Start-up and Optimization of Portable, Packaged Wastewater Treatment Units for Drill Sites in the Kingdom of Saudi Arabia

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- Health & Safety / Travel
- Instrumentation
- Equipment

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- Identified Deficiencies
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Summary

Drill Rigs 101

- Self-contained, “temporary” camps
- Support Facilities:
  - Office & Living Quarters
  - Bathrooms / Showers
  - Kitchen / Mess Hall
  - Laundry
- **Everything Mobile**
- **Focused on Production**
- Built on flat pads with bermed ponds for drilling fluids – and sanitary wastewater

Project Background

- Government of KSA issued a directive to drilling contractors to provide “treatment” of sanitary wastewater prior to discharge
  - Sustainable reuse/recharge of treated wastewater
  - California Title 22 discharge requirements for unrestricted reuse
  - Primary limit turbidity <2 NTU; additional secondary limits
  - Final chlorination to eliminate health risks
- ERM’s client under contract to provide numerous portable, packaged wastewater treatment unit to drilling contractors

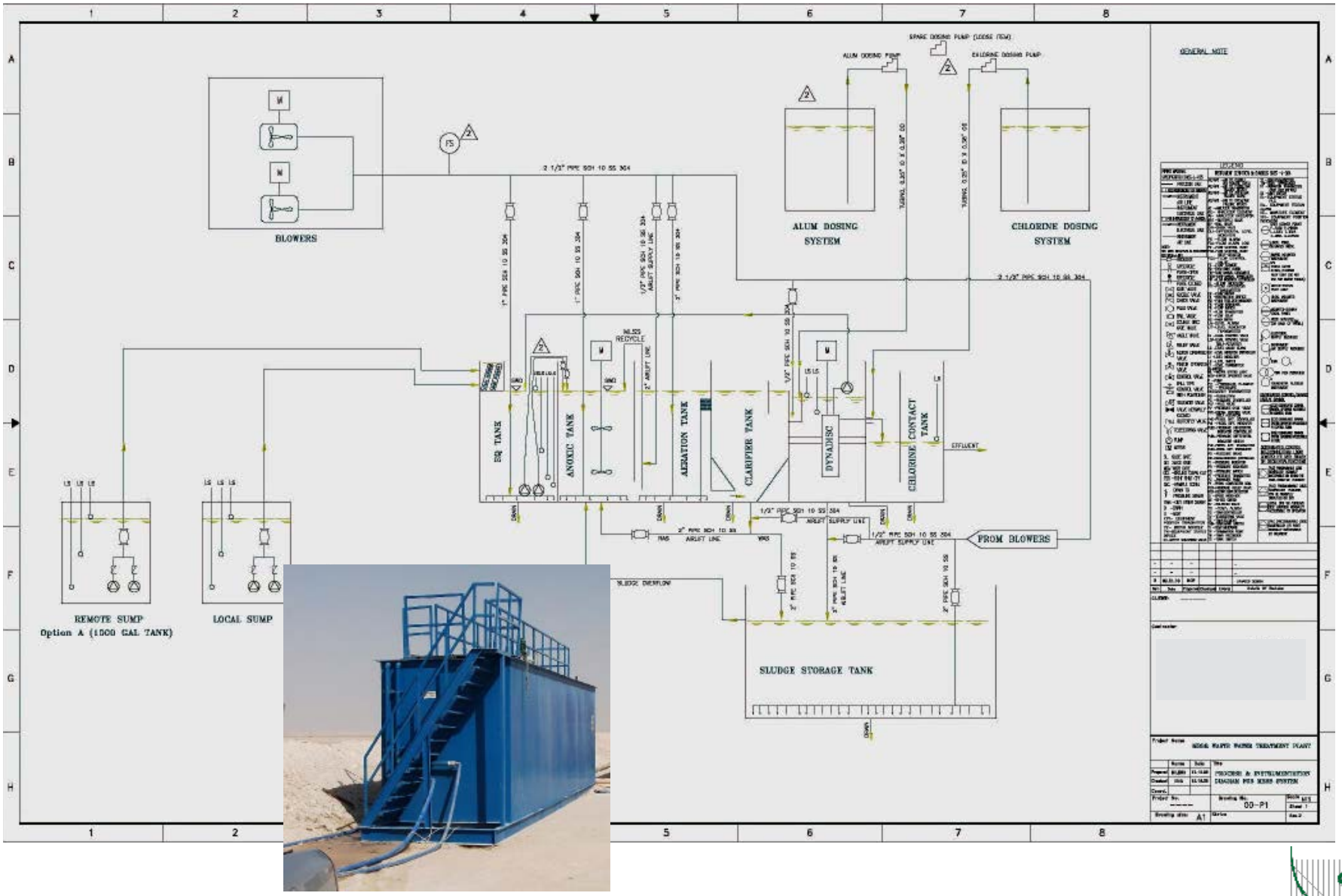
Project Background

- Upon initial deployment of demonstration units, significant operational problems arose
  - Frequently in “upset”
  - Multiple re-seedings with biomass
  - Could not reliably meet the <2 NTU requirement
  - Additional units could not be delivered until technology/design field-proven
- ERM provided in-field technical assistance for troubleshooting and system optimization by mobilizing an experienced wastewater engineer with operations experience from the US to KSA.

System Basics

- Moving Bed Bioreactor (MBBR) / Integrated Fixed-Film/Activated Sludge (IFAS)
  - Influent Equalization
  - Anoxic Tank
  - Aerobic Tank (dispersed media)
  - Clarifier
  - DynaDisc Filtration
  - Chlorine Contact Chamber
