Water and Wastewater Management for Refineries and Other Industrial Facilities

Presentation Overview

- Federal and State Regulatory Trends in Wastewater and Stormwater
- Water Usage in the Refineries and Other Industrial Facilities
- Wastewater Treatment Challenges and Drivers
- Treatment Solutions and Case Studies
- Water Usage Minimization
- Summary
- Q & A

Federal and State Regulatory Trends in Wastewater and Stormwater

Federal and State Regulatory Trends

- Washington State Wastewater Regulatory Update
- Federal Refinery ELGs Update
- Holistic approach to contaminant management

Washington State Regulatory Update

Washington State Regulatory Update

- Timeline
  - Public meetings and public comment period closed in March 2015
- Scope
  - Adds New Water Quality Standards for Protection of Human Health
  - Impacts to TMDLs and NPDES Permits
- Status
  - Comments currently under consideration

Washington State Regulatory Update

- Proposed Human Health Water Quality Standard (WQS) based on:
  - fish consumption rate (FCR)
  - cancer risk

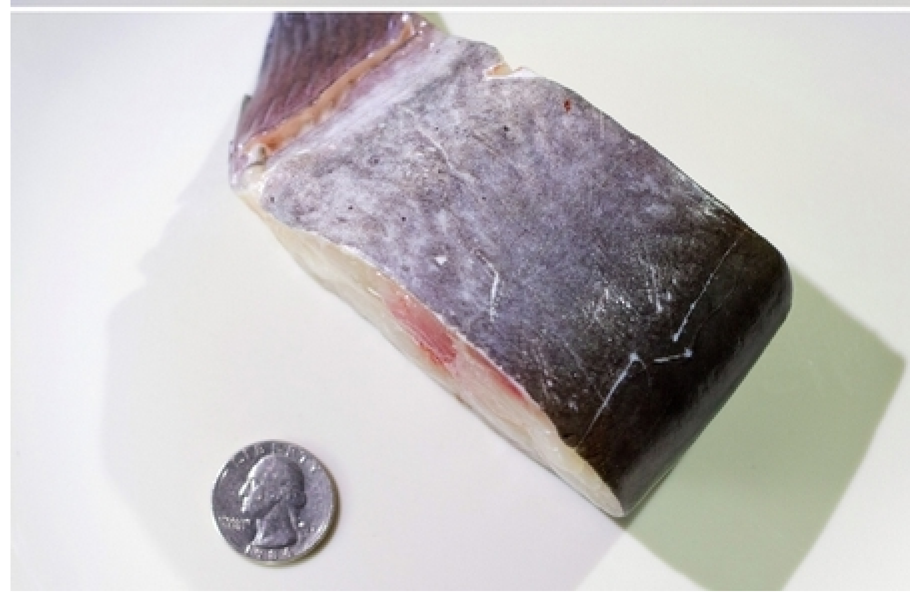
	Current	Proposed
FCR (grams per day)	6.5	175
Cancer Risk	1×10^{-6}	1×10^{-5}

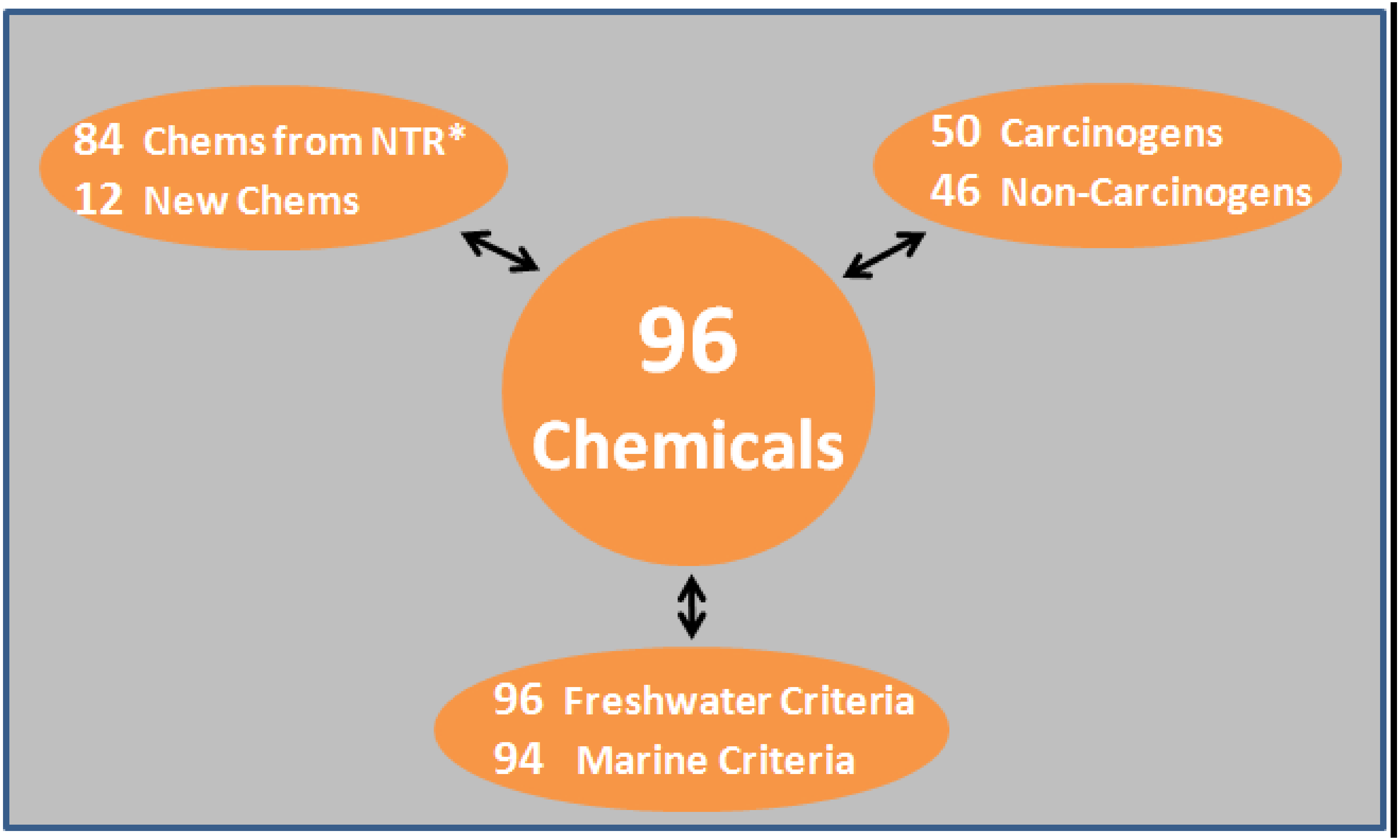
- Human Health WQS standards enacted in Oregon in 2011 based on 175 g/day FCR and 1×10^{-6} cancer risk.
- Current human health standards are based on the 1992 National Toxics Rule.

