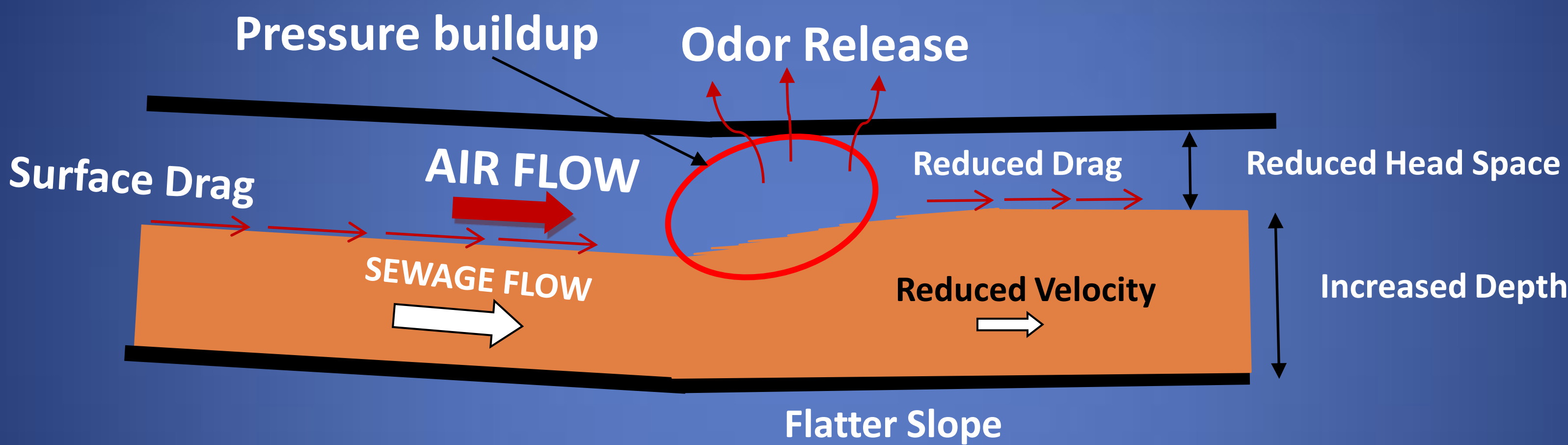
Positive Pressure: 0.25 inches water column

Airflow Phenomenon in Gravity Sewers



Surface Drag Induces Airflow in Gravity Sewers
Velocity Affects Stripping of Odorous Compounds

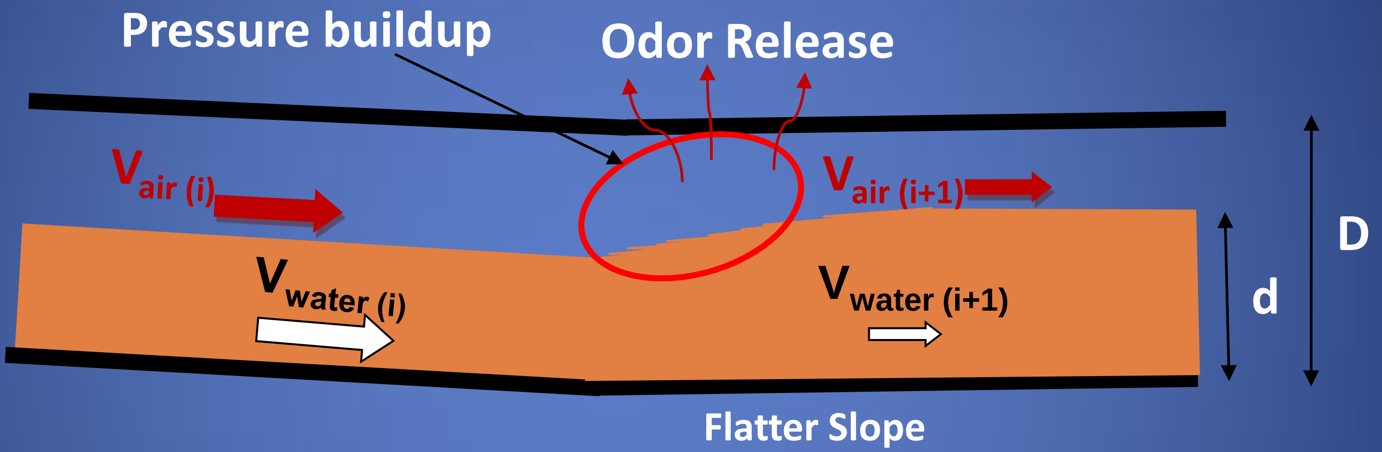
Pressure Buildup and Odor Release



Reduced Surface Drag and/or Head Space Causes Pressure Build Up and Potential Odor Release

Empirical Modeling Approach

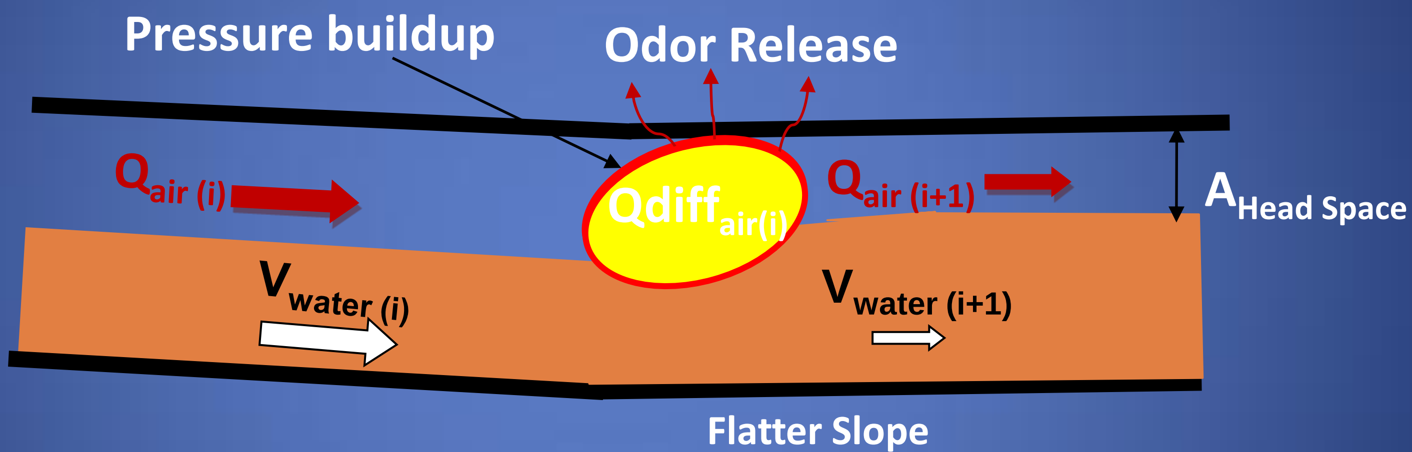
1. Estimates V_{air} Using Empirical V_{air}/V_{water} ratios



d/D	V_{air}/V_{water}
< 0.1	0.15
0.1 - 0.2	0.25
0.2 - 0.48	0.35
0.48 - 0.75	0.60
0.75 - 0.85	0.35
> 0.85	0.15

