

WASTEWATER TREATMENT SYSTEMS

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2021 R8PA CONFERENCE SUMMARY - ASSUMPTIONS

- THE HOSPITALITY SUITE WAS THE ONLY PLACE WHERE FOLKS ACTUALLY LEARNED SOMETHING THIS WEEK
- SPENCER HAS NOT SLEPT SINCE LAST SATURDAY...AND LOOKS THE PART
- NANCY DRANK THE STATE OF WYOMING OUT OF MICHELOB ULTRA
- DEAN CAUGHT EVERY WALLEYE IN THE STATE OF NORTH DAKOTA AND HAS PICS
- CURT CHEATED...I MEAN WON THE POKER TOURNAMENT HE ORGANIZED
- SCOTT PARTICIPATED DURING THE DAY BUT SECRETLY WORKED ON THE AMALGAM RULE IN HIS ROOM FOR THE PAST 3 DAYS
- AL ARRANGED A MOUNTAIN BIKE RIDE THAT WAS WAY TOO FAR AND TALKED ABOUT HOW HE CAN STILL TAKE ME IN A GAME OF ONE-ON-ONE BASKETBALL
- EVERY PERSON IN THE ROOM HAS HAD A GREAT 3 DAYS OF LEARNING AND NETWORKING

LAGOONS

- MOST BASIC FORM OF WASTEWATER TREATMENT – LITERALLY A HOLE IN THE GROUND TO COLLECT SEWAGE
- HOW DO THEY WORK:
 - SEWAGE FLOWS FROM COLLECTION SYSTEM TO THE LAGOON FOR TREATMENT – USUALLY BOD & TSS REMOVAL
 - ALGAE – BYPRODUCT OF PHOTOSYNTHESIS IS OXYGEN
 - WIND AND RAIN PRODUCE OXYGEN
 - BOD REMOVED BY OXYGEN – TSS REMOVED BY DETENTION TIME IN LAGOON
 - BUGS IN SLUDGE REDUCE WASTE FURTHER

LAGOONS

- CAN BE AERATED OR NON-AERATED DEPENDING ON THE PERMIT LIMITS
- NUMEROUS TYPES OF LAGOON SYSTEMS
 - PRIMARY, POLISHING, ETC.
- CHEMICAL ADDITION
 - PH ADJUSTMENT
 - OFTEN CARBON LIMITED
 - NOT ENOUGH BOD TO FEED BUGS
- TYPICALLY NEED TO REPORT:
 - FLOW – INFLUENT AND EFFLUENT
 - PH AND TEMPERATURE
 - BOD
 - TSS
 - AMMONIA
 - CHLORINE RESIDUAL - TOTAL

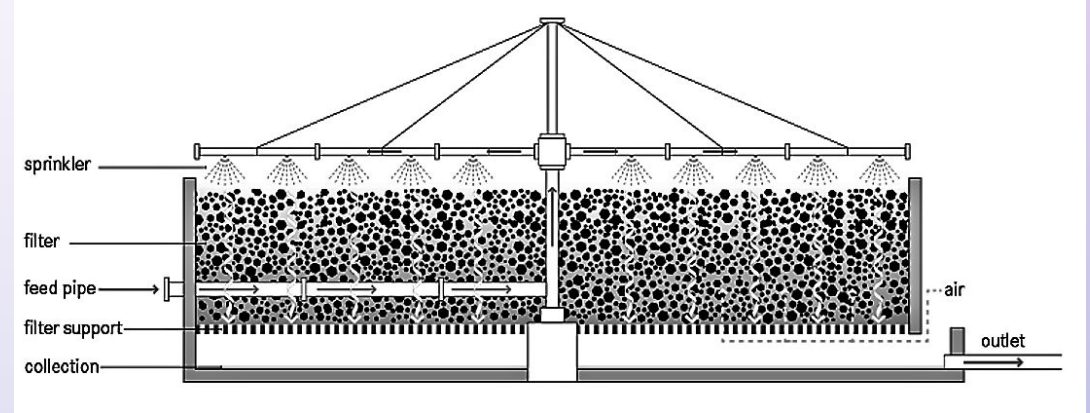
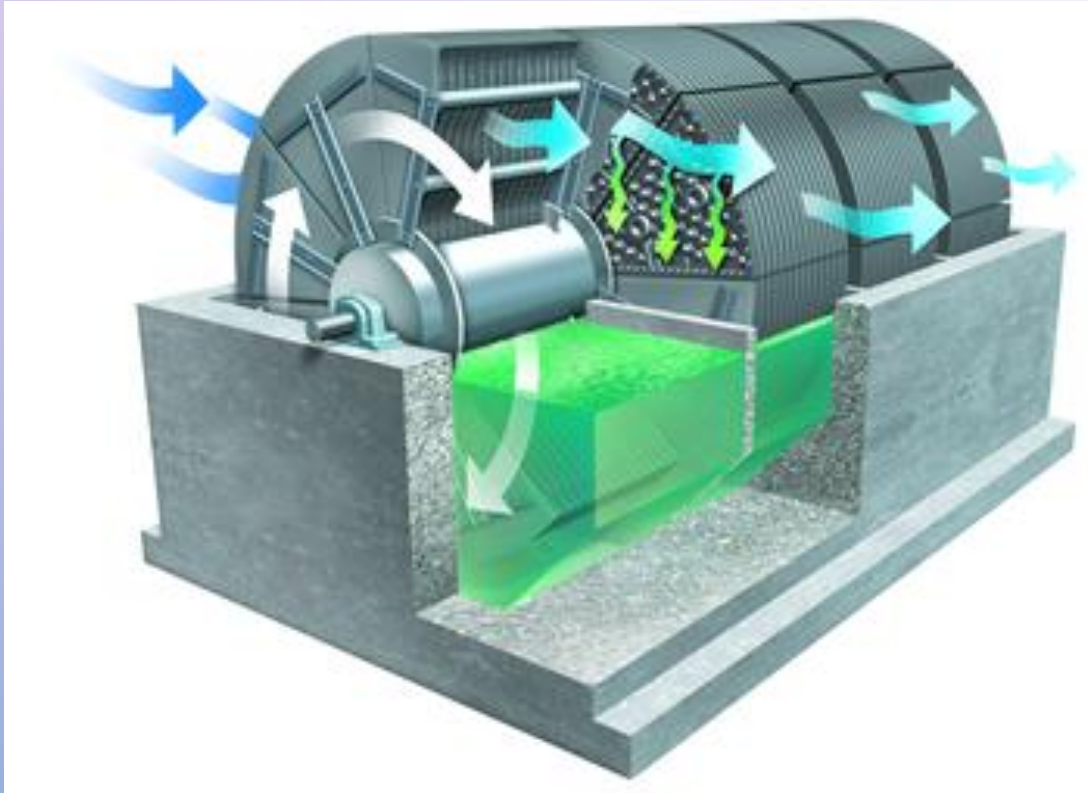
LARGE & SMALL LAGOONS



ROTATING BIOLOGICAL CONTACTORS & TRICKLING FILTERS

- RBC'S AND TRICKLING FILTERS ARE ANOTHER TREATMENT SYSTEM YOU MAY SEE
- RBC'S ESSENTIALLY USE A LARGE DISC FOR THE BUGS TO GROW ON AS THE DISC ROTATES THROUGH THE WASTEWATER
- TRICKLING FILTERS USE A ROCK OR SIMILAR MEDIA TO ALLOW THE BUGS TO GROW ON AS WASTEWATER PASSES THROUGH THEM
- THESE ARE EXTREMELY OUTDATED AND ARE NOT EFFICIENT WAYS TO TREAT WASTEWATER...THIS IS THE LAST YOU WILL HEAR OF THEM FOR THIS PRESENTATION!

