HCTP Plant Wide Odour Control Assessment

Presentation to Neighbourhood Liaison Committee

September 12, 2005

TORONTO

AWS Engineers & Planners Corp.

PURPOSE OF THE STUDY

- Fully investigate and quantify odourous air emissions due to wastewater treatment operations at HCTP
- Develop conceptual odour mitigation measures

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- City not under any MOE order to perform odour assessment
- Worst odour sources currently produce noticeable odours in surrounding community at times
- Recommend how to reduce odour impact to acceptable levels
- Ultimate objective odour limit of 1 odour unit (ou) at nearest receptor
- Conceptual designs implemented as capital projects in future
- Effectiveness in controlling odours, achieved cost-effectively

PROJECT TEAM

AWS Engineers & Planners Corp.

Prime Consultant and Project Team Leader

Odor and Corrosion Technology Consultants, Inc.

Expertise in Odour Control and Corrosion Prevention

Canadian ORTECH Environmental Inc.

Odour emission sampling, measurement and characterization

RWDI West Inc.

Odour modelling

HIGHLAND CREEK TREATMENT PLANT (HCTP)

- Rated at 218,000 m^3/d, with average flow of 165,000 m^3/d
- Serves population of approximately 310,000
- Staged construction:
  - Old Plant (1956)
  - New Plant (1975 and 1980)

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TREATMENT PROCESS:

- Grit removal
- Screening
- Primary sedimentation
- Activated sludge process
- Phosphorus removal (ferric chloride)
- Final sedimentation
- Disinfection

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- Solids handling: anaerobic digestion of primary and secondary sludges, followed by centrifuge dewatering
- Incineration of dewatered sludge in multiple hearth incinerators
- Ash pumped to lagoons
- Ash removed from full lagoon by truck and landfilled

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- Located in industrial/residential area (park on south, residential neighbourhoods north and east, industrial park west)
- Limited buffer zone surrounding plant
- Walking paths in park to south less than 5 metres from plant fence line

PROPOSED PROCESS CHANGES AND IMPROVEMENTS

- Headworks grit collection system reliability improvements
  - Channel covers remain in place longer, reduced odour
- Separate waste activated sludge thickening facilities, removing waste activated sludge from the primary clarifiers
  - Simplify operation of primary clarifiers, reduced odour and corrosion in primary effluent channels
- Improved sludge dewatering equipment
  - Enable lower sludge blanket in primary clarifiers, reduced odour
- Improved incineration:
  - Newer Fluidized Bed Incinerators enable more complete combustion at higher, more uniform temperatures, reduced odour

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STUDY METHODOLOGY

- Identify all odour sources with potential for off-site odour impacts
- Sample all potential odour sources to determine individual contribution to off-site impacts (2 rounds)
- Determine mass odour emission rate for each source, develop source ranking
- Model impacts of measured emissions, calibrated for HCTP and surrounding community
- Conduct community odour survey to verify model results and community odour impacts
- Develop viable odour control strategies to mitigate odours at each source impacting surrounding community
- Model mitigated odour options, including process optimization impacts, to determine potential odour release improvements
- Determine capital and operating costs for proposed solutions and recommend cost-effective design

CURRENTLY INSTALLED ODOUR CONTROL TECHNOLOGIES

- Headworks Building
  - Ozone contactor for screen and grit channel exhaust fans (non-operational)
- Aeration Facilities
  - Wet chemical packed tower scrubbers

SULPHIDE GENERATION

- Bacterially mediated process in submerged portion of sanitary sewers
- Fresh domestic sewage typically free of sulphide
- Dissolved sulphide caused by:
  - Low dissolved oxygen
  - Long detention time in collection system
  - Elevated wastewater temperatures

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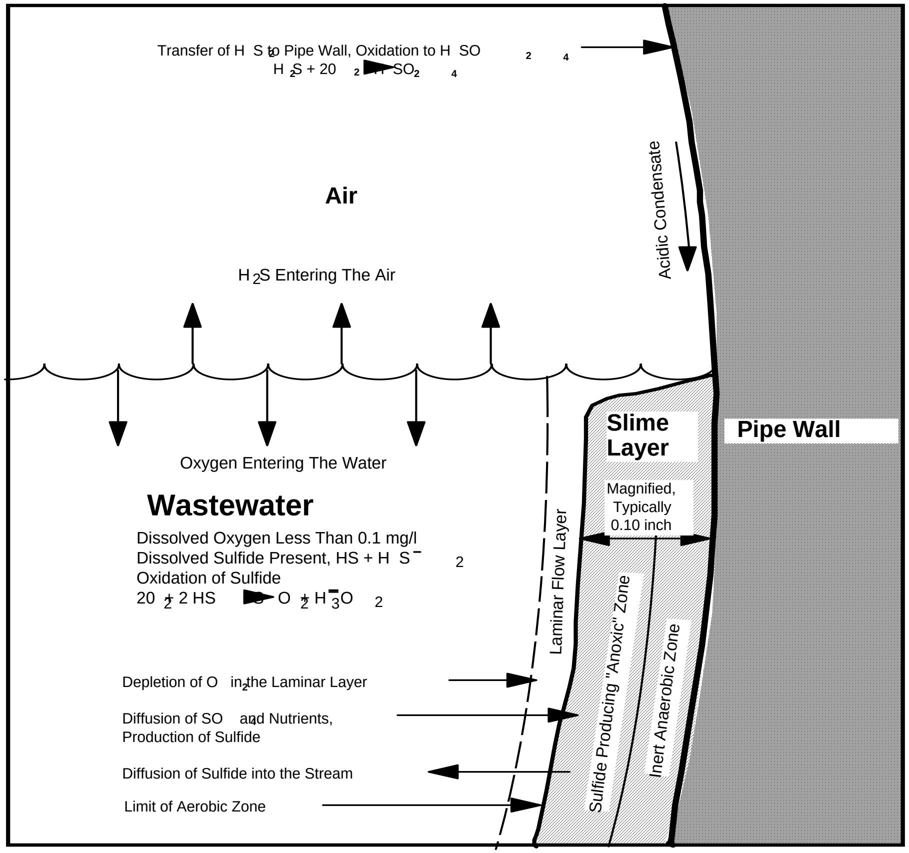

SLIME LAYER CHEMISTRY AND BIOLOGY

- Hydrogen sulphide gas causes odour and corrosion
  - Colourless
  - Extremely odourous
  - Detectable by humans at very low concentrations (0.00047 ppm)

Very hazardous to humans in high concentrations

>10 ppm: nausea, headache, conjunctivitis

>100 ppm: serious breathing problems, sense of smell lost

>300 ppm: death can occur within minutes

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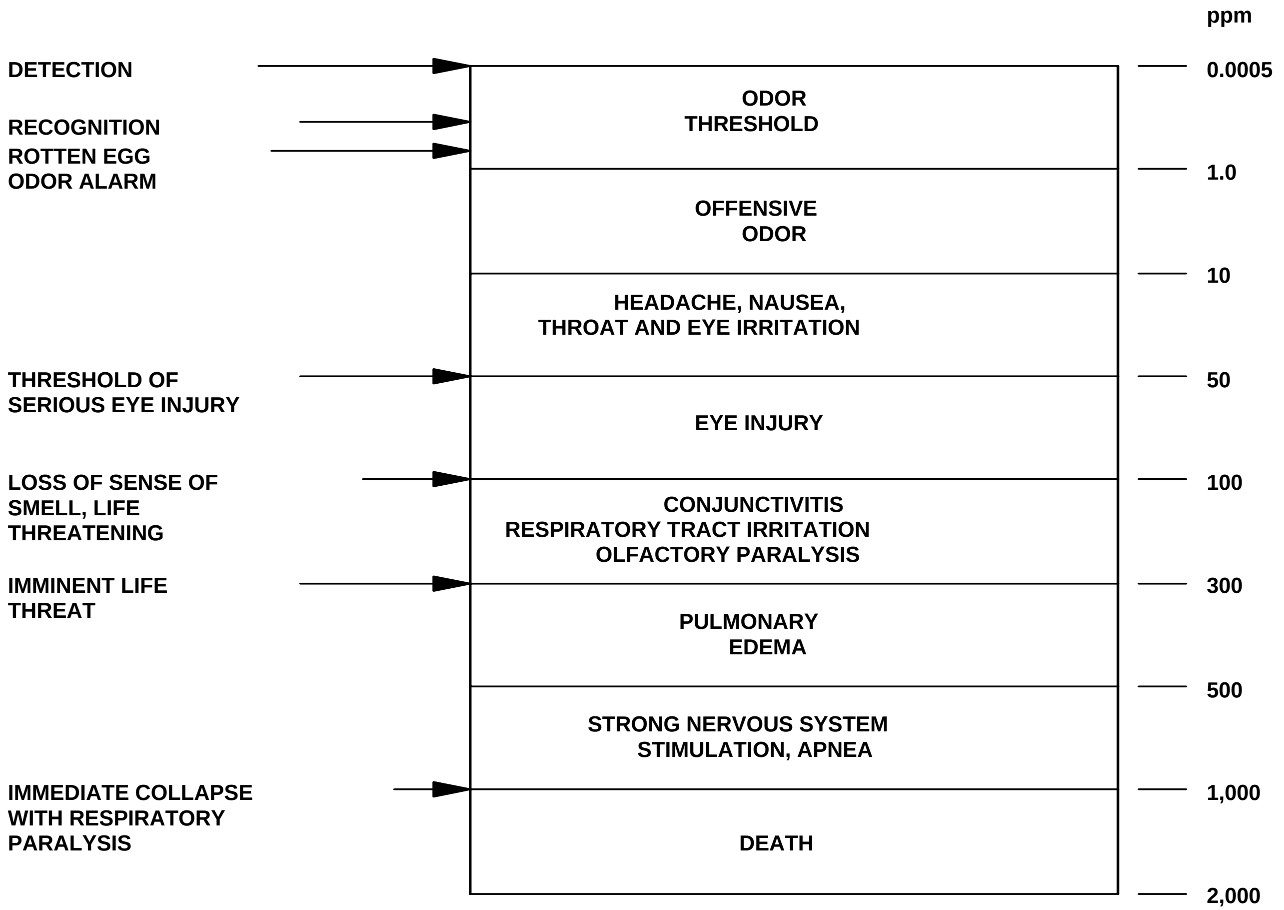

GENERAL TOXICITY SPECTRUM – HYDROGEN SULPHIDE GAS

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- Turbulence and hydraulic outfalls generate droplets, increase surface area of liquid, drive out more hydrogen sulphide as free gas
- Higher wastewater temperatures increase metabolism of sulphate-reducing organisms; for example, each 7^{o}C wastewater temperature increase doubles production of sulphide
- Hydrogen sulphide typically problem in colder climates during warmer months
  - Present in small quantities at HCTP; significant release of hydrogen sulphide a seasonal phenomenon

ODOUROUS COMPOUNDS IN WASTEWATER

- Ammonia, hydrogen sulphide, sulphur dioxide (inorganic – no carbon)
- Turbulence and hydraulic outfalls generate droplets, increase surface area of liquid, drive out more odourous compounds as free gases

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ODOUROUS COMPOUNDS in WASTEWATER

Name	Formula	Characteristic Odour	Odour Threshold in Air (ppm)
Hydrogen Sulphide	H2S	Rotten Eggs	0.00047
Ammonia	NH3	Sharp, Pungent	0.037
Skatole	C9H9N	Fecal, Nauseating	0.0012
Indole	C2H6NH	Fecal, Nauseating	NA
Methylamine	CH3NH2	Putrid, Fishy	0.021
Alkyl Mercaptan	CH2=CH- CH2-SH	Strong Garlic, Coffee	0.00005
Amyl Mercaptan	CH3-(CH2) 3- H2-SH	Unpleasant, Putrid	0.0003
Benzyl Mercaptan	C6H5 CH2-SH	Unpleasant, Strong	0.00019
Ethyl Mercaptan	C2H5SH	Skunk	0.00019
Sulphur Dioxide	SO2	Pungent, Irritating	0.009
Methyl Mercaptan	CH3SH	Decayed Cabbage	0.0011
Dimethyl Disulphide	CH3SSCH3	Rotten Cabbage/Garlic	0.001
Thiocresol	CH3-C6H4-SH	Skunk, Rancid	0.000062
Diamine Butane	NH2(CH2)4NH2	Decayed Fish	NA
Thiobismethane	CH3SCH3	Rotting Meat	0.0011

CONCRETE AND METALLIC CORROSION

- Aerobic bacteria colonize pipe crowns, walls, other surfaces above waterline in wastewater pipes and other structures
  - Able to consume hydrogen sulphide gas and oxidize it to sulphuric acid
    - Adequate hydrogen sulphide gas (>2.0 ppm)
    - High relative humidity
    - Carbon dioxide gas
    - Atmospheric oxygen