  - Air Blowers (aeration and sludge lift pumps)
  - Waste Sludge Holding Compartment
  - Set-up for chlorine (sodium hypochlorite) and alum addition
- No flow meters or instrumentation for process control monitoring
- No equipment or tools for general maintenance

The Portable, Packaged MBBR Units



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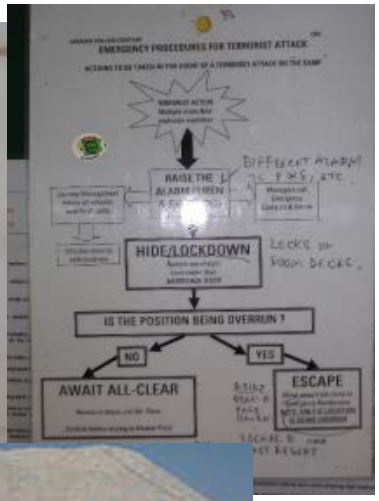
MBBR Highlights

- MBBR Process Benefits
  - Higher “Effective” MLSS without Higher Clarifier Solids Loading
  - Enhanced Nitrification
  - Improved Process Stability
  - Improved SVIs / Reduced Sludge Production
- MBBR Design Considerations
  - Primary Treatment
  - Aeration / Mixing
  - Media Mobility

Health & Safety / Difficulties

- Getting there (and back) is half the battle
  - Language / Culture
  - Basic Hygiene
  - Hostile Environment
  - Terrorism
- Lack of instrumentation and equipment.



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Initial Observations

All critical system components in working order, but…

- Almost Complete Lack of Daily Maintenance
  - Inconsistent Flow Leading to:
    - Inconsistent “feeding” of Biomass
    - Frequent Overflows
  - Why?
    - Time Demands
    - Rotating Personnel/Lack of Continuity
    - Inexperience/Lack of Training
- Field Modifications
- Chemical additions wasting material & diverting attention

Initial Observations (continued)

- Frequent Flow Interruptions / Poor Flow Control
  - Bar Screen
  - Influent transfer valves 100% open
  - Blocked screen between anoxic/aerobic tanks (media migration)
  - Kitchen Grease
- Light brown, thin biomass; pin floc
  - Suggested “young” sludge age from continued difficulties
  - Poor settling characteristics
  - Clarifier solids carry-over
- Floating Cap in Clarifier
  - Denitrification in clarifier
  - Hardened with dust and heat
- 1 to 1.5 feet of dark sludge in clarifier, septic odor suggested inadequate recycle/wasting

