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Pipeline & Process Service

Pipeline Deposit Assessment and Cleaning Techniques

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Solving challenges.™

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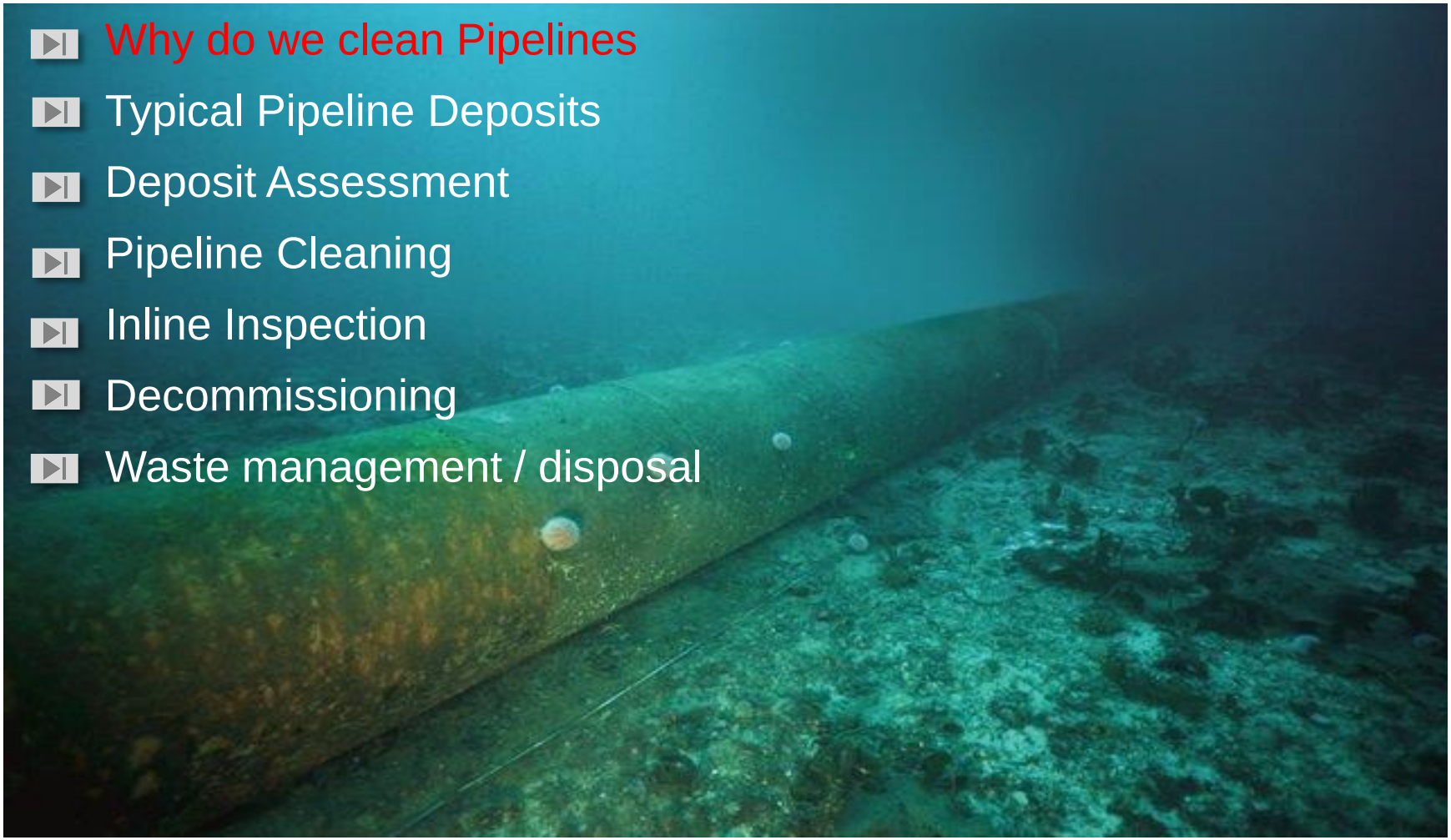
Agenda



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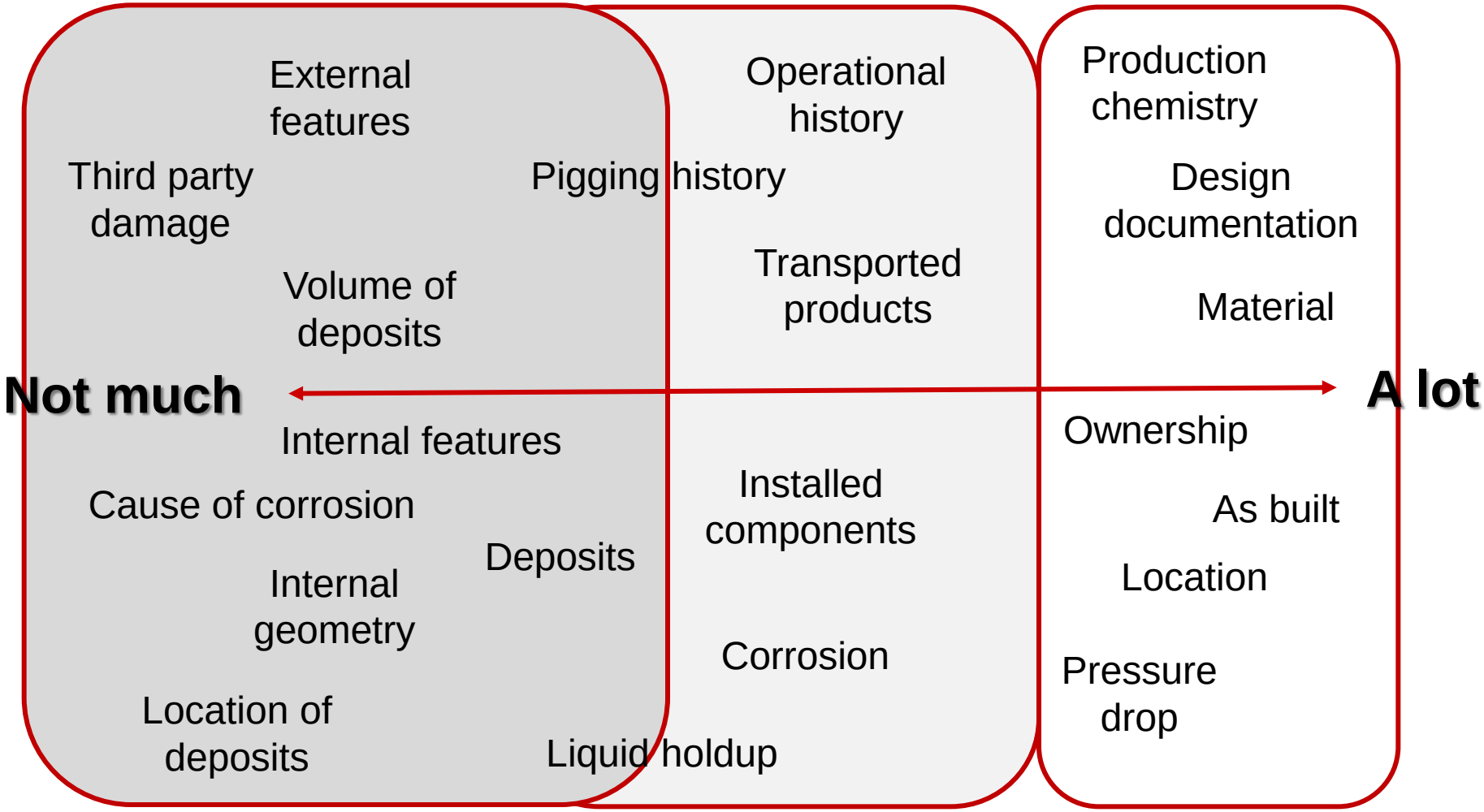
But why clean pipelines?