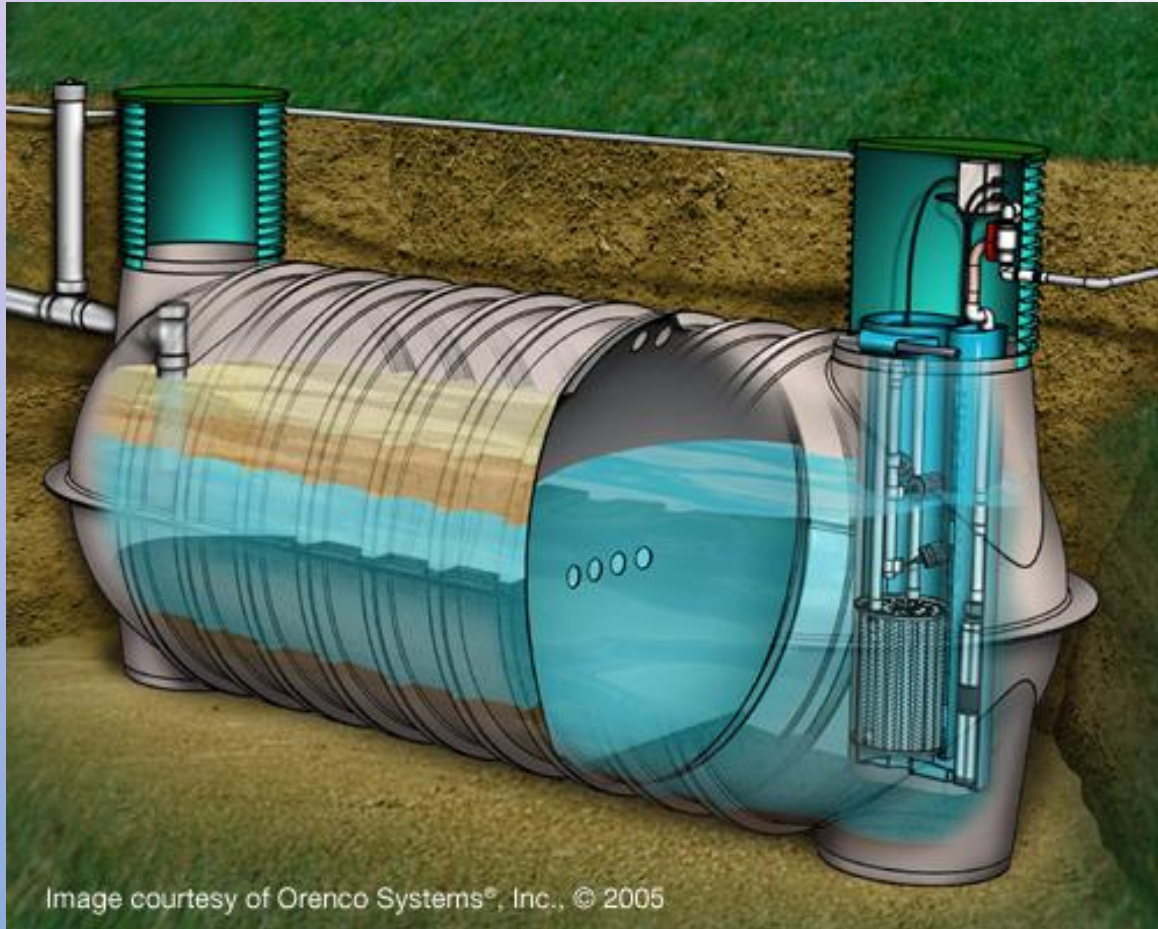
RBC & TRICKLING FILTER



ON-SITE WASTEWATER TREATMENT SYSTEM (OWTS)

- OWTS ARE TYPICALLY INSTALLED AT VERY RURAL AREAS WITH LOW FLOWS AND USUALLY WITHOUT THE SPACE FOR A LAGOON
- SIMILAR TO A SEPTIC TANK
 - MOUNTAIN CAMPGROUNDS, SEASONAL ATTRACTIONS
- FLOW LESS THAN 20,000 GALLONS PER DAY – PERMITTED BY COUNTY (CDPHE REG. 43)
- FLOW GREATER THAN 20,000 GALLONS PER DAY – PERMITTED BY CDPHE
 - PH/TEMP, BOD, TSS, CHLORINE RESIDUAL

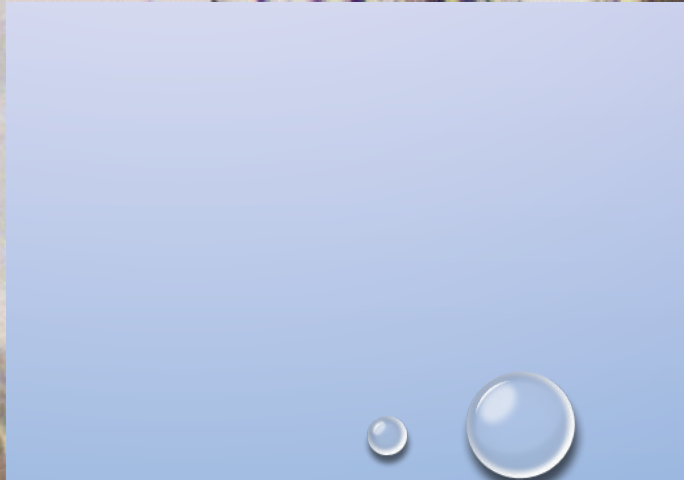
ORENCO SYSTEM



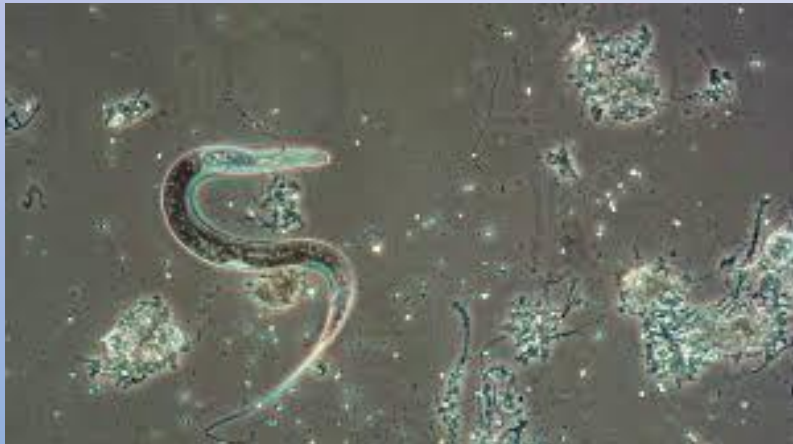
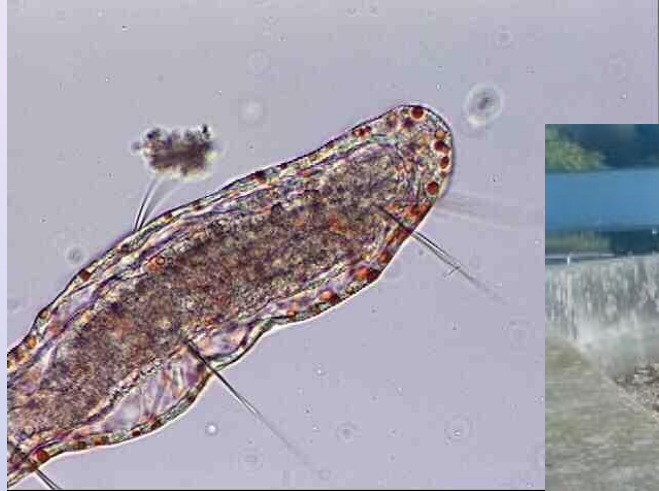
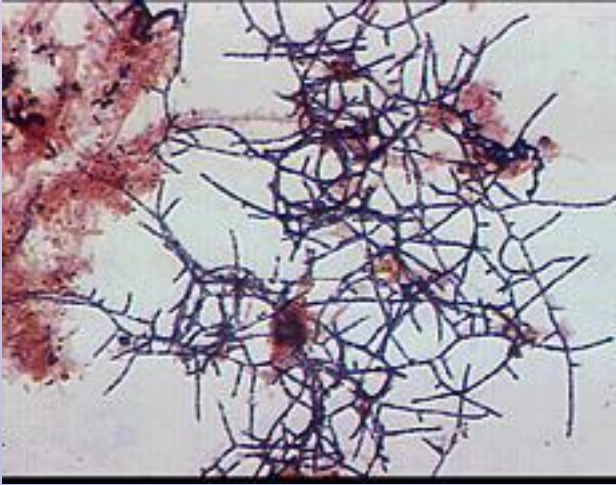
ACTIVATED SLUDGE

