Rajiv Gandhi Institute of Petroleum Technology

BTP- II PRESENTATION

FLOW ASSURANCE USING OLGA SOFTWARE

PETROLEUM ENGINEERING & GEO ENGINEERING DEPARTMENT

SUBMITTED BY

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OVERVIEW

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2. ABOUT SOFTWARE
3. ANALYSIS

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    II. MULTIPHASE FLOW

    III. THERMAL EFFECTS

4. INPUT TOOLS & FUNCTIONS
5. CASES
6. OBSERVATION
7. IMPROVEMENTS & SCOPE

CASE 1 - NO WAX DEPOSITION + VERTICAL PIPE

- SUB CASE I - FLOWLINE UNDER SOIL
- SUBCASE II - FLOWLINE ABOVE SOIL

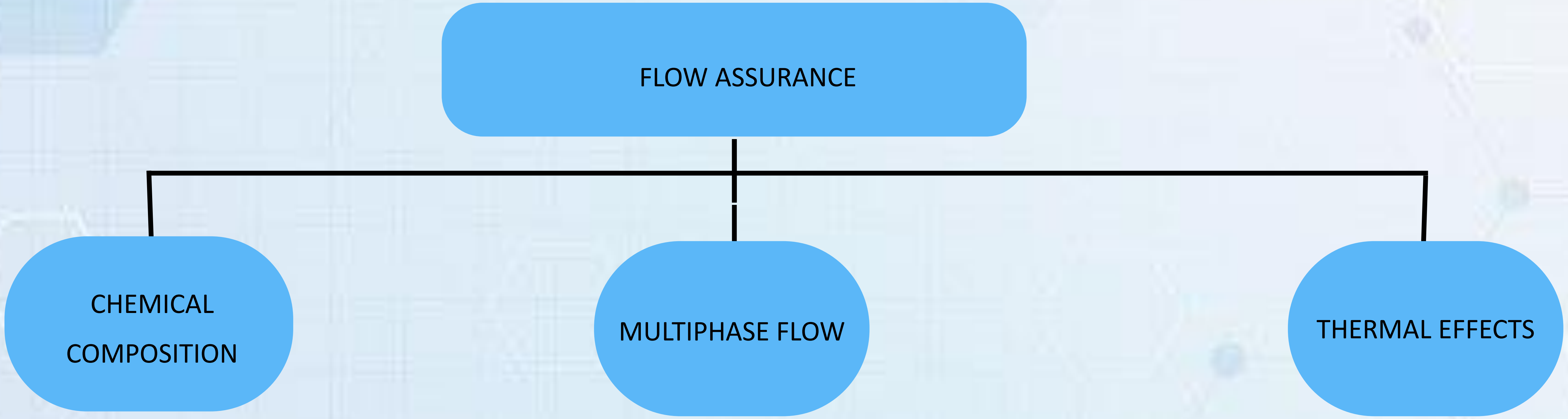
CASE 2 - WAXY CRUDE + NETWORK

- SUBCASE I -EFFECT OF THERMAL CONDUCTIVITY
- SUB CASE II - EFFECT OF PIPELINE THICKNESS

CASE 3 - ASPHALTENE + HORIZONTAL PIPE

INTRODUCTION

- Flow Assurance is a process that is used to ensure that hydrocarbon fluids are transmitted economically from the reservoir to the end user over the life of a project in any environment