Current and Proposed Daily Fish Consumption Rates

Current Washington State FCR

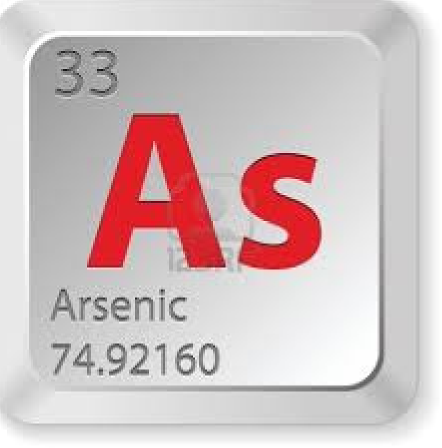
Proposed Washington State FCR and Current Oregon State FCR




84 Chems from NTR*
12 New Chems
50 Carcinogens
46 Non-Carcinogens
96
Chemicals
96 Freshwater Criteria
94 Marine Criteria

Arsenic: Special Case

- Why a special case?
- Ecology proposes to set the human health criterion for arsenic at the safe drinking water Maximum Contaminant Limit (MCL) for total arsenic.
- This criterion is coupled with a requirement to reduce anthropogenic sources of arsenic in facility effluent.



Total Maximum Daily Limits (TMDLs)

- New WQSs require review of and changes to the 303(d) waterbodies list
- Review has indicated that there would be 55 new 303(d) listings but only 5 on water bodies with NPDES permits

State WQS Implementation Tools

- Compliance Schedules (revised/clarified)
- Intake Credits (new)
- Variances (as in current regulation)

Key Conclusions from Ecology's Cost Benefit Evaluation of the Proposed Rule

On new WQSs:

"…we estimate zero incremental cost to existing facilities under the proposed rule amendments."

On related changes to 303(d) listings*:*

"…no existing facility, with current production/flow levels, would likely be impacted by any changes to 303(d)-listed waterbodies that would occur as a result of the proposed rule amendments."

Comments on Washington's Proposed Rule

- Wide ranging comments: from "overly protective" to "not protective enough"
- EPA: concerns with cancer risk basis, ultimate calculated standards, and downstream (Oregon) waters
- Concerns that analytical methods will improve over time and will result in stricter requirements and high costs to address
- Concern that with no cost and no changes in behavior there will be no benefit to human health and the environment.

Next Steps for Washington's Proposed Rule

- Comment period closed March 23, 2015
- Consideration of comments and possible revisions to rule.
- Ecology prepares formal package with final rule and submits to EPA for approval
- EPA is concerned about the timeline and may write its own WQ rules for Washington State.

Federal Wastewater Trends for Refineries

Federal Effluent Limitation Guidelines for Petroleum Refining Industry

- ***Timeline*** of ELGs Development for Petroleum Refining Industry
- ***Scope*** of EPA 2015 Detailed Study
- ***Status Summary*** of ELGs Development for Petroleum Refining

Timeline of ELGs Development for Refineries

Scope of 2015 Detailed Study for Petroleum Refining Sector

- Metals, dioxin, and dioxin-like compounds
- Sources within the refinery
- Effects of new air pollution controls on wastewater
- Current wastewater treatment technology performance

EPA expects to use this study to determine whether petroleum refining warrants new or revised ELGs.

Status Summary of ELGs Development for Petroleum Refining

- Detailed Study in Process
- Comments submitted by API and AFPM
- Possible coverage of new ELGs (e.g. for dioxins and certain metals)
  - BAT, BPT;
  - NSPS (for new sources);
  - PSNS, PSES (for pretreatment);
  - Stormwater Permit.

Holistic Approach to Contaminant Management

Understanding

- Track mass of specific parameter across the envelope of the facility.