Initial Response

- Postpone non-critical field modifications
- Reset system and grow stable biomass
  - Maintain forward flow
  - Increase Return Activated Sludge rate
- Overcome Lack of Maintenance
  - Set Basic Rules for Operation by Rig Personnel
    - Mandatory system inspections 4 times per day
    - Five Simple Steps
      - Clean Influent Bar Screens
      - Open/clear/reset influent flow valves
      - Check/skim clarifier
      - Turn off mixer in anoxic tank – clear perforated plates
      - Waste sludge for ~10 minutes, then reset to recycle
  - Establish Rig Personnel Change-out/Handover Procedures

Tools for Optimization

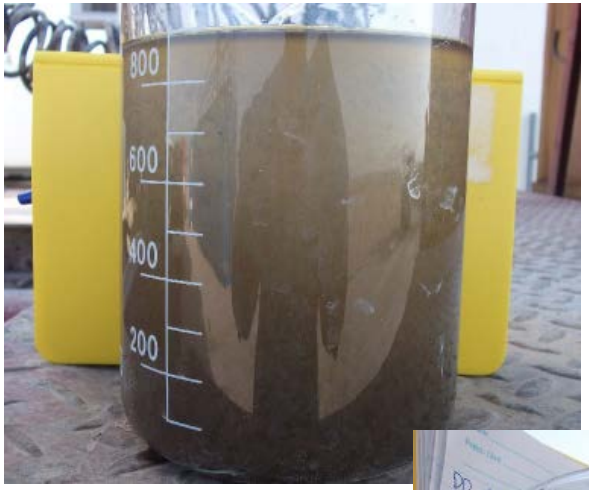
- Hach Portable Hand-held Turbidity and Suspended Solids Instrument (by Client)
- Hach Portable pH/DO/Conductivity/ ORP Instrument
- Sludge Judge
- Other:
  - Screen cleaner – squeegee on broom handle
  - Media removal – Fine-mesh fish net on pole
  - Dip cup – plastic beaker on pole with hose clamps
  - Settling Apparatus – 1000 mL beaker
  - Sample containers – triple-rinsed 5L bleach jugs
- Patience & Creativity

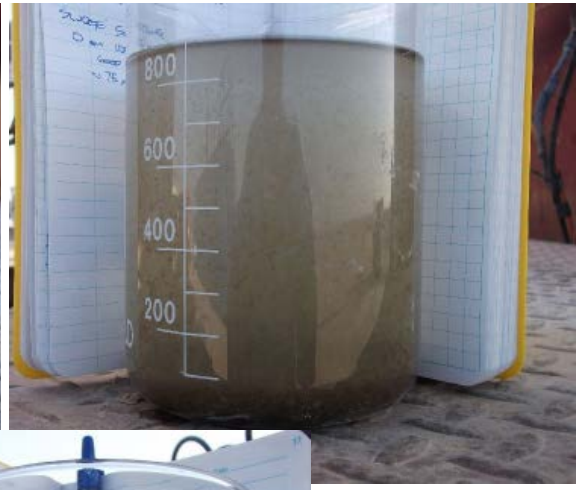
Monitoring Phase at AD-15

- After establishing/implementing 5 Rules for Basic Operation (and completing 1 field modification), began Monitoring Phase
- Monitored:
  - Estimate of flows; use of equalization
  - DO, pH & ORP for operational control
  - Sludge settling characteristics using jar test
  - Total Suspended Solids as estimate for biomass density
  - Turbidity for primary discharge limit
- Settings
  - Set and marked valves based on observed flow
  - Adjusted sludge wasting duration