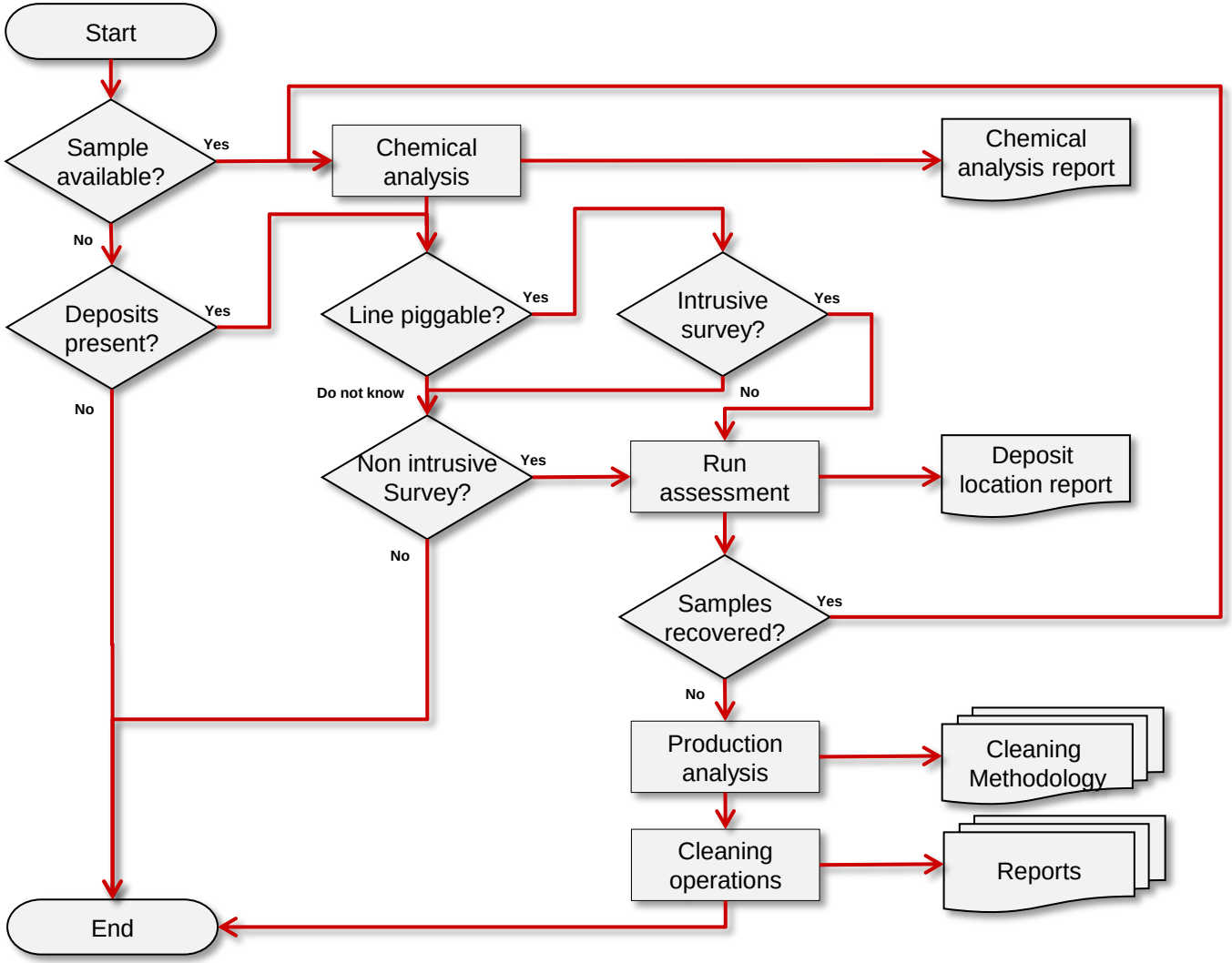
- Commissioning
- Maintenance / production / efficiency of the system
- To enable inspection
- Change of service
- To decommission

What we know about any pipeline



Note: Halliburton does not have ILI technology but *do have* a *proven track record* in cleaning and *assuring successful pipeline inspections*

Project Planning / Engineering



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Chemical analysis of a deposit in a pipeline

- Laboratory chemical analysis of the produced fluids
- Samples removed during regular pigging operations

- Issues
  - Is the sample representative?
  - What if there are a number of different types of deposit?
  - If a sample is obtained - where in the pipe did it originate?

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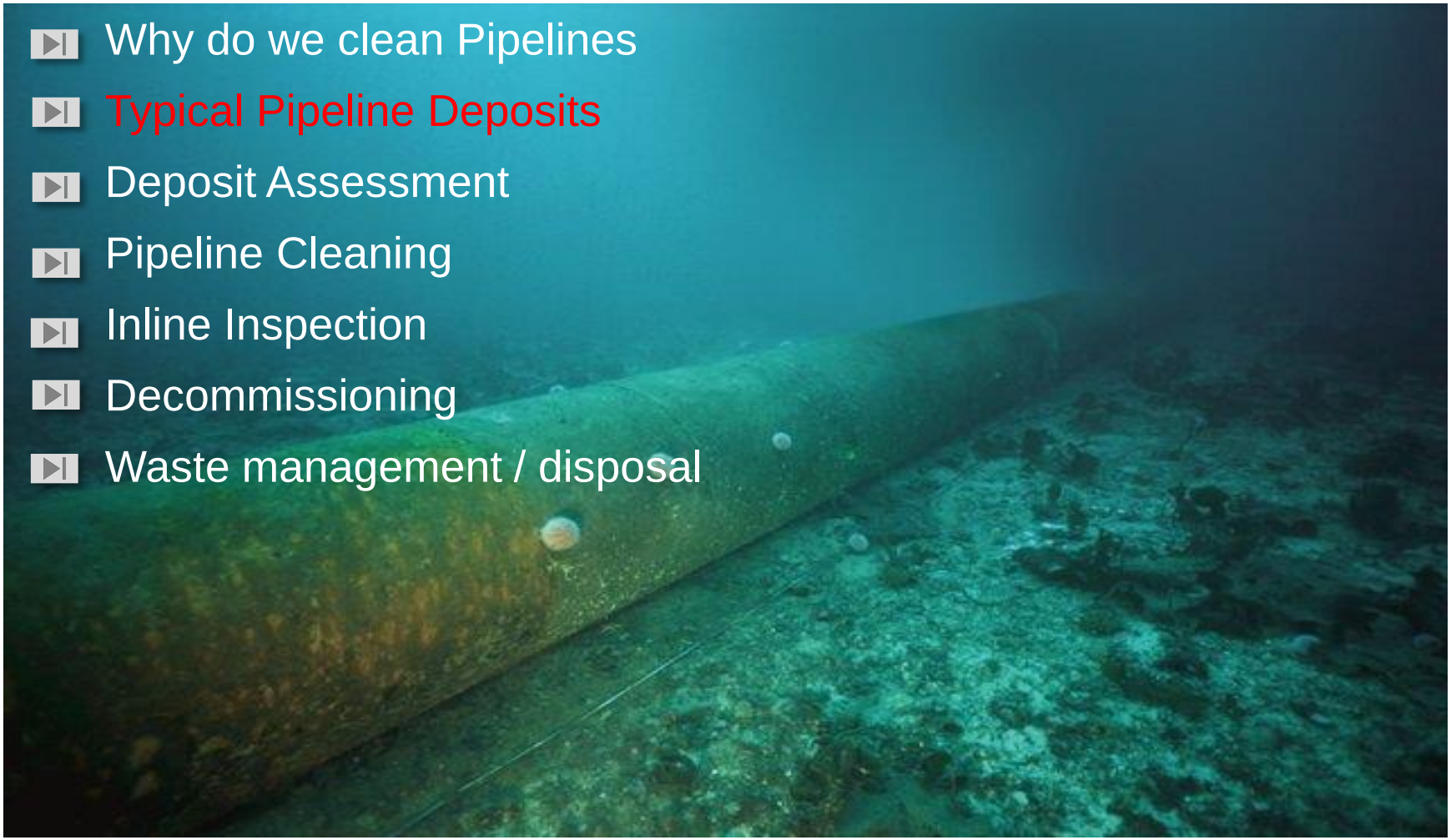
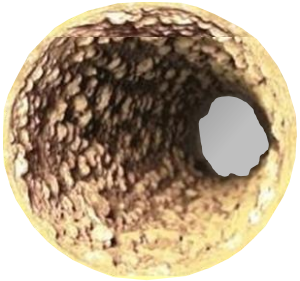


Typical pipeline deposits

- Paraffin wax
- Asphaltenes
- Salts & scales
- Sand and well fines
- Hydrates
- Water
- Erosion & corrosion products
  - “Black powder”
  - FeS’s, FeO’s, Fe_2CO_3
- Emulsions