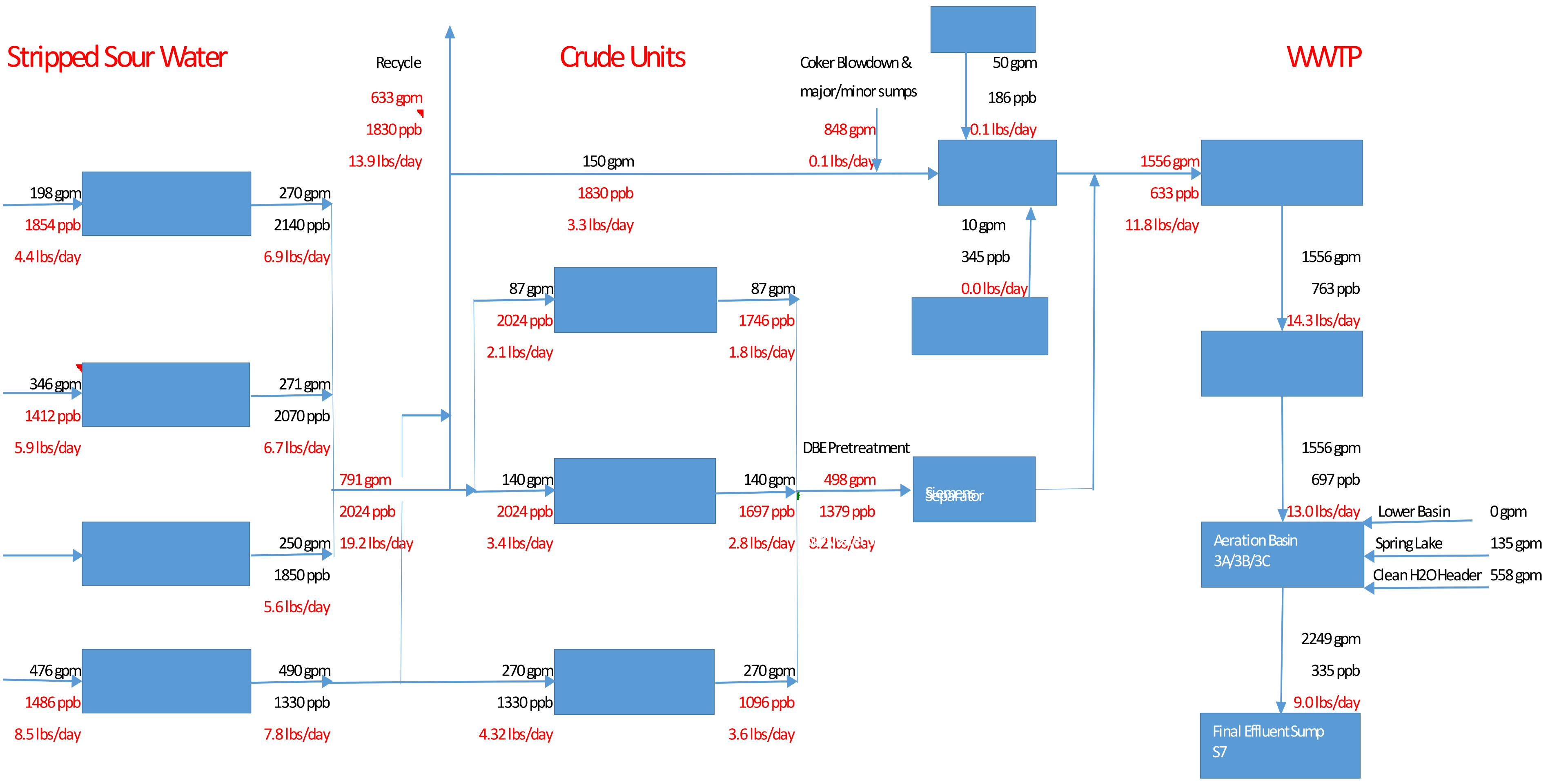
Prevention

- Consider pollution prevention opportunities.

Removal

- Target removal where it can be most cost-effective.

Example: material balance for single parameter within facility boundary



Red indicates calculated value

Black indicates measured value

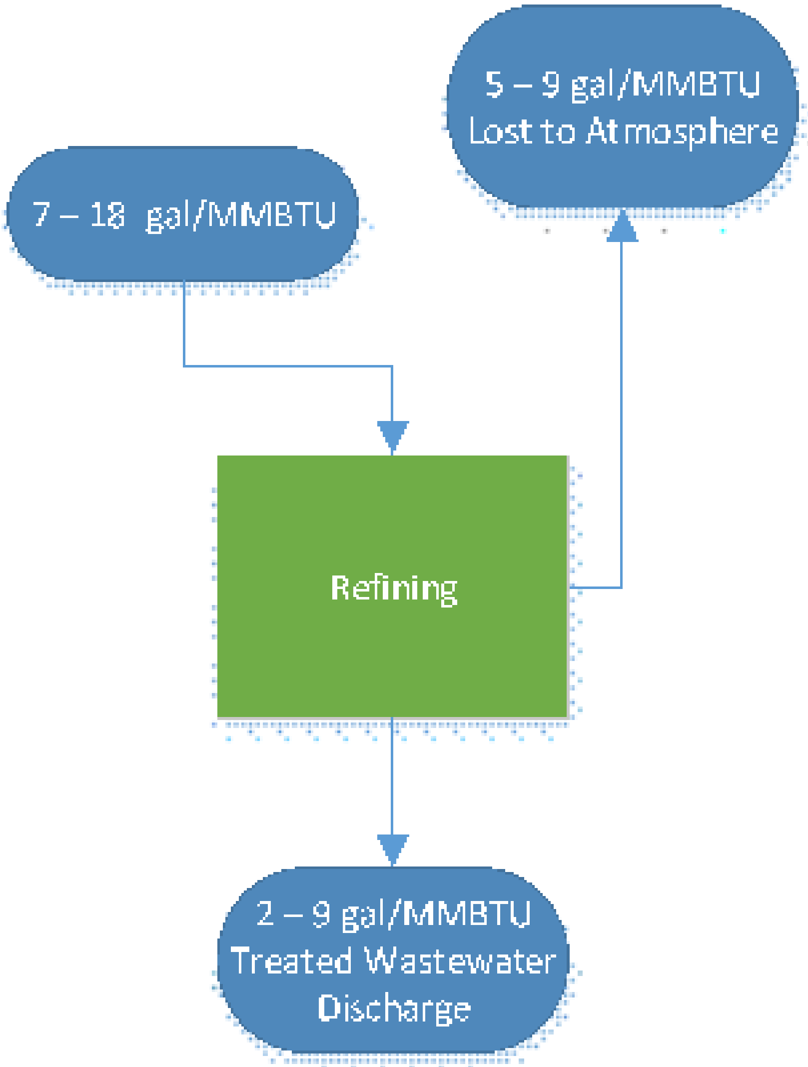
Water Usage in the Refineries and Other Industrial Facilities