Empirical Modeling Approach

2. Estimate $Q_{air} = V_{air} \times A_{head\ space}$

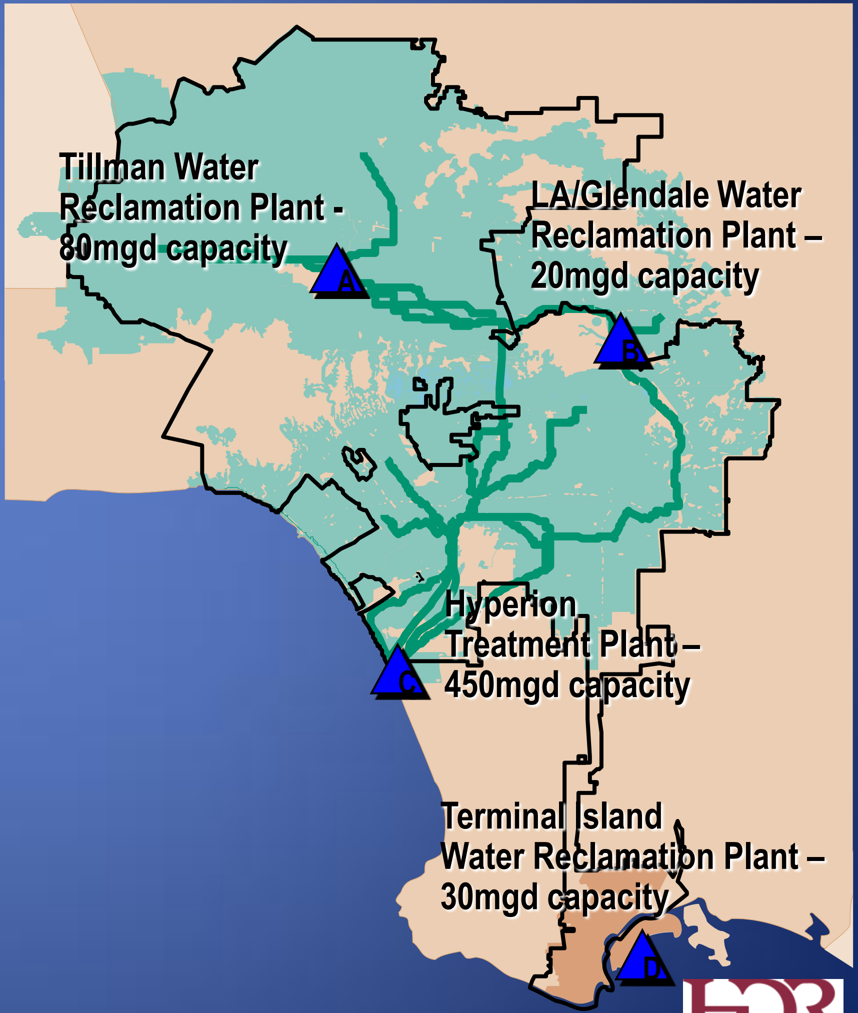


3. Compute $Qdiff_{air(i)} = Q_{air(i)} - Q_{air\ (i+1)}$

Positive $Qdiff_{air(i)}$ Means Pressure Buildup

City of Los Angeles
Wastewater Collection System

- Complex system
- Serves > 4 million people
- Service area >600 sq. mi.
- 6,500 miles
- 140,000 maintenance holes
- 47 wastewater pumping plants
- 29 Satellite Agencies
- Conveys 450 MGD average daily flow



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Overall Study Goal

Minimize Odor Issues in the
City of Los Angeles Sewer System

Study Objectives

- Identify sources and causes of odor
- Establish effective means of reducing odor
- Determine best location(s) and most effective technologies for Air Treatment Facilities (ATF)

Airflow Modeling Components and Purpose

- **Empirical Airflow Model**
  - Approximated airflow behavior
  - Predicted locations of high pressures
  - Measured pressures in field
- **Theoretical Airflow Model**
  - Computed airflow rates and air pressures
  - Evaluated management techniques
    - Extraction
    - Sewer modifications
  - Identified best locations for air extraction and treatment

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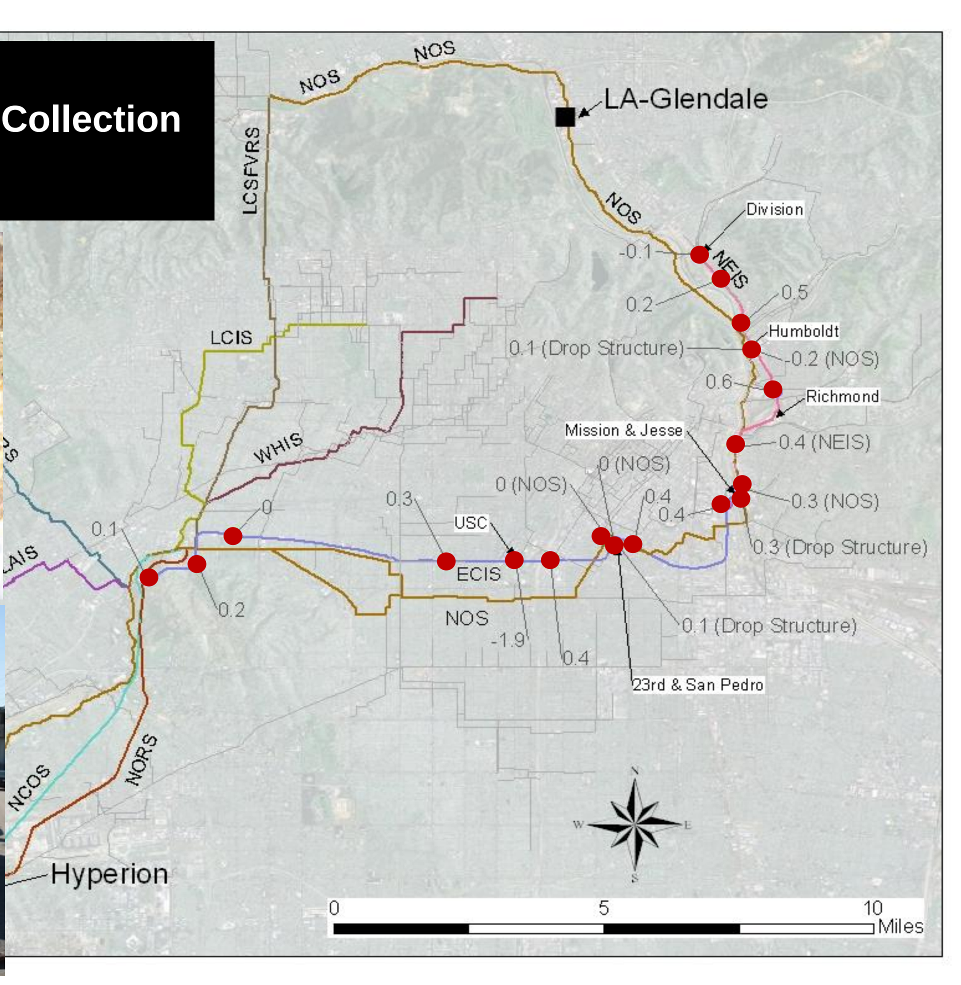
Sewer Pressure Data Collection



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Results of Empirical Model

- Used LA Sewer Model to Locate Pressure Buildup Areas ("Hot Spots")
- Analyzed At Various Flow Regimes
- Provided Reasonable Prediction of Positive Pressure Locations and Airflow Rates
- Could Not Predict Pressures For Future Conditions
- Could Not Simulate Some Structures
  - Drop Structures
  - Air Extraction (Ventilation/Treatment)
  - Siphons

Reasonably Analyzed the Existing System

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Theoretical Model Principles

- Air Mass Continuity (node) $\sum kQ = 0$
- Energy Principle (loop) $\sum \Delta P = 0$
- Airflow in Headspace $Q_n = f(\Delta P_n, U_{\mathrm{wn}}, T_n)$
- Air Leaking In and Out $Q_{Ej} = Cd_j A_{0j} \sqrt{2g(P_{Ej} - P_{\mathrm{AT}j})}$
- Drop Structure Impact $\Delta P_{\mathrm{DS}} = f(Q) = \gamma Q^2 + \alpha Q + \beta$
- Air Jumpers $hj = \frac{Q^2}{2gA^2}(\frac{fL}{D} + k_e)$ Junctions $hj = kV_d{}^2 / g$
- Air Extraction (Q_{out}, P_j)