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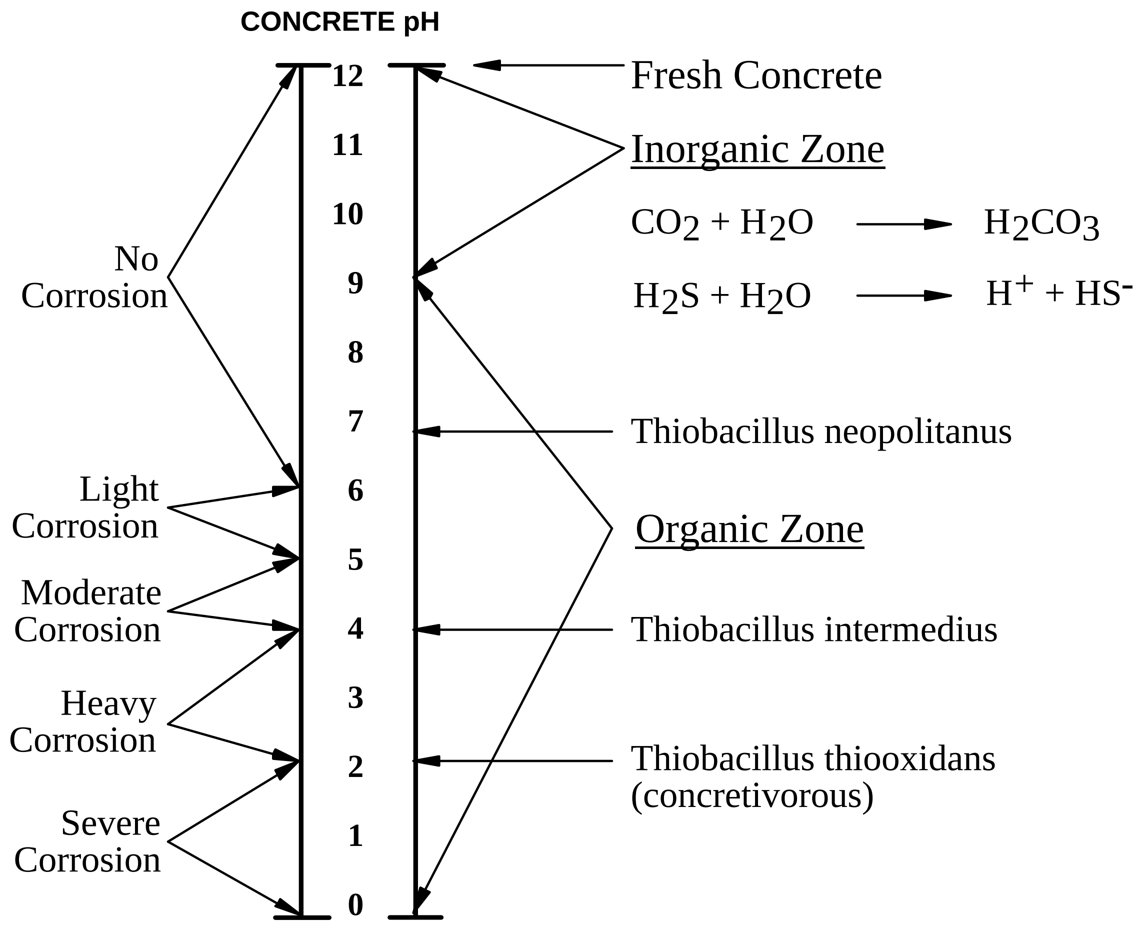

BIOGENIC CONCRETE CORROSION PROCESS

BIOGENIC CONCRETE CORROSION PROCESS

- Complex interaction of many different chemicals and organisms
- Concrete loss can be as much as 25 mm a year in heavy sulphide environments
- Most metals, including stainless steel, can be attacked and destroyed by exposure to sulphuric acid resulting from hydrogen sulphide gas

SEWER VENTILATION DYNAMICS

- Flowing wastewater in sanitary sewers drags air along above the surface
- High velocity, turbulent gravity sanitary sewers often suffer odour problems due to combined effects of increased ventilation and odour stripping
- Fast moving air columns above wastewater can collide with slower moving air generating high pressure zone pushing out odourous air and leading to complaints

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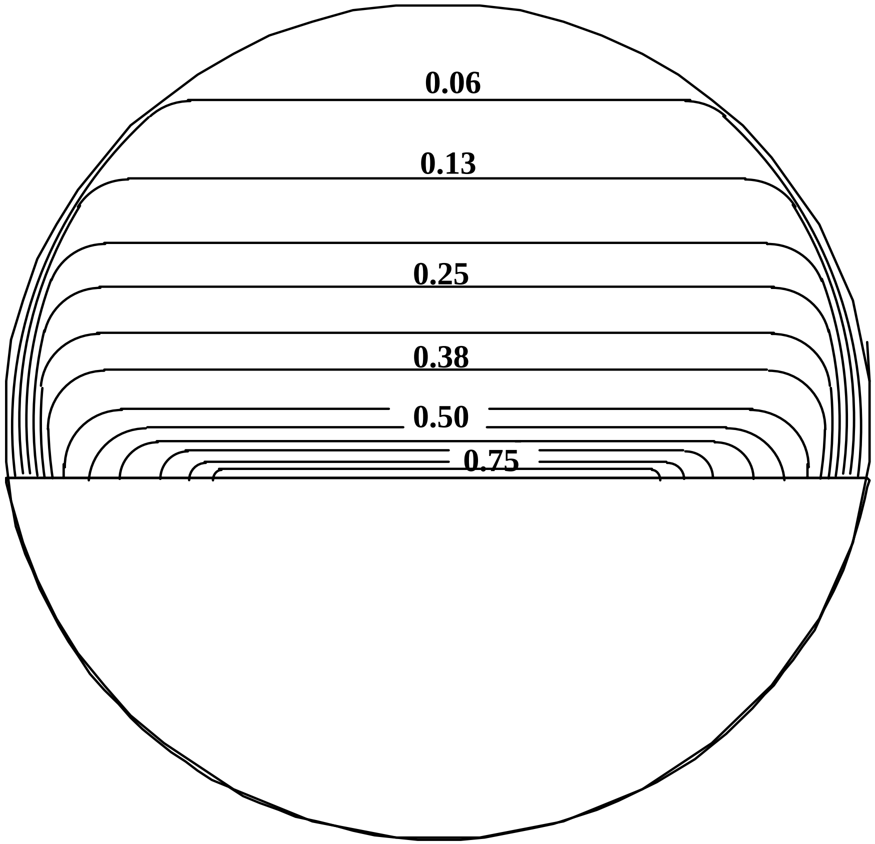

IDEALIZED SEWER AIR VELOCITY CONTOURS - % WASTEWATER VELOCITY

ODOUR CONTROL TECHNOLOGIES

- Wastewater odour generation and sulphide production result from complex biological and chemical interactions
- Most odour control technologies attempt to interrupt one or more biological/ chemical interrelationships to stop cycle of odour production
- Two categories:

  Liquid phase (more common in wastewater collection systems than treatment plants – possible seasonal consideration for collection system upstream of HCTP to reduce influent hydrogen sulphide load)

VAPOUR PHASE (more applicable to treatment plants):

- Counteractant scrubbers
- Packed bed scrubbers
- Carbon adsorbers
- Palletized permanganate adsorbers
- Ammonia/carbon adsorbers
- Bioscrubbers
- Biofilters

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- Technologies evaluated aimed at capture and treatment of odour after release as vapour or gas (most applicable to range of odour compounds and concentrations at HCTP):
  - Activated carbon
  - Biofilters
  - Bioscrubbers
  - Wet packed tower scrubbers

ACTIVATED CARBON

- Odourous compounds adsorbed and trapped on surface of carbon
- High surface to volume ratio, large amount of surface area to adsorb odours
- Non-polar, adsorbs wide variety of odourous compounds
- Can be activated by catalyst to improve adsorptive capacity or target specific odourous compound
- Requires periodic regeneration (chemical or thermal), or replacement after adsorptive capacity depleted
- Able to remove hydrogen sulphide at almost any loading rate with very high efficiency
- Once capacity of media reached, no further treatment provided and odour breakthrough occurs
- Discharge stack required

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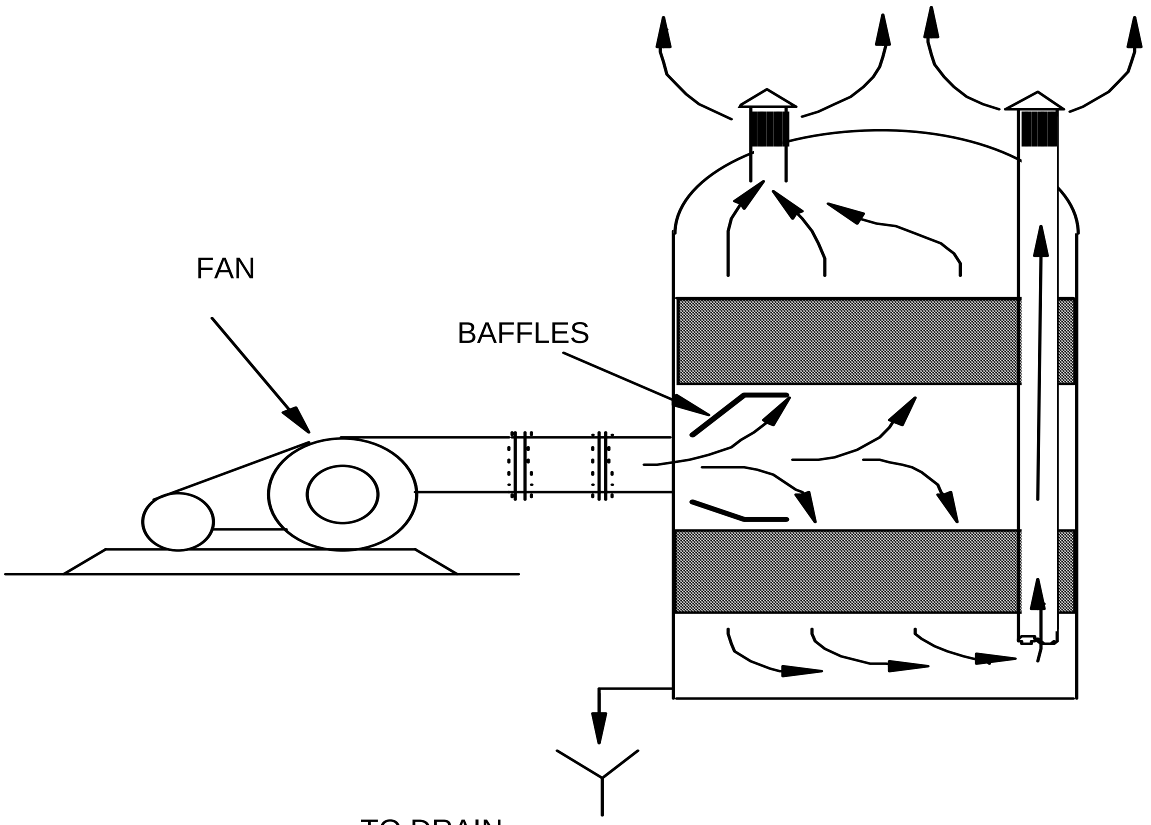

SINGLE STAGE, DUAL-BED CARBON ADSORBER SYSTEM

BIOFILTERS

- Adsorb and oxidize odourous compounds using microorganisms growing in soil, compost or inorganic strata
- Successful in treating hydrogen sulphide, low concentrations of ammonia, all types of organic odours and volatile organic compounds (municipal wastewater treatment plants, pumping stations, composting facilities, rendering plants, solids processing facilities)
- Odours adsorbed into moisture film surrounding substrate particles, as well as directly onto particles
- In use in U.S. since 1959 for treating hydrogen sulphide in wastewater collection and treatment systems
- Popular due to: simplicity of system, lack of intensive mechanical equipment, lack of treatment chemicals
- Major components: fan to transfer odourous air to biofilter, header/lateral piping (typically PVC headers with perforated laterals in gravel bed) and distribution plenum, substrate, irrigation and/or humidifying system

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- Media: earth, garden soil, peat, loam, rice hulls, yard compost, sludge compost, wood and bark chips, mushroom compost (all effective in removing hydrogen sulphide), shredded bark/chipped wood blended with high organic content materials, man-made materials