Paraffin Wax

Scale



Scale

Black Powder

Hydrate

Sludge / Emulsion

Pipeline deposits and probable cause

Paraffin wax	▪ Fluid temperature change ▪ Fluid pressure change
Inorganic Scale	▪ Fluid temperature change ▪ Fluid pressure change ▪ Co-mingled incompatible aqueous fluids
Iron Oxide, Iron Sulphide or Iron Carbonate	▪ Direct chemical reaction of transported fluid components with pipe alloy ▪ Ineffective removal of mill-scale from new pipe during pre-commissioning ▪ Improper dewatering, drying and / or lay-up of pipe during pre-commissioning or remedial works
Sand / well fines	▪ Produced from the well with the hydrocarbons
Emulsions	▪ Energised mixing of different liquid and / or solid phases
Hydrate	▪ Combination of hydrocarbon gas, water, low temperature and high pressure

Impact of deposits

- ↓ Production
- ↓ Efficiencies
- ↓ Reliability
- ↓ Product quality
- ↓ Profitability

- ↑ OPEX costs
- ↑ Pumping costs
- ↑ Maintenance cost
- ↑ Risk

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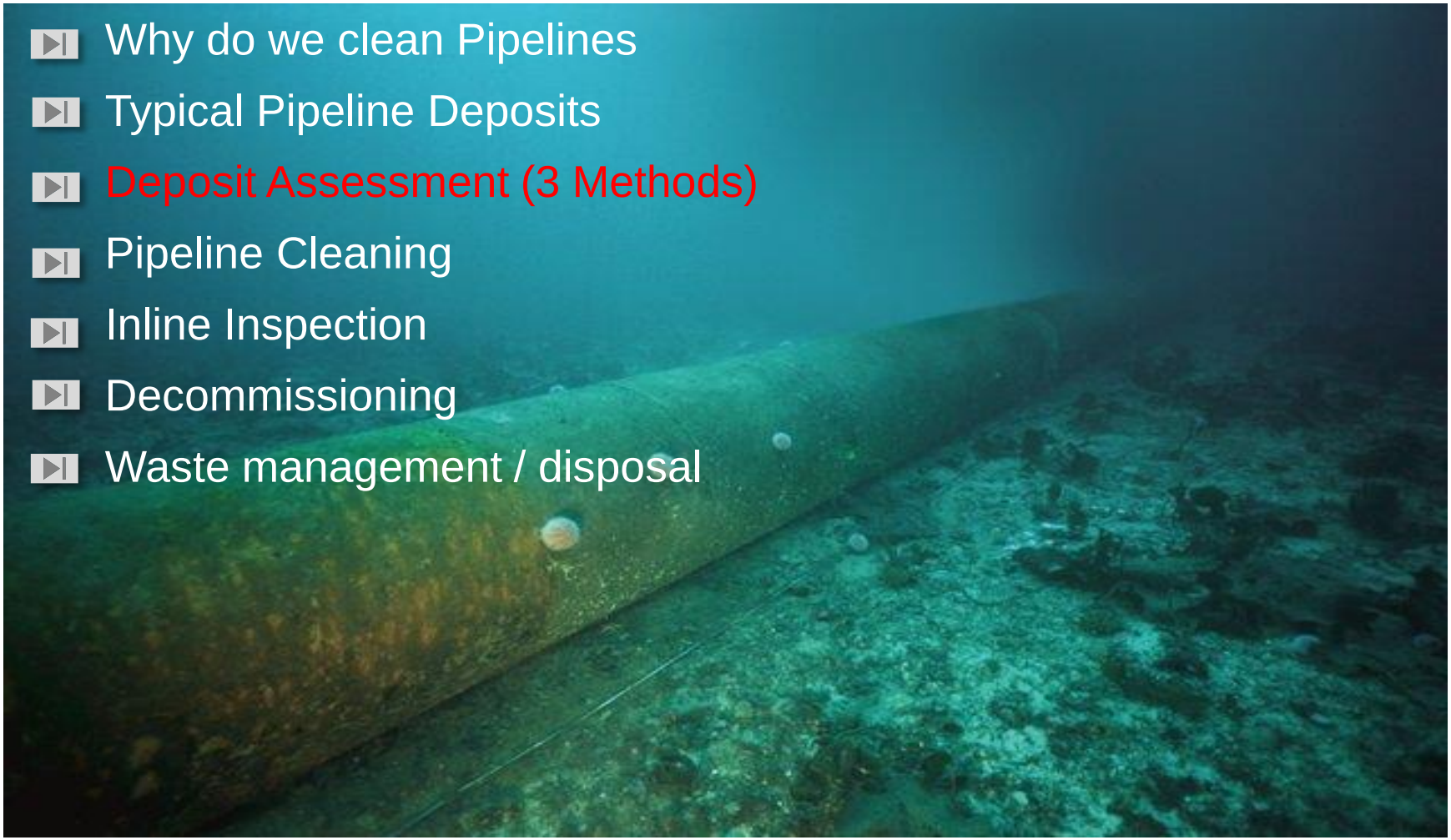
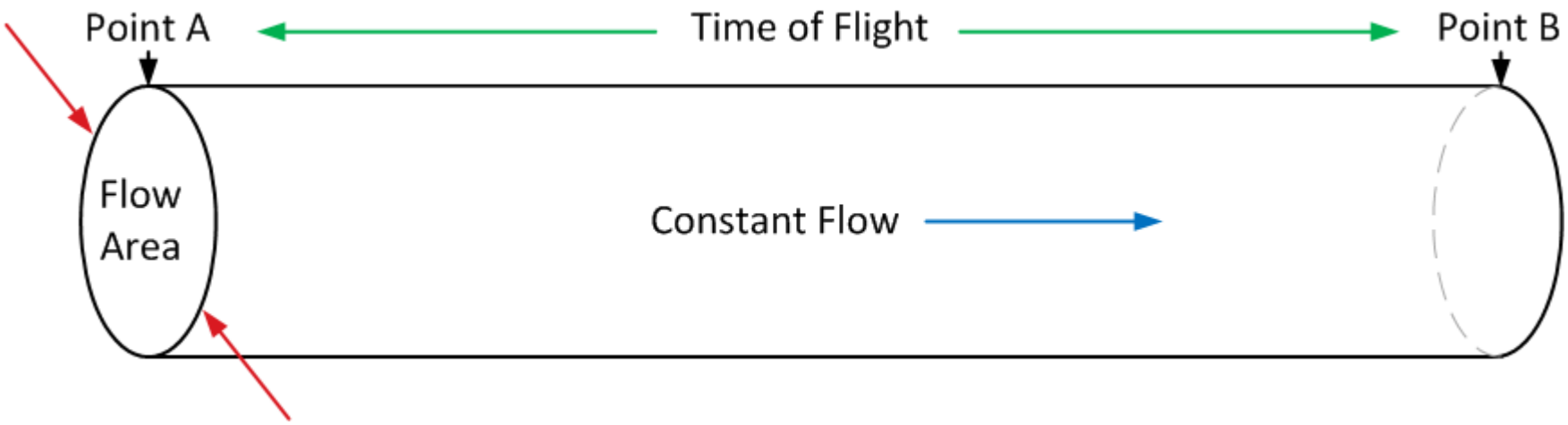


Deposit measurement – Time of Flight

- Constant flow conditions
- Known flow area / volume
- Calculated transit time



Deposit measurement – Time of Flight example

- Achieve constant flow
- Launch a gel tracer
- Maintain constant flow
- Data log flow and pressure
- Record time to transit the pipeline

At constant flow the fluid velocity will change based on the available flow area

Time of flight technique

Issues:

