Geosyntec consultants

EVALUATING OPTIONS FOR PFAS TREATMENT, DESTRUCTION & DISPOSAL

AN OVERVIEW OF THE TECHNOLOGY EVALUATION APPROACH

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Agenda

- ❑ PFAS Treatment – A Multi-Media Overview
- ❑ PFAS Treatment Technologies
- ❑ Technology Selection Drivers
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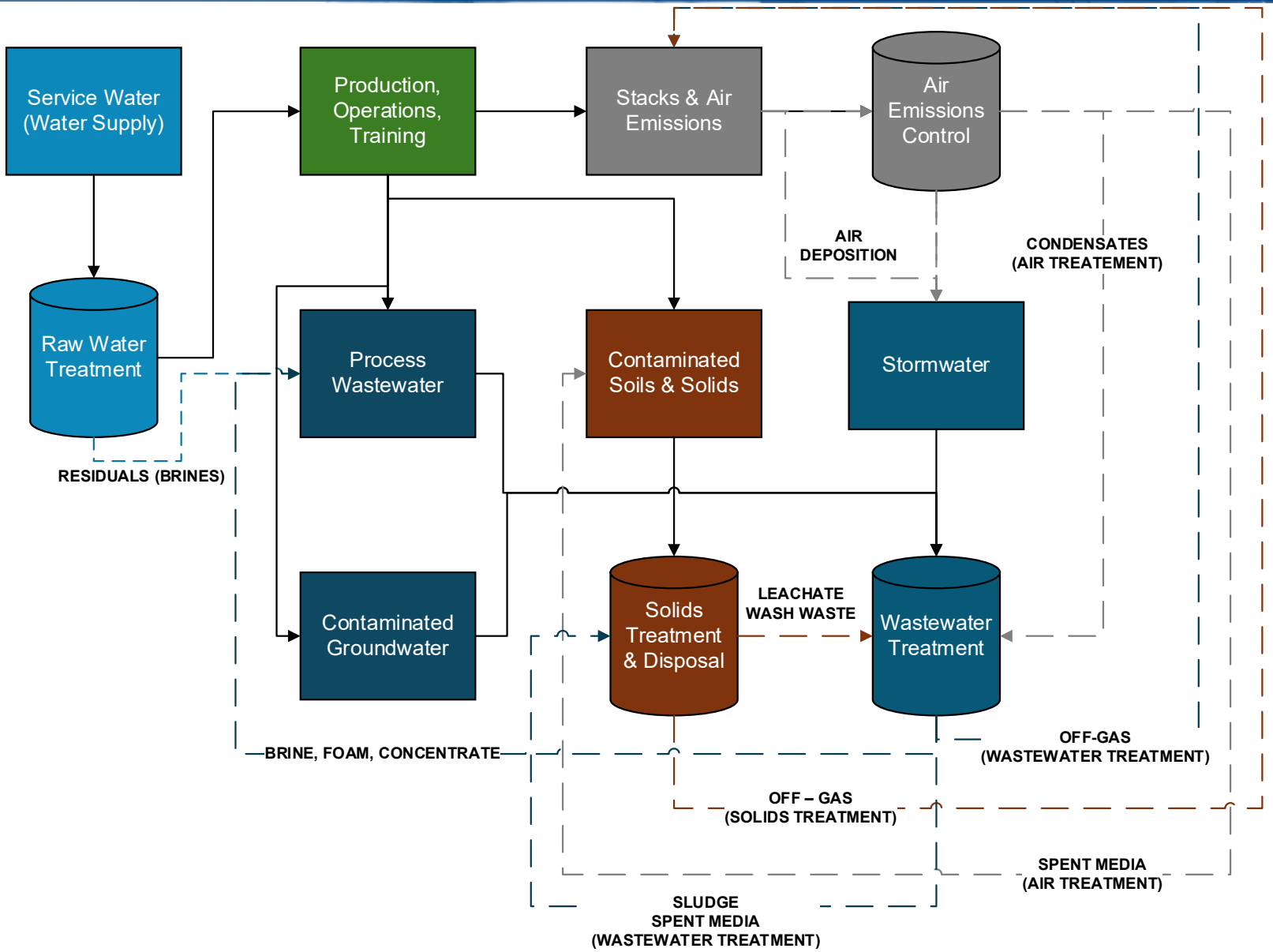
- ❑ Cost Drivers in PFAS Treatment – Examples
- ❑ Regulatory and Compliance Considerations
- ❑ Technology Selection/Implementation Approach
- ❑ Key Takeaways