I. CHEMICAL COMPOSITION

- Hydrates
- Wax
- Asphaltenes
- Naphthenates

II. MULTIPHASE COMPONENTS

- Oil
- Gas
- Water

III. THERMAL EFFECTS

- Heat transfer coefficient
- Material aspects

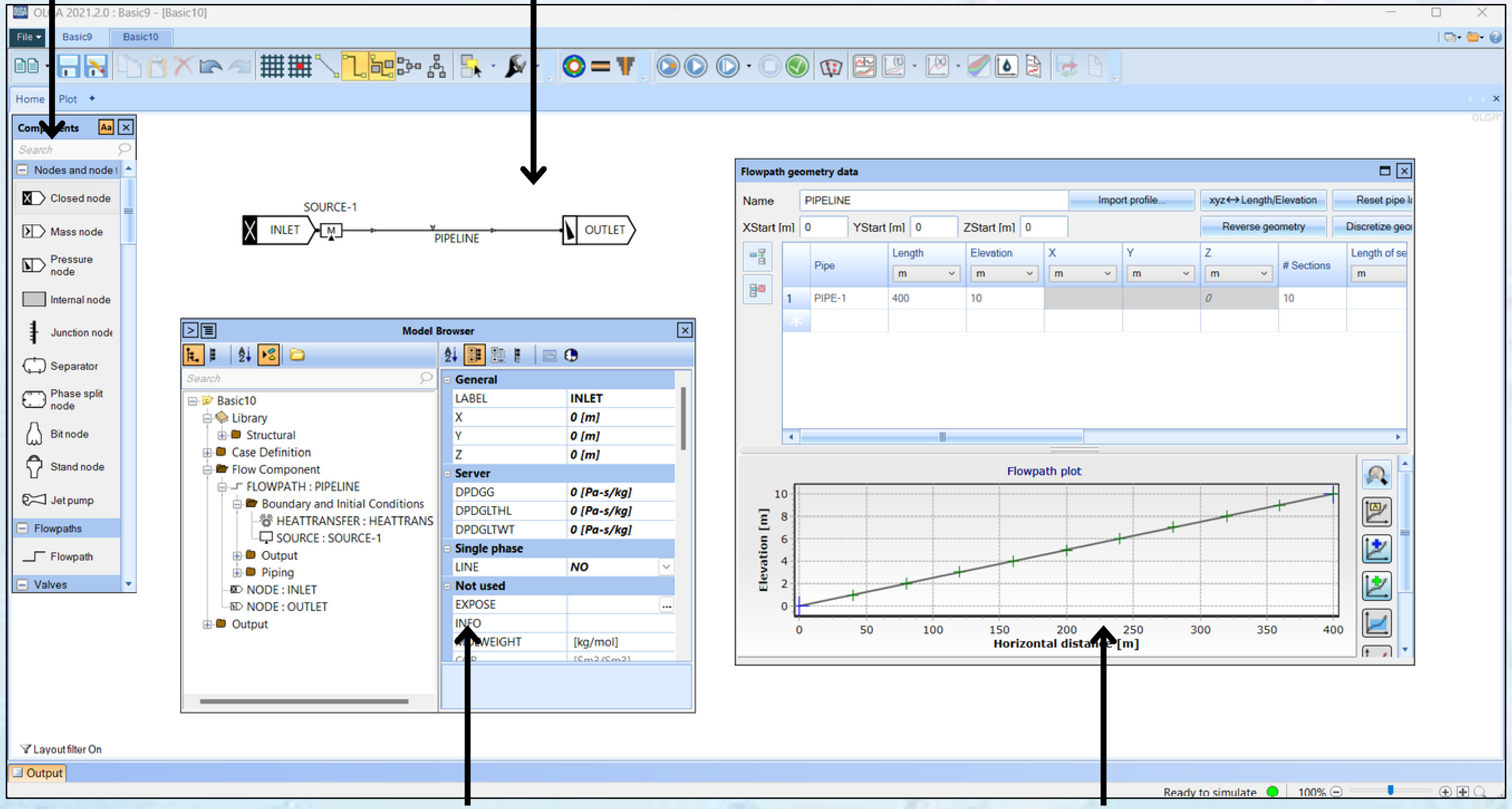
OLGA SOFTWARE

- OLGA is a modelling tool for the transportation of oil, natural gas and water in the same pipeline, so-called multiphase transportation.
- The name is short for "oil and gas simulator".
- It's a Transient Dynamic simulator

Main windows displayed on the screen

Components

Diagrammatic Representation



Model Browser

Flow path Geometry Data

External Tool Used

- MultiFlash - For generating input fluid files in OLGA

I. CHEMICAL COMPOSITION

- Wax formation occur due to presence of n - paraffins in crude (C>16)
  - Asphaltene formation occurs due to presence of polycyclic aromatic compound
- Hydrates will occur because of presence of free water