Advantages: relatively inexpensive to construct out of simple, readily available materials, require minimal operator attention and maintenance, can be landscaped/disguised as part of landscape, provide over 99 percent hydrogen sulphide removal efficiency, low profile and improved aesthetics compared to chemical or carbon scrubbers, beneficial reuse of municipal solid waste (e.g., yard waste compost), ideally suited to treat normal wastewater odours, very economical, able to treat average concentrations of organic odour, and hydrogen sulphide concentrations up to 50 ppm on continuous basis

Disadvantages: build-up of sulphur in substrate when treating continuously high hydrogen sulphide concentrations (due to insufficient irrigation water); designed to prevent this condition

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- Living bacteria do not adjust as quickly to extreme changes in influent odour concentrations as do other technologies; daily fluctuations in odour strength and intensity readily handled, but major changes in influent odour concentration require one to three days of adjustment to achieve similar odour removal efficiencies

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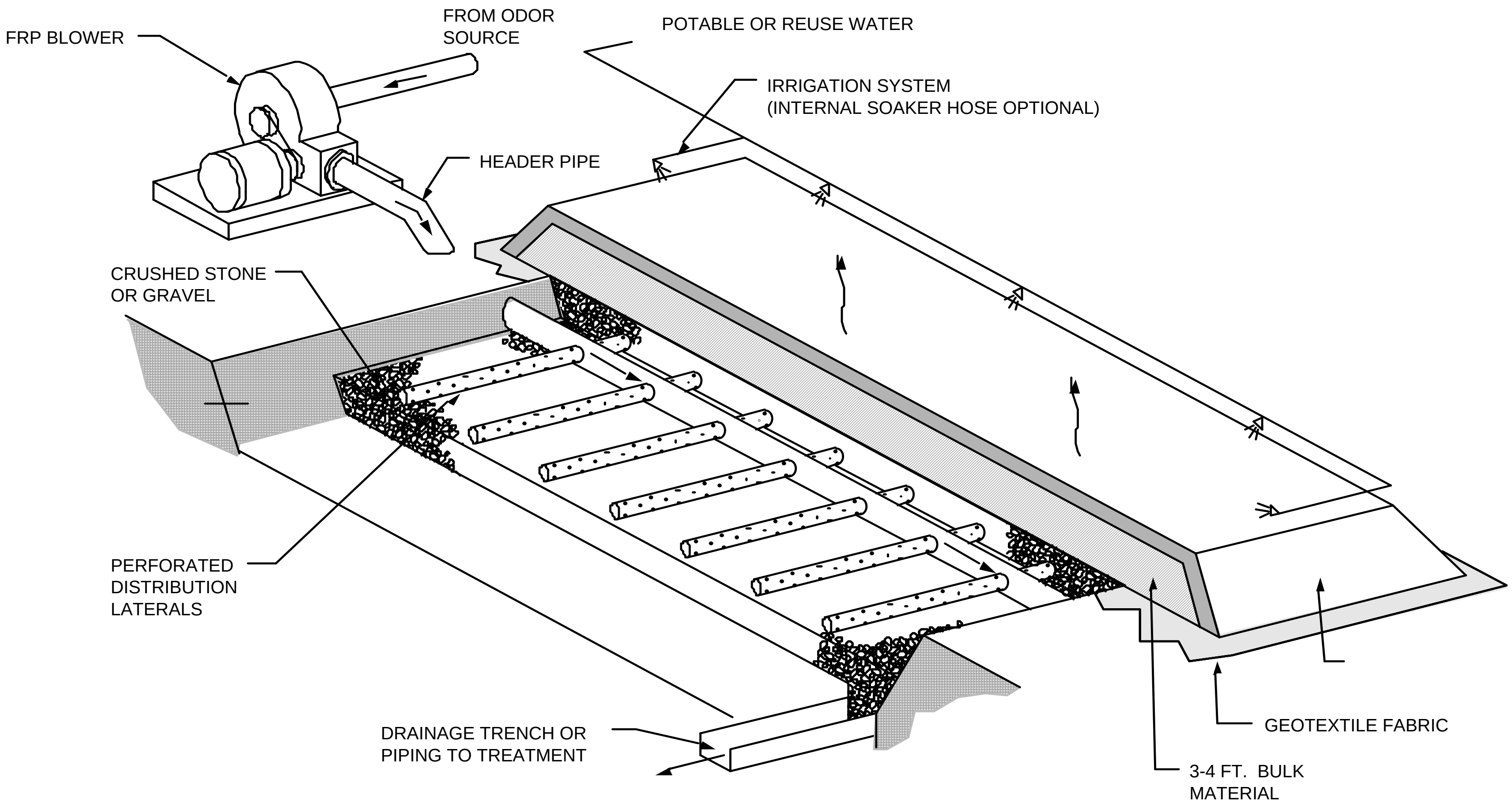

TYPICAL IN-GROUND BIOFILTER

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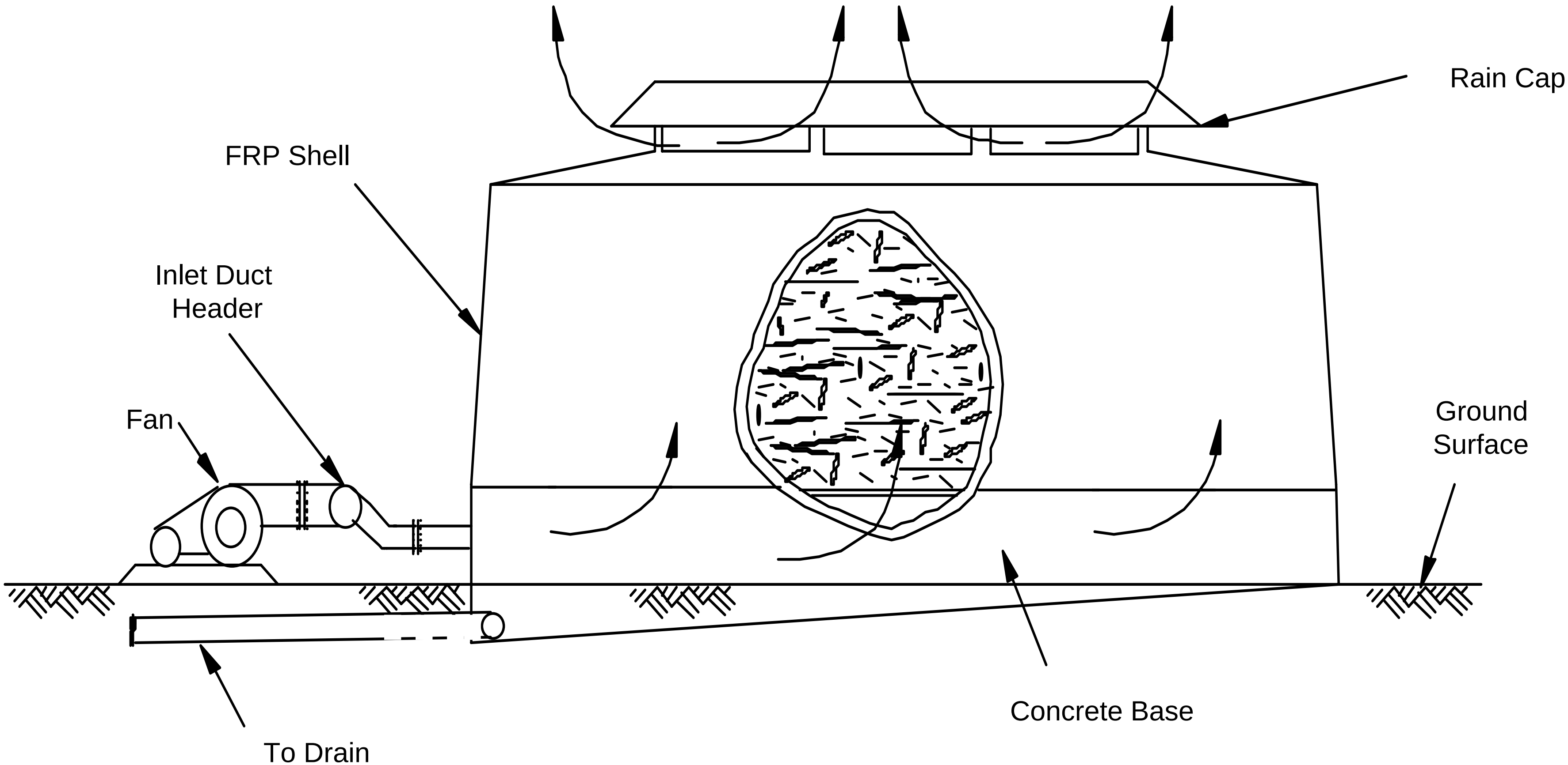

TYPICAL PACKAGED BIOFILTER

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IN-GROUND BIOFILTER

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PACKAGE BIOFILTER SYSTEM

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WET PACKED TOWER SCRUBBERS

- Adsorb odourous compounds from gas stream into droplets of chemical solution
- For treatment of hydrogen sulphide, typically use sodium hydroxide, or mixture of sodium hydroxide and sodium hypochlorite
- Large volume of chemical/water solution pumped to top of reaction vessel and cascaded over packing media
- Thin film of water and chemicals on packing media provides surface area for absorption of odourous compounds into the water
- Complete sulphide and organic odour oxidation achieved with chlorine during contact time provided by recirculation sump in bottom of reaction vessel
- By-products of chemical reaction removed by continuous flushing with fresh water

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Advantages: more effective for removal of hydrogen sulphide than for organic odour compounds, greater than 99 percent with optimized chemical feed

- Reaction vessels can be used in series for higher removal efficiencies, or to allow removal of different compounds
- Capacity to sustain shock loads by automatically increasing chemical dosage based on measured pH and oxidation-reduction potential
- Chemical feed can be optimized for odourous air constituents
- Chemical solution is recirculated, and chemicals added only when required

Disadvantages: complex due to number of pieces of major equipment required (i.e., chemical metering pumps, recirculation pumps, pH probes, oxidation-reduction probes with controllers), make-up water for chemical solution requires water softener to prevent scaling problems with spray nozzles and packing media, least effective on organic odours and compounds

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- Discharge stack required
- Higher chlorine concentration required in scrubber to break molecular bonds; generate wide assortment of chlorinated compounds, many of which are volatile (some listed as hazardous air pollutants)
- Support equipment requires significant amount of operator attention for adjusting make-up water rates and checking chemical feed rates
- Higher operational and maintenance costs associated with scrubber equipment and for continuous chemical addition
- Over time, hardness in water will form scale on packing causing large portions of media to clump together, reducing surface area and causing flow channeling; media periodically washed with acid solution to dissolve scale
- Sulphur scaling can be problem for scrubbers treating continuously high concentrations of hydrogen sulphide; once formed, little can be done to remove sulphur other than replacing packing

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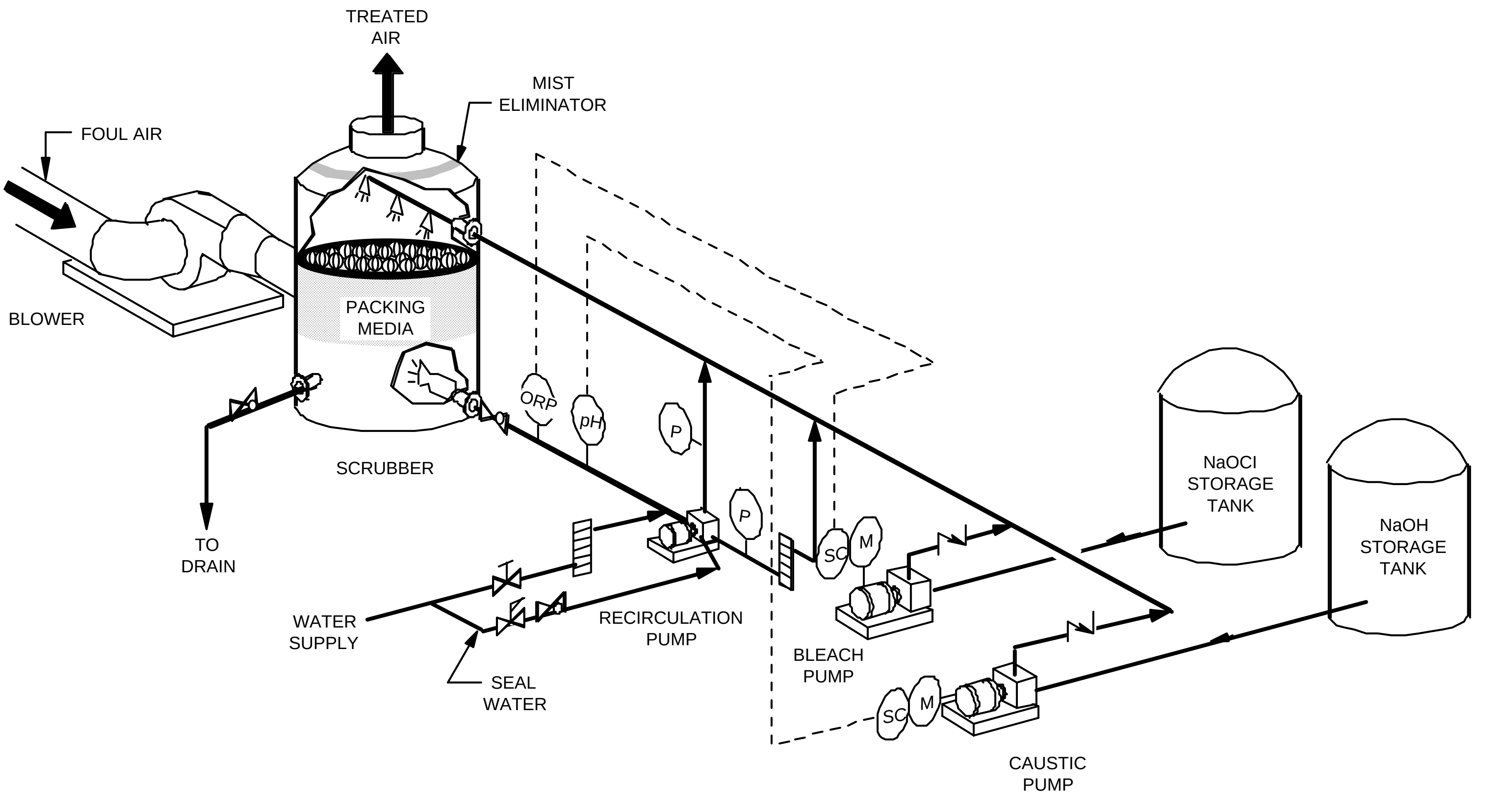