Performance of AD-15 MBBR

Settling Test – Initial Results on 10/26/10





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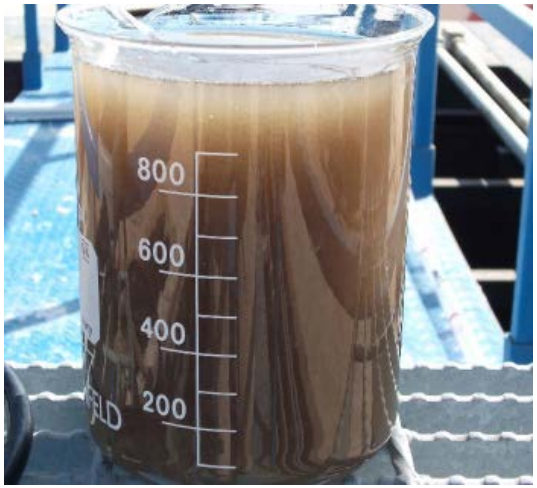
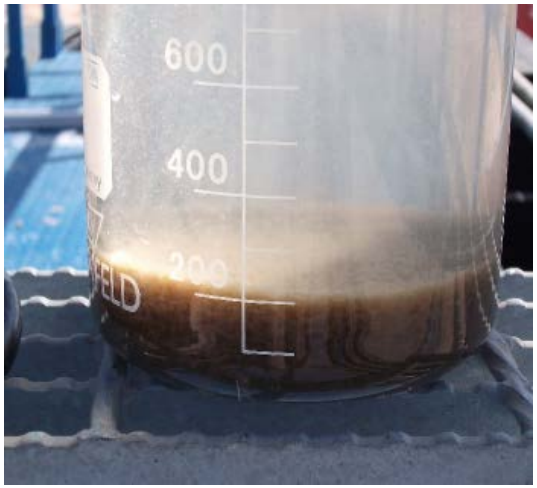
Performance of AD-15 MBBR

Settling Test – Results on 10/29/10 (morning)





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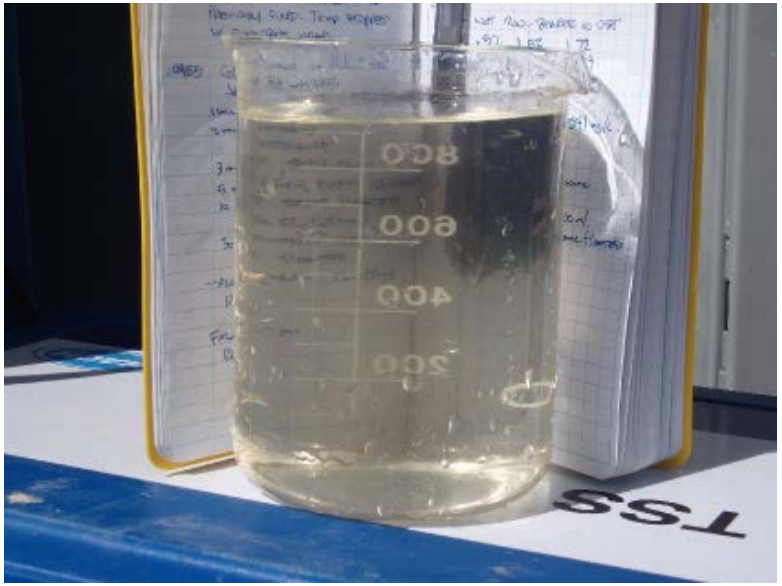
Performance of AD-15 MBBR

Settling Test – Results on 10/29/10 (afternoon)



