Self Lubricated Transport of Bitumen Froth from Concept to Commercial Demonstration

Syncrude

Outline

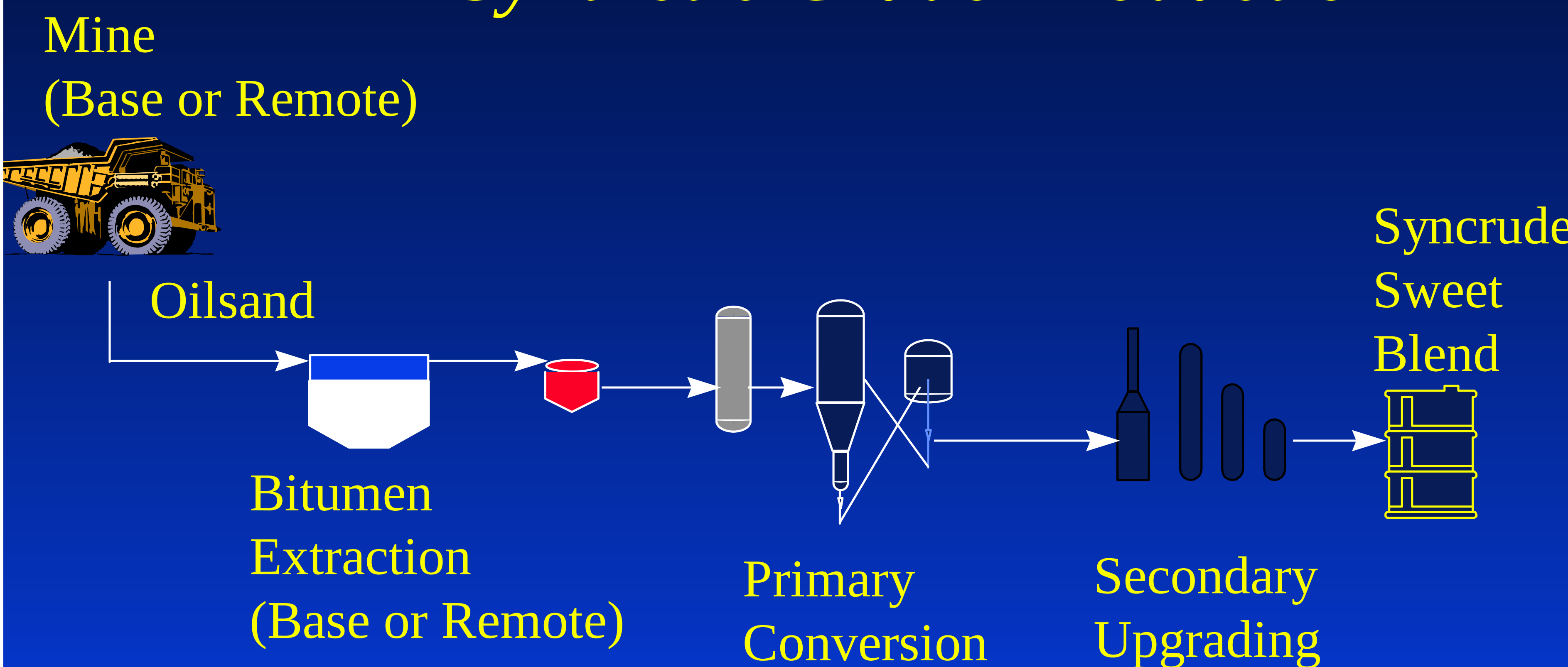
Background

Technology Development Program

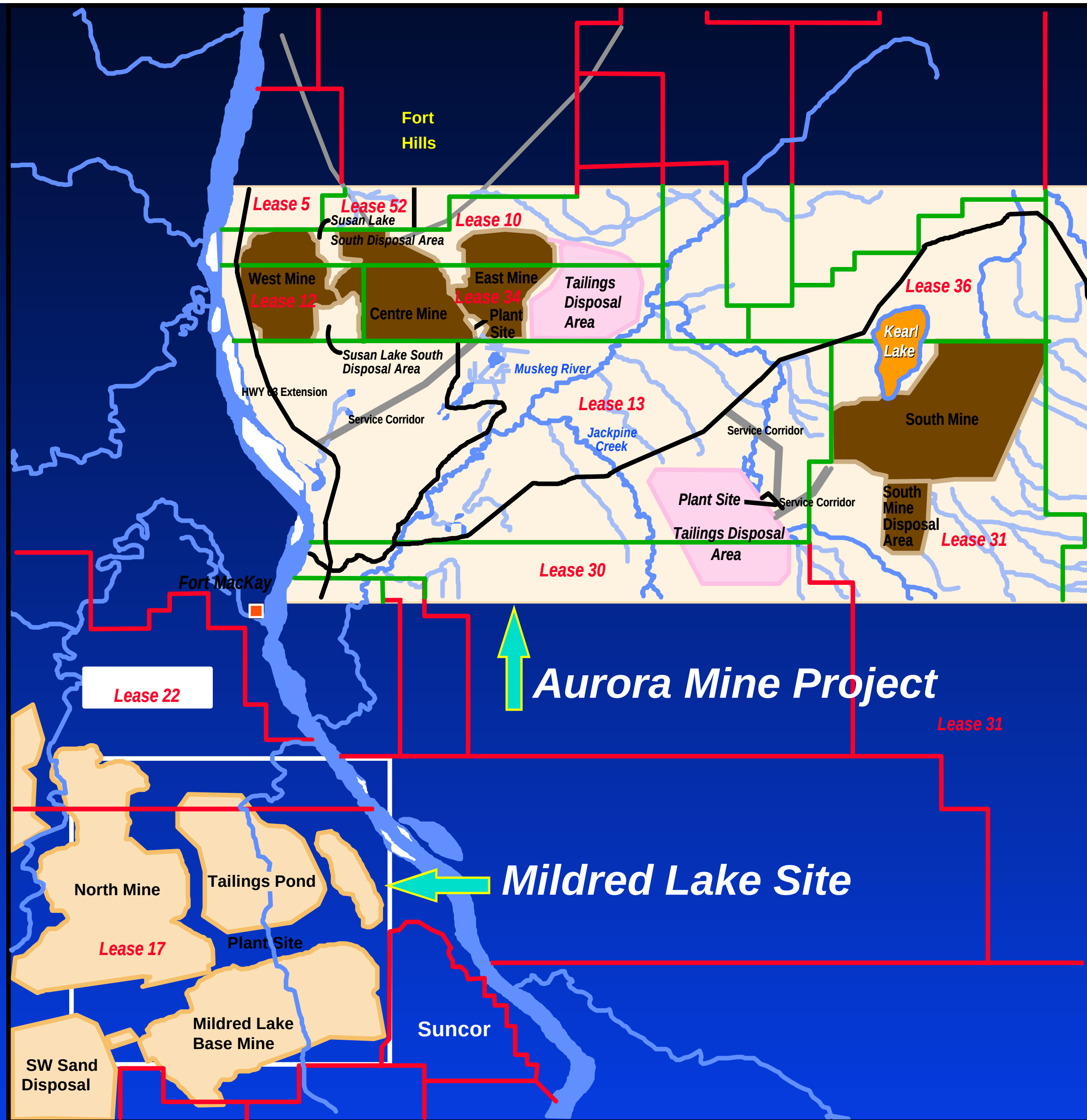
- Economic and Technical Screening of Bitumen Transfer Options
- Pilot Work to Explore the Most Attractive Alternatives
- Commercial Demonstration
- Final Selection - Pipeline Design and Economics