TYPICAL SINGLE-STAGE PACKED BED SCRUBBER SYSTEM

BIOLOGICAL SCRUBBERS

- Relatively new in North America, generally accepted in Europe
- Similar to conventional chemical packed-bed scrubber, except chemical solution replaced by bio-active solution distributed over plastic packing media in vessel while odourous air forced upward
- Two types: suspended-growth, fixed film
- Suspended-growth: odour compounds adsorbed or dissolved into bio-active solution, and partially oxidized by microorganisms, further oxidized in separate oxidation reactor
- Mixed liquor can be used as bio-active solution and recirculated from aeration basin to scrubber and back again with further oxidation of adsorbed odour compounds in aeration basin
- Return activated sludge can also be used as bio-active solution
- Fixed film: grow thin biofilm on packing material, odour compounds adsorbed or dissolved into the water matrix and diffused into biofilm where biological culture aerobically degrade them

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- Biofilm must stay thin to enhance mass transfer of compounds and avoid anaerobic activity, requiring biomass sloughing mechanisms – similar in operation to trickling filter
- Type of organism to be used in bioscrubber depends on odourous compound being treated; ideally, bioscrubber designed to operate with different types of organisms to allow treatment of wide variety of odourous compounds

Advantages: effective for most odour compounds, but especially hydrogen sulphide and mercaptans, potential to provide chemical scrubber removal efficiencies with little or no chemical cost

Disadvantages: typically manufacturer-supplied, above-ground facilities, best suited to treat hydrogen sulphide rather than organic odour compounds that require longer vessel residence times for treatment

  - Discharge stack required

ODOUR TECHNOLOGY SUMMARY

- Bioscrubbers not considered most appropriate for HCTP because organic odour compounds constitute large percentage of airstream and would be largely untreated
- Wet packed tower scrubbers most maintenance intensive, use very large amounts of chemical, and require that sodium hydroxide and sodium hypochlorite stored on-site; also have been historically ineffective at HCTP
- Carbon adsorbers and biofilters considered suitable technologies to treat odourous air streams at HCTP
- Carbon adsorbers preferred technology where airstream generally dry with low odour concentrations (e.g., headworks room air)
- Biofilters preferred technology for airstreams with elevated humidity (e.g., headworks grit channels), as well as high and sustained hydrogen sulphide concentrations and/or volatile organic compounds, providing long-term reliability and treatment efficiency

AIR SAMPLING AND MONITORING

Round 1:

- July 23, 2004 – August 10, 2004
- 31 sample locations
- identified worst odour sources from major unit process emission sources
- triplicate samples taken

Round 2:

- September 23, 2004 – November 9, 2004
- 16 sampling locations
- duplicate samples taken

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COMPONENTS:

- Total Odour (measured as odour units) – *Round 1 and 2*
- Volumetric Flow Rates at Emission Sources – *Round 1 and 2*
- Air Temperature – *Round 1 and 2*
- Direct Sensory Evaluation (measuring intensity, hedonic tone, and character) – *Round 1 and 2*
- Total Reduced Sulphur Compounds – *Round 1*
- Community Odour Survey Results – *Round 1 and 2*
- Continuous H_2S – *Round 1*
- Continuous Differential Pressure - *Round 1*

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TOTAL ODOUR SAMPLING:

- “Odour panel” used to measure mixtures of odours, otherwise potentially non-detectable for specific odour compounds
- Total odour concentration testing reported as “odour units” (ou) or dilutions to threshold” (D/t)
- Odour samples evaluated within 12 hours of collection
- Specialized facility at ORTECH, designed to provide odour-free environment
- Evaluations began at high dilution level, and dilution lowered in stages
- At each stage, odour panelists registered response by entering identity of sample port where odour detected
- Panelists’ responses processed to determine odour threshold value (OTV) for sample

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- OTV is the point where 50% of odour panel can just detect the particular odour (assumed to be the level of odour in air that can be detected by 50% of the population)
- OTV is actually a dilution factor, with no units; however, for convenience OTV is expressed in “odour units” (ou)

DIRECT SENSORY EVALUATION

- Sets of three samples from selected locations at optimum predilution analyzed for "intensity", "hedonic tone", and "character"
- Some sample locations not selected for direct sensory evaluation due to potential hazards to panelists (e.g., high concentrations of hydrogen sulphide, or concern of health hazard)
- Panelists opened bag, sniffed contents and evaluated:
  - Intensity: 0 to 4 (no odour to extreme) – impossible to compare when samples are collected at different dilutions
  - Hedonic tone: -3 to +3 (very unpleasant to very pleasant)
  - Character: dominant character from seven or eight panelists chosen as the character of the odour

COMMUNITY ODOUR SURVEYS

- Two community odour surveys conducted, generally coinciding with Round 1 and Round 2 sampling and monitoring
- Evaluation of odours by experienced and trained observers in structured field observation session
- Set of observation routes developed in advance, based on the HCTP odour complaint log
- Each route on a radius taken from the HCTP plant centre; maximum eight observation points
- Odour characterization changed from predominantly “stagnant water” and “raw sewage” closer to HCTP, to predominantly “chlorine” further away from HCTP
    - Area sources detected closer to HCTP with “stagnant water” and “raw sewage” descriptors, aeration scrubber exhaust stack emissions detected further from HCTP with “chlorine” descriptor

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Preliminary Odour Source Emission Ranking

Sample Location	**Emission Rate (ou/s)**	**% of Total Emission**
New Plant Aeration	301,110	42.5
Headworks Facility (Covers off)	270,744	38
Incinerator Complex	75,633	11
Old Plant Aeration Scrubbers	26,338	4
New Plant Primary Clarifiers	23,988	3.5
Old Plant Primary Clarifiers	8,352	1
New Plant Secondary Clarifiers	1,440	<1
Old Plant Secondary Clarifiers	944	<1
Total HCTP Emission	708,549	

HEADWORKS FACILITY

- Grit removal, mechanical screening and processing equipment
- Common wastewater influent channel distributed to five aerated grit channels
- Screw augers remove grit from channels, grit pumps convey grit to cyclone degritters and grit classifiers
- Grit ultimately discharged to uncovered residual container
- Exiting aerated grit channels, wastewater flows through five coarse climber screens
- Screenings discharged onto belt conveyor, and ultimately discharged to same uncovered residual container used for grit

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AERATED GRIT CHANNEL COVERS

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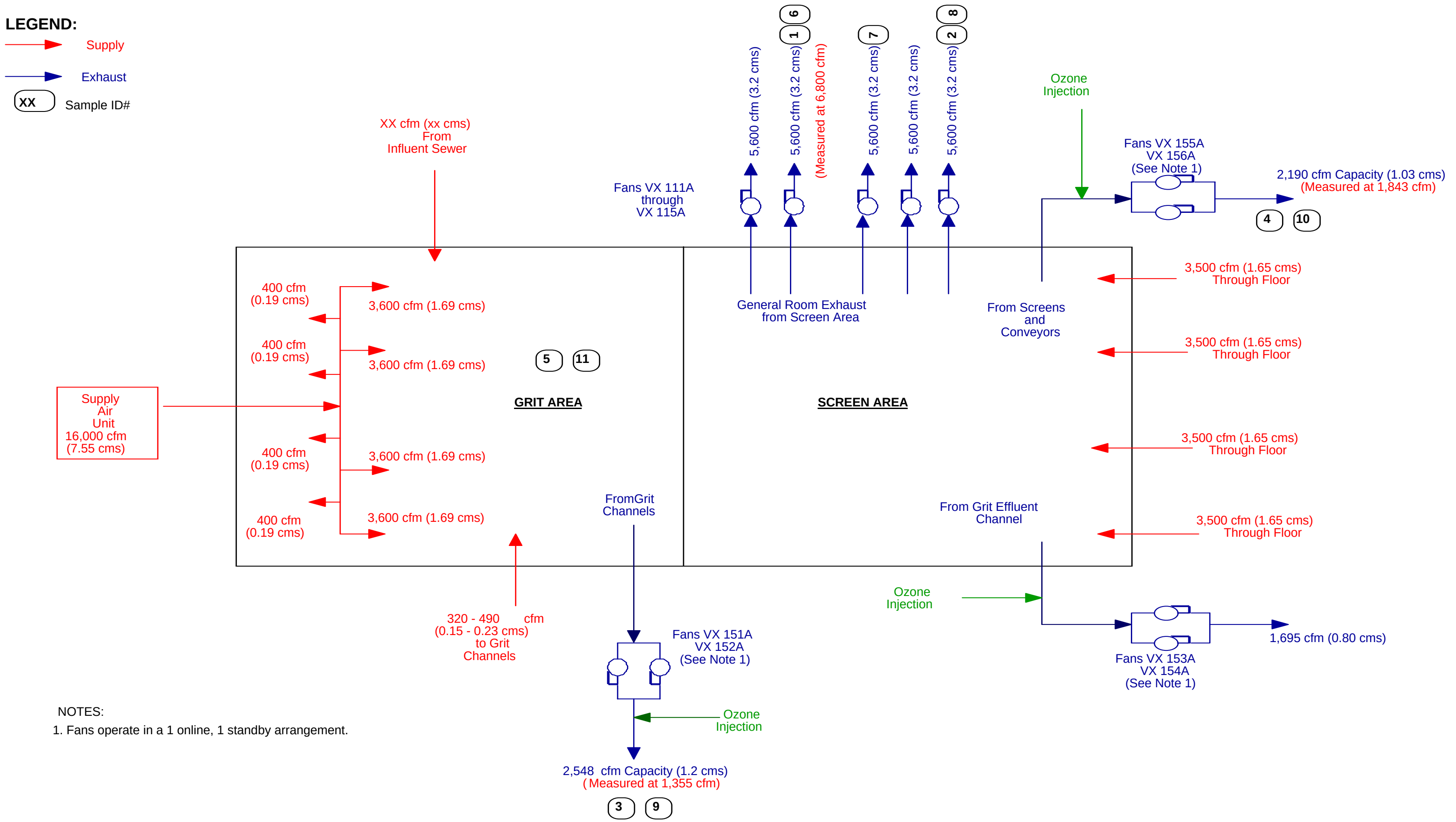

NOTES:

1. Fans operate in a 1 online, 1 standby arrangement.

HEADWORKS VENTILATION/ODOUR CONTROL SCHEMATIC

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HYDROGEN SULPHIDE CORROSION – INFLUENT
BYPASS SLUICE GATE

PRIMARY CLARIFIERS

- Wastewater exiting Headworks Facility directed to two sets of Primary Clarifiers (New and Old Plant)
- New Plant: four large rectangular clarifiers with traveling bridge sludge removal mechanisms
- Old Plant: eight smaller, centre feed square clarifiers with circular collector mechanisms
- Primary clarifiers usually one of major odour sources at wastewater treatment plants
- Odour values from overflow weirs at New Plant primary clarifiers approximately eight times higher than Old Plant primary clarifiers