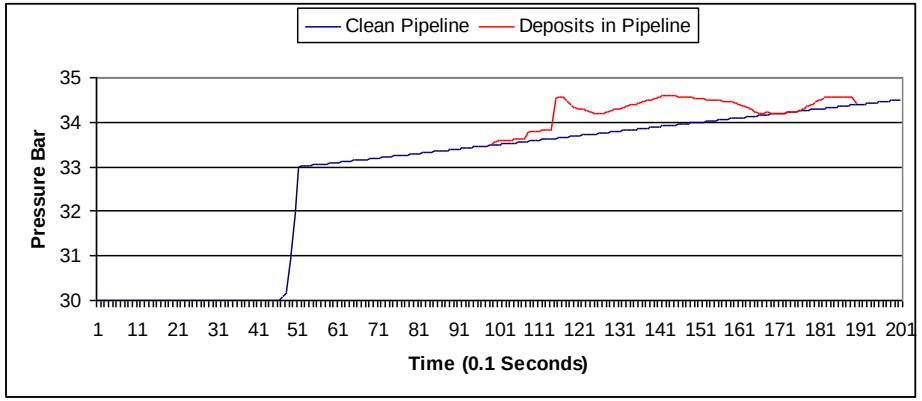
- With ‘time of flight’ the deposit profile will be unknown

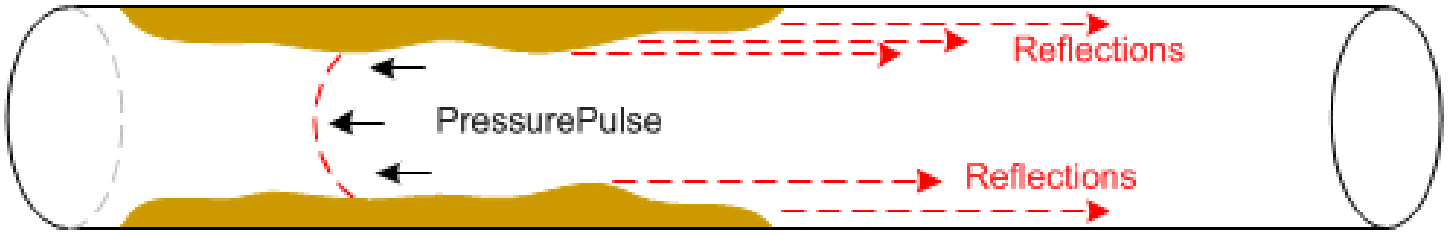
- Do we have this …

- Or this ……

Deposit location – PressurePulse technology

- Achieve constant flow
- Induce pressure pulse
- The pulse travels at the speed of sound
- The line packing signal reflects the flow conditions at the front of the pulse





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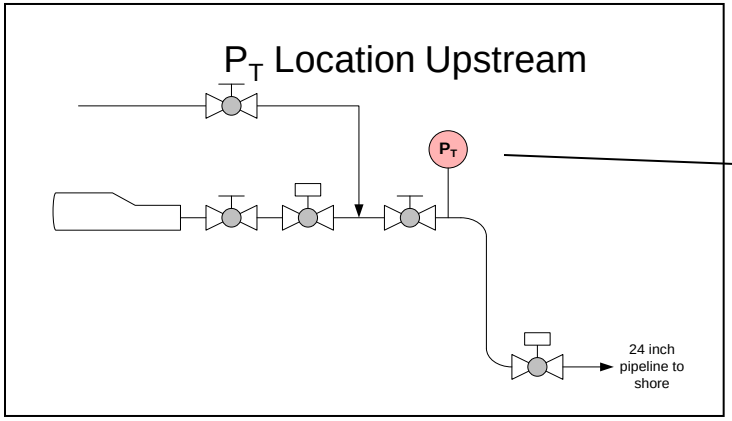
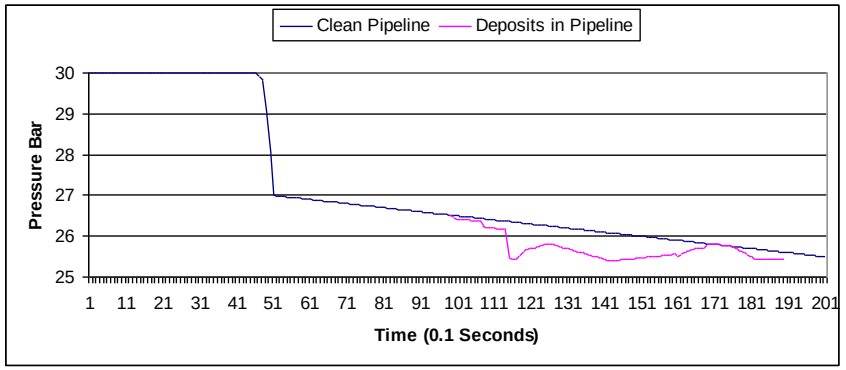
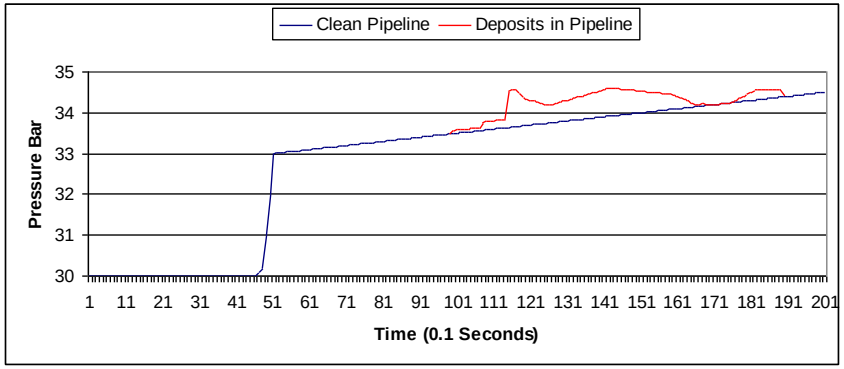
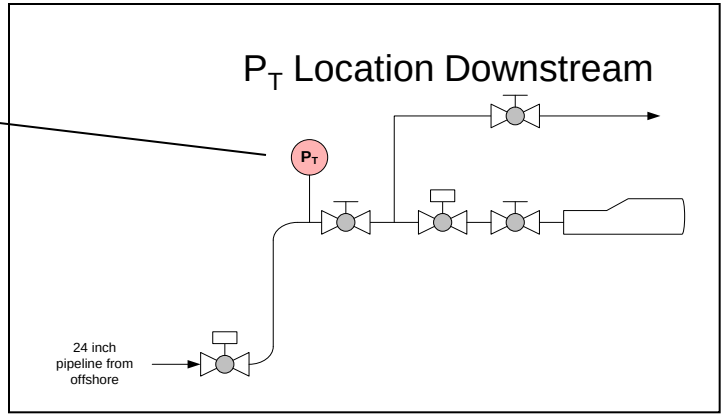
PressurePulse – Line packing profile









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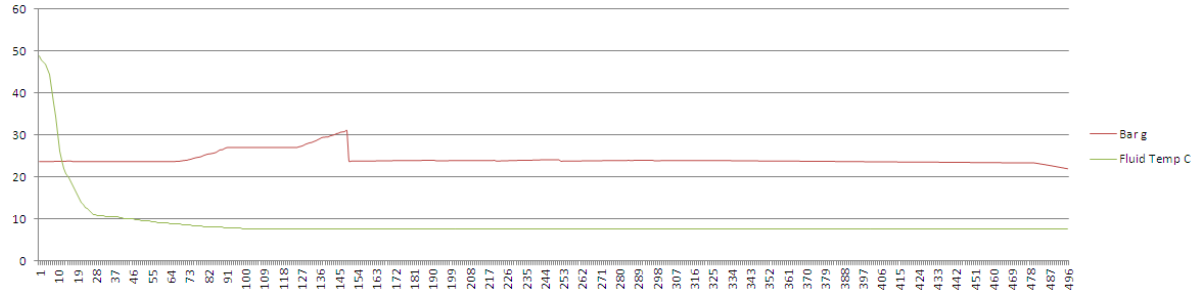
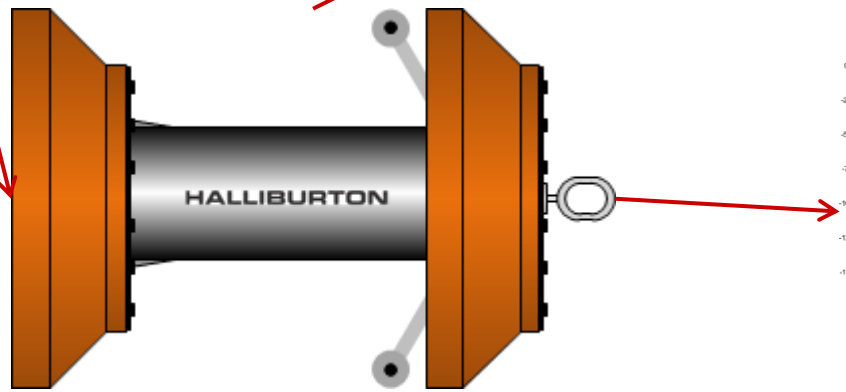
Deposit location – PressurePulse technology