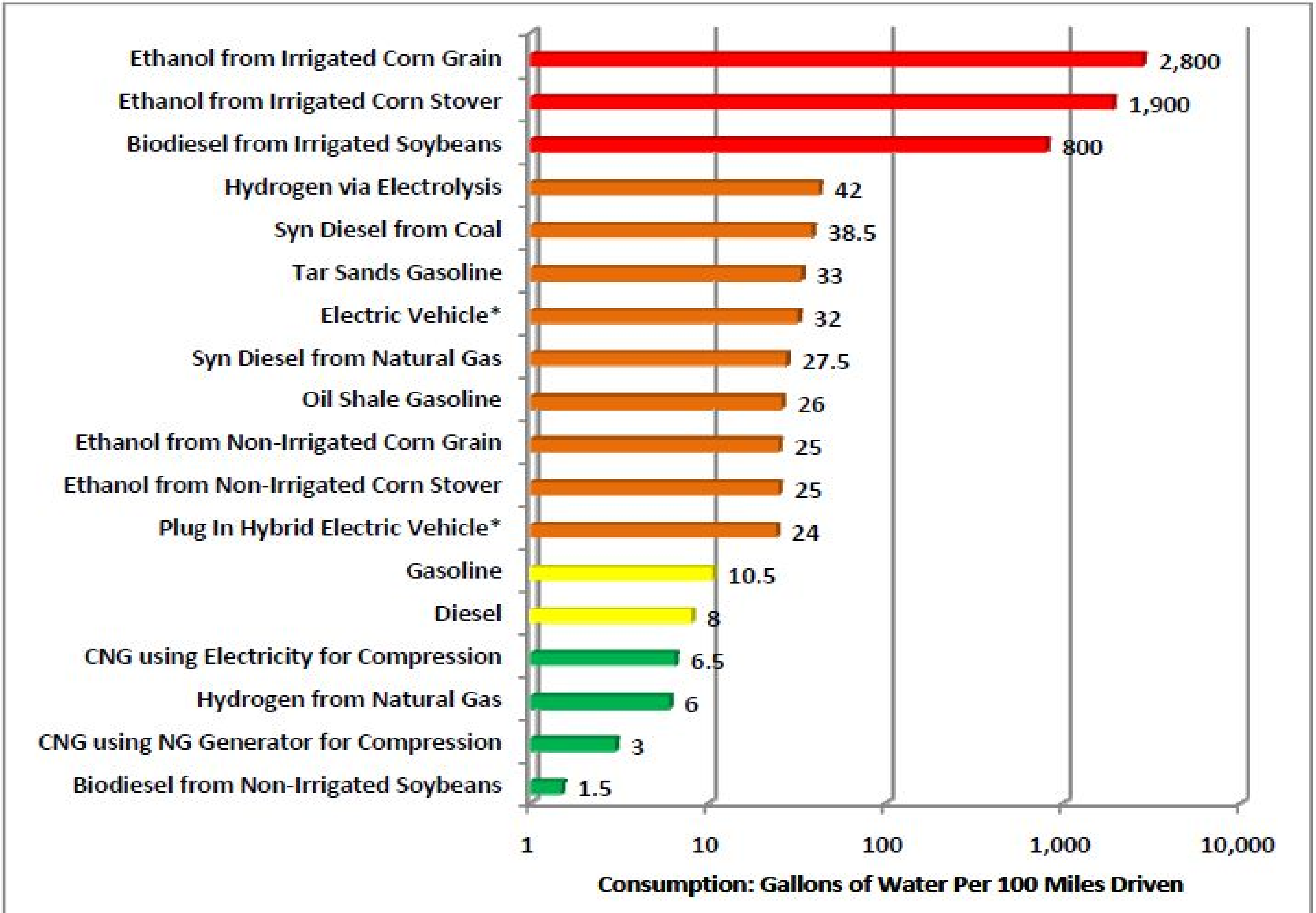
ch2m SM

Water Usage in the Refinery and Other Industrial Facilities

- “Energy-Water Nexus” – Energy production relies heavily on availability of water.
- Major uses of water include
  - Process Water
  - Cooling water
  - Utilities Water
  - Fire Water
- Many common uses and elements with other manufacturing industries
- Infrastructure includes Intake structures, water treatment, wastewater treatment, conveyance, storage, and discharge