ASPHALTENE

EXAMPLE

Temperature: **57.674 °C** Pressure: **1.000 atm**

Number of Phases: **3** Solution Stability: **Stable**

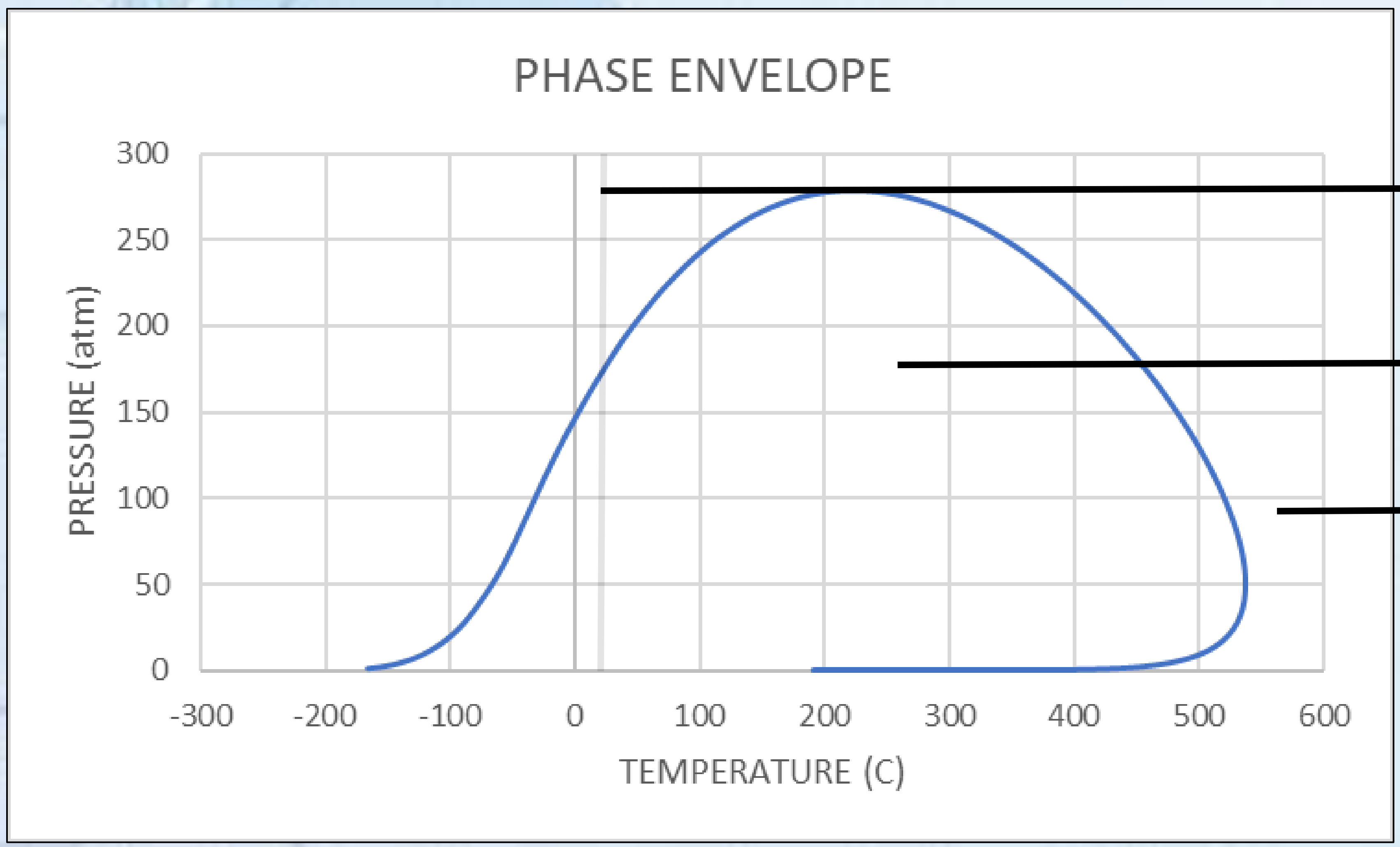
Phase Compositions

	Component	OVERALL (mol fraction)	GAS (mol fraction)	LIQUID1 (mol fraction)	WAX (mol fraction)
95	N75	7.53524092e-07	0	4.901500656e-07	0.02021124295
96	N76	6.08947727e-07	0	3.582121533e-07	0.0166615013
97	N77	4.98981003e-07	0	2.679835734e-07	0.01387384609
98	N78	4.089413179e-07	0	2.038974279e-07	0.01150655073
99	N79	3.352039281e-07	0	1.645986575e-07	0.009453708429
100	N80+	9.607977285e-07	0	1.579749708e-07	0.02981457656
	Total	**1**	**0.7331665312**	**0.2668026567**	**3.081209572e-05**