- WHAT IS ACTIVATED SLUDGE: SUBSTANCE USED FOR REMOVING POLLUTANTS FROM WASTE WATER BY A BIOLOGICAL REACTION THAT INVOLVES OXYGEN. THE **ACTIVATED SLUDGE** IS THEN SEPARATED FROM THE TREATED WASTEWATER AND DISPOSED OF OR RETURNED TO THE PROCESS AS NEEDED.
- IN SHORT, IT IS THE BUGS “SELECTED” TO TREAT WASTEWATER BASED ON THE DISCHARGE REQUIREMENTS.
- CERTAIN BUGS ARE SELECTED TO COMPLETE SPECIFIC WORK IN THE TREATMENT PROCESS, AND OTHER BUGS ARE INDICATORS OF AN UPSET CONDITION

GOOD WASTEWATER BUGS



BAD WASTEWATER BUGS



THE ACTIVATED SLUDGE TREATMENT SYSTEM

THE BASICS

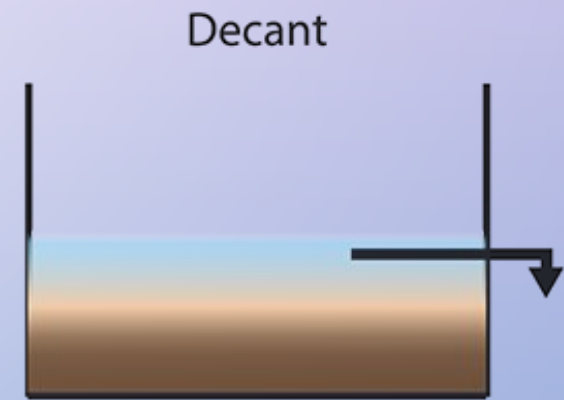
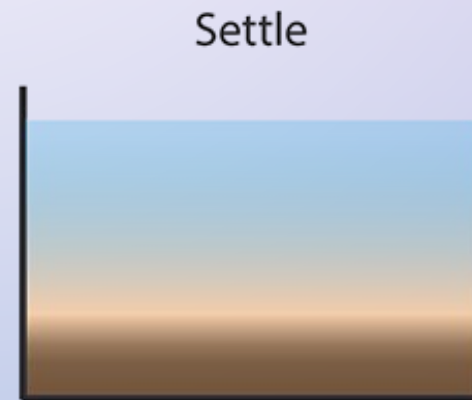
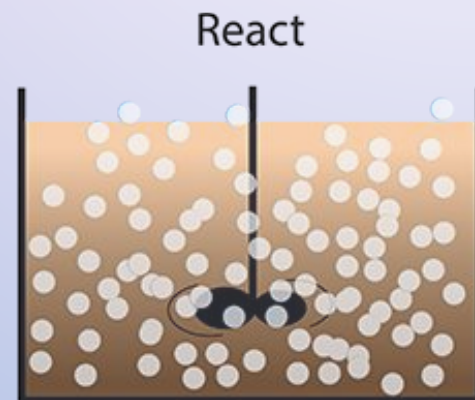
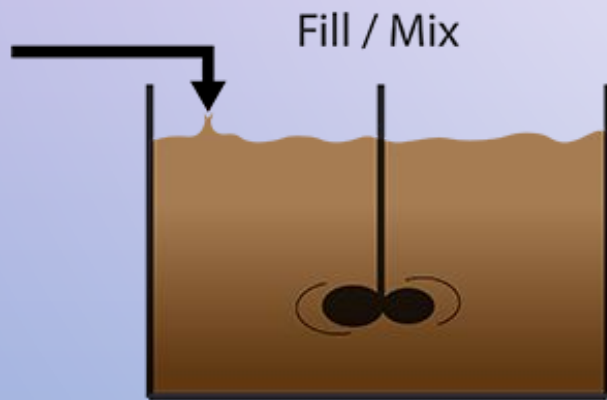
- HEADWORKS – USUALLY A SCREEN TO REMOVE LARGE OBJECTS (WOOD, ROCKS, PLASTICS, LARGE PAPER PRODUCTS) AND GRIT (SAND, STONES, EGG SHELLS)
- REACTOR OR AERATION BASIN – WHERE THE MAGIC HAPPENS! THIS IS WHERE THE INFLUENT COMES IN CONTACT WITH THE ACTIVATED SLUDGE
- CLARIFICATION – SOLIDS (BUGS) ARE SETTLED OUT TO LEAVE A CLEAR WATER
- DISINFECTION – KILL OR STERILIZATION OF VIRUS AND BACTERIA