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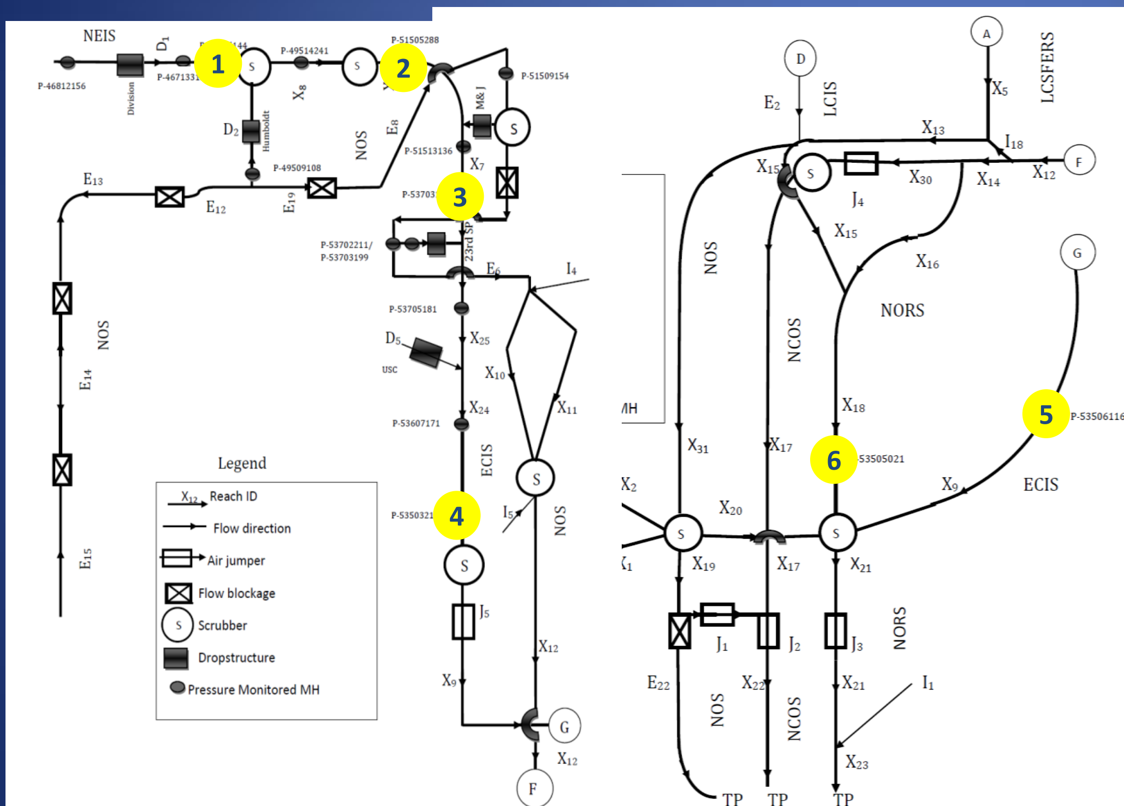
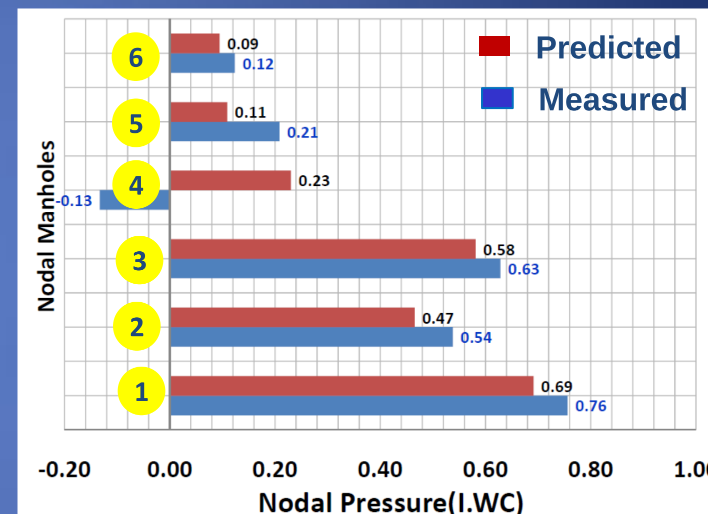
Drop Structure Physical Models

Air Model Input Data

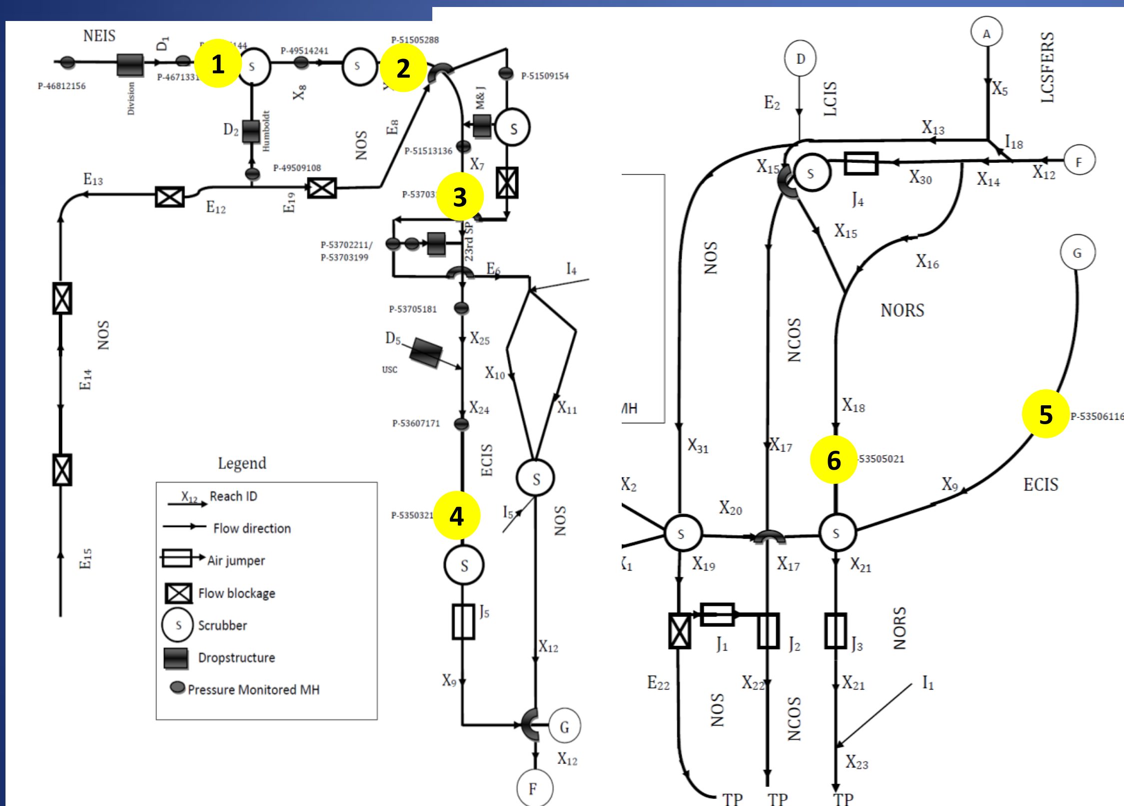
- Depth and Velocity (Hydraulic Model)
- Drop Structure Characteristic Curve (Physical Model)
- Field Pressure Data P_{av} and P_{max}

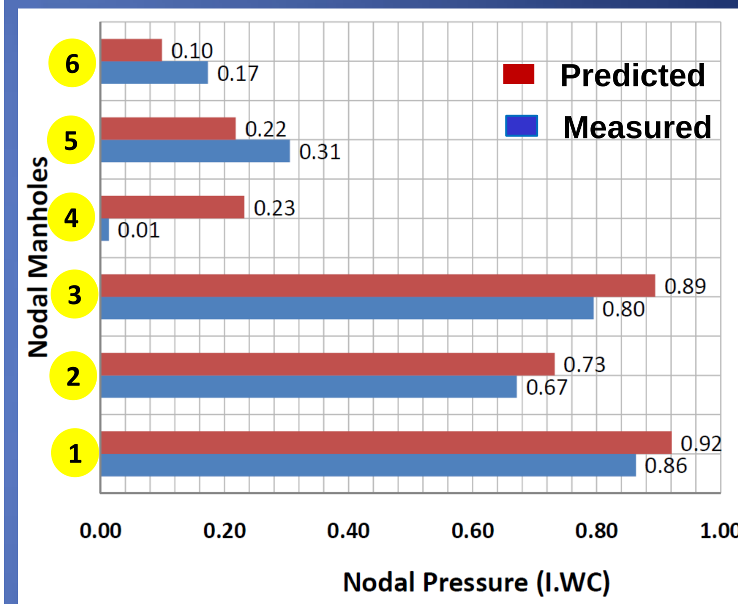
Model Calibration at Average Flow





Model Calibration Peak Hour Flow





Theoretical Model Summary

- Computed Airflow and Air Pressures
- Analyzed Various Flow Scenarios
- Simulated Drop Structures, ATF(s), Siphons (air jumpers), and Air Curtains, etc.