Oil Sands Location

Syncrude Canada From Oilsand Mining to Synthetic Crude Production



Aurora Mine Location



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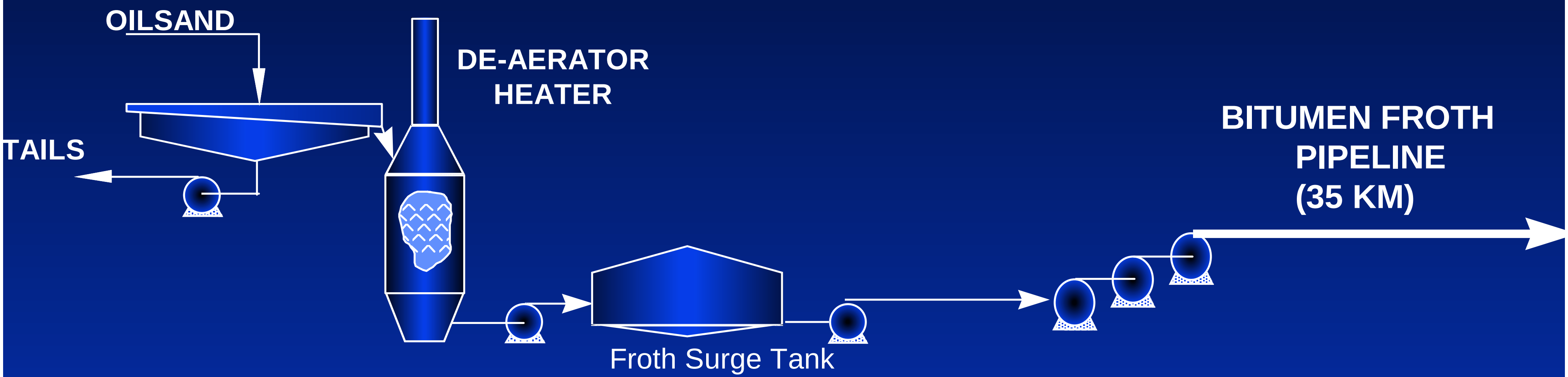
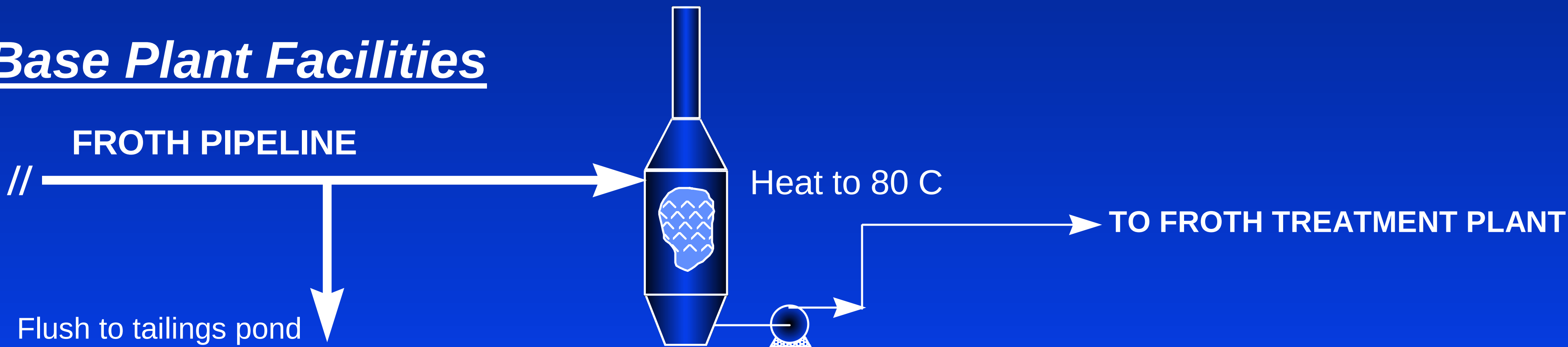
Self Lubricating Flow

Aurora Facilities



Base Plant Facilities



Bitumen Froth

- An intermediate product from an oilsand extraction process
- Typical Composition:
  - 60 % Bitumen
  - 30 % Water
  - 10 % Soilds
- Highly Viscous - Oil Continuous Phase

Insert viscosity graphs

Technology Development

Economic and Technical Screening of Froth Transport Options

Diluted Froth?

Core-Annular flow?

Emulsified Froth?

Heated Froth?