- LETS START WITH THE SMALLER SYSTEMS

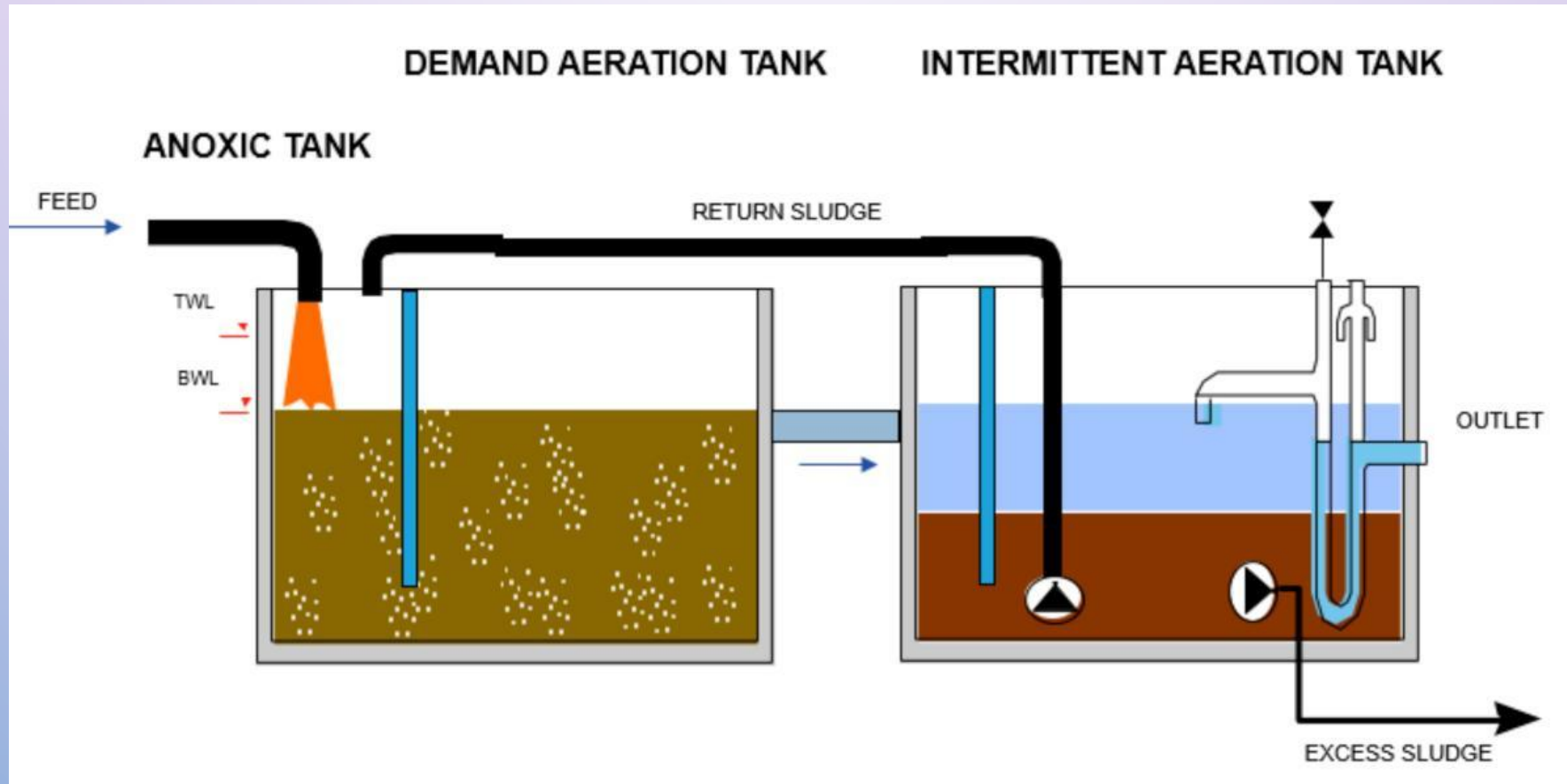
SEQUENCING BATCH REACTORS (SBR'S)

- USUALLY A SMALL TO MEDIUM SIZE FACILITY
- ALL TREATMENT IS COMPLETED IN ONE REACTOR, OR TANK
- FILL...REACT...SETTLE...DECANT – HENCE “SEQUENCING BATCH REACTOR”
- VARIATIONS OF THIS BASED ON DISCHARGE PERMIT LIMITS
- PH/TEMP
- BOD/TSS
- AMMONIA
- E-COLI OR TOTAL COLIFORM
- REGULATION 85/31 – TIN, PHOSPHORUS, TKN, NO₂+NO₃, TN

CONVENTIONAL SBR

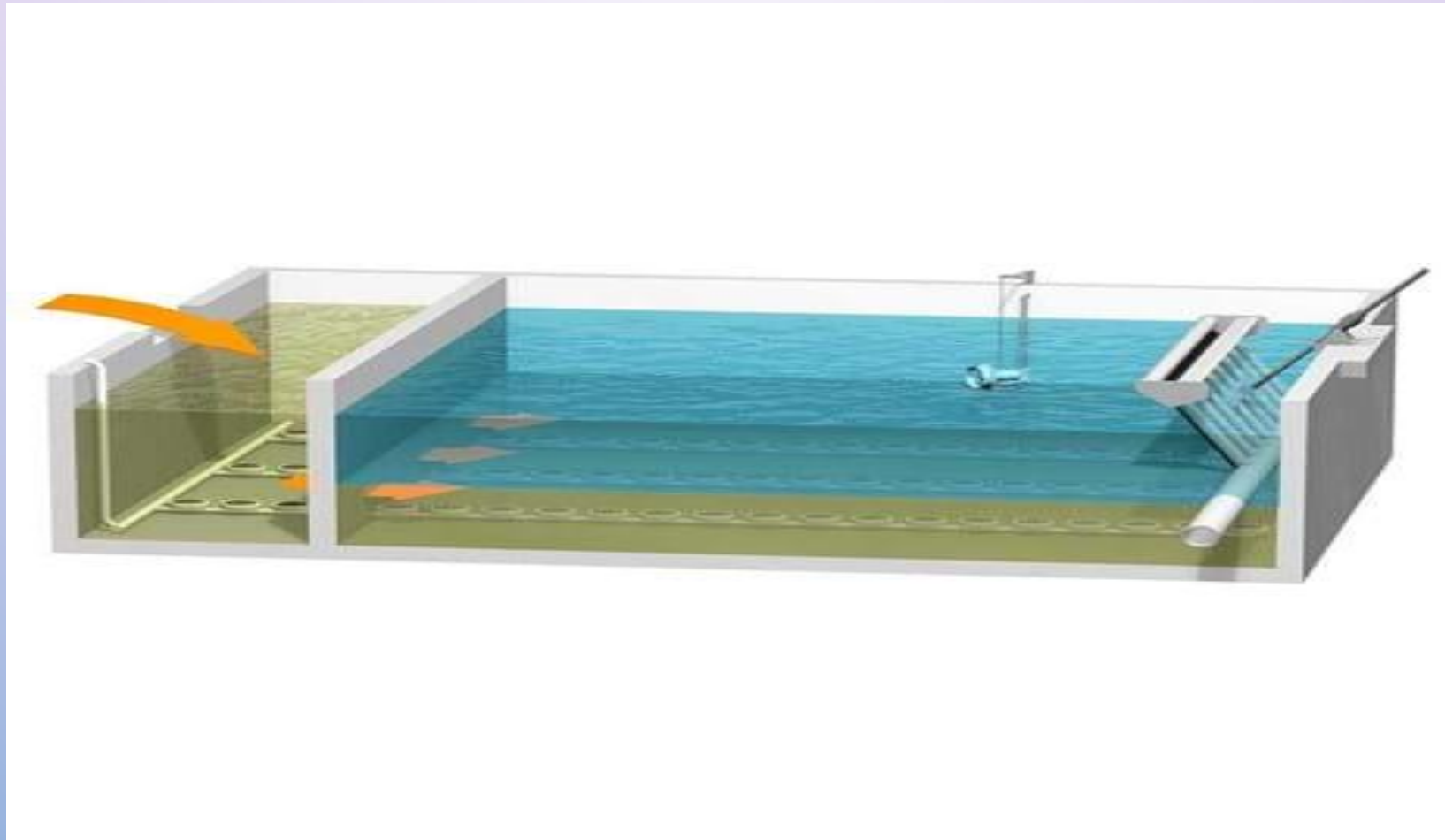


FLUIDYNE SBR



ICEAS SBR

INTERMITTENT CYCLE EXTENDED AERATION SYSTEM



SBR PROCESS CONTROL/REPORTING

- SBR'S DO HAVE OPERATIONAL VARIABLES THAT NEED TO BE MONITORED TO MAINTAIN COMPLIANCE AND SAVE FUNDS!
- DO AND/OR ORP – ONLINE DO/ORP PROBES ARE CRITICAL. DO/ORP WILL BE DETERMINED BY THE OPERATOR. ORP = OXIDATION REDUCTION POTENTIAL (REDOX REACTION)
- PH AND TEMPERATURE – MANY PERMITS ARE GETTING MWAT STANDARDS – ALL HAVE A PH LIMIT. INFLUENT PH USEFUL FOR SLUG LOADS
- AMMONIA – MOST PERMITS HAVE AN AMMONIA LIMIT
- TSS – EFFLUENT LIMIT IN EVERY PERMIT