Model Can Be Used as a Good Planning and Decision- Making Too

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Originally 8 Proposed Air Treatment Facility Locations

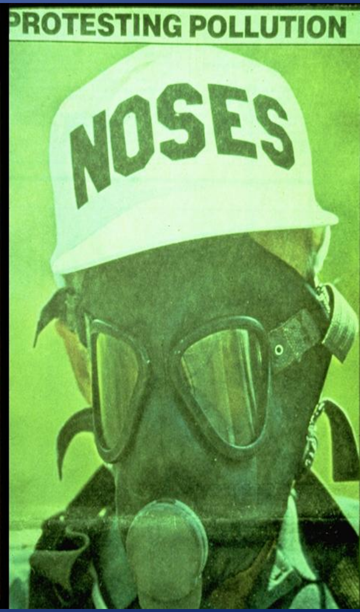
Final 4 Planned Air Treatment Facility Locations

NCOS ATF – 12,000 cfm 3 BTFs

Eliminated 4 Originally Planned ATFs at an Estimated Savings of $50 Million

Ventilation Model Can Help Control Odorous Emissions from Sewers and Tunnels

- ❖ A Sensitized Community Is Much More Difficult to Please
  - ➢ Creation of crusaders (lawyers) and loss of trust
  - ➢ Criteria for success go way up
- ❖ Ventilation Model Can Help Plan For Impacts
  - ➢ Predict location of hot spots
  - ➢ Assess impacts of drop structures
  - ➢ Analyze effects of extractions



Ventilation Model Approach

- Plan
  - Use HDR Ventilation Model and Utility Sewer Model
  - Validate the model in the summer
  - Collect H_2S data
  - Assess impacts of tunnel or sewer connections
  - Assess emissions mitigation techniques (extraction, drop structures, etc)
- Output
  - Air flow rates at hot spots under various flow regimes
  - Locations of most influence for air extraction
  - Options for control
  - Estimates of H_2S concentrations

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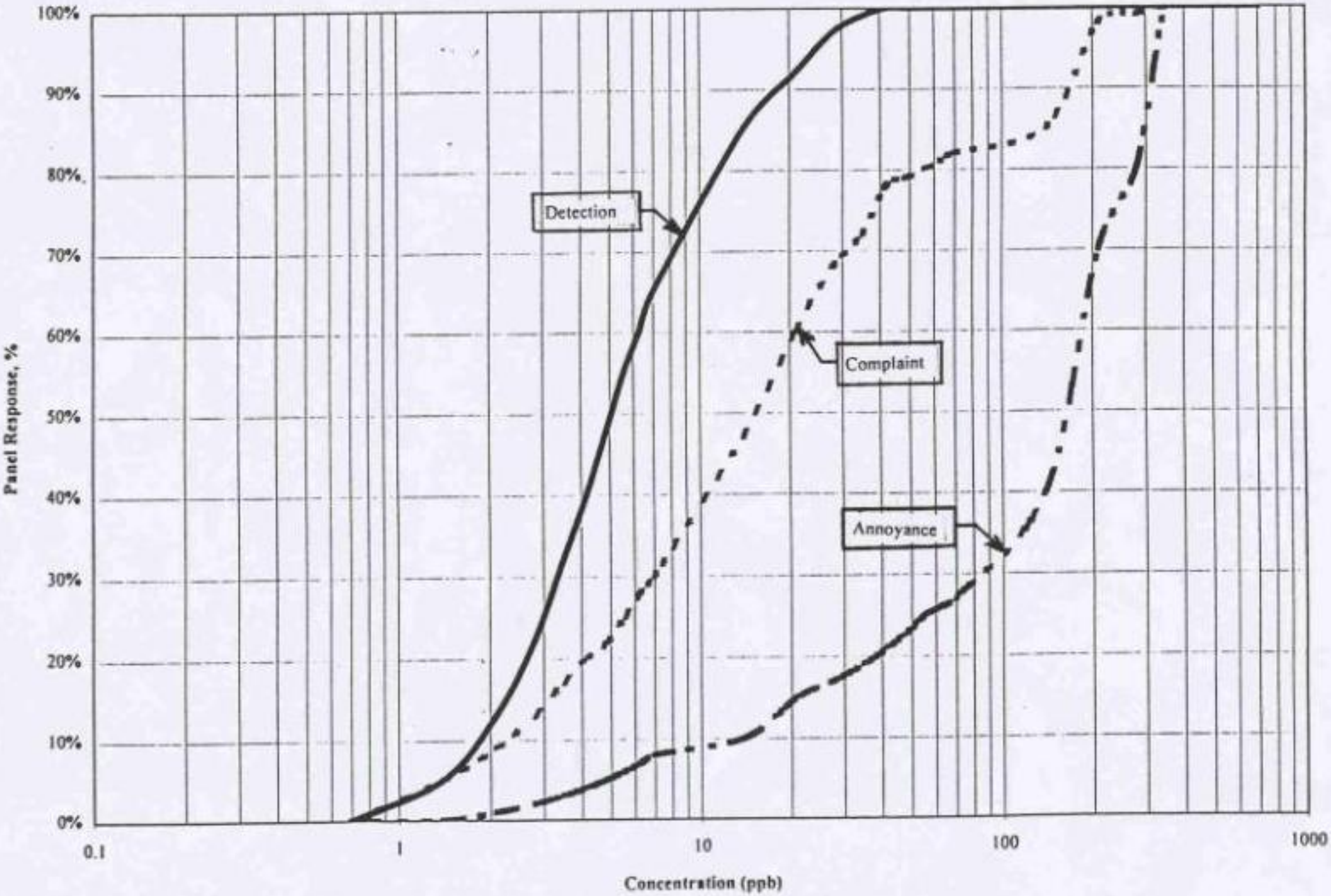
Most Important Odor Control Principles

- **Location, Location, Location**
  - Distance to nearest detector
  - The number of detectors
  - Direction of prevailing winds
- **Control Technology Parameters**
  - Airflow rates
  - H_2S concentration
  - Emitted H_2S mass emission rate
- **Most Often Need BACT**
  - PPM to PPB = 99.9% efficiency