Pilot Work to Explore the Most Attractive Options

Commercial Demonstration

Final Selection

Screening Study
Incremental Supply Costs for Froth Transport

Description	Capital Cost ($M) Difference	Operating Cost ($M/Yr) Difference	Supply Cost Diff. ($/BBL)
Naphtha Diluted Froth	Base	Base	0.00
Core Annular Flow	-28.8	-0.05	-0.11
Froth Emulsion	-24.5	4.35	0.06
Heated Froth	-32.5	0.70	-0.05

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Technical Screening of Options

- **Naphtha Diluted Froth**
  - **Key concern is froth separability**
- **Core Annular Flow**
  - **Key concerns are fouling and re-start**
- **Heated Froth**
  - **Heat transfer equipment adds complexity at Aurora**

Conclusion
Economic and Technical Screening

Diluted Froth - Best chance for technical success, however separability is an issue

Core Annular - Best economics, but needs development for this application

Technology Selection

Economic and Technical Screening of Froth Transport Options

Pilot Work to Explore the Most Attractive Options

- Naphtha Diluted Froth Pipeloop
- Core Annular Flow Pilot

Commercial Demonstration

Final Selection

Naphtha Diluted Froth Test Program Conclusions

- High shear or high viscosity conditions results in emulsion formation and poor froth separability
- Low shear pumping to avoid emulsion is feasible
- Addition of demulsifier prior to shearing eliminates emulsion

Technology Selection

Economic and Technical Screening of Froth Transport Options

Pilot Work to Explore the Most Attractive Options

- Naphtha Diluted Froth Pipeloop

- Core Annular Flow Pilot

Commercial Demonstration

Final Selection

Core Annular Flow Pilot Test Objectives

- **Key Issues**
  - **Pipeline Fouling**
  - **Ability to re-start the pipeline**
- **Objectives**
  - **Investigate fouling and re-start**
  - **Establish an operating envelope**

Insert Pressure Profiles from Minn

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University of Minnesota Results

- Froth pumped in core flow mode for periods of up to four days
- No indication of pipeline blockage
- Reasonable operating envelope; 0.7 to 2.5 m/s
- Longer shutdowns required water addition

Self Lubricating Flow Insights

– Froth is self-lubricating
– Fouling is inhibited by the liberated water
– A minimum velocity of 0.7 m/s is required

Self Lubricating Flow Insights

- A proposed mechanism :
  - Froth is unstable at high shear rates
  - Dispersed water droplets coalesce
  - Clay particles inhibit fouling : “ Powdering the dough”
  - Clay particles act like surfactants