N - PARAFFINS

WAX PHASE

II. MULTIPHASE FLOW



SINGLE PHASE LIQUID REGION

TWO PHASE REGION (OIL + GAS)

SINGLE PHASE GAS REGION

FLOW REGIMES (VERTICAL PIPE)

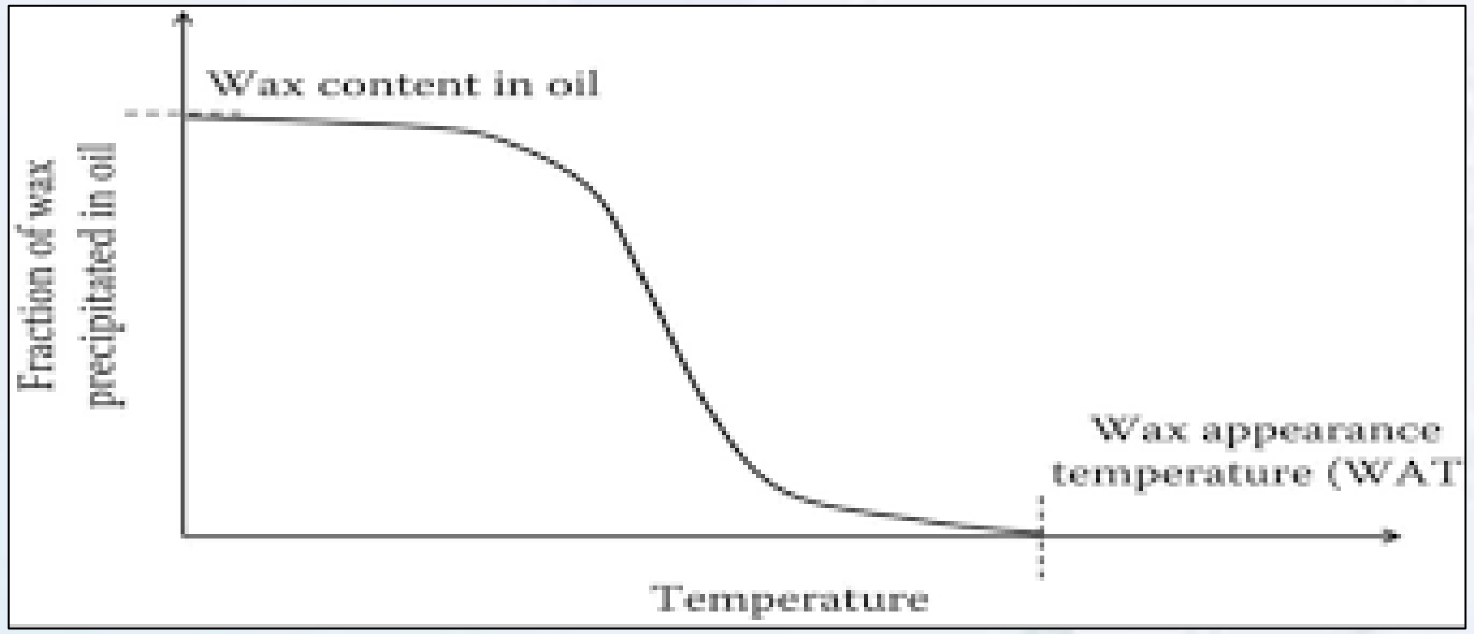
- Bubble Flow
- Slug Flow
- Churn Flow
- Annular Flow

- When the pressure and temperature of the crude reduces, gas starts evolving out of oil creating two phase flow in the pipelines