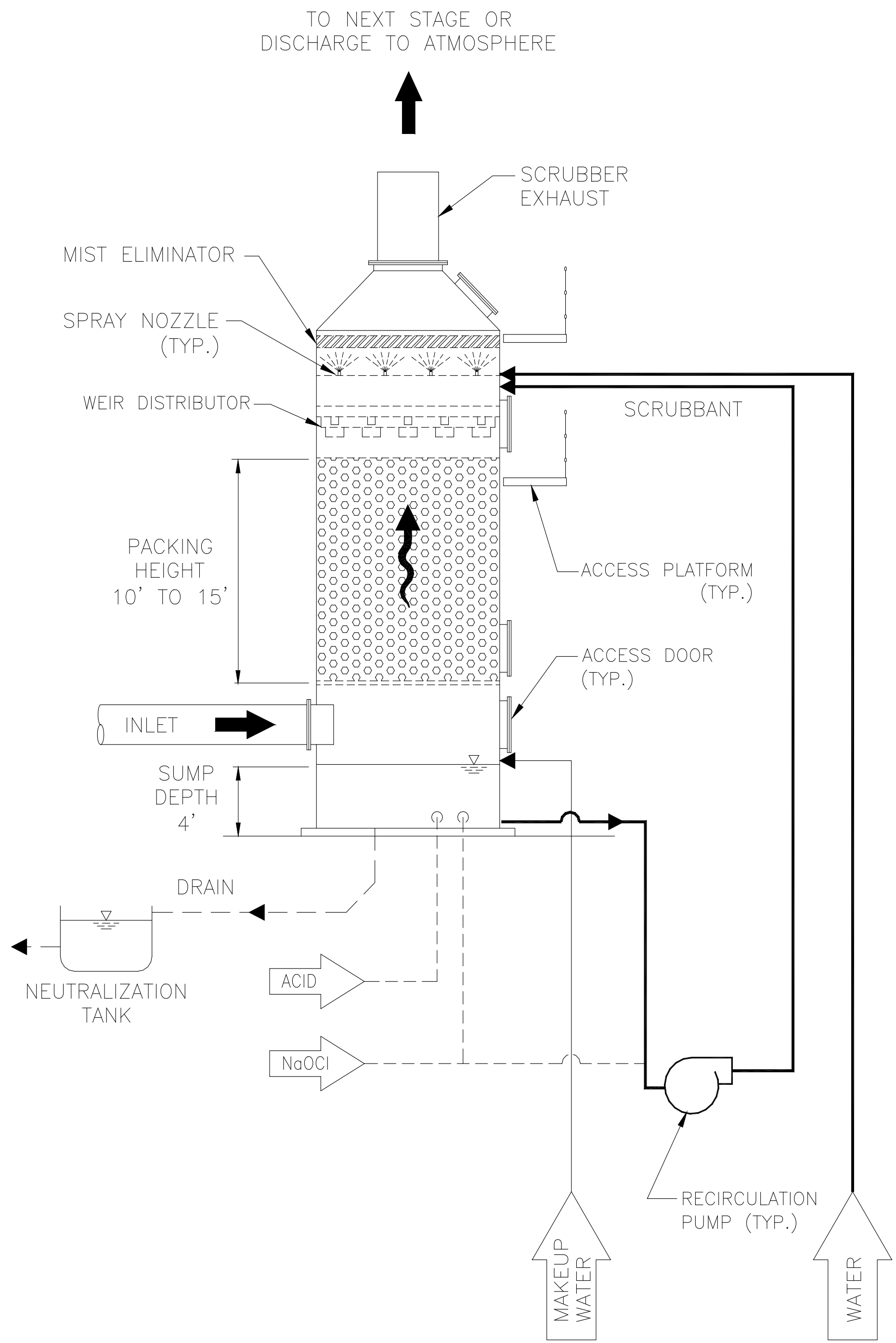
From MOP No. 22, Pg. 107



Odor Control Scrubbers

Packed Tower Scrubbers

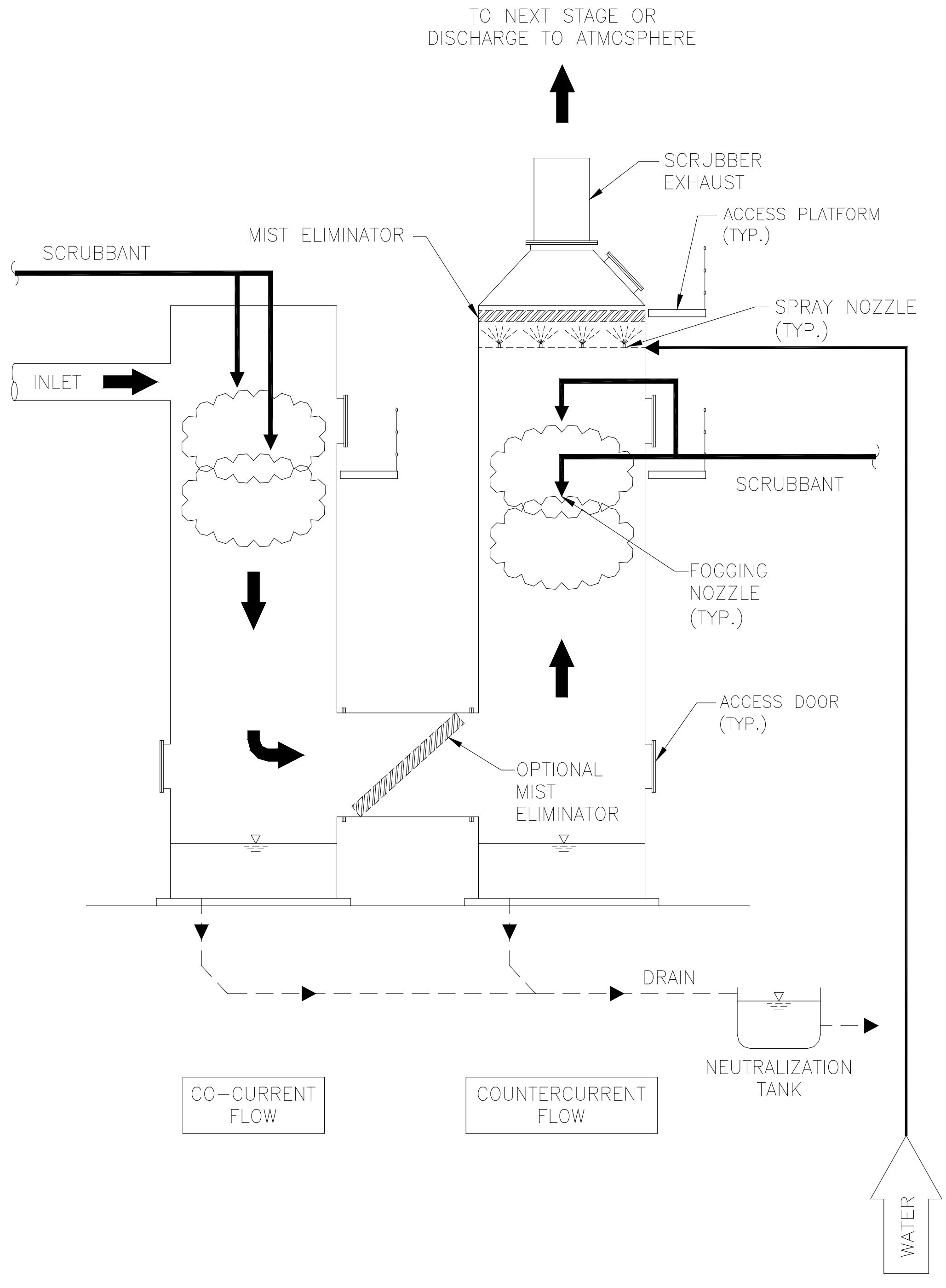
- Gas Velocity Enhances Gas Phase Diffusion to Liquid Film
- Plastic Packing Creates Liquid Film (Transfer Area)
- Liquid Recirculation Allows Efficient Chemical Use
- Sump Allows Reaction Time
- Liquid Blowdown Important to Prevent Chemical Backpressure