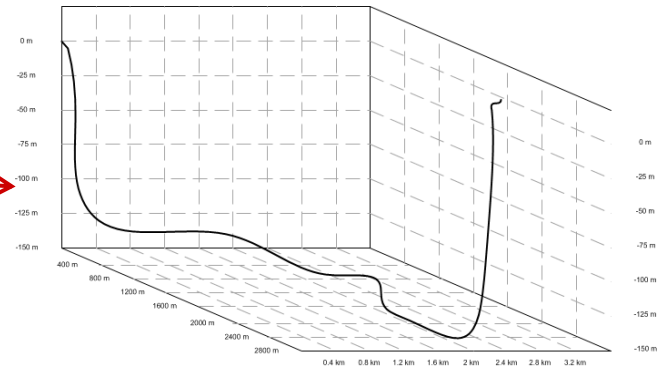
Debris assessment tools – Intrusive systems

- Data log of pipeline pressure, temperature plus the line geometry

Data logger mounted in a pig







Deposit location method comparison

	Method 1	Method 2	Method 3
	Time of Flight	**PressurePulse**	**Intrusive**
Can be done on line	Yes	Yes	Yes / ?
Can locate deposits	No / ?	≈Yes	Yes
Can quantify deposits	Yes	≈ Yes	≈Yes
Requires a pig	No	No	Yes
Data analysis required	Yes	Yes	Yes
Accuracy	Good[#1]	Good[#2]	Good
Risk of blockage	Low	Low	Low / ?[#3]
Cost	$$	$$	$$$$

Note #1: The system will quantify the deposit but will not locate the deposit

Note #2: Good accuracy under ideal conditions

Note #3: If a foam pig is used the blockage risk may be minimal

Three example cleaning projects

Project 1 GoM

- Line pressure drop high
- Throughput declining
- Complete blockage highly likely

After SureStream Flow Assurance Services a production increase of 3,020 bbl/day

Project 2 W Africa

- Unable to pig the line
- Unable to inspect the line
- High concerns over corrosion

After SureStream Flow Assurance Services successful ILI and a production increase of 3,000 bbl/day

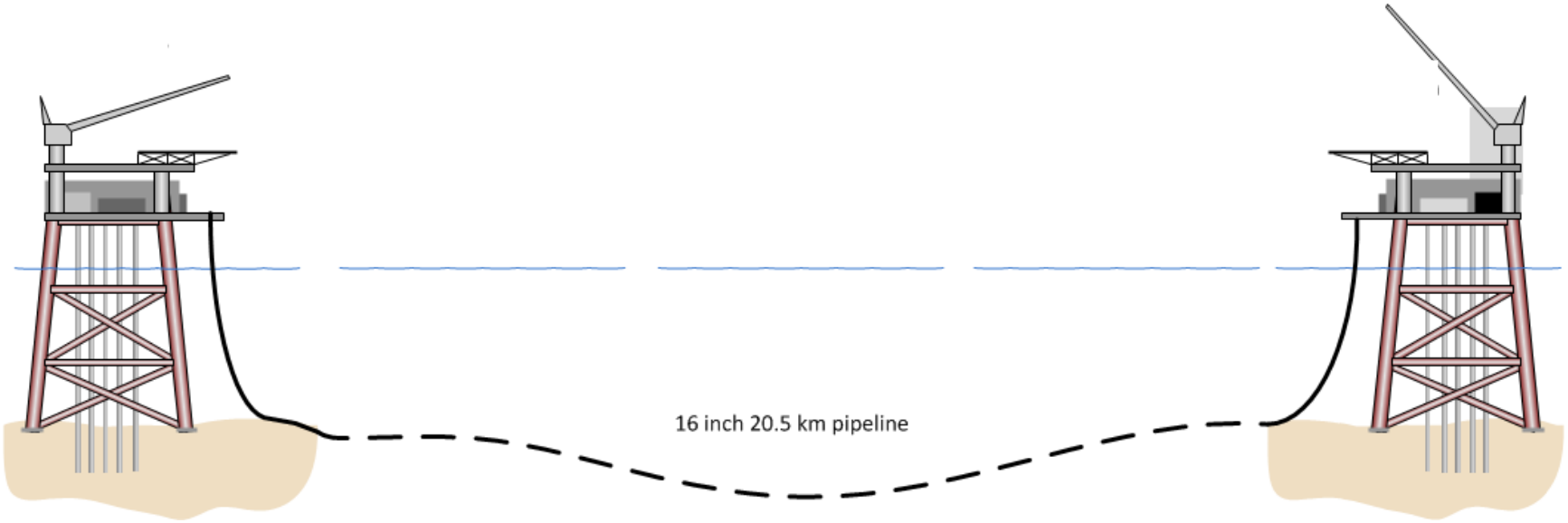
Project 3 N Sea

- Line to be decommissioned
- Hydrocarbon decontamination scope
- Oil in water acceptance criteria of 20 ppmv

SureStream Flow Assurance Services chemical & mechanical cleaning efficiently resulting in <20 ppm.

In almost all projects after completion of services a production increase has been experienced

Case Study – West Africa



- 16 inch oil pipeline
- 20.5 km
- Unknown quantity of deposits in the pipeline
- Cleaning required to enable pipeline inspection

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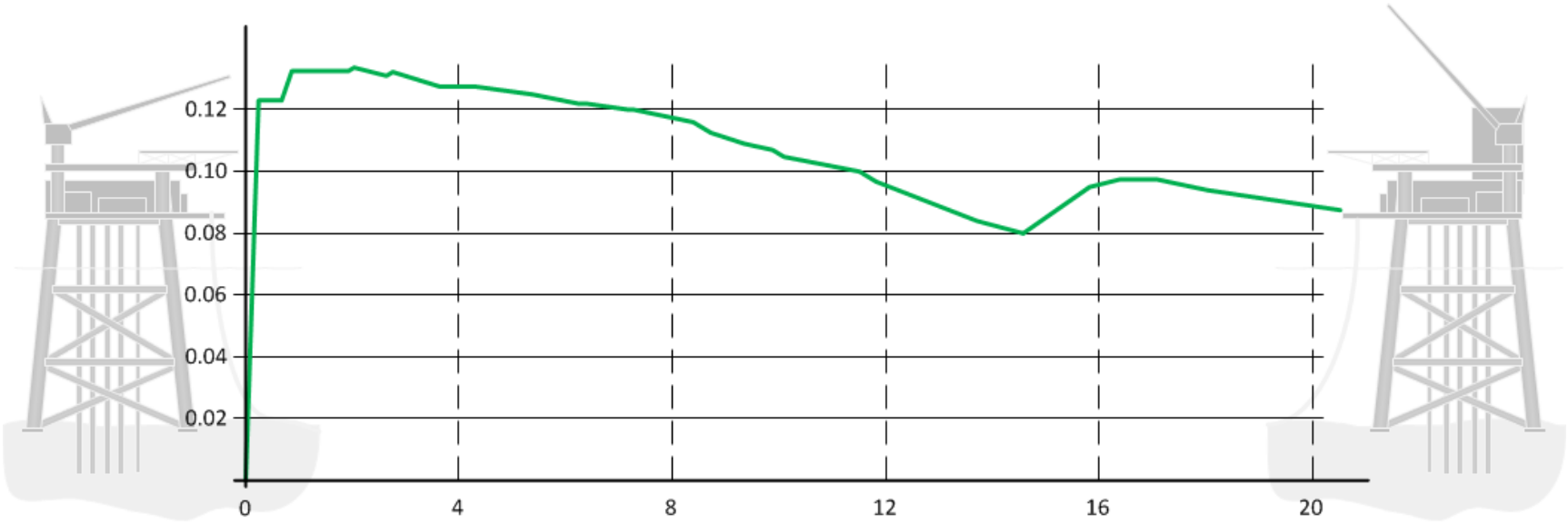
Case Study – West Africa



- Deposit profile prior to cleaning
- Survey indicated approximately 350 cubic meters of material in the pipeline