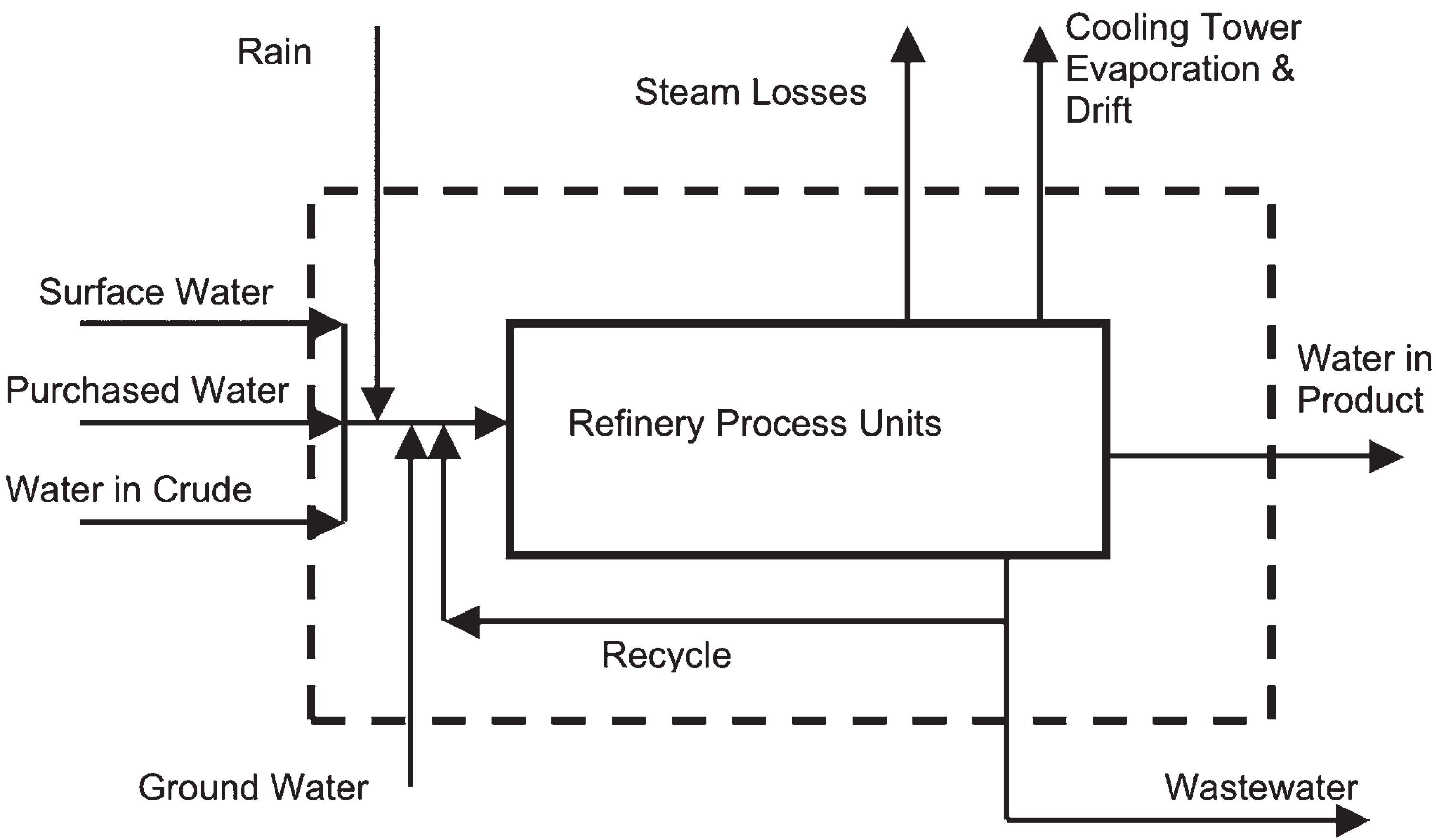
Average Water Usage in Refineries





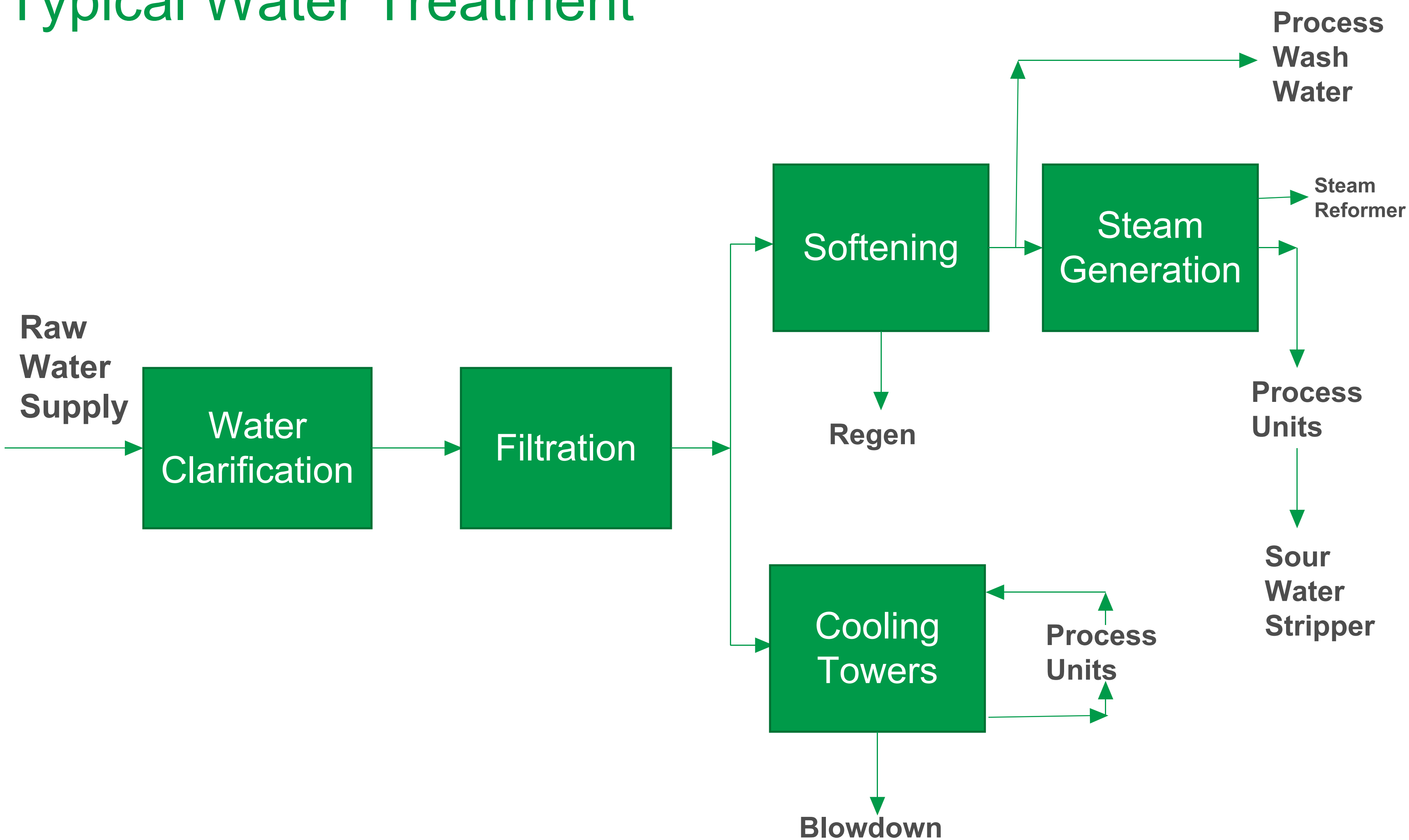
*Source: Adapted from King and Webber 2008a; *Adapted from King and Webber 2008b*

Refinery Water Balance



Source: IPIECA

Typical Water Treatment



Refinery Unit Processes & Wastewater Sources

- Crude oil and product storage
- Crude desalting
- Crude fractionation
- Thermal cracking
- Catalytic cracking
- Hydrocracking
- Reforming
- Polymerization
- Alkylation
- Isomerization
- Solvent Refining
- Dewaxing
- Hydrotreating
- Deasphalting
- Drying and Sweetening
- Wax finishing
- Grease manufacture
- Lube Oil finishing
- Hydrogen Manufacture
- Blending and Packaging

Major Refinery Wastewater Streams

- Desalter Discharge
- Sour Water
- FCC Scrubber Blowdown
- Cooling Tower Blowdown
- Boiler Blowdown
- Tank Draws (BS&W)
- Spent Caustic
- Oil Water & Sludge

Wastewater Treatment Challenges and Drivers

Wastewater Treatment Challenges and Drivers

There are three major categories of drivers that are catalyst for action

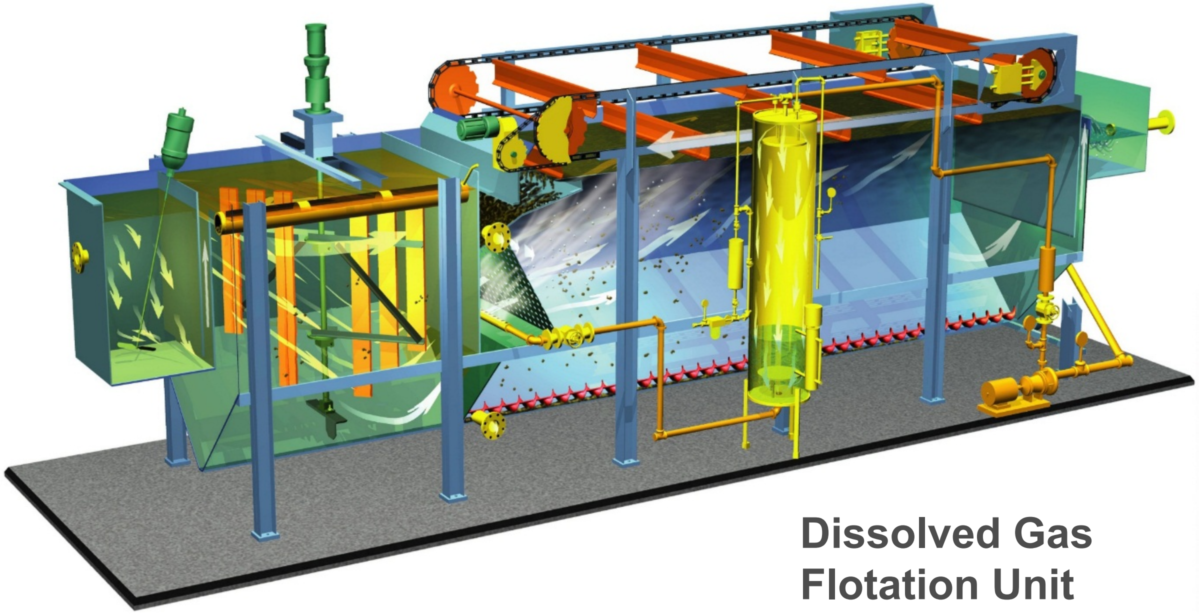
- Regulatory Drivers
- Commercial & Technological Drivers
- Sustainability & Corporate Governance