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PRIMARY CLARIFIER EFFLUENT CHANNEL CORROSION

AERATION TANKS

- Aeration tanks receive wastewater from primary clarifiers; eight units each in New Plant North and South (round) and Old Plant (rectangular) facilities
- Aeration tanks covered either by building or flat concrete roof
- Exhaust air from all enclosed aeration tanks collected and treated by wet packed tower scrubbers
- New Plant North aeration tanks covered with flat concrete roofs; North Plant South aeration tanks covered with circular buildings
- Old Plant aeration tanks covered with Quonset huts
- Wet packed tower scrubbers use sodium hypochlorite as scrubbing solution; ozone can be injected into scrubber exhausts, but is no longer used

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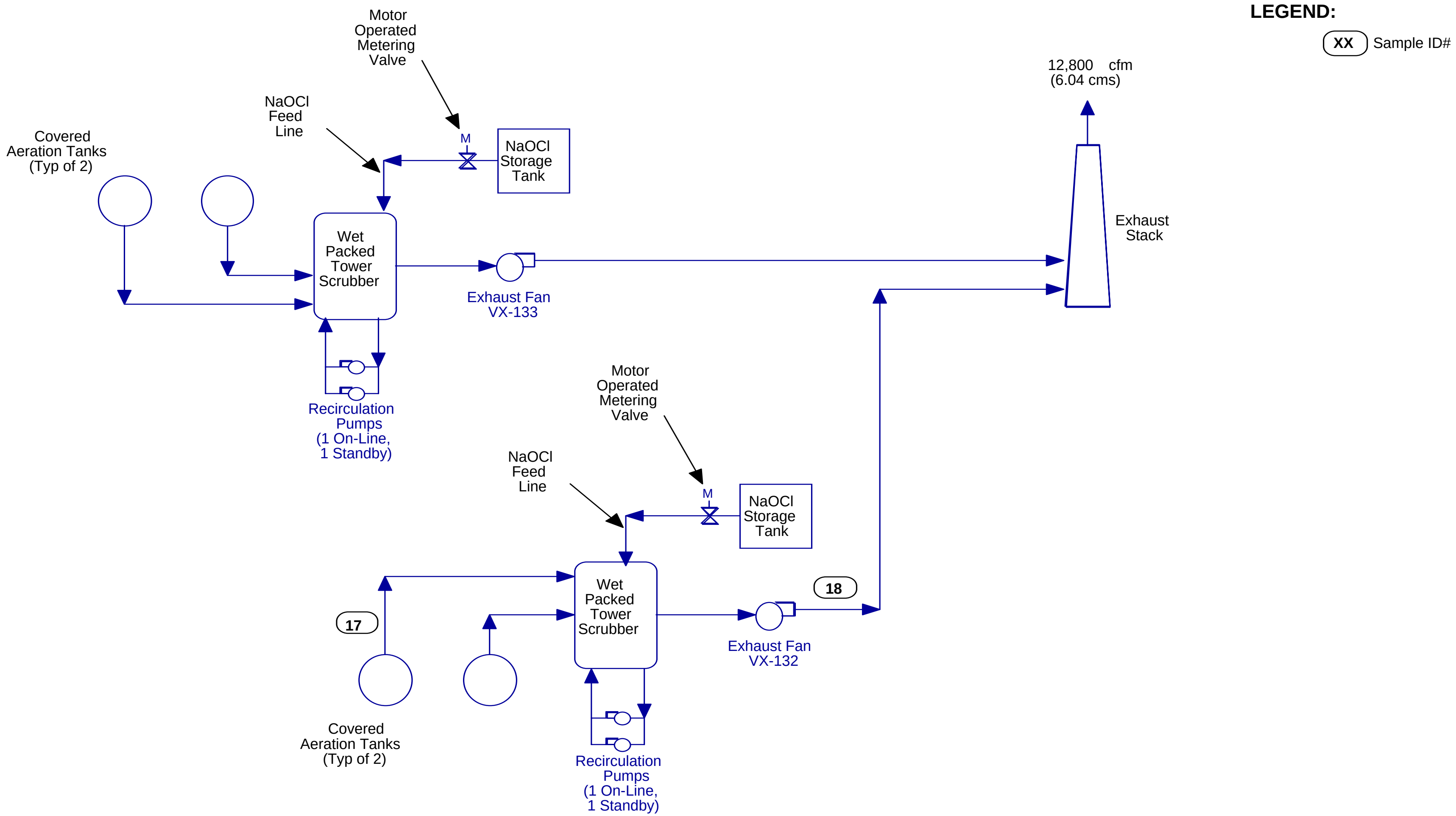

NEW PLANT – NORTH AERATION ODOUR CONTROL SCHEMATIC

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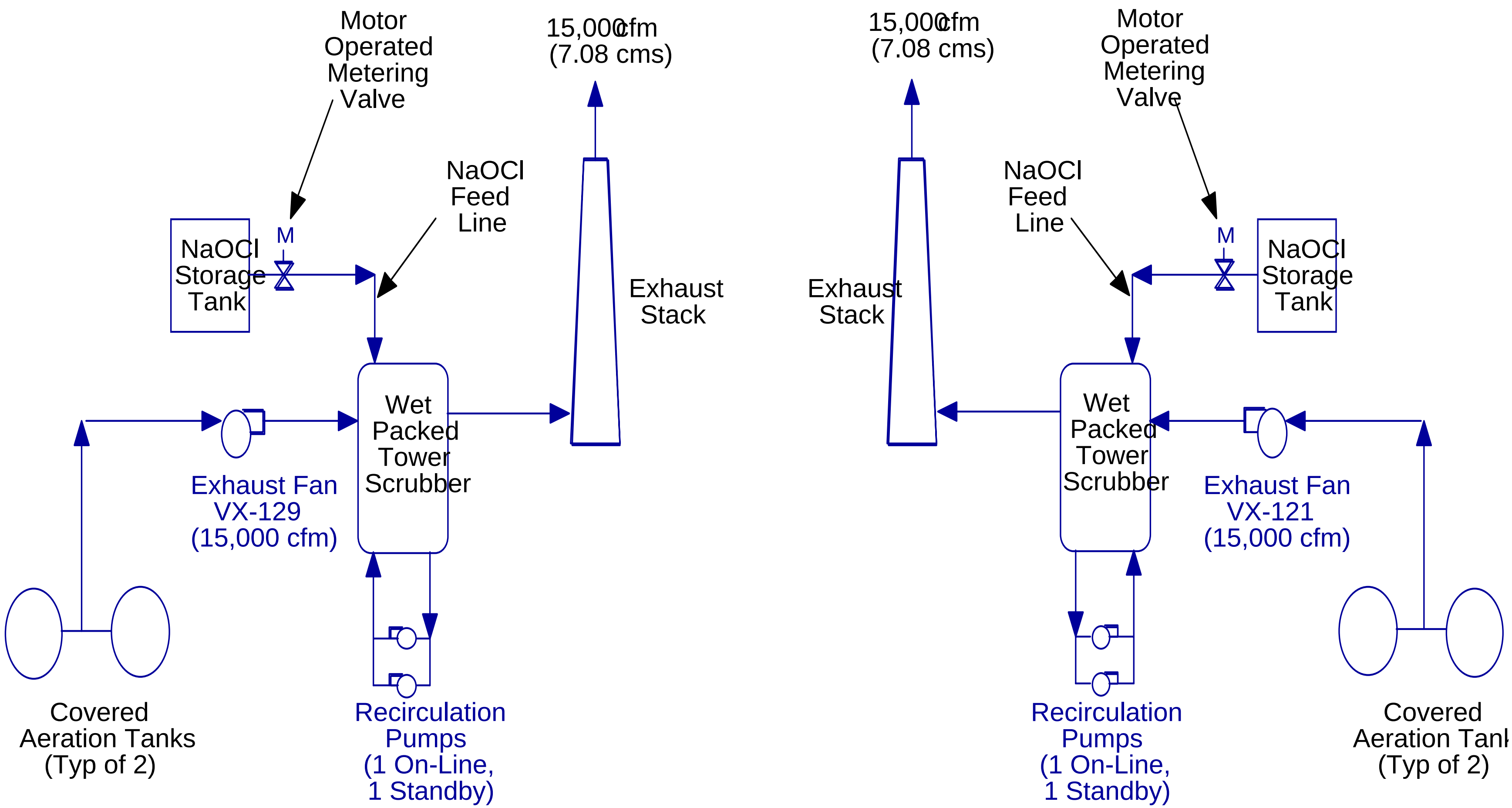

NEW PLANT – SOUTH AERATION ODOUR CONTROL SCHEMATIC

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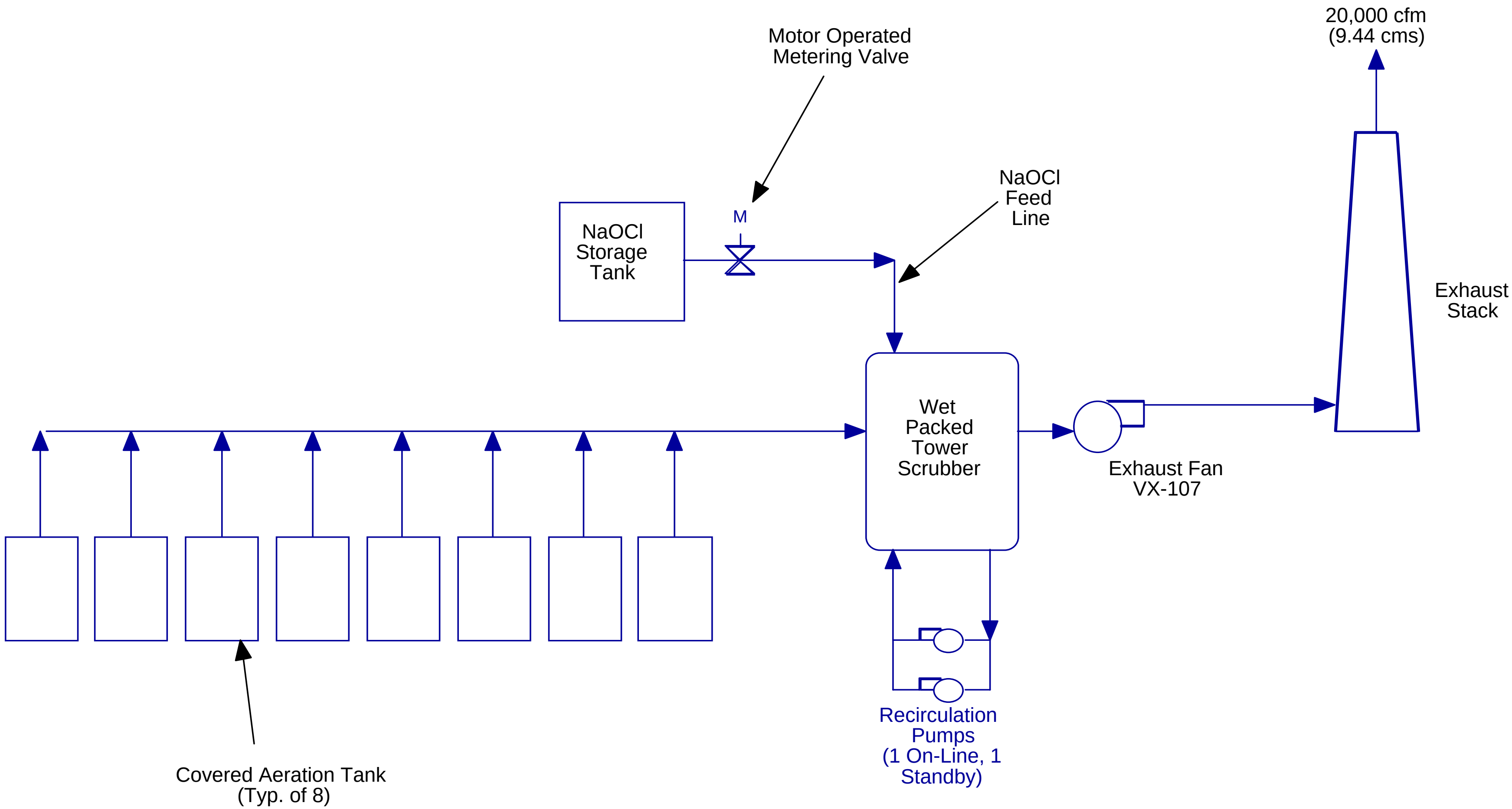

OLD PLANT – AERATION ODOUR CONTROL SCHEMATIC

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SECONDARY CLARIFIERS

- New and Old Plant secondary clarifiers similarly arranged (square, centre feed units with circular collector mechanisms); New Plant units significantly larger than Old Plant units
- Secondary clarifiers lowest rated odour sources, representing approximately 1% of total plant emission
- Characteristic odour typically not offensive, and has very high odour threshold
- Very few wastewater treatment plants cover and/or treat air from secondary clarifier unit process

INCINERATOR COMPLEX

- Numerous supply and exhaust fans
- Sludge treatment side decommissioned and not considered
- Two multiple hearth incinerators to accommodate HCTP sludge production
- City of Toronto currently conducting "Biosolids and Residuals Master Plan" (determine most appropriate future strategy for biosolids handling and disposal at wastewater treatment facilities)
- If incineration is selected method of disposal at HCTP, likely that multiple hearth incinerators would be replaced with fluidized bed incinerator units
- Incinerator complex large, open structure with multiple levels above and below grade

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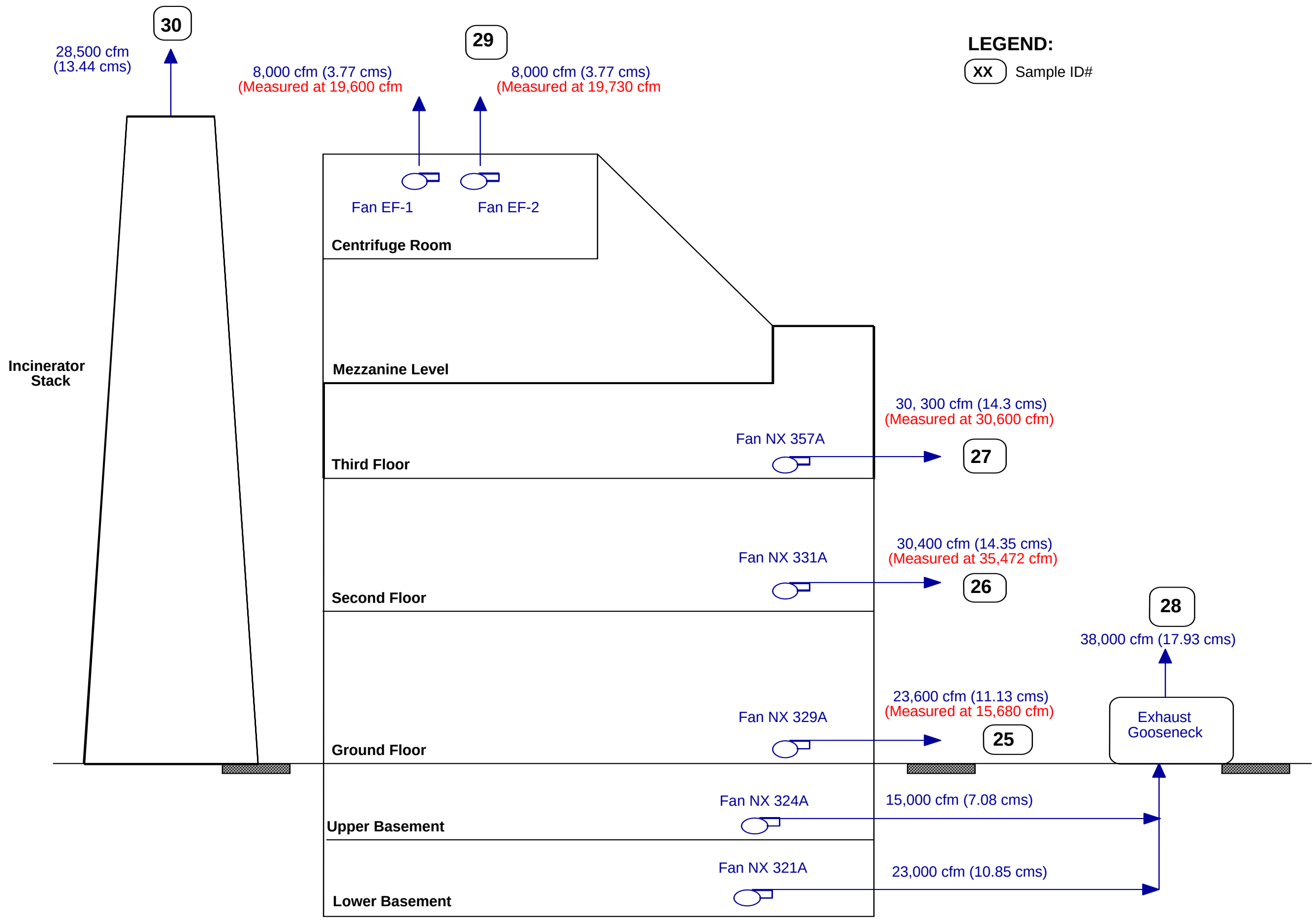

INCINERATOR FACILITY ODOUR CONTROL SCHEMATIC

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DIGESTER COMPLEX

- Digester complex located at west edge of HCTP
- Facility not fully functional and not operating in steady-state conditions during sampling phases; not included for monitoring or evaluation
- Ultimate fate of Digester complex may be impacted by results of “Biosolids and Residuals Master Plan”

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DISPERSION MODELLING

- Odour sources at HCTP identified and samples taken during two rounds
- Odour threshold values determined by sampling techniques
- Mass emission rates determined based on odour threshold values and source emission rates
- Background/existing conditions at HCTP determined by modelling
- Facility drawings, source schematics, property boundary, building heights, source exhaust parameters used in model development
- Air quality model: CALPUFF and meteorological module: CALMET used to predict off-site odour impacts surrounding HCTP
- Community odour survey compared to modelling results as verification

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Receptor Type	Receptor Description
Complaint	94 Meadowvale Rd
Complaint	22 Meadowvale Rd
Complaint	565 and 568 Coronation Dr
Complaint	6 Dunwatson Dr
Complaint	10 Tesson Place
Complaint	184 and 186 Beach Grove
Complaint	20 Satok
Complaint	18 Peppertree Dr
Complaint	26 Segan Dr
Complaint	45 Janellan
Representative COS	Holmcrest Tr. and Lawrence/Cherryhill
Representative COS	Bathgate Dr
Representative COS	Centennial Dr/Haviland
Representative COS	Centennial Dr/Cherrydale

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Summary of Exceedences at 11 Receptors – Background Conditions

Receptor Type	Max 1 hr Conc (odour units)	Max 10 min Conc (odour units) [1]	Exceedences >5 OU 10-min [2]	Exceedences >1 OU 10-min [3]
Trail receptor	302	499	1347	2059
94 Meadowvale Rd	11	19	74	384
22 Meadowvale Rd	15	24	98	490
565 and 568 Coronation Dr	25	41	212	889
6 Dunwatson Dr	15	24	98	490
10 Tesson Place	20	32	120	587
184 and 186 Beach Grove	25	41	212	889
20 Satok	45	75	602	1310
18 Peppertree Dr	28	45	258	985
26 Segan Dr	5	9	11	202
45 Janellan	45	75	602	1310
Total			**5438**	**11767**

Notes:

[1] 1 hr concentrations to 10 minute concentration conversion factor of 1.65.

[2] Exceedence threshold of 5 OU 10-min or 3 OU 1-hr.

[3] Exceedence threshold of 1 OU 10-min or 0.6 OU 1-hr.

ODOUR CONTROL ALTERNATIVES

- HCTP is undergoing several unit process upgrades; “Facility Forecast” and “Biosolids and Residuals Master Plan” will impact odour generating conditions moving forward
- Suggested that odour control upgrades be considered in two phases:
  - Treat highest odour sources first
  - Treat odour sources least likely to be changed as result of “Facility Forecast” and “Biosolids Residual Master Plan”
  - Quantify impact of Phase I improvements after construction and commissioning, and consider before committing to expense of Phase II improvements
- Major decisions concerning sludge handling and disposal that could impact the Incinerator Complex and Digester Complex can be made prior to implementing odour controls

PHASE I ODOUR CONTROLS

- Highest odour sources
- Combination of process optimization recommendations to reduce odour and need for new odour control systems
- Facilities with lowest potential to be substantially modified by planned capital improvement projects
- Headworks Facility, Primary Clarifiers, Aeration Tanks currently comprise approximately 90% of total HCTP odour emission

HCTP Plant Wide Odour Control Assessment

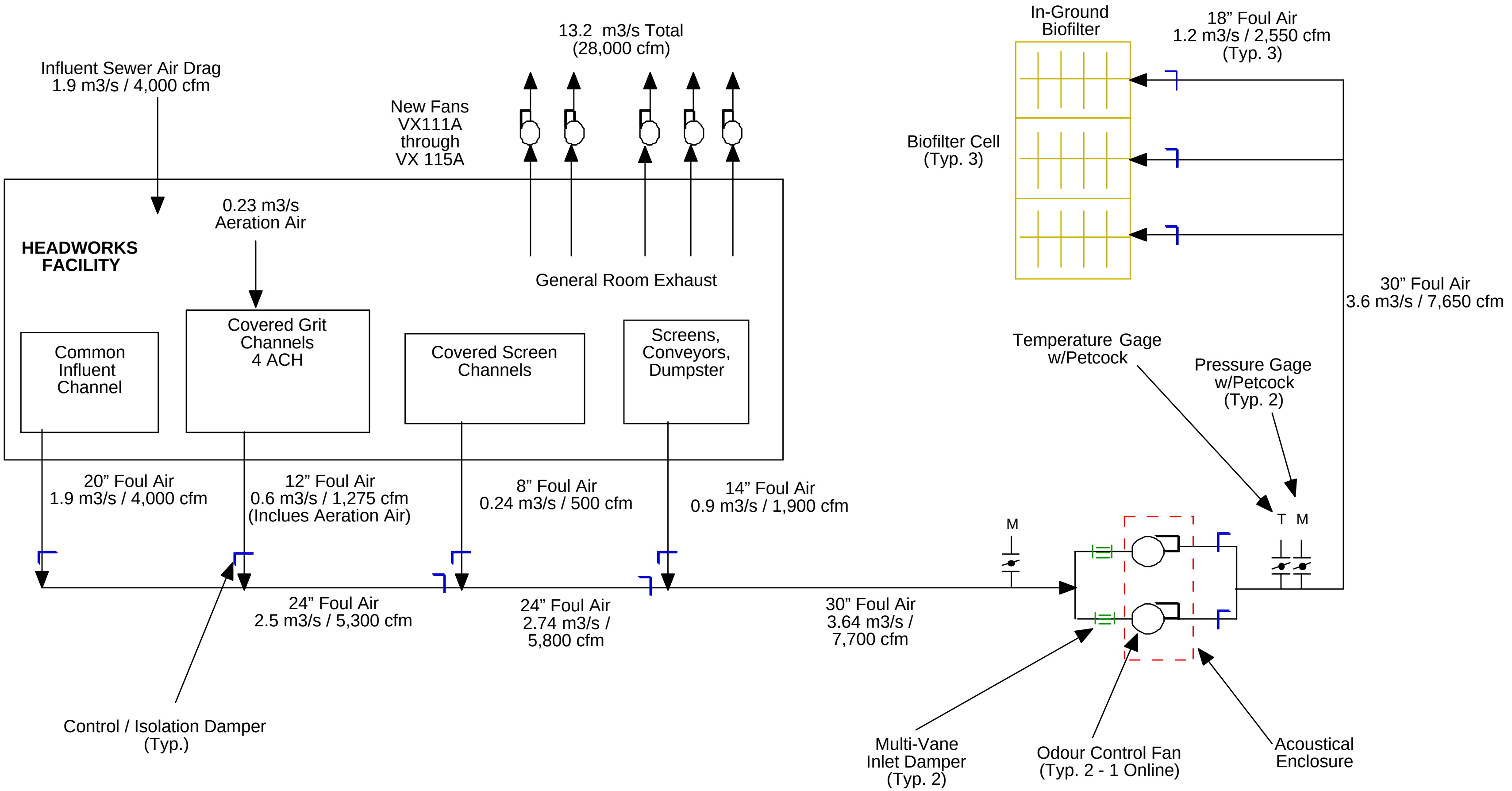
HEADWORKS FACILITY

- Second ranked odour source at HCTP, approximately 38% of total plant emission
- Most significant item: ability to keep removable fiberglass covers on aerated grit channels
- Essential that process problems with plugging of aerated grit channels be resolved, allowing fiberglass covers to remain in place (considered and addressed in "Facility Forecast")
- Additional process optimization steps to reduce odour emissions from Headworks Facility:
  - Introduce covered storage bin for grit and screenings
  - Better housekeeping around grit classifier/cyclone degritter area
  - Replace existing floor exhaust ventilator units; maintain differential pressure relative to covered wastewater channels; keep all doors closed to maintain facility balance

PROPOSED ODOUR CONTROL SYSTEM

- Treat air from covered unit processes only, with operating room air space vented to atmosphere without treatment
- Existing stainless steel ductwork within building reused to convey air to exterior wall and connect to new odour control duct routed to new odour control system
- New exhaust ductwork connections needed to common influent channel covers (channel currently not ventilated)
- Air from covered Headworks Facility processes expected to contain moderate concentrations of hydrogen sulphide and volatile organic compounds, as well as have a high relative humidity
- Organic media biofilter using locally available media suggested odour treatment technology

HCTP Plant Wide Odour Control Assessment



HEADWORKS FACILITY ODOUR CONTROL SCHEMATIC

HCTP Plant Wide Odour Control Assessment

PRIMARY CLARIFIERS

- Fourth ranked odour source at HCTP, approximately 4.5% of total plant emission
- Experience and sampling indicate that approximately 90% of total primary clarifier odour emission originates from scum collection and overflow weir areas
  - Suggested that only the highly odourous areas be covered in Phase I, and settling zone (less than 0.5% of total plant odour emission) be left uncovered
  - Covering the entire settling zone would present challenges:
    - Odour control system size
    - Enclosure type (either building style enclosure over traveling bridge mechanism, or flat covers over retrofitted channel with chain-and-flight collector mechanisms)
    - Electrical classification of new enclosed space

HCTP Plant Wide Odour Control Assessment

PROPOSED ODOUR CONTROL SYSTEM

- Install corrosion resistant covers (e.g., fiberglass or aluminum)
  - Scum collection and overflow weirs of rectangular channels in New Plant
  - Effluent weirs only of square units in Old Plant
  - Arrangement will not interfere with sludge withdrawal mechanisms on either set of primary clarifiers; no impact on area classification
- Maintain negative pressure in covered portion of primary clarifiers
- Air from covered Primary Clarifier processes expected to contain hydrogen sulphide and volatile organic compounds, as well as have a high relative humidity
- Due to nature of expected air streams and proximity to aeration channels, suggested that air streams be combined and treated in single biofilter unit

CORROSION PROTECTION

- Up to 5 cm of concrete loss visible
  - Process optimization steps expected to reduce sulphide generation in primary clarifiers and hydrogen sulphide release in effluent channels (but not below corrosion threshold)
  - Suggested that effluent channels be rehabilitated immediately, as there could be exposed reinforcing steel and structural integrity is a concern
  - Properly installed coating system should have life expectancy of approximately 5 to 7 years; PVC lining system should last at least 25 years, and possibly longer
  - Coatings have lower initial capital cost, but life-cycle costs indicate worth installing PVC sheet lining system to rehabilitate concrete channels

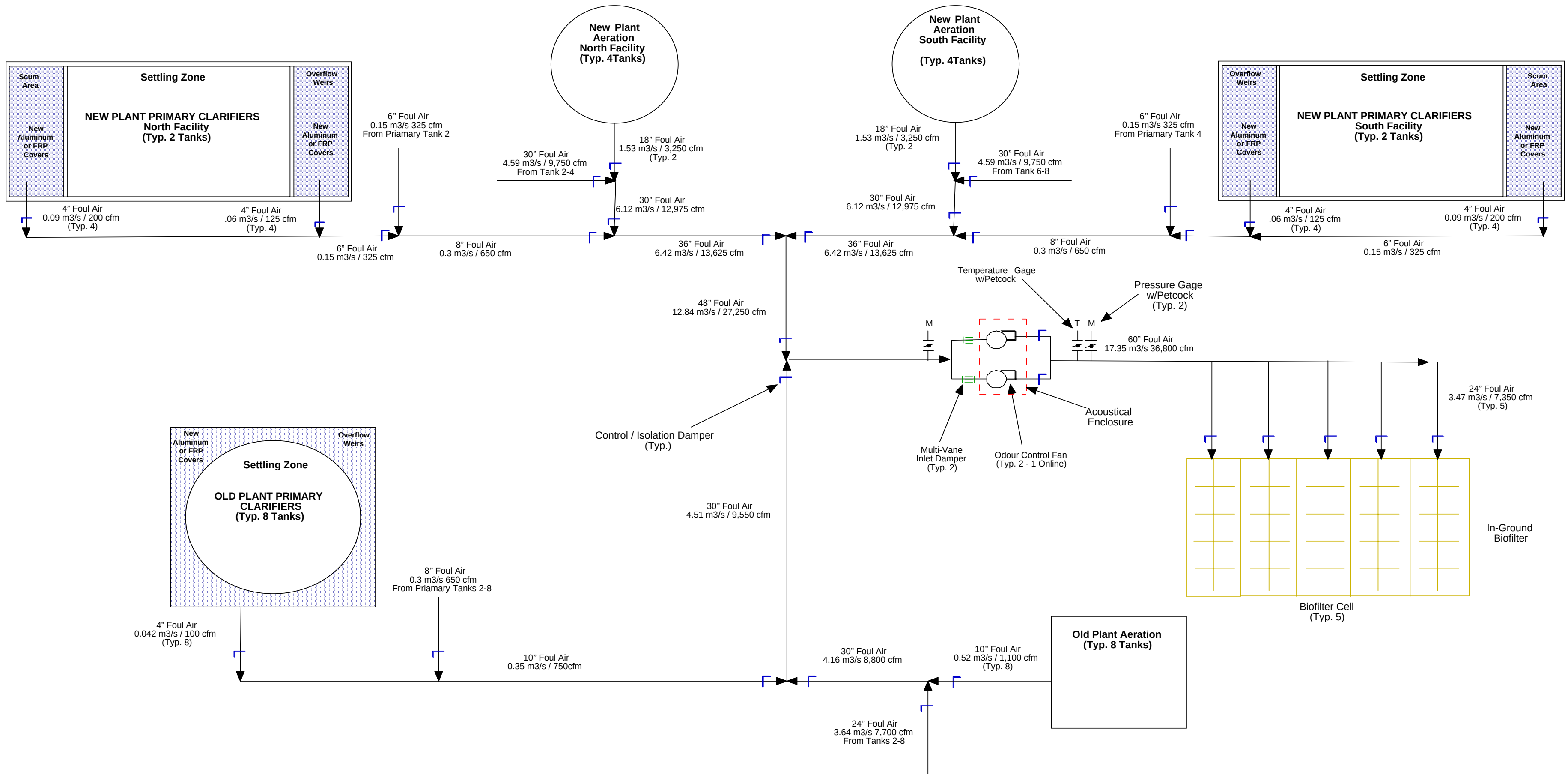
AERATION TANKS

- Highest ranked odour source at HCTP, approximately 42.5% of total plant emission
- Existing wet packed tower scrubbers not operated efficiently, and not most applicable odour treatment technology for this source (sodium hypochlorite used in some scrubbers actually creating odours relative to adjacent scrubbers operated only with water)
- Eight aeration tanks in each of New and Old Plants, all covered by flat concrete slabs or buildings

PROPOSED ODOUR CONTROL SYSTEM

- Maintain negative pressure in existing aeration tank enclosures by ventilating spaces at 110% of peak aeration rate
- Collect and treat all air in new odour control system
- Due to expected nature of air streams and proximity to primary clarifiers, suggested that air streams be combined and treated in single biofilter unit

HCTP Plant Wide Odour Control Assessment



PRIMARY CLARIFIER/AERATION FACILITY ODOUR CONTROL SCHEMATIC

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HCTP Plant Wide Odour Control Assessment

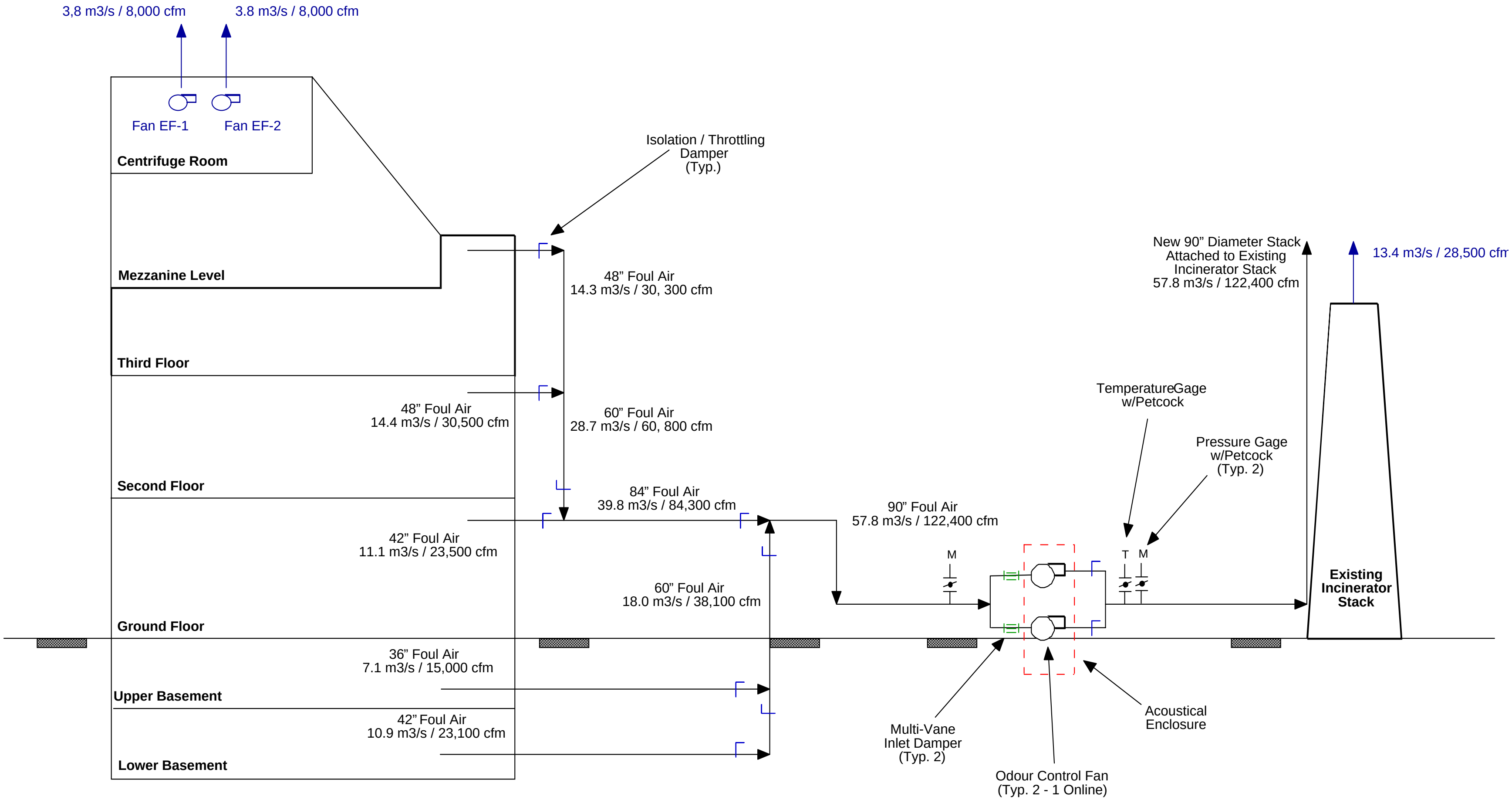
INCINERATOR COMPLEX

- Third highest ranked odour source at HCTP, approximately 11% of total plant emission
- Four main odour sources: (1) incinerator stack, (2) five general room exhausts, (3) centrifuge room exhaust, (4) ash lagoons
- Dispersion modelling results indicated that general room exhausts releasing untreated air on north and east sides of building have largest impact on nearby receptors (e.g., trail receptor at south plant boundary)
- Ash lagoons also contribute to trail receptor, but impact is lower as total emissions are less
  - Cost and logistics to treat odours from ash lagoons would be significant
- Incinerator complex could be impacted by “Biosolids and Residuals Master Plan”

PROPOSED ODOUR CONTROL SYSTEM

- Collect and disperse five general room exhausts, rather than treat them:
  - Significant volume (approximately 57.7 cms) would require treatment
  - Little or no room south of the railroad tracks for a treatment facility; air would have to be routed to the plant north of the railroad
  - Odour detection threshold is low
- Remove five existing general room exhaust fans, and replace with two new coated steel centrifugal fan units located adjacent to existing incinerator stack
- Exhausts from five levels manifolded together and routed to new fans
- Fans would discharge to new 2300 mm diameter exhaust stack mounted to existing incinerator stack

HCTP Plant Wide Odour Control Assessment



INCINERATOR COMPLEX ODOUR CONTROL SCHEMATIC

TORONTO

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ODOUR REDUCTION IMPACT

- Suggested Phase I odour control measures modelled using CALPUFF model developed for background conditions
- Results show significant reduction of odours within community
  - 89% reduction in number of exceedences greater than 1 odour unit
  - 96% reduction in number of exceedences greater than 5 odour units
  - peak 10 minute odour threshold dropped from 499 odour units to 16 odour units
- Phase I modelling assumed that biofilters would be an odour source, with odour detection threshold at 350 odour units
- As this was considered without odour character, biofilters and secondary clarifiers ended up being most significant remaining odour sources

HCTP Plant Wide Odour Control Assessment

Phase I Mitigation Results

Receptor Type	Background Condition		Phase I Improvements	
	Max. 1hr. Conc. (ou)	Max. 10 min. Conc.	Max. 1hr. Conc. (ou)	Max. 10 min. Conc.
Trail receptor	302	499	10	16
94 Meadowvale Rd	11	19	1	1
22 Meadowvale Rd	15	24	1	2
565 and 568 Coronation Dr	25	41	1	2
6 Dunwatson Dr	15	24	1	2
10 Tesson Place	20	32	2	4
184 and 186 Beach Grove	25	41	1	2
20 Satok	45	75	5	8
18 Peppertree Dr	28	45	1	2
26 Segan Dr	5	9	1	1
45 Janellan	45	75	5	8

HCTP Plant Wide Odour Control Assessment

Odour Sources at Trail Receptor for Phase I Mitigation

Ranking	Source Group	Max 1 hr Conc (odour units)	Max 10 min Conc (odour units)	Contribution (%)
-	ALL	10	16	100%
1	APBIO	4	6	36%
2	SEC	2	4	23%
3	INBC	1	2	14%
4	NPP	1	2	13%
5	OPP	1	1	7%
6	HWBIO	1	1	6%
7	HWS	0	0	0%

Notes:

INBC = Incinerator main stack, new stack, 2 ash lagoons (IAL1-2) and 2 centrifuge room exhausts (EF1-2).

HWS = Headworks general exhaust stacks (111-115).

HWBIO = Headworks Biofilter.

APBIO = Aeration and Primary Biofilter.

NPP = New Plant Primaries (settling zone) (NPP P9 to P12

OPP = Old Plant Primaries (settling zone) (OPP P1 to P8).

SEC = New and Old Plant Secondaries (NPS F9 to F16 and OPS F1 to8).

HCTP Plant Wide Odour Control Assessment

- Project Team experience is that well operating biofilters do not cause off-site odour complaints
- Phase I model run likely overstated off-site impact of biofilter exhausts
  - Background odour of well functioning biofilter approximately 200 to 250 odour units, with positive Hedonic Tone (i.e., not offensive) and character description: woodchips or wet leaves
  - As part of other odour assessment projects, City of Toronto took odour measurements of other natural odour sources, found that Lake Ontario had peak odour measurement of 111 odour units and field of uncut grass had peak odour measurement of 105 odour units
  - Obviously, these natural odour sources do not cause complaints; in the Project Team's experience, neither do well operating biofilters
  - Project Team has experience with biofilters installed immediately next to houses, walking paths, other types of receptors – with no odour complaints registered

HCTP Plant Wide Odour Control Assessment

- Suggested Phase I odour control measures modelled again using CALPUFF model developed for background conditions, assuming no odour impacts from biofilters or secondary clarifiers
- Results show significant reduction of odours within community
  - 95% reduction in number of exceedences greater than 1 odour unit
  - 99% reduction in number of exceedences greater than 5 odour units
  - peak 10 minute odour threshold dropped from 499 odour units to 14 odour units
- Trail receptor still has highest off-site odour values

HCTP Plant Wide Odour Control Assessment

Phase I Mitigation Results (Biofilters and Secondaries "No Impact")

Receptor Type	Background Condition		Phase I Improvements	
	Max. 1hr. Conc. (ou)	Max. 10 min. Conc.	Max. 1hr. Conc. (ou)	Max. 10 min. Conc.
Trail receptor	302	499	9	14
94 Meadowvale Rd	11	19	0	1
22 Meadowvale Rd	15	24	1	1
565 and 568 Coronation Dr	25	41	1	1
6 Dunwatson Dr	15	24	1	1
10 Tesson Place	20	32	1	1
184 and 186 Beach Grove	25	41	1	1
20 Satok	45	75	2	3
18 Peppertree Dr	28	45	1	1
26 Segan Dr	5	9	1	1
45 Janellan	45	75	2	3

HCTP Plant Wide Odour Control Assessment

Trail Receptor Odour Sources (Biofilters & Secondaries "No Impact")

Ranking	Source Group	Max 1 hr Conc (odour units)	Max 10 min Conc (odour units)	Contribution (%)
-	ALL	9	14	100%
1	INBC	9	14	100%
2	NPP	0	0	0%
3	OPP	0	0	0%
4	HWS	0	0	0%

Notes:

INBC = Incinerator main stack, new stack, 2 ash lagoons (IAL1-2) and 2 centrifuge room exhausts (EF1-2).

HWS = Headworks general exhaust stacks (111-115).

NPP = New Plant Primaries (settling zone) (NPPC P9 to 12).

OPP = Old Plant Primaries (settling zone) (OPPC P1 to P8).

HCTP Plant Wide Odour Control Assessment

PHASE II ODOUR CONTROLS

- Remaining odour sources and contingency measures from Phase I in attempt to achieve 1 odour unit at nearest receptor
- Remaining odour sources still causing off-site odour impacts generally large area sources with low detection thresholds (i.e., ash lagoons, primary clarifier settling zones)
- Other sources: new biofilters, general room exhausts from Headworks Facility
- Assumed that all new dispersion stacks 65 m tall (maximum height considered by MOE)

HEADWORKS FACILITY

- Remaining odour source: general room exhausts
- Under Phase I, process optimization improvements alone expected to substantially reduce odour emissions from general room exhaust stacks
- If recommended improvements do not reduce odours to projected levels and/or are shown to contribute to off-site odour complaints, then they should be treated
- Source is low odour concentration tempered air stream with low relative humidity
- Decommission existing general room exhaust fans and venturi exhaust stacks
- Install two new centrifugal fans and carbon beds located to north of Headworks Facility

CONTINGENCY MEASURES

- Project Team experience is that well operating biofilters do not cause off-site odour complaints
- If biofilter is found to contribute to off-site odours after Phase I improvements have been incorporated, then unit would be retrofitted with perimeter concrete footings and removable flat aluminum cover, new biofilter exhaust dispersion fans installed, and exhaust routed to new 2300 mm diameter, 65 metre tall dispersion stack

HCTP Plant Wide Odour Control Assessment

PRIMARY CLARIFIERS

- Remaining odour source after Phase I improvements would be settling zones of primary clarifiers
- Large area source with low mass emission, occupying more than 80% of tank area
- Cost and complexity of treating odour would be high
- Two potential alternatives:
  - Alternative 1: Retrofit New Plant primary clarifiers to chain-and-flight style collector mechanisms, provide low-profile aluminum covers over settling zones; provide aluminum covers over Old Plant primary clarifiers; exhaust air from below covers for treatment in aeration/primary clarifier biofilter
  - Alternative 2: Construct building over New Plant primary clarifiers, provide aluminum covers over Old Plant primary clarifiers, exhaust air from building and below covers for treatment in aeration/primary clarifier biofilter

HCTP Plant Wide Odour Control Assessment

INCINERATOR COMPLEX

- "Biosolids and Residuals Master Plan" may have significant impacts on Incinerator Complex:
  - Potentially abandonment in favour of other means of sludge disposal
  - Replacement of multiple hearth incinerators with fluidized bed units (experience indicates approximately 50% air volume emitted, approximately 90% reduction in odourous emissions)
- Either option would impact odour emissions from the Incinerator Complex
- Fluidized bed incinerators would improve odour emissions, but dispersion modelling indicated that the existing incinerator stack was not a significant problem
- Phase II focus:
  - Ash lagoons
  - Centrifuge room exhaust

HCTP Plant Wide Odour Control Assessment

ASH LAGOONS:

- Very low odour detection threshold with low mass emission
- Closest unit process to trail receptor
- Lagoons operated in alternating pattern (i.e., one lagoon used to settle ash, second lagoon being drained and cleaned)
- Mitigate potential for odour complaints by covering lagoons, ventilate beneath covers to maintain negative pressure, discharge exhaust through new stack
- Project Team unaware of any ash lagoons that have been covered
- Each ash lagoon 30 metres x 150 metres; cover each lagoon separately with overhead truss-type flat roof system; concrete perimeter wall and possibly concrete piers or centre wall for support
- Cover system removable to accommodate periodic maintenance and ash removal
- Air discharged through new 2300 mm diameter, 65 metre tall dispersion stack adjacent to lagoons

HCTP Plant Wide Odour Control Assessment

TORONTO

AWS Engineers & Planners Corp.

ODOUR REDUCTION IMPACT

- Suggested Phase II odour control measures modelled using CALPUFF model developed for background conditions
- Results show reduction of odours within community
  - 98% reduction in number of exceedences greater than 1 odour unit
  - Objective of 1 odour unit not achieved, despite extreme measures to cover, treat and disperse remaining odour emissions

HCTP Plant Wide Odour Control Assessment

Phase II Mitigation Results

Receptor Type	Max 1 hr Conc (odour units)	Max 10 min Conc (odour units)	Number of Exceedences greater than 1 OU 10-min
Trail receptor	3	4	193
94 Meadowvale Rd	0	1	0
22 Meadowvale Rd	1	1	0
565 and 568 Coronation Dr	1	1	1
6 Dunwatson Dr	1	1	0
10 Tesson Place	1	1	1
184 and 186 Beach Grove	1	1	1
20 Satok	1	2	19
18 Peppertree Dr	1	1	1
26 Segan Dr	1	1	1
45 Janellan	1	2	19
Total			**236**
% Reduction vs. Background			**98%**

- Source of remaining odours from modelling determined to be secondary clarifiers; emissions from these tanks eliminated from modelling as secondary clarifiers not deemed to be offensive odour source (e.g., not considered in Ashbridges Bay Treatment Plant odour study)

HCTP Plant Wide Odour Control Assessment

Phase II Mitigation with No Emissions from Secondaries

Receptor Type	Max 1 hr Conc (odour units)	Max 10 min Conc (odour units)	Number of Exceedences greater than 1 OU 10-min
Trail receptor	1	1	1
94 Meadowvale Rd	0	1	0
22 Meadowvale Rd	0	1	0
565 and 568 Coronation Dr	1	1	0
6 Dunwatson Dr	0	1	0
10 Tesson Place	0	1	0
184 and 186 Beach Grove	1	1	0
20 Satok	1	1	4
18 Peppertree Dr	1	1	0
26 Segan Dr	1	1	1
45 Janellan	1	1	4
Total			**10**
% Reduction vs. Background			**99.9%**

- Off-site objective of 1 odour unit virtually achieved by not considering impact of secondary clarifiers

SUMMARY

- Several capital projects ongoing at HCTP to increase treatment efficiency
- "Facility Forecast" and "Biosolids and Residuals Master Plan" being prepared, and could substantially alter some of the most significant odour sources at HCTP
- Odour control systems are currently used at HCTP, but are either old or misapplied treatment technologies for particular source and type of odour
- Odour dispersion modelling of existing conditions indicated fairly significant off-site odour impact in community, with 9,595 exceedences of 1 odour unit and 3,634 exceedences of 5 odour units per year
- Maximum predicted existing condition off-site odour impact was 499 odour units at the trail receptor on the south plant boundary
- Odour control measures, including optimization of existing wastewater treatment systems and new odour control systems, are required in order to reduce off-site impact substantially

HCTP Plant Wide Odour Control Assessment

- Two phased approach is suggested in order to contain and treat odours generated at HCTP:
  - Phase I – install some odour control systems for the Headworks, Primary Clarifiers, Aeration Tanks, and Incinerator Complex exhaust
  - Phase II – additional measures considered after Phase I constructed and operational, and further monitoring performed to assess level of odour reduction achieved

PHASE I

- Mixture of wastewater process improvement recommendations and new facilities to mitigate odours from highest odour emitting sources at HCTP
- Suggested Phase I improvements would achieve 90% reduction in off-site odour exceedences at 11 sensitive receptors

PHASE II

- Suggested Phase II improvements focus on remaining odour sources at HCTP and contingency measures, after Phase I improvements implemented
- Phase II odour control technologies would be considered once impact of Phase I improvements quantified, and recommendations and implementation of “Facility Forecast” and “Biosolids and Residuals Master Plan” have been realized
- Primary clarifiers will have been operated with lower sludge blanket depths once processing constrictions corrected
- Suggested Phase II improvements would virtually achieve goal of 1 odour unit at 11 sensitive receptors, but only if secondary clarifiers are assumed not to be an offensive odour source

Questions?