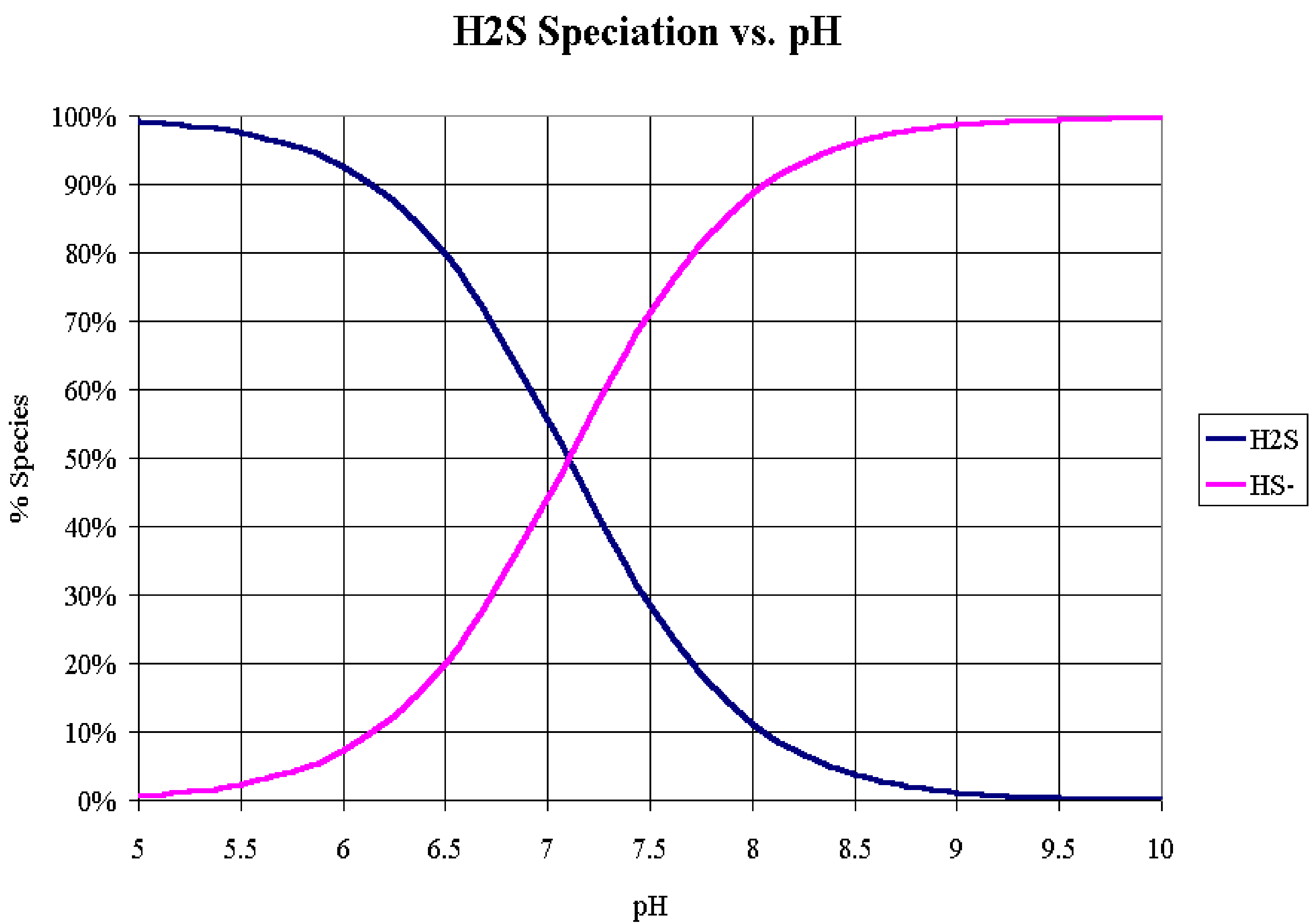


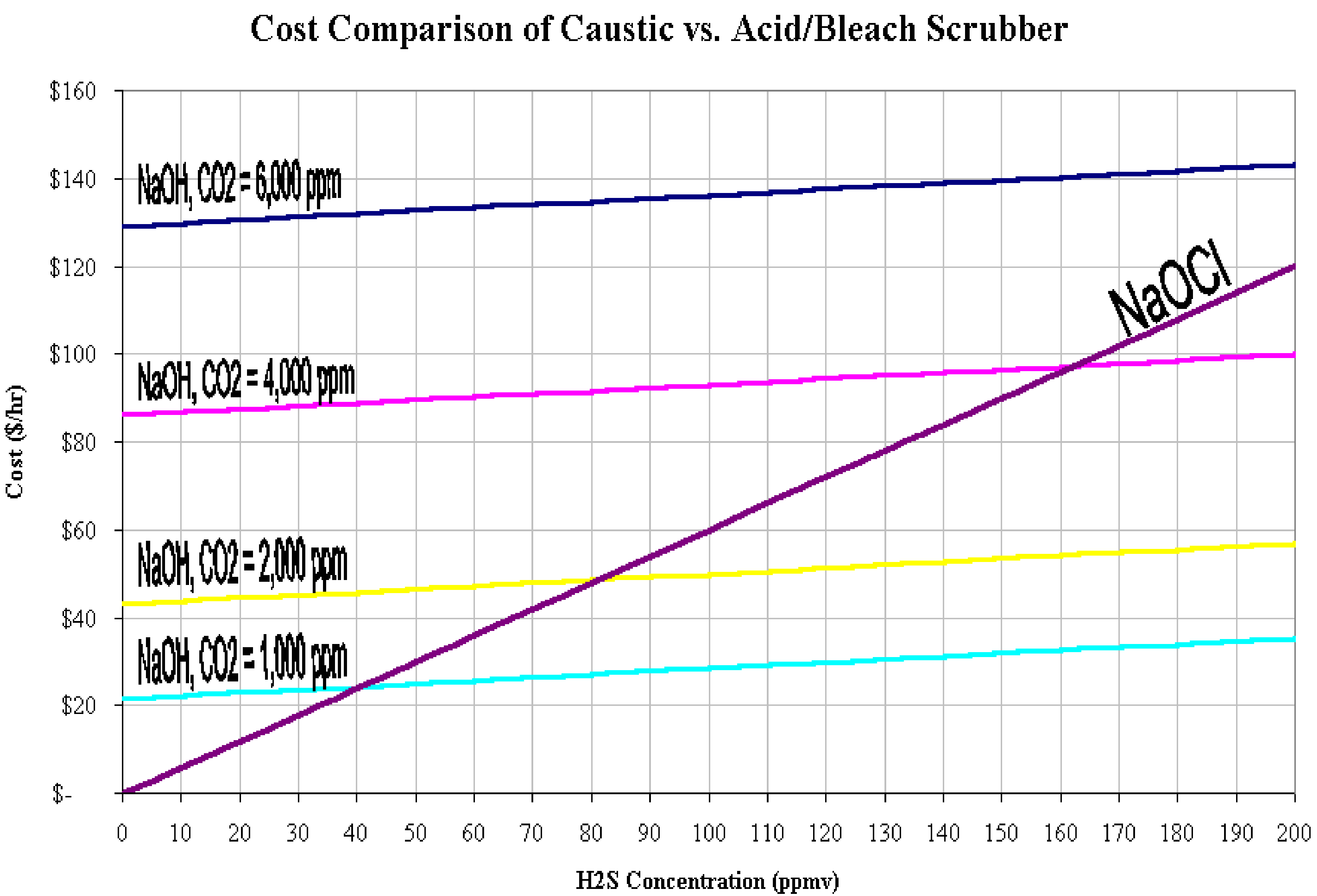
Odor Control Scrubbers

Misting Scrubber

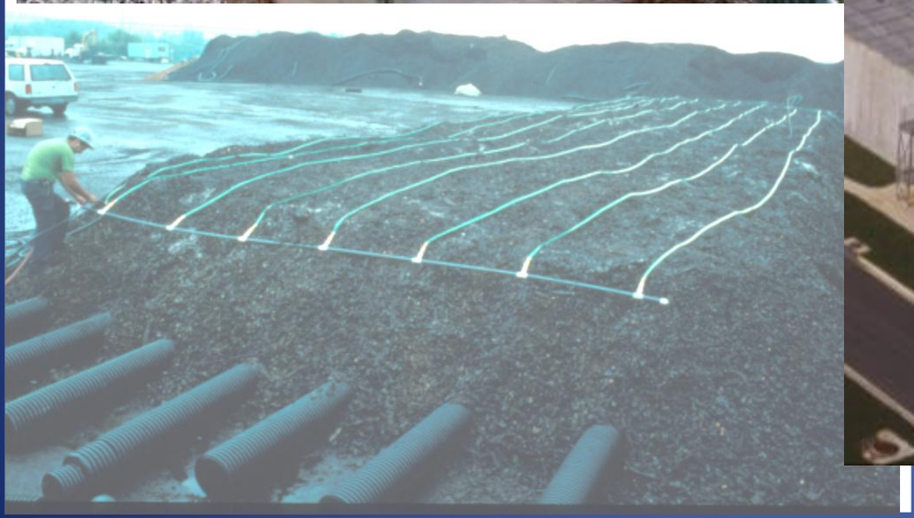
- Spray Contacts Odorous Chemicals in Gas Phase
- Spray Nozzles Creates Liquid Droplet (Transfer Area)
- Once Through Chemicals Maximizes Chemical Gradient
- Reaction Time Limited to Reactor Detention Time




H2S Speciation vs. pH
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Species
5
5.5
6
6.5
7
7.5
8
8.5
9
9.5
10
pH
H2S
HS-