PFAS Treatment - A Multi-Media Overview



PRIMARY TREATMENT STREAMS
Service Water
Stacks & Air Emissions
Process Wastewater
Contaminated Groundwater
Contaminated Soils or Solids

SECONDARY TREATMENT STREAMS
Water Treatment Residuals (Brine)
Air Treatment Residuals (Condensates, Spent Media)
Stormwater
Wastewater, Groundwater, Stormwater Treatment Residuals (Off- Gas, Sludge, Spent Media, Brine, Foam)
Solids Treatment Residuals (Off- Gas, Wash Waste, Leachate)

PFAS Treatment Technologies

LIQUID PHASE

- Granular Activated Carbon
- Ion Exchange
- Reverse Osmosis
- Nanofiltration
- Foam Fractionation
- Regenerable Ion Exchange
- Other Adsorptive Media
- Enhanced Pretreatment
- Supercritical Water Oxidation (SCWO)*
- Hydrothermal Alkaline Treatment (HALT)*
- Evaporation
- Photoactive Reductive Defluorination (PRD)*
- Ultraviolet Photocatalysis*

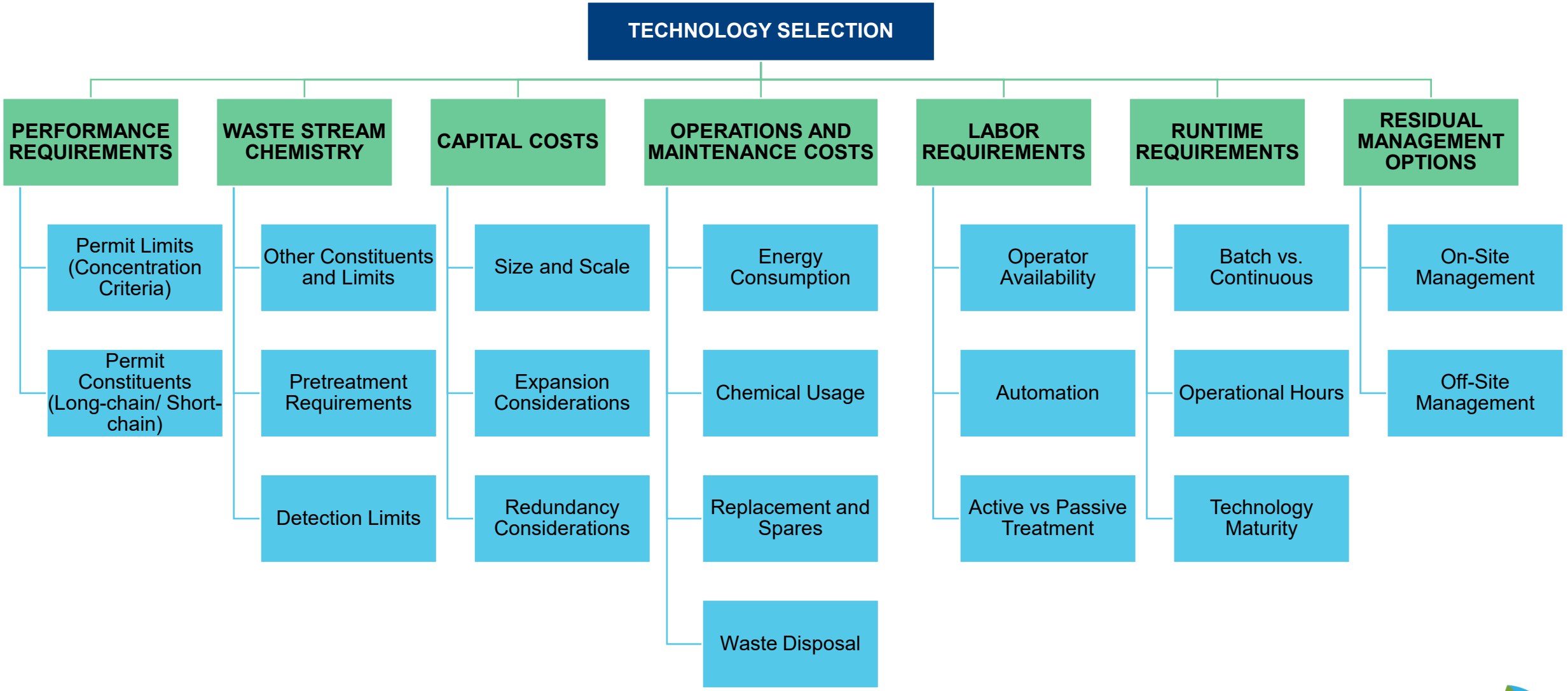
GAS PHASE

- Granular Activated Carbon
- Other Adsorbents
- Catalytic Oxidation*

SOLID PHASE

- Supercritical Water Oxidation (SCWO)*
- Soil Washing and Dewatering
- Solid Stabilization
- Smoldering Combustion*
- Incineration*
- Gasification*