Source: http://www.phillips66.com

Typical Wastewater Treatment Challenges

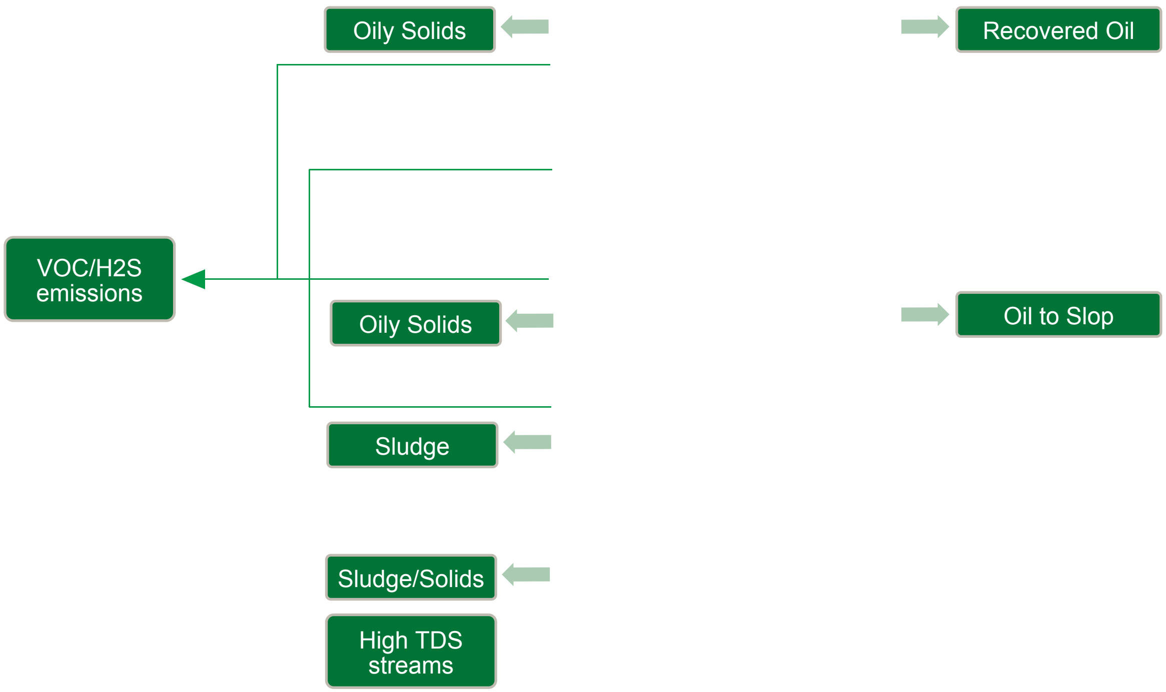
Typical Contaminants

- Oil & Grease
- H_2S and Ammonia
- Organics (COD, TOC)
- Nutrients (Nitrogen & Phosphorous)
- Metals
- Phenols



Dissolved Gas Flotation Unit

Treatment Solutions – Refinery Wastewater Treatment Overview



Typical Treatment Phases and Objectives

Treatment Phase	Treatment Objective
Primary Oil/Water Separation	Remove free oil and suspended solids
Equalization	Minimize fluctuations in flow and composition
Secondary Oil/Water Separation	Remove oil down to 5 – 30 ppm
Secondary (Biological) Treatment	Remove soluble organics and inorganics (trace metals)
Tertiary (Advanced) Treatment	Variable. Removal of trace and refractory materials (organics, nutrients, metals, suspended solids)

Typical Treatment Phases and Technologies

Treatment Phase	Typical Technologies
Primary Oil/Water Separation	Phase Separators: API, CPI
Equalization	Tank – floating or fixed roof
Secondary Oil/Water Separation	Flotation: DAF, DNF, DGF, IGF
Secondary (Biological) Treatment	Activated sludge, IFAS, MBR
Tertiary (Advanced) Treatment	Variable. Filtration, adsorption, oxidation, disinfection, precipitation, ion exchange

Regulatory Drivers – More Stringent Limits

Change in regulations or compliance requirements, e.g. effluent discharge permits.

- More stringent Permit Limits, e.g.
  - Arsenic
  - Selenium
  - Dioxins
  - Nutrients - Nitrogen and Phosphorous
  - Temperature
- 316 (b) Water Intake Regulations
- NESHAP

Commercial Considerations

Flexibility to process a range of crude slates, e.g. “opportunity crudes” that provide economic benefits

- Variation in types of crudes processed creates technological challenges for wastewater treatment
  - Sour crudes require more water for removal of sulfur compounds
  - Heavy crudes produce difficult to treat desalter discharges that often require pre-treatment prior to primary oily water treatment
  - Primary oil water separation facilities are often inadequate when treating heavy crudes, e.g. API units require more hydraulic retention time, pre-treatment to break emulsion, etc.
  - Light sweet crude from shale regions that can contain entrained H2S and paraffin waxes that cause fouling

Technology Considerations

Newer technologies for compliance reliability, better operability, and life-cycle cost savings

- Elevated API & DAF units that provide continuous and reliable solids separation & handling
- Covered API & DAF units for emission control and compliance with NESHAP regulations
- Tank-based biological treatment systems instead of in-ground aeration basins for groundwater protection & RCRA issues
- Use of pure oxygen to enhance oxygen transfer and reduce emissions
- Removal of trickling filters and rotating biological contactors due to emissions and operational issues.
- Use of high-rate biological systems such as MBR

API Units Design Upgrade

Below Grade API Units

Elevated API Units

Technology Considerations (cont.)