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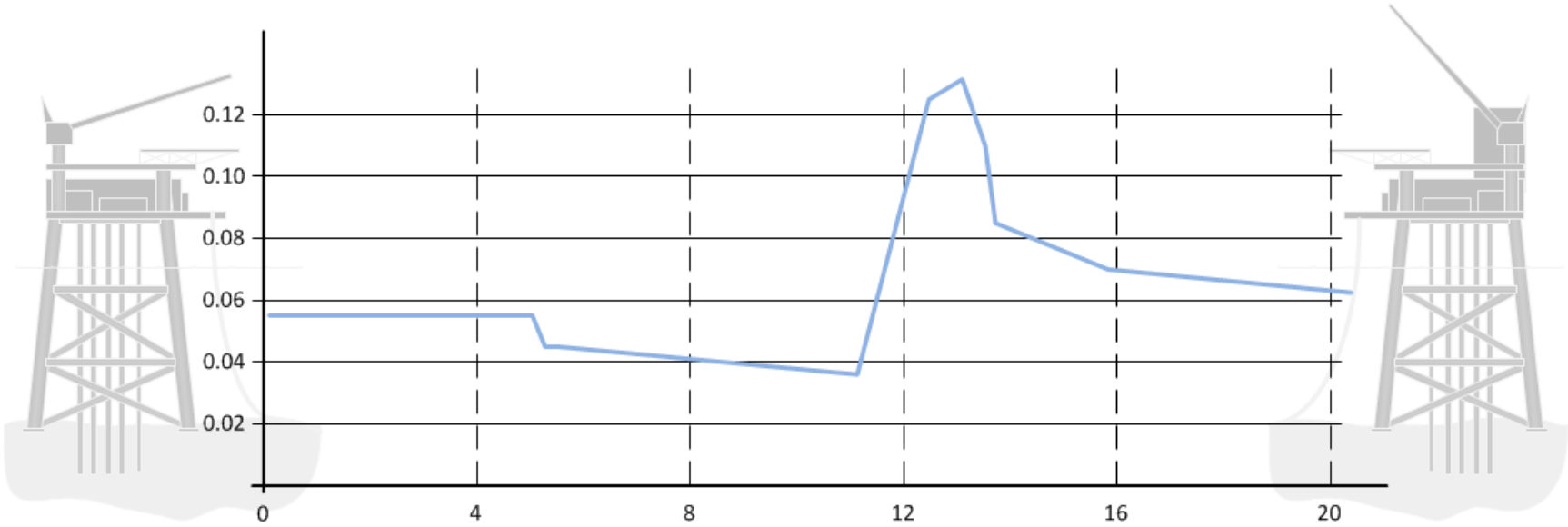
Case Study – West Africa



- Deposit profile after the first stage of the cleaning operation

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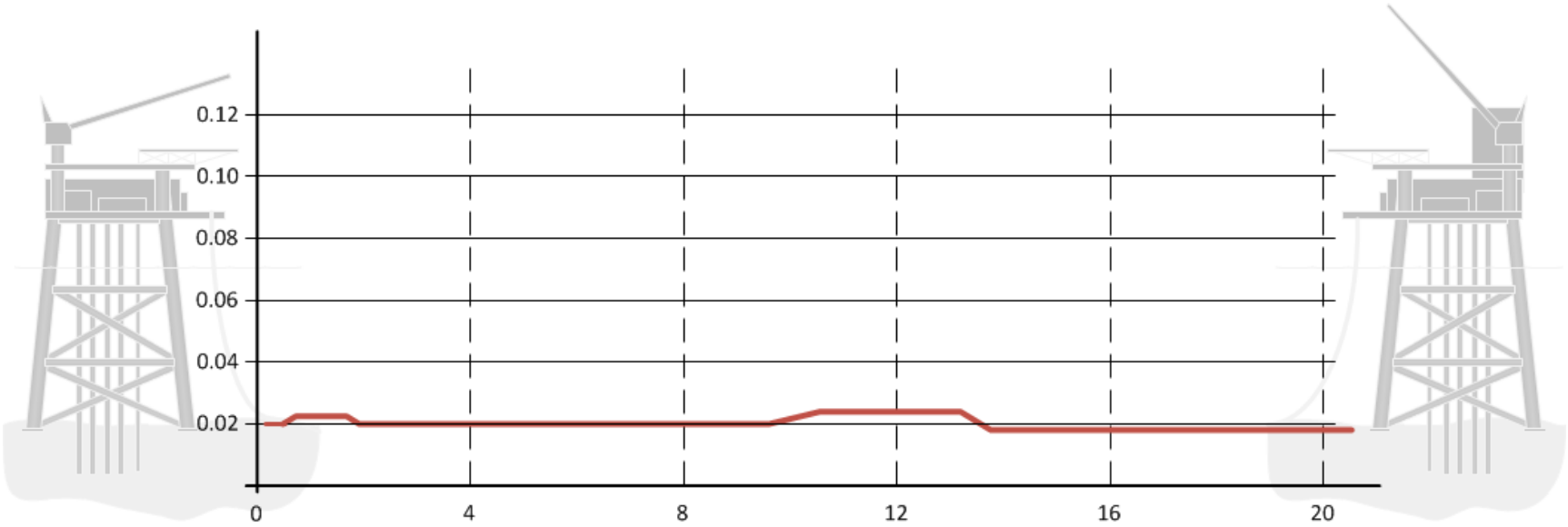
Case Study – West Africa



- Deposit profile after the third stage of the cleaning operation

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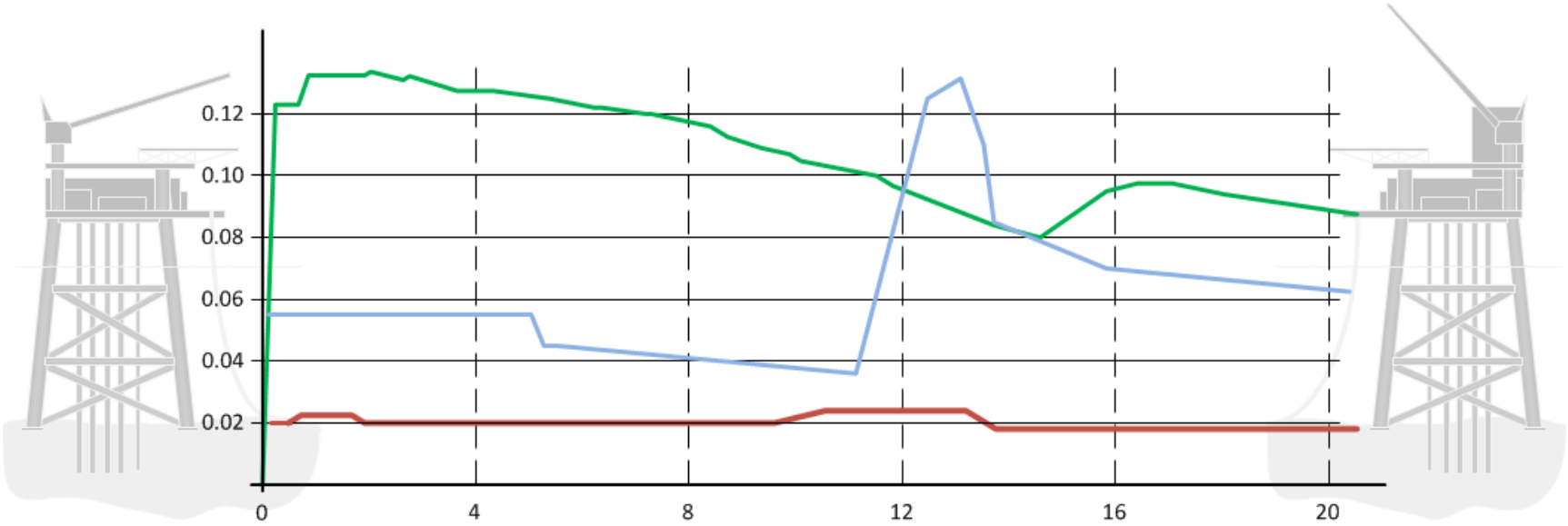
Case Study – West Africa



- All three profiles
- Approximately *577,500 kg* of sand and material removed from the pipeline