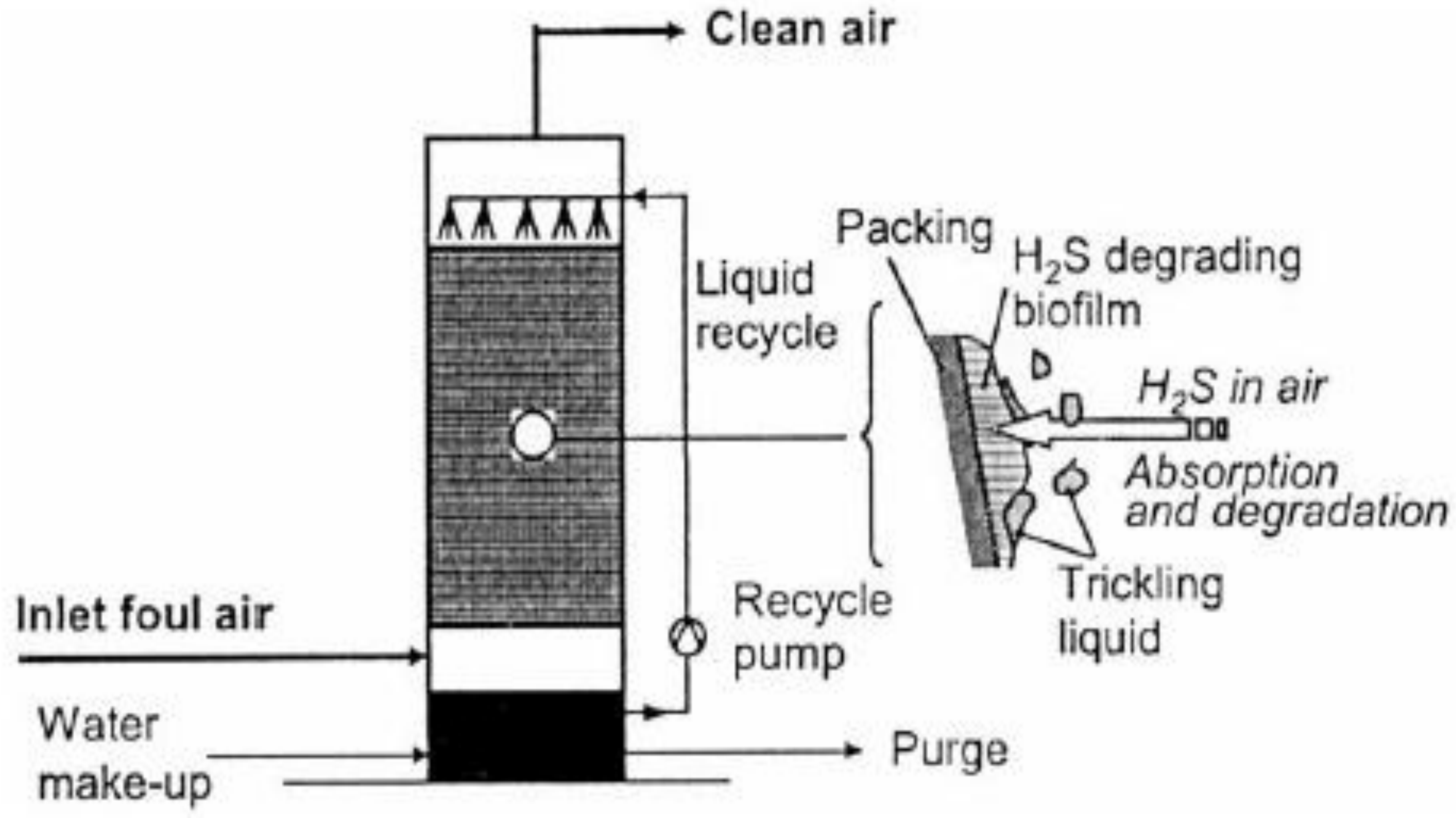

Cost Comparison of Caustic vs. Acid/Bleach Scrubber
$160
$140
$120
$100
$80
$60
$40
$20
$-
Cost ($/hr)
NaOH, CO2 = 6,000 ppm
NaOH, CO2 = 4,000 ppm
NaOH, CO2 = 2,000 ppm
NaOH, CO2 = 1,000 ppm
NaOCl
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
H2S Concentration (ppmv)