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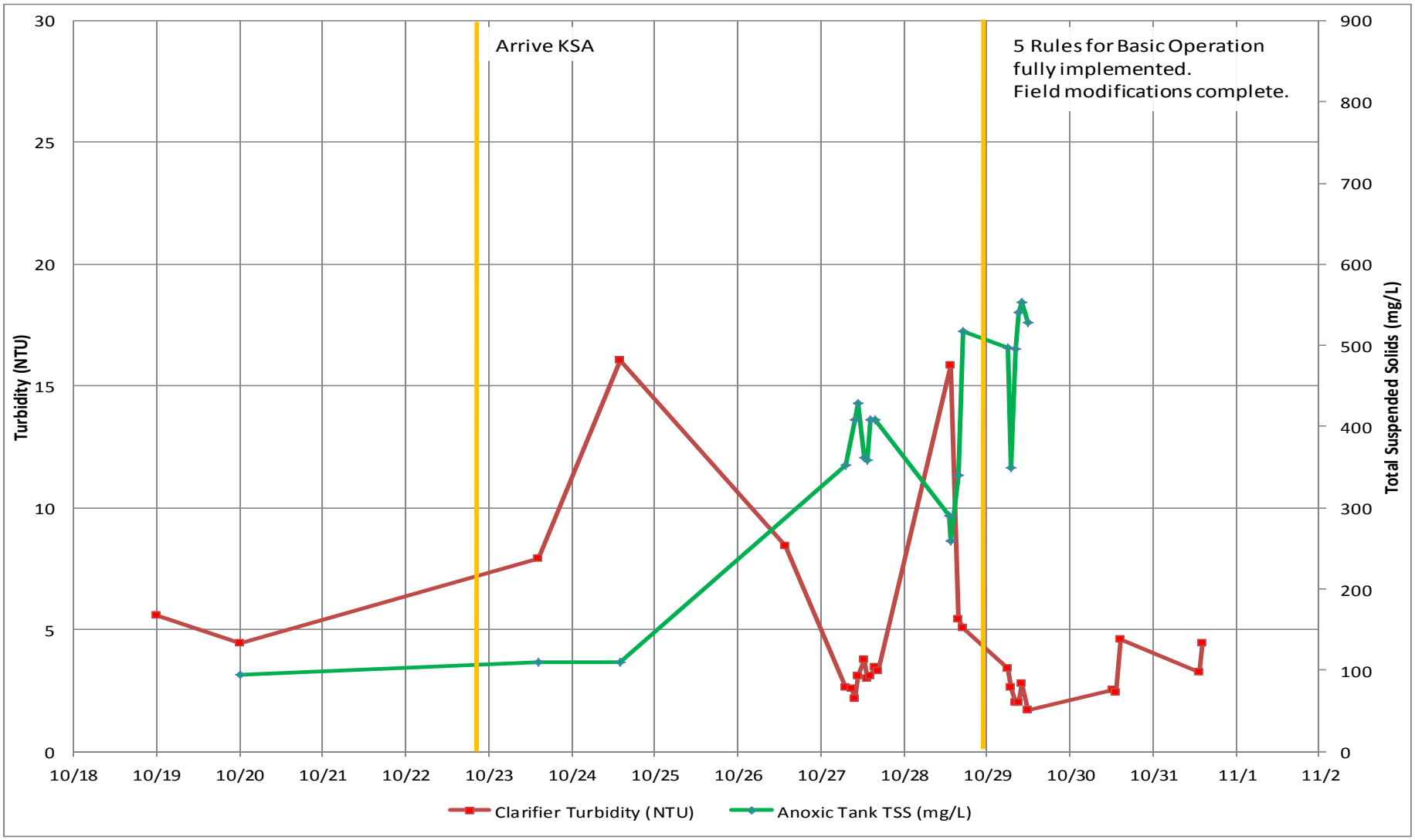
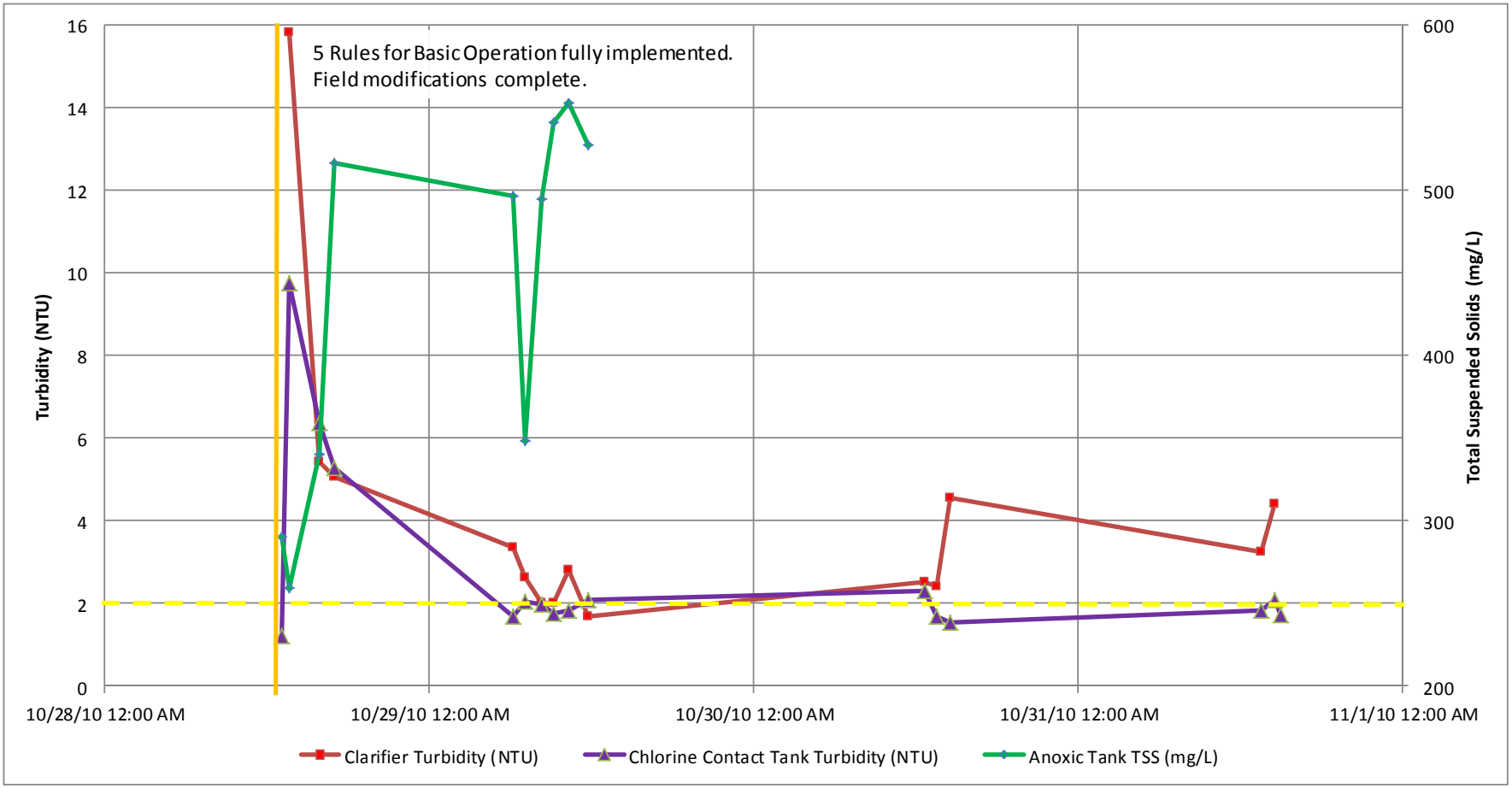
Performance of AD-15