CONVENTIONAL WASTEWATER TREATMENT

- CONVENTIONAL TREATMENT, OR A MODIFICATION OF, IS THE MOST COMMON FORM OF TREATMENT:
- USUALLY THIS IS YOUR LARGER SYSTEMS – 1 MGD OR LARGER
- CONSISTS OF A SERIES OF TANKS TO COMPLETE THE WASTEWATER TREATMENT PROCESS
- NUMEROUS TYPES OF EQUIPMENT AND VARIATIONS OF EACH TYPE
- NITRIFICATION AND/OR DENITRIFICATION SYSTEMS

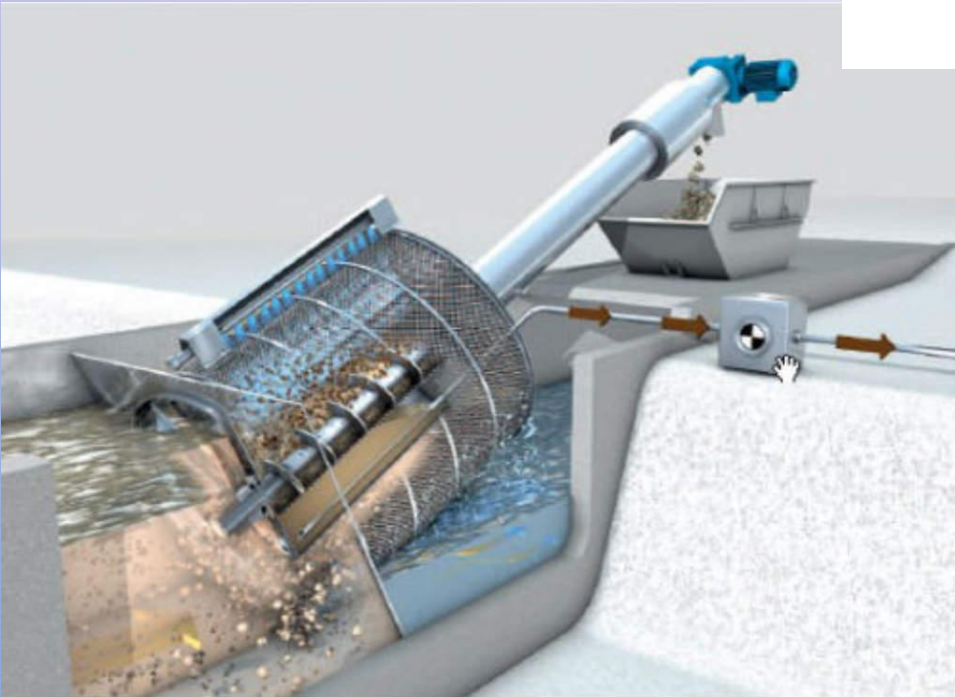
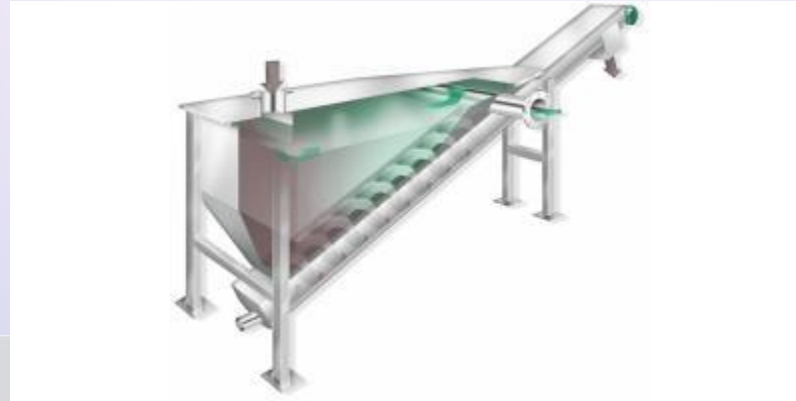
NITRIFICATION

- CONVERSION OF AMMONIUM (NH₄) TO NITRATE (NO₃)
- NH₄ □ NO₂ □ NO₃
- HOW IS THIS DONE? ADDITION OF OXYGEN!
- SOURCES OF AMMONIA?
- SOME FACILITIES MAY ONLY NEED TO NITRIFY – NO NITRATE/TIN LIMITS
- WHY ARE WE CONCERNED WITH NITRATE IN OUR DISCHARGE?
- PROCESS CONTROL FOR NITRIFYING PLANTS IS DO/ORP AND AMMONIA
- BOD AND TSS ARE OF CONCERN AS WELL AND ON THE PERMIT

DENITRIFICATION

- CONVERSION OF NITRATE TO NITROGEN GAS
- $\text{NO}_3 \rightarrow \text{N}_2$
- HOW IS THIS DONE? TURN OFF THE AIR AND ALLOW THE BUGS TO CONSUME THE NO_3
- WHEN BUGS DO NOT HAVE FREE O_2 TO CONSUME, THEY WILL SELECT NO_3 AS A FORM OF FOOD BECAUSE IT IS SOLUBLE (EASY TO GET INTO THE CELL WALL).
- MOST FACILITIES NEED TO NITRIFY AND DENITRIFY TO MEET PERMIT LIMITS
- PROCESS CONTROL FOR NITRIFICATION/DENITRIFICATION SYSTEMS:
 - DO/ORP, PH, TEMP, NO_2 , NO_3 , AMMONIA, BOD, TSS

EQUIPMENT HEADWORKS



HEADWORKS PROCESS CONTROL

- PH AND TEMPERATURE – VERY LOW OR VERY HIGH PH STREAMS WILL INHIBIT DOWNSTREAM PROCESSES
- VERY HOT INFLUENT WILL INHIBIT DOWNSTREAM PROCESSES
- HIGH OR LOW PH AND TEMP. USUALLY INDICATES INDUSTRIAL DISCHARGE
- SOME SYSTEMS HAVE AERATED GRIT SYSTEMS – DO POTENTIALLY
- ONLINE AMMONIA ANALYZERS
- ONLINE TSS ANALYZERS

PRIMARY CLARIFIERS – LARGE FACILITIES

- PRIMARY CLARIFIERS ARE FOUND IN SOME LARGE WASTEWATER TREATMENT FACILITIES
- PRIMARY CLARIFIERS ARE USED TO REMOVE FLOATING AND SETTLEABLE SOLIDS AFTER SCREENING AND GRIT REMOVAL
- PRIMARY CLARIFIERS CAN REDUCE THE INFLUENT BOD AND TSS LOADING TO THE TREATMENT SYSTEM IF OPERATED CORRECTLY
- OFTEN ARE USED AS EQUALIZATION BASINS IF THE FACILITY RECEIVES HIGH FLOWS DURING CERTAIN TIMES
- PROCESS CONTROL IS LIMITED DUE TO THE NATURE OF THE LIQUID AND ENVIRONMENT
 - SLUDGE DEPTH AND SOME LABORATORY WORK COMPLETED ON PRIMARY CLARIFIERS