Technology Selection

Economic and Technical Screening of Froth Transport Options

Pilot Work to Explore the Most Attractive Options

- Naphtha Diluted Froth Pipeloop
- Self Lubricating Flow Pilot

Commercial Demonstration

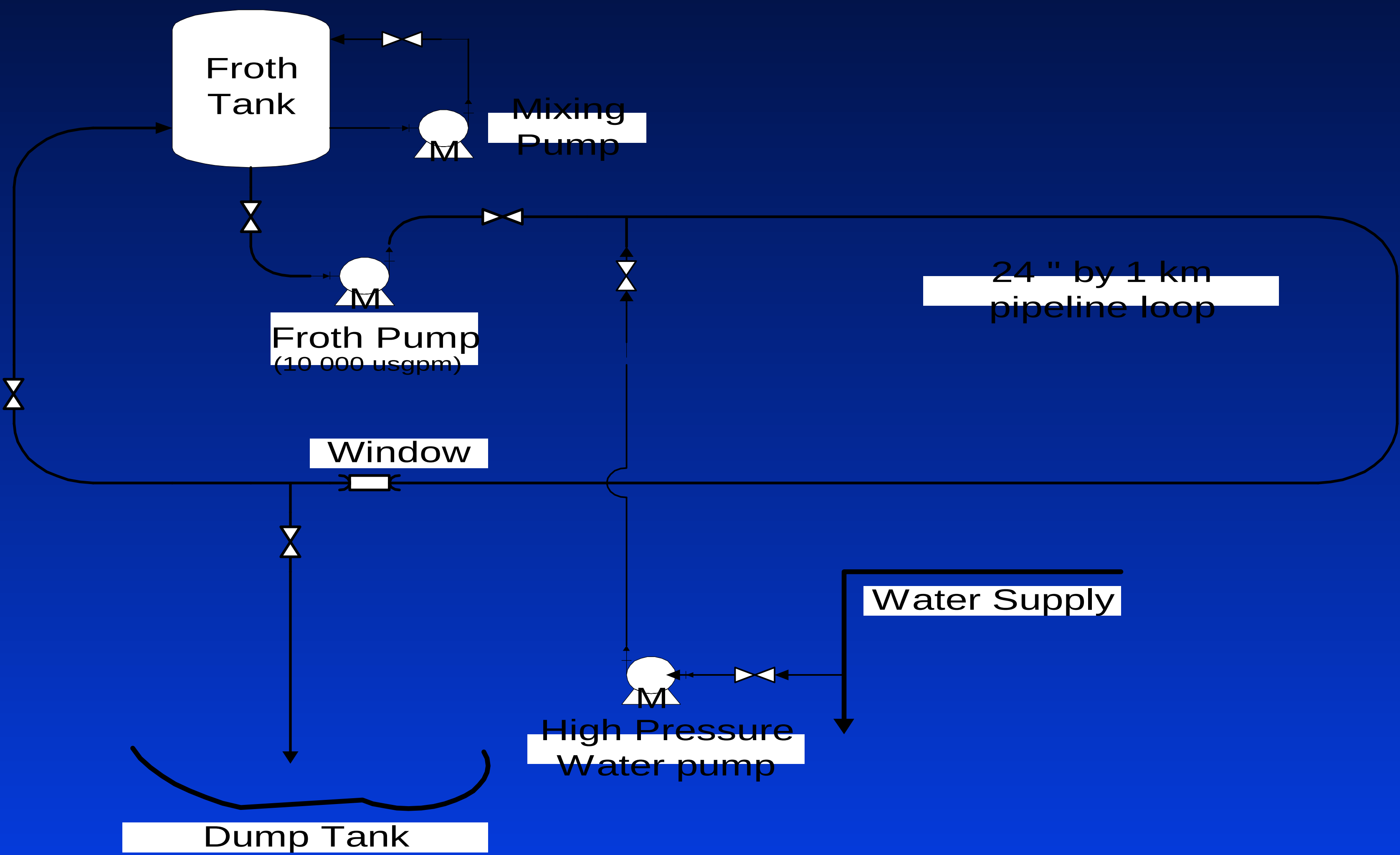
Final Selection

Self Lubricating Flow
Commercial Scale Test Objectives

- Establish SLF given shear regime at large diameter
- Re-start characteristics at large diameter
- Gain confidence in our ability to commercialize

Insert PFD & NFL photos

Self Lubricated Flow
Commercial Scale Demonstration



Preliminary Results from Commercial Scale Tests

- Successfully established lubricated flow in 24” by 1 km pipeline
- Successful use of a centrifugal pump
- Pipeline shutdowns from 1 minute to 6 hours tested
- Successful re-starts - no high pressure water required

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Technology Selection

Economic and Technical Screening of Froth Transport Options

Pilot Work to Explore the Most Attractive Options

Commercial Demonstration

Final Selection

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Final Selection

Pipeline Design & Economics

- Aurora Train 1, 35 MMBBLS/Yr for 2001
- Aurora Train 2, 80 MMBBLS/Yr (Total) for 2005
- Design optimized by minimizing Net Present Cost (NPC) versus pipeline diameter. (NPC captures pipeline costs, pump and motor costs, and operating costs).
- Minimum velocity criteria is a key economic driver

- Self Lubricating Flow has an NPC that is $ 55 M lower then Naphtha Diluted Froth

Final Selection (cont'd)

Self Lubricating Flow selected for Aurora Pipeline Project.

Bases is the large Net Present Cost advantage, and minimal risk based on commercial scale pilot results

Future Work

- Can critical velocity for lubrication be expressed usefully as critical stress?
- What is the thickness of the lubricating water and how does it depend on system parameters?
- How will re-start in a 35 km pipeline differ from a 1 km pipeline?

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