Water Treatment

- Use of membranes (e.g. ultra-filtration) for raw water treatment instead of traditional clarification & flocculation
- Higher quality water has potential to provide life-cycle savings by reducing maintenance costs on water infrastructure such as cooling towers, piping, pumps, etc.

Sustainability & Corporate Governance

- Increased focus on sustainability or sustainable water usage solutions
- Increased focus on reducing water foot print
- Enhanced wastewater treatment recycle and reuse as source water
- Use of Engineered Natural Treatment systems to supplement traditional wastewater treatment

Corporations are increasingly focusing on the above issues in response to sustainable solutions demanded by citizens and NGO groups, to reduce impact of its operations on environment, and to reduce water risk

Case Studies

Case Study: Arsenic removal from Refinery Wastewater in the Western US

- Driver to target arsenic. Change in discharge location and permit limits
- Selected Technology: iron Co-precipitation
  - Addition of iron salts (ferric chloride) produce ferric hydroxide.
  - Arsenic can adsorb to ferric hydroxide
  - Particles can be removed by flotation, filtration, or combination of the two.
  - Overall removal of arsenic is controlled by performance of flotation/ filtration.
- Alternative Technologies:
  - Ion exchange
  - Reverse Osmosis/Nanofiltration
  - Reactive Filtration
  - Lime softening

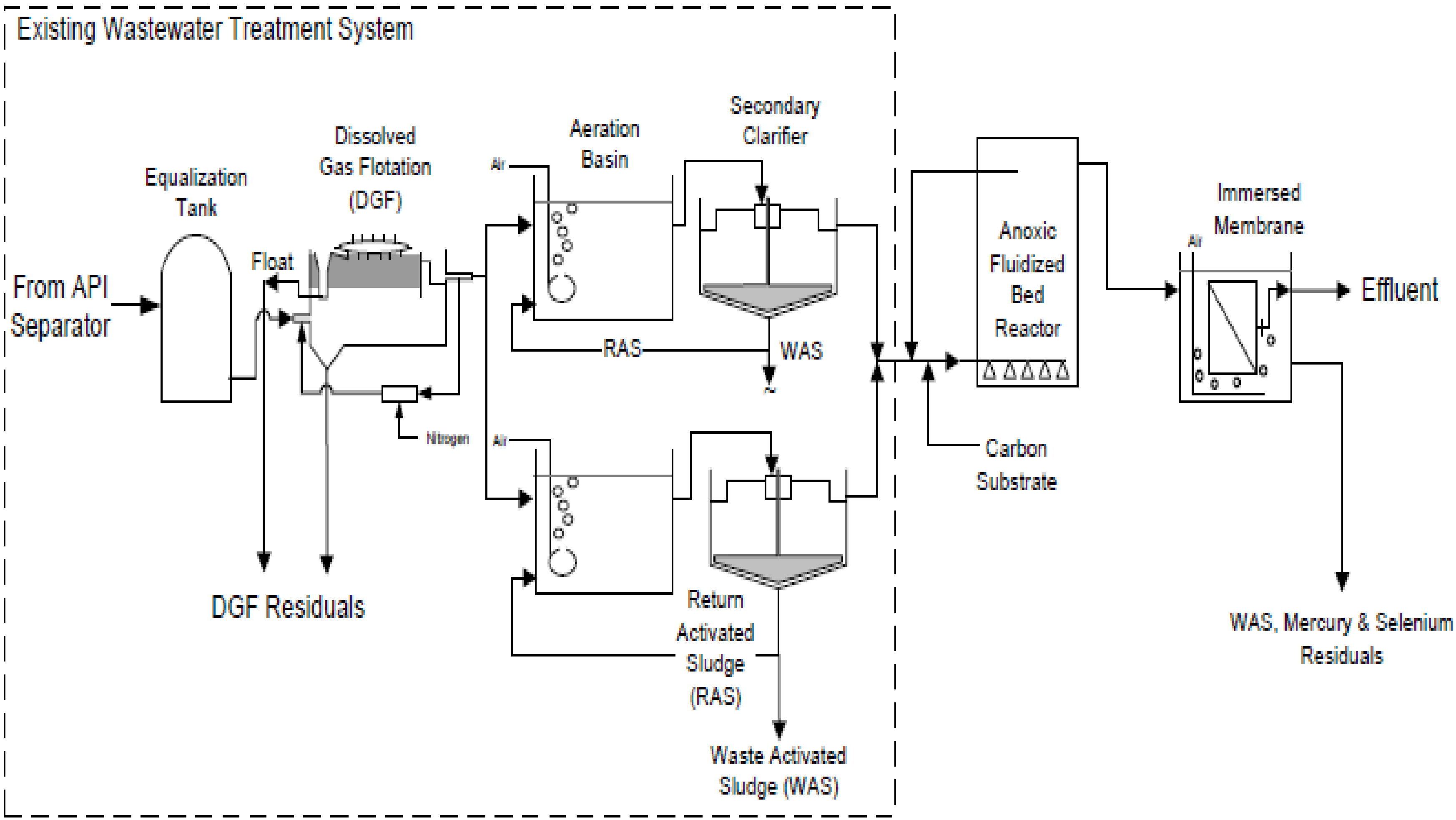
Arsenic Removal: Generalized Process Flow Diagram for Source Treatment

Case Study: Mercury and selenium removal from refinery wastewater – Confidential client

- Water quality based limits of 0.011 µg/L for mercury and 4.6 µg/L for selenium.
- Sitewide analysis for species, concentration, and fate within the facility
- Selected Selenium Removal Technology: Anoxic biotreatment followed by membrane filtration
- Selected Mercury Removal Technology: Anoxic biotreatment followed by membrane filtration

- Integrated Treatment Solution:
  - Anoxic biological treatment for low level selenium removal and conversion of all selenium to insoluble Se(0)
  - Followed by membrane filtration for insoluble selenium & mercury removal
  - Compatible with future treatment needs for nitrogen and phosphorus
  - Compatible with zero liquid discharge and water reuse

Integrated Treatment for Selenium and Mercury Removal for End-of-Pipe Treatment



Bahrain Petroleum Company
Awali, Bahrain

MBR WWTP Piloting, Process Engineering, and FEED Package

- Facility:
  - 267,000 bpd refinery
  - 3,800 gpm base oily sewer flow
- Unique Conditions:
  - High salinity, temperature and flow
  - Stringent TKN limits
  - Treat spent caustic
- Treatment Technologies Considered:
  - Attached growth
  - Suspended growth conventional
  - Suspended growth membrane bioreactor (MBR)

Water Usage Minimization

Water Usage Minimization

- Water risk management and sustainability goals are becoming more important to corporations
- Increasing emphasis on reducing fresh water usage
  - Lowering consumption via internal water recycle and reuse
  - Reuse of the wastewater effluents
  - Use of POTW effluents as water source
- Smaller water footprint reduces competition with other stakeholders such as domestic users, farmers, etc.