PRIMARY CLARIFIERS



AERATION BASINS (REACTORS)

- AERATION BASINS, OR REACTORS COME IN MANY DIFFERENT TYPES AND SIZES, DEPENDING ON THE FLOW RATE AND DESIGN.
- THIS IS WHERE THE OXIDATION OF AMMONIA TO NITRATE CONVERSION TAKES PLACE, AND OFTEN TIMES THE DENITRIFICATION FROM NITRATE TO GAS
- MULTIPLE OPERATIONAL DESIGN OPTIONS:
 - EXTENDED AERATION – FLOWS IN AND FLOWS OUT BASED ON HYDRAULIC LOADING
 - STEP FEED – MULTIPLE STAGES WHERE INFLUENT IS INTRODUCED TO THE REACTOR
 - OXIDATION DITCH – ROUND AERATION SYSTEM FOR LONGER DT
 - MANY MORE, THIS IS JUST SOME OF THE COMMON SYSTEMS YOU MAY ENCOUNTER

AERATION BASIN PROCESS CONTROL

- REACTORS ARE WHERE MOST OF THE INSTRUMENTATION WILL LIVE
- SYSTEMS WILL OPERATE THE REACTORS ON DO AND/OR ORP, USUALLY
- NUMEROUS PROBES IN REACTORS IN DIFFERENT LOCATIONS TO ASSURE TREATMENT
- PH/TEMP, TSS, NITRATE, AND PHOSPHORUS ANALYZERS MAY ALSO BE USED
- TRENDING OF THE ANALYZERS ON SCADA IS BECOMING MORE COMMON

EXTENDED AERATION SYSTEM

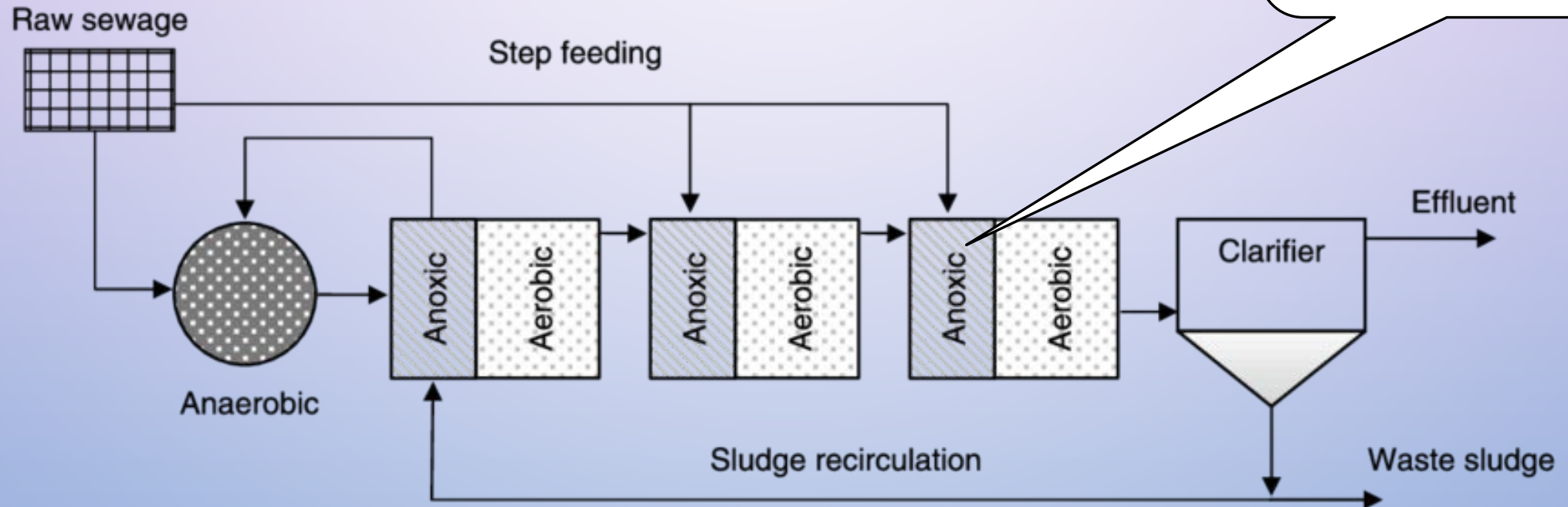
Does the white foam
look normal?

Nitrification System
Only?



STEP FEED SYSTEM

Anoxic – Absent of Free Oxygen, but presence of Nitrate.
Nitrification/Denitrification System?



OXIDATION DITCH – RACE TRACK

Looks like an Oval
Extended Air,
right?

Air On and Off,
PLUS mixing



AERATION

WE KEEP TALKING ABOUT IT, BUT HOW DOES IT WORK?

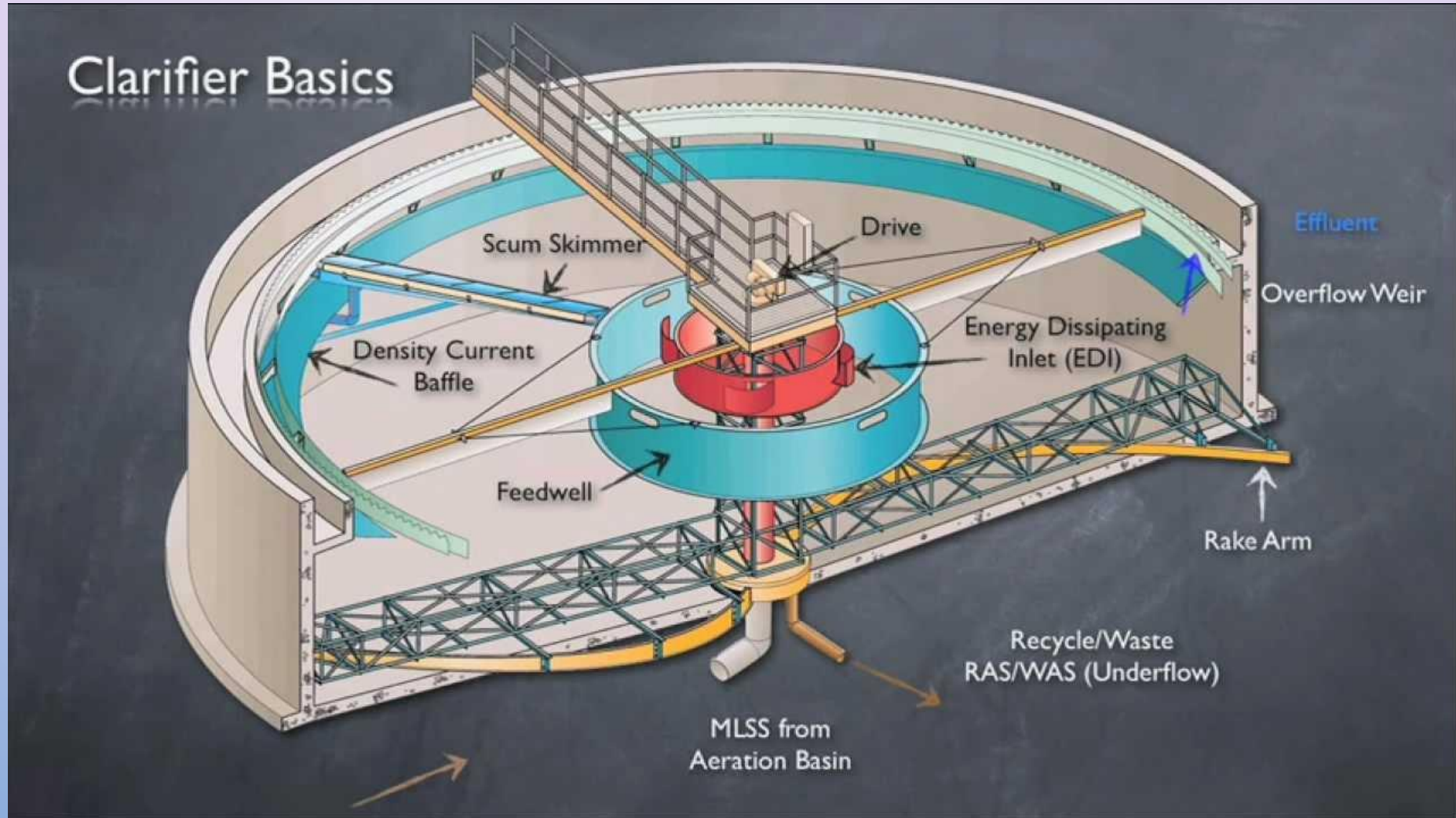
- AERATION IS SUPPLIED TO THE REACTORS IN NUMEROUS WAYS INCLUDING:
- BLOWERS, BRUSHES, JET SYSTEMS, ETC.
- FINE BUBBLE AND COURSE BUBBLE DIFFUSERS