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Track Record

Location	Survey Fluid	Length	Diameter	Deposit Type / Operation
Thailand	Oil (liquid at the operating pressure)	10.9km	16 inch	Locate a pig mandrel stuck in the line for several years
Gabon	Treated sea water	3.57km	16 inch	Deposit assessment
UK	Potable water (mainly liquid but with gas pocket)	0.48km	4 inch	Locate a sand blockage in a flexible riser
UK	1) Oil export 2) Treated sea water	107km	16 inch	1) Detect the position of the blockage (pig stuck) 2) Assess the wax deposit in the line post remediation
UK	Condensate (liquid at the operating pressure)	57.9km	8 inch	Wax deposit assessment
Norway	Oil	100km+	8 inch	Wax deposit assessment
UK	Oil	30km	8 and 10 inch	Wax deposit assessment
Gabon	Oil	20km	16 inch	Sandy deposit (sand, oil and water emulsion). Monitored cleaning operation.
North Sea	Water	3.5km	17 inch	Water flooded for inspection, displaced gas/oil/water. Scale.
Australia	Water	63km	14 inch	Stagnant. Lost pig.
Netherlands	Gas	20km	12 inch	Lost object, deposit demo

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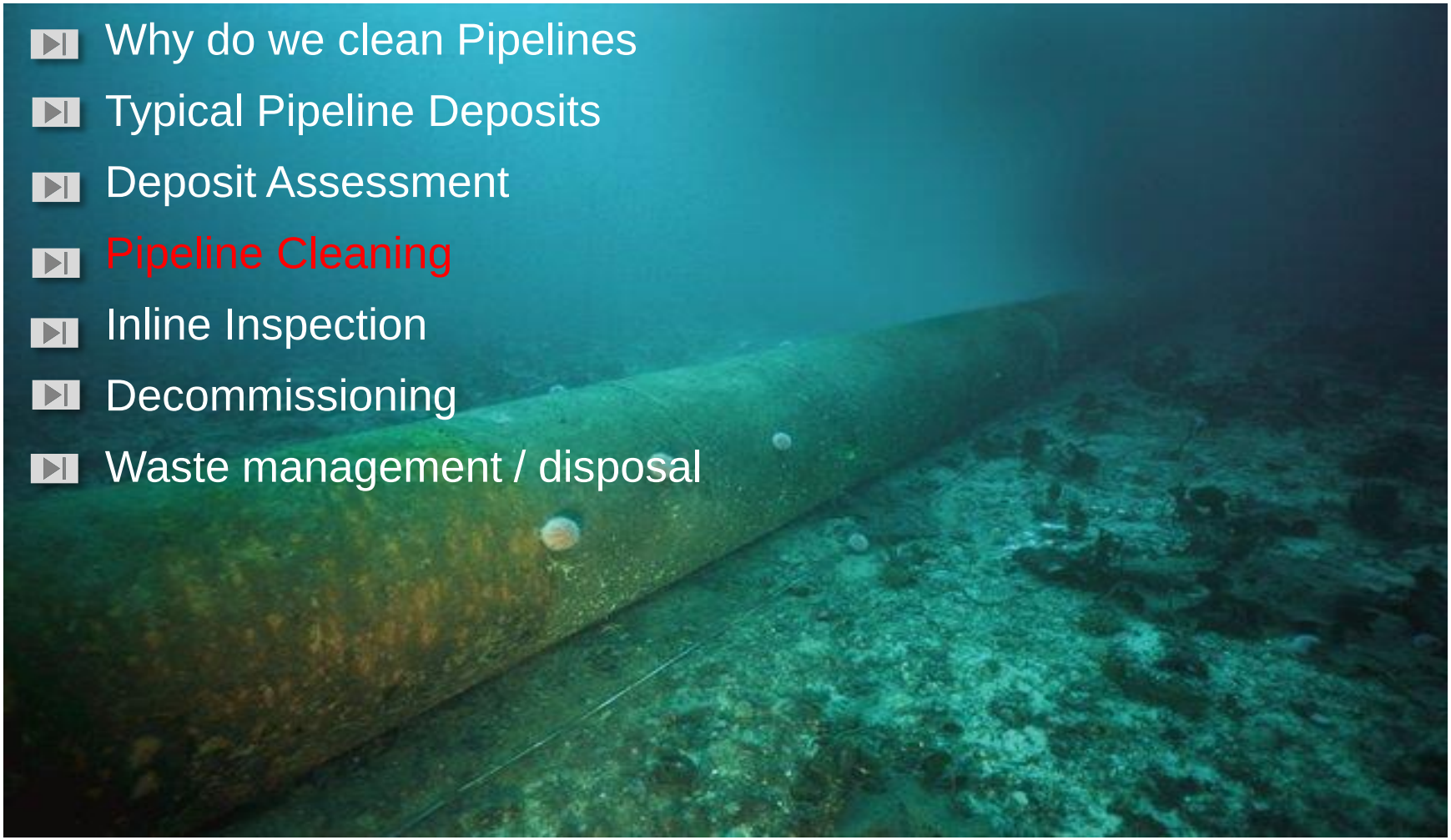


Pipeline cleaning / deposit removal

- Prior to removal
  - Deposit may be evenly distributed or at a specific orientation
  - Probably adhered to pipe wall
  - Probably cause reduced flow area

- After removal from the pipe wall deposits are
  - transported out of the pipeline
  - not accumulated at the 6 o’clock position

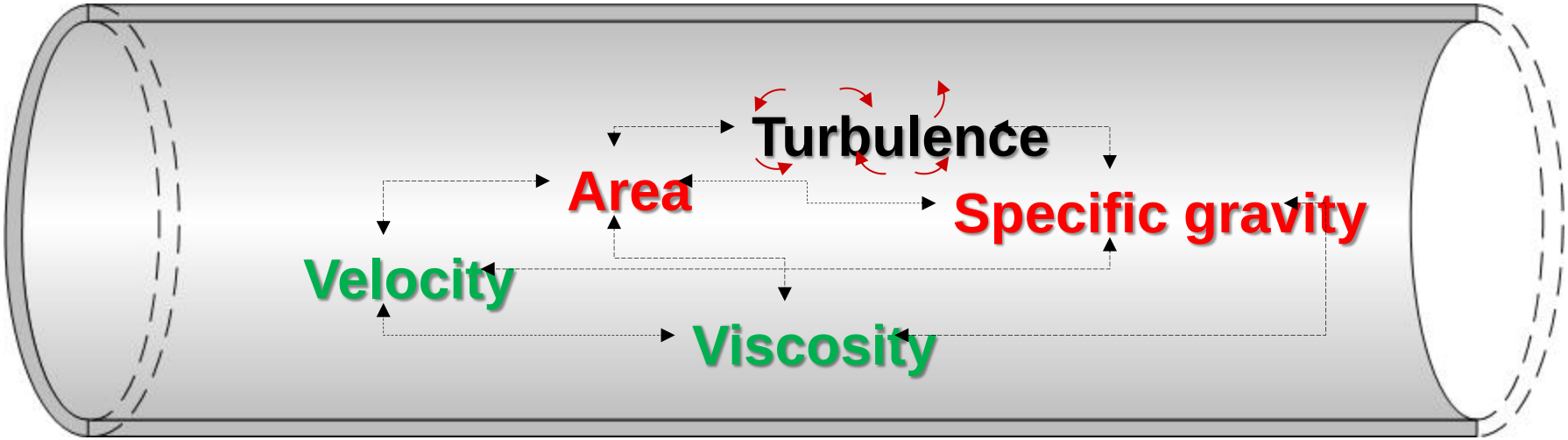
Key considerations for pipeline cleaning operations

- If the cleaning is to be completed with routine pigs:
  - How much material is transported with each pig?
  - How much material is in the pipeline?
  - How much material will have to be removed?
  - Where will the removed material be disposed of?
  - How much will disposal cost?
- Pipeline deposit calculations
  - Paraffin wax
  - Sand
  - Corrosion

Transportation of deposits / debris

Many factors affect particle behaviour

- **Fluid properties**
- **Particle properties**
- **Flow regime**



Cleaning with pigs

- Key considerations when using pigs:-
  - Deposit hardness
  - Deposit adhesion
  - Deposit volume
  - Deposit abrasion
  - Deposit Restriction
  - Fluid flow rate
  - Flow type
    - Laminar
    - Turbulent
  - Fluid properties
  - Fluid carrying capacity