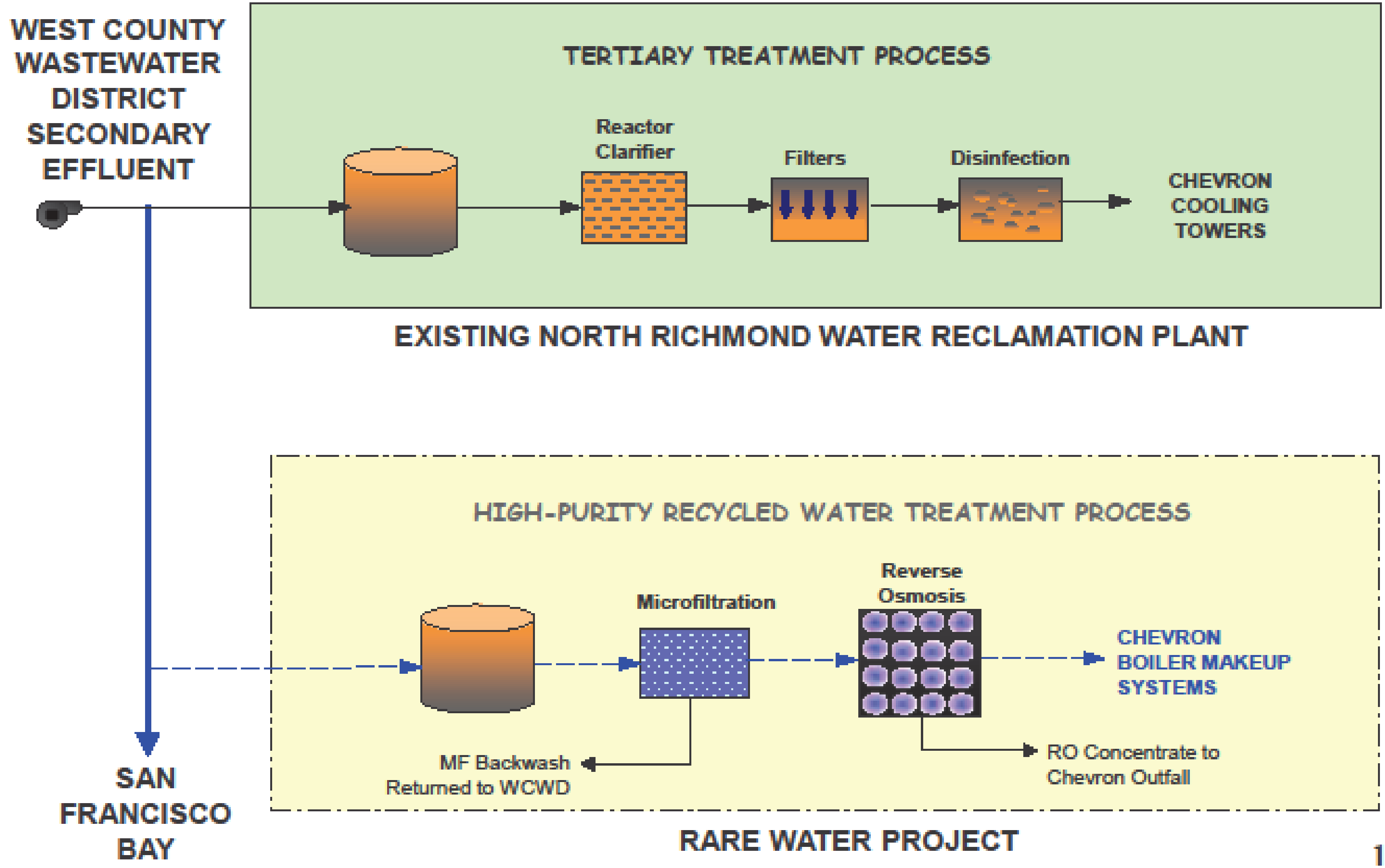
Recycle and Reuse

- Internal Recycle and Reuse
  - Up-cycle cooling towers to minimize blowdowns
  - Condensate recovery and recycle
  - Reuse of stripped sour water in desalters
- Reuse of treated wastewater treatment plant effluents as utility and fire water
- Sourcing of POTW effluents as source water; some treatment is generally required before use

Water Reuse Example: Chevron's Richmond, CA Refinery

- Richmond Advanced Recycled Expansion (RARE) Water Project, a joint effort with the East Bay Municipal Utility District.
- Refinery already using 4.3 MGD reclaimed water for cooling water
- New treatment plant within refinery, operated by EBMUD, includes MF and RO
- Project freed up 3.5 million gallons of freshwater per day for public use.
- In honor of the RARE project, Chevron was named Recycled Water Customer of the Year by the Water Reuse Association in April 2011.

Treatment Process Comparison



Sustainability Considerations

- Provide direct tangible value to the operation
  - Water risk reduction and security of supplies
  - Maximize lifecycle production
  - Reduce variable operations costs
  - Reduce operational and environmental risk
- Strike the right balance on triple bottom line performance
  - Economic
  - Socioeconomic/community

"…a concept and strategy by which communities seek economic development approaches that benefit the local environment and quality of life."

www.austin.tx.us/zoning/glossary.htm

"..Leave the world a better place than you found it, take no more than you need, try not to harm life or the environment, make amends if you do."

-Paul Hawken, "Ecology of Commerce," 1993

Summary

- Refining is one of the oldest and most well established industries that is crucial to support our way of life
- Refining has evolved over time, from simple crude distillation to very complex vertically integrated refining and petrochemical complexes
- Regulations surrounding Health, Safety & Environment have evolved over time
- Challenges surrounding water sourcing, treatment, wastewater treatment and discharge have gotten more complex.
- Holistic water management approach offers many benefits: increasing compliance reliability, reducing costs, reducing water risk, supporting sustainability, and being a good corporate citizen

Summary

……water issues will only become more complex over time due to competition for water, changing weather pattern, and more stringent discharge regulations. Proactive approach and careful planning are required if the industry is to adapt and thrive in the future and compete successfully with alternative fuel sources.

Questions?

Thank you