CLARIFIERS

- NOW THAT WE HAVE MADE IT THROUGH THE HEADWORKS AND INTO THE REACTORS, THE WASTEWATER SHOULD BE TREATED, RIGHT?
- WE NEED TO REMOVE THE SOLIDS (BUGS) FROM THE WATER
- THEORETICALLY, WHEN THE FLOW HAS MADE ITS WAY TO THE CLARIFIERS, IT SHOULD BE FREE OF AMMONIA AND NITRATE
 - IF NITRATE IS PRESENT, BULKING COULD OCCUR
 - IF AMMONIA IS PRESENT, VIOLATION OF AMMONIA LIMITS IS LIKELY
- CLARIFIERS ACT AS A SLOW SPOT IN THE ROAD TO DISINFECTION
- THE MIXED LIQUOR SUSPENDED SOLIDS (MLSS) IS CONVEYED TO THE CLARIFIERS AND ALLOWED TO SETTLE OUT, LEAVING CLEAR LIQUID TO FLOW TO DISINFECTION

CLARIFIERS



CLARIFIERS – NORMAL AND BULKING



RAS, MLR & WAS

- RAS – RETURN ACTIVATED SLUDGE
 - USUALLY SLUDGE (BUGS) THAT IS RETURNED FROM THE SETTLING THAT TAKES PLACE IN THE CLARIFIERS TO CONTINUE TO WORK – BACK TO HEADWORKS
 - CONCENTRATION IS EXTREMELY IMPORTANT!
- MLR – MIXED LIQUOR RETURN OR INTERNAL RECYCLE
 - MLSS FROM REACTOR PUMPED BACK TO THE FRONT OF THE REACTOR AT HIGH RATE TO EXTEND THE AMOUNT OF TIME THE BUGS ARE IN CONTACT WITH NITRATE TO DENITRIFY
 - THOUGHTS ON WHY I BRING UP RAS AND MLR AT A PRETREATMENT CONFERENCE?
- WAS – WASTE ACTIVATED SLUDGE
 - SLUDGE (BUGS) THAT ARE NO LONGER NEEDED TO DO WORK – SENT TO DIGESTION
 - CONCENTRATION IS EXTREMELY IMPORTANT!
 - AGAIN, WHY DO WE CARE ABOUT THE BUGS IN A DIGESTER AT A PRETREATMENT CONFERENCE?

DISINFECTION

- DISINFECTION CAN BE “KILL” OF VIRUS AND BACTERIA OR “STERILIZATION”
- CHLORINE IS USED IN SOME LARGE AND SMALL FACILITIES – KILLS VIRUS AND BACTERIA
 - GAS CHLORINE AND LIQUID HYPOCHLORITE
 - NEED TO DECHLORINATE PRIOR TO DISCHARGE
- ULTRA VIOLET IS PRIMARILY USED FOR DISINFECTION – STERILIZES VIRUS AND BACTERIA
 - NO CHEMICAL ADDITION AND MUCH SAFER

CHLORINE AND UV DISINFECTION



ANCILLARY EQUIPMENT

- AEROBIC DIGESTERS – AERATED WASTE ACTIVATED SLUDGE DIGESTION
- ANAEROBIC DIGESTERS – DIGESTION BY HEAT AND ABSENCE OF OXYGEN
- DAF'S – DISSOLVED AIR FLOATATION – CAN BE USED IN NUMEROUS PLACES IN A FACILITY
- RDT'S – ROTATING DRUM THICKENER – DECREASE VOLUME OF SLUDGE IN DIGESTER
- SCREW PRESS & CENTRIFUGE – DEWATER SLUDGE FOR DISPOSAL
- TERTIARY TREATMENT – ADDITIONAL TREATMENT TO EFFLUENT TO MEET STRICTER REQUIREMENTS AND/OR REUSE