Performance of AD-15



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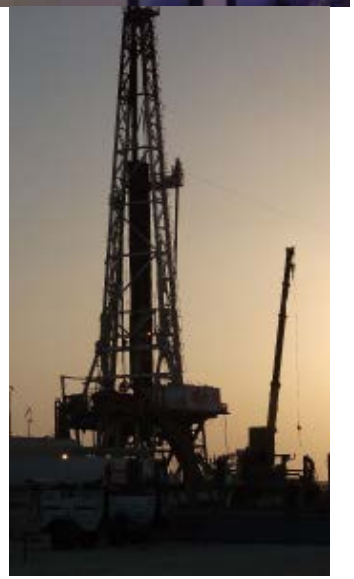
Further Performance Recommendations

- Documentation does not include basic health and safety information regarding working with sanitary wastewater.
- Each deployed MBBR unit should be equipped with basic tools for daily maintenance.
- Each MBBR unit should be posted with a laminated *Normal Operations Guide* (The 5 Rules). Link to photographs to aid in identifying the proper valve or tank.
- A flow meter or easily conducted field method for evaluating daily forward flow should be installed/implemented.
- On a periodic basis, an experienced person should evaluate system operations (field measurements, lab samples, microscopic, etc.).
- One chemical tote is located on a shelf well above waist height. Transferring chemicals into the tote is difficult and presents a safety issue.
- Chemical dosing lines should be rerun with unbroken lengths of tubing, instead of ferruled connections.

Summary

- In general, the MBBR units at AD-15 and N-236 were not being properly maintained prior to ERM's arrival in KSA.
- Forward flow was set to take full advantage of the equalization tank and provide a steady flow to downstream processes.
- 5 Basic Rules implemented to provide continuous flow.
- RAS changed from daily event (if ever) to a continuous recycle between 50 and 100% of the forward flow.
- Over a 9-day period, ERM personnel demonstrated that a quality effluent could be produced with minimal (but not zero) daily attention.
- Based on field testing, a 2 NTU daily average discharge limits is readily achievable if the MBBR units are operated properly.

Project Update / Questions



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