Transportation of deposits / debris

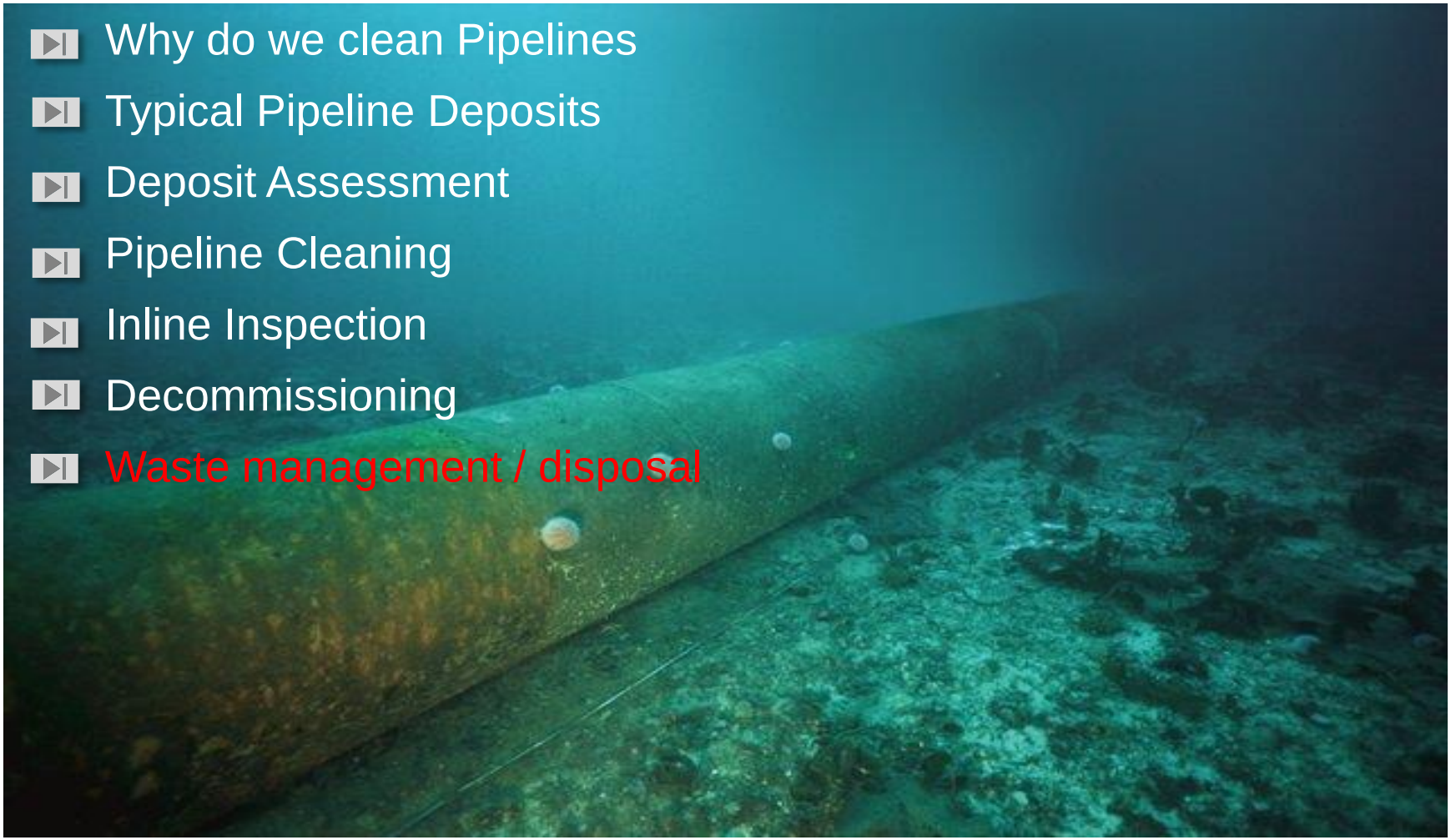
Transportation of deposits / debris

- Fluid design based on deposit and pipeline properties
  - Custom formulation per project
  - Compatability with production
  - Vast database of fluid characteristics
  - Particle / fluid interaction reasearch
  - Experienced laboratory technicians and chemists
  - Extensive track record





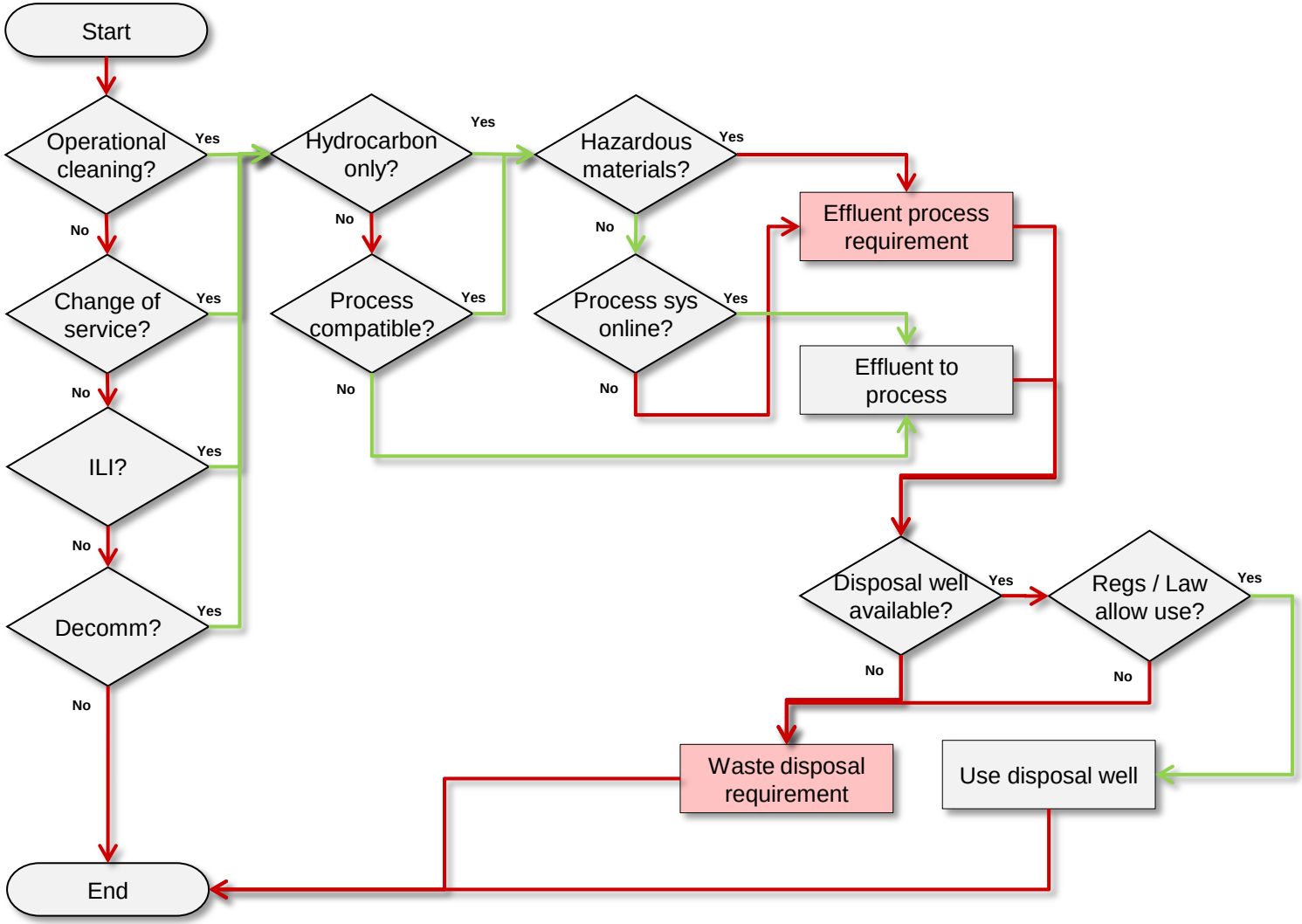

Agenda



Waste management / disposal

- Waste from pipeline cleaning operations has to be disposed of
- Waste disposal can be the most costly part of a cleaning program
- The three P's for minimising waste disposal costs
  - Plan, Plan & Plan

Project planning for waste disposal



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