Technology Selection Drivers



Cost Drivers in PFAS Treatment

PRIMARY DRIVERS

- **Pretreatment Requirements** and Complexity of Pretreatment (Scaling, Fouling, Competition)
- Hydraulic Capacity and System Scale
- **Runtime Requirements** & Automation
- **Residual Management** and Disposal
- Analytical Costs

SECONDARY DRIVERS

- PFAS Permit Limits
- Other Constituents
- Active vs. Passive Treatment

Cost Drivers in PFAS Treatment - Examples

- Example 1 – Effect of Pretreatment: 300 gpm groundwater treatment system
  - Pretreatment (chemical reaction, clarification, media filtration), granular activated carbon, ion exchange
  - Annual cost to remove iron, manganese, total organic carbon (chemicals, media) > Annual cost of PFAS media

- Example 2 – Effect of Automation: 250 gpm stormwater treatment system
  - Intermittent operations – batch mode as and when stormwater is generated. Ultrafiltration to remove solids, granular activated carbon, ion exchange with automated backwashing and operations capability. Limited operator availability and automation desired
  - Retrofit for automation and controls will cost ~ 50% of total capital costs

- Example 3 – Effect of Residuals Management: 35 MGD wastewater treatment system
  - Current system produces waste sludge that is dewatered and landfilled (some PFAS detections)
  - If PFAS limits on solids are established and/or landfills refuse PFAS waste, operations costs associated with trucking and disposal increases by 250%. Total annual operations and maintenance costs will double

Regulatory & Compliance Considerations

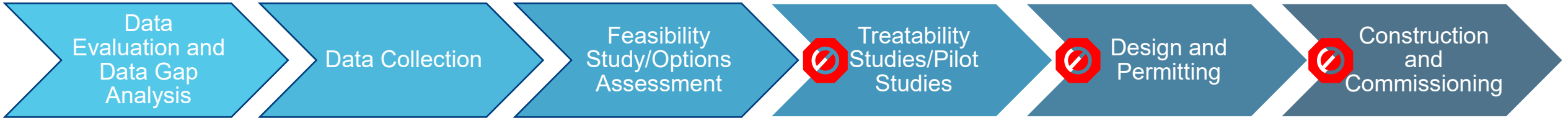
Current Considerations

- What are the current permit limits and potential site-specific interferences in PFAS analysis? *affects process treatment train*
- What is the duration of treatment? *affects automation, operations and maintenance costs*
- Removal or destruction – *affects operations and maintenance costs, and timeline*

Future Considerations

- What other waste streams could be regulated and how would we handle them? *affects hydraulics, footprint, and capital costs*
- What other PFAS compounds could be regulated in the future – how do we handle expansion? *affects hydraulics, footprint, and capital costs*
- What technologies are promising and could provide value in the future? *affects footprint, capital, and operations and maintenance costs*

Technology Selection/Implementation Approach



- Consider a phased approach for best value with key decision points/off-ramps to modify strategy
- Establish a design basis that is representative of conditions (quantity and PFAS composition)
- Supplement design basis with data collection to fill key data gaps (e.g., interference causing compounds)
- Evaluate technologies based on performance, ease of operations, scalability, media-applicability, and anticipated mass balance (i.e., how much can we treat, and how do we handle residuals), and anticipated costs ***[off-ramp]***
- Confirm selected technologies and/or treatment train by performing lab-scale and pilot scale tests (confirm performance, operational approach, and overall costs) ***[off-ramp]***
- Design and permitting ***[off-ramp]***
- Construction and commissioning

Key Takeaways

- It is critical to consider PFAS as a **multi-media contaminant** even when dealing with a single contaminated matrix
- PFAS treatment **costs can be significantly affected** by **non-typical considerations** (i.e., non-PFAS removal related) - e.g., pretreatment, automation, residual management
- It is vital to evaluate **current and future potential regulation** during the design phase
- A phased-approach to technology selection and implementation with predetermined off-ramps