Custom and Modular Biofilters

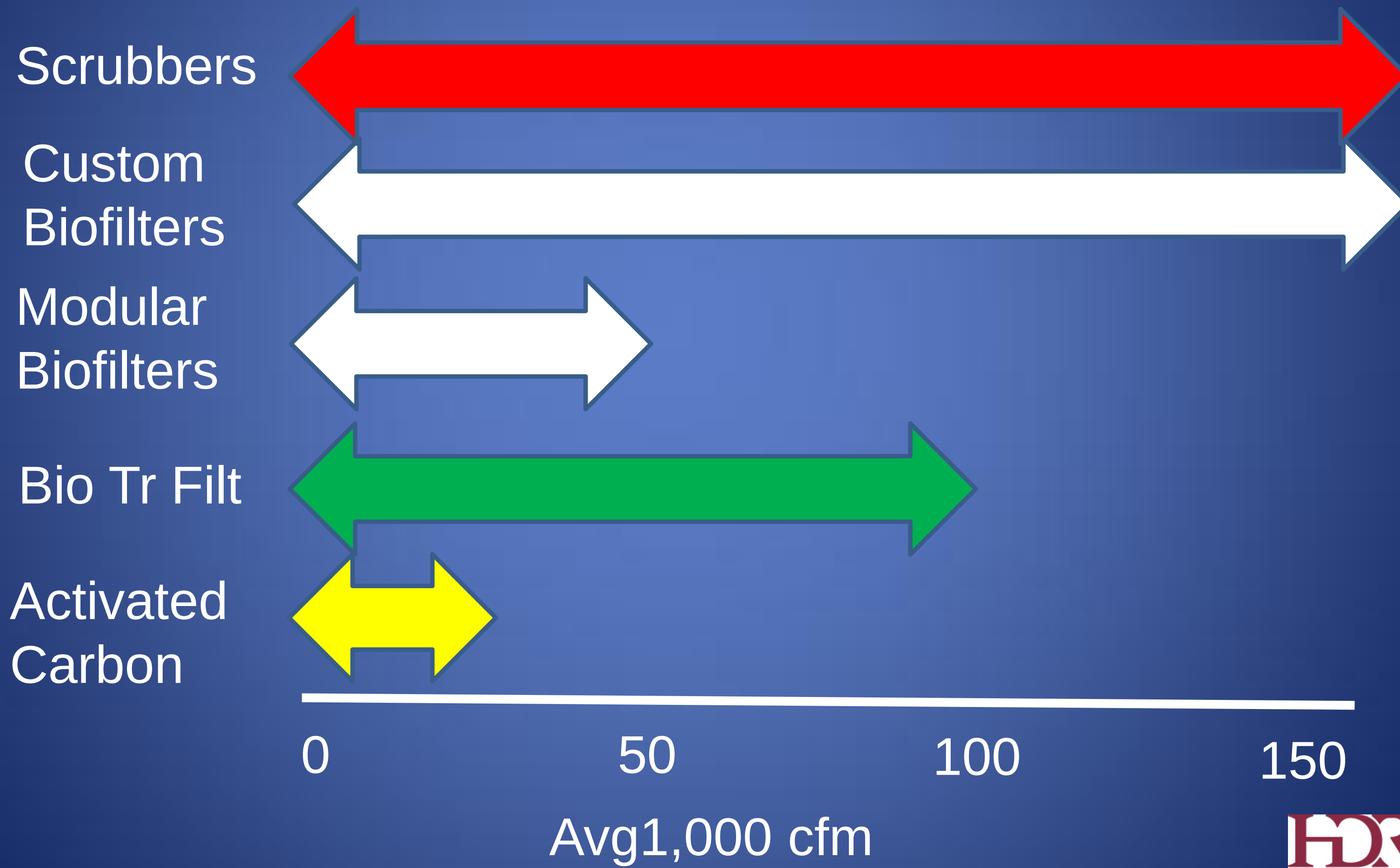


Bio Trickling Filters

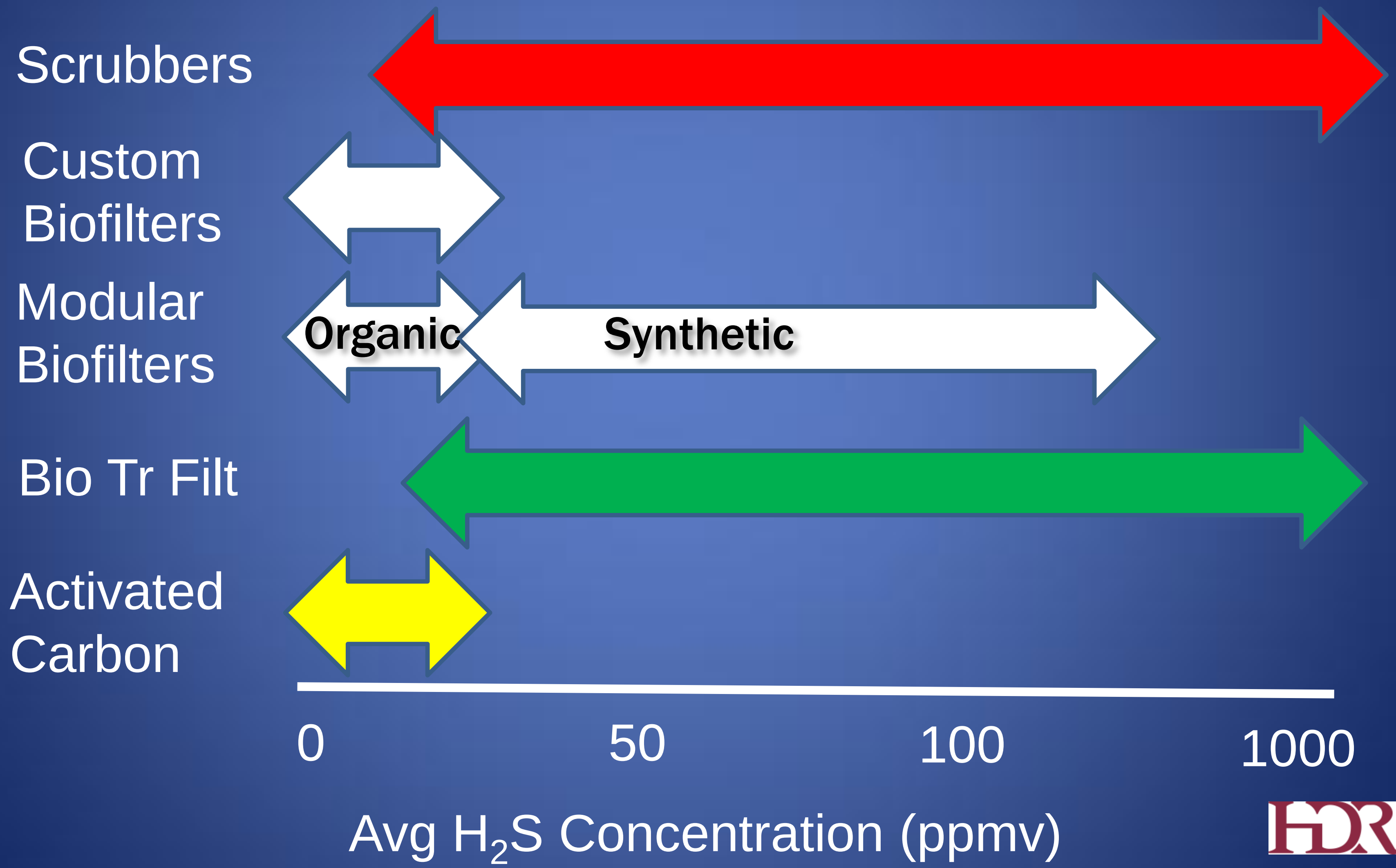
Bio Trickling Filter



Practical Capacities of Odor Control Technologies



H_2S Concentration vs Odor Control Technology



Scrubbers - Any Flow and Any H_2S Concentration

Custom Biofilters - Any Flow & H_2S < 25 ppmv

Organic Biofilters - < 25 kcfm & H_2S < 25 ppmv

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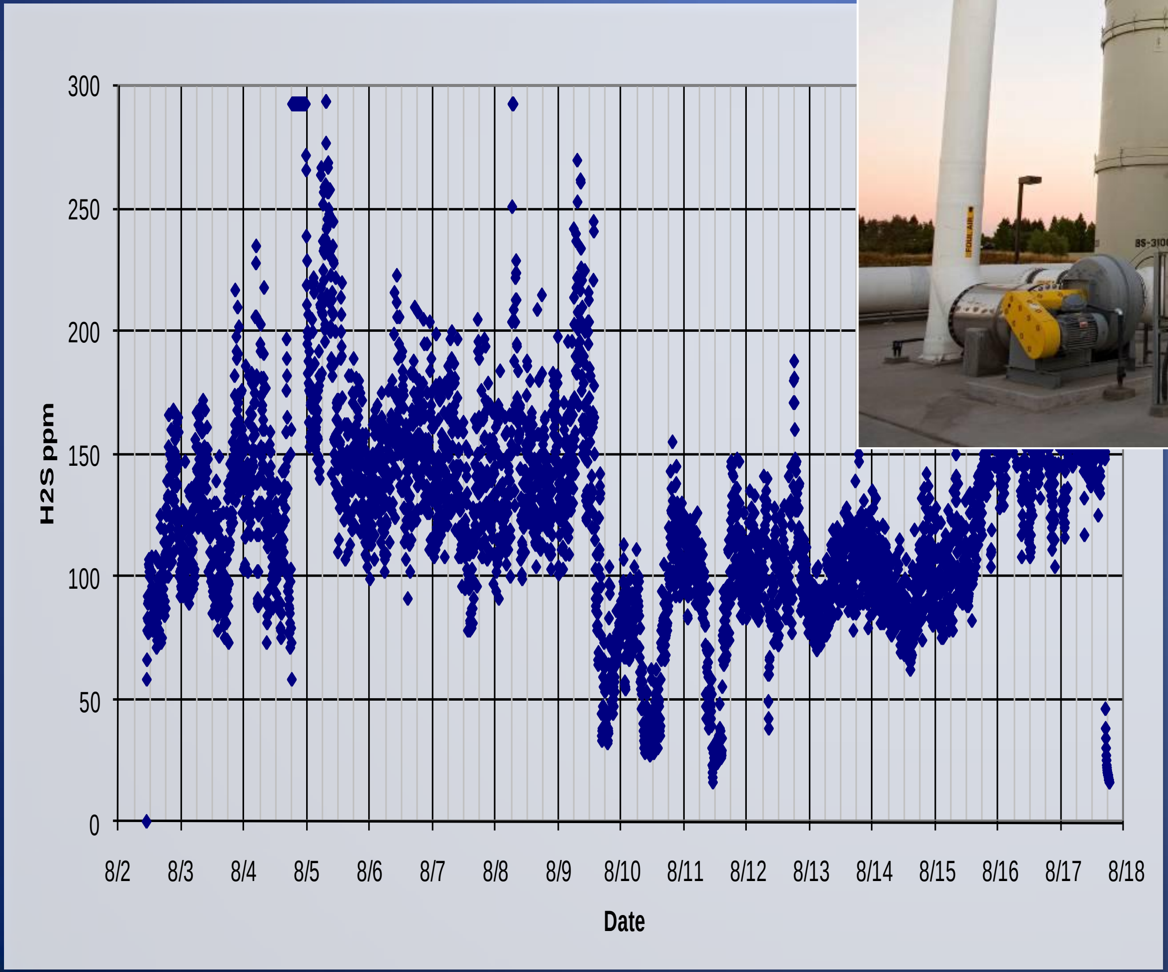
Synthetic Biofilters – Flow < 50 kcfm & H_2S < 50 ppmv

Biotowers – Any Flow & H2S >10 ppmv



Carbon – Flow < 15 kcfm & H2S <25 ppmv

Note – Sometimes Carbon Becomes Biofilter

Recommendations

- Establish Air Flow Rates and H_2S Concentrations
  - Need Ventilation Model to Estimate Hot Spots and Air Flow Rates
  - Look At H_2S Data and Predicted Hydraulic Regimes To Estimate Range of H_2S Concentrations
- Consider Location of Receptors and Determine Control Efficiency Requirements

Recommendations

- Use Estimated Flow and Estimated H_2S Concentrations to Establish Type(s) of Control Technologies Most Appropriate
- Evaluate Options and Costs – Pick a Solution
- Develop a Plan for Higher Flow Rates and/or Higher H_2S Concentrations
  - Parallel Ducts and Controls
  - Multiple Stages or Technologies
- An Ounce is Worth a Pound of Cure

Thank You

Lawrence.Hentz@hdrinc.com