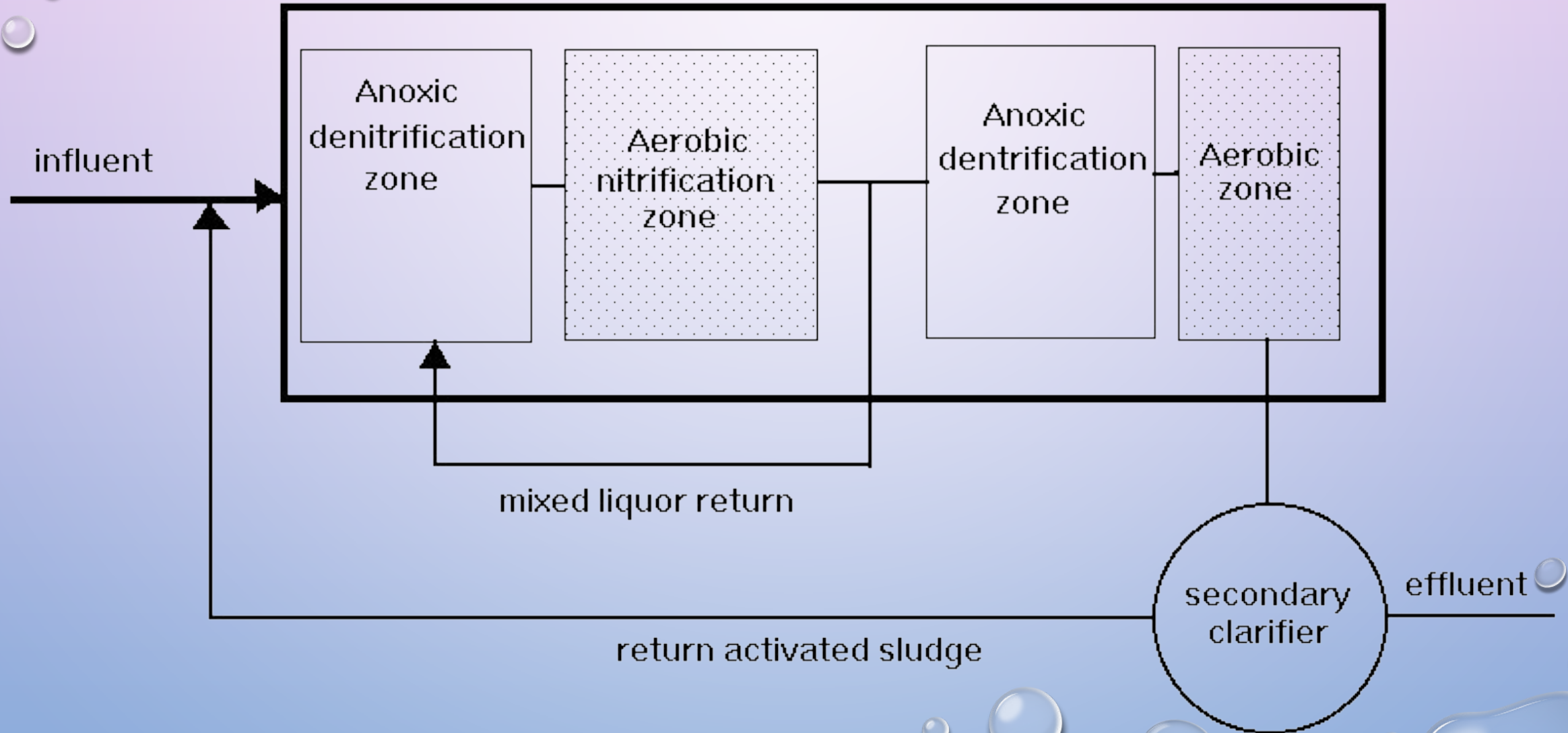
BIOLOGICAL NUTRIENT REMOVAL FACILITIES

- REGULATION 85: AMMONIA, NO₃, NO₂, NO₃+NO₂, TIN, TKN, TN , TP
 - MONTHLY FOR MAJORS/BI-MONTHLY FOR MINORS
 - UPSTREAM AND DOWNSTREAM SAMPLES
- REG. 85 (TIN < 10 PPM) (TOTAL P < 1.0 PPM)
- THIS IS THE REGULATION ALL WASTEWATER FACILITIES IN COLORADO ARE TRYING TO ACHIEVE
- SOME FACILITIES ARE DOING COMPLETE UPGRADES TO MEET NEW REGS
- SOME FACILITIES ARE MODIFYING EXISTING FACILITIES TO MEET NEW REGS
- REGULATION 31 – RIGHT AROUND THE CORNER – EVEN STRICTER LIMITS ON NUTRIENTS
 - WHAT IS THIS GOING TO DO TO OUR LIVES AS PRETREATMENT FOLKS AND OUR LOCAL LIMITS?

BIOLOGICAL NUTRIENT REMOVAL (BNR) HOW DOES THAT WORK?

- NUMEROUS VARIATIONS OF BNR THROUGHOUT THE WORLD
- ESSENTIALLY, ADDITIONAL TANKS TO CREATE AN ENVIRONMENT FOR BUGS TO COMPLETE THE WORK OF REMOVING NUTRIENTS FURTHER THAN WITH CONVENTIONAL TREATMENT
- DOES NOT ALWAYS REQUIRE ADDITIONAL TANKS – COULD BE DIFFERENT FLOW SCHEME, TURNING THE AIR ON AND/OR OFF IN AREAS WITHIN A REACTOR
- SBR'S – SMALL FACILITIES THAT CAN DO VERY GOOD BNR!
- ANOXIC ZONES, SWING ZONES, EXTREME RAS RATES, MLSS RETURN, ANAEROBIC SELECTORS, CHEMICAL ADDITION (FERRIC, ALUM, ETC.)...
 - ADDITION OF FERRIC AND ALUM TO THE TREATMENT PLANT? HOLY COW, WHAT DOES THIS MEAN FOR MY REMOVAL CALCULATIONS?

REACTOR



BNR PROCESS VARIABLES

- INFLUENT – AMMONIA/NO₃/BOD/COD/TSS LOADING
- ANOXIC ZONES - PH/TEMP/NH₄/NO₂/NO₃/BOD/COD/TSS/P/TIN/TKN/DO/ORP
- AEROBIC ZONES - PH/TEMP/NH₄/NO₂/NO₃/BOD/COD/TSS/P/TIN/TKN/DO/ORP
- MLSS – TSS/AMMONIA/NO₂/NO₃/P/DO/ORP
- RAS & WAS – TSS/AMMONIA/NO₂/NO₃/P/DO/ORP
- EFFLUENT TO CLARIFIERS - PH/TEMP/NH₄/NO₂/NO₃/BOD/COD/TSS/P/TIN/TKN

IFAS & MBBR

- IFAS – INTEGRATED FIXED FILM ACTIVATED SLUDGE
- MBBR – MOVING BED BIOFILM REACTOR
- 2 NAMES FOR ESSENTIALLY THE SAME TECHNOLOGY
- ADDITION OF MEDIA WITHIN A REACTOR WHICH ALLOWS FOR MORE SURFACE AREA FOR THE BUGS TO GROW – INCREASES ORGANIC CAPACITY OF A REACTOR



MBR TECHNOLOGY

- MEMBRANE BIO REACTOR
- BASICALLY HAVE 3 OPTIONS
 - HOLLOW CORE
 - FLAT PLATE
 - CERAMIC
- HIGH TSS IN REACTORS THAT NEEDS TO BE MONITORED CLOSELY TO ENHANCE PERFORMANCE
- VARIABLE INCREASES/DECREASES IN WASTE CHARACTERISTICS WILL DESTROY THESE EXPENSIVE UNITS

HOLLOW CORE



FLAT PLATE AND CERAMIC MEMBRANES



SIDE STREAMS

- CENTRATE, FILTRATE, PRESSATE
 - LIQUID FROM SOLIDS DEWATERING – AMMONIA, NITRATE, PH, TEMP, TOTAL P, TIN...POLYMER
- DIGESTER DECANT
 - SUPERNATANT FROM AEROBIC DIGESTION – AMMONIA, NITRATE, PH, TEMP, TOTAL P, TIN
- WATER PLANT RESIDUALS?
 - WTP BACKWASH FOR SOME WWTP'S IS A CONCERN – RO BRINE, INORGANICS, HIGH METALS...
 - WHO HAS A PERMIT FOR THE WATER PLANT IN THE SERVICE AREA?

LABORATORY & FIELD INSTRUMENTS

- PH/TEMP
- DO/ORP – ONLINE AND HAND HELD?
- BOD/COD & TSS
- AMMONIA, NITRATE, NITRITE, CHLORIDE, PHOSPHORUS, TIN, TKN, TN
- METALS – SOME PERMITS HAVE STRICT METALS LIMITS
- SCADA
- SAMPLERS

QUESTIONS OR COMMENTS?

- WASTEWATER TREATMENT IS THE ONLY SCIENCE IN THE WORLD THAT HAS NO CONTROL OF WHAT COMES IN, BUT MUST HAVE A PERFECTLY DEFINED OUTPUT. EVERY DAY IS A SCIENCE PROJECT!
- THANK YOU FOR YOUR TIME!
- DAVE LEWIS – DAVE@DIRECTDISCHARGE.COM OR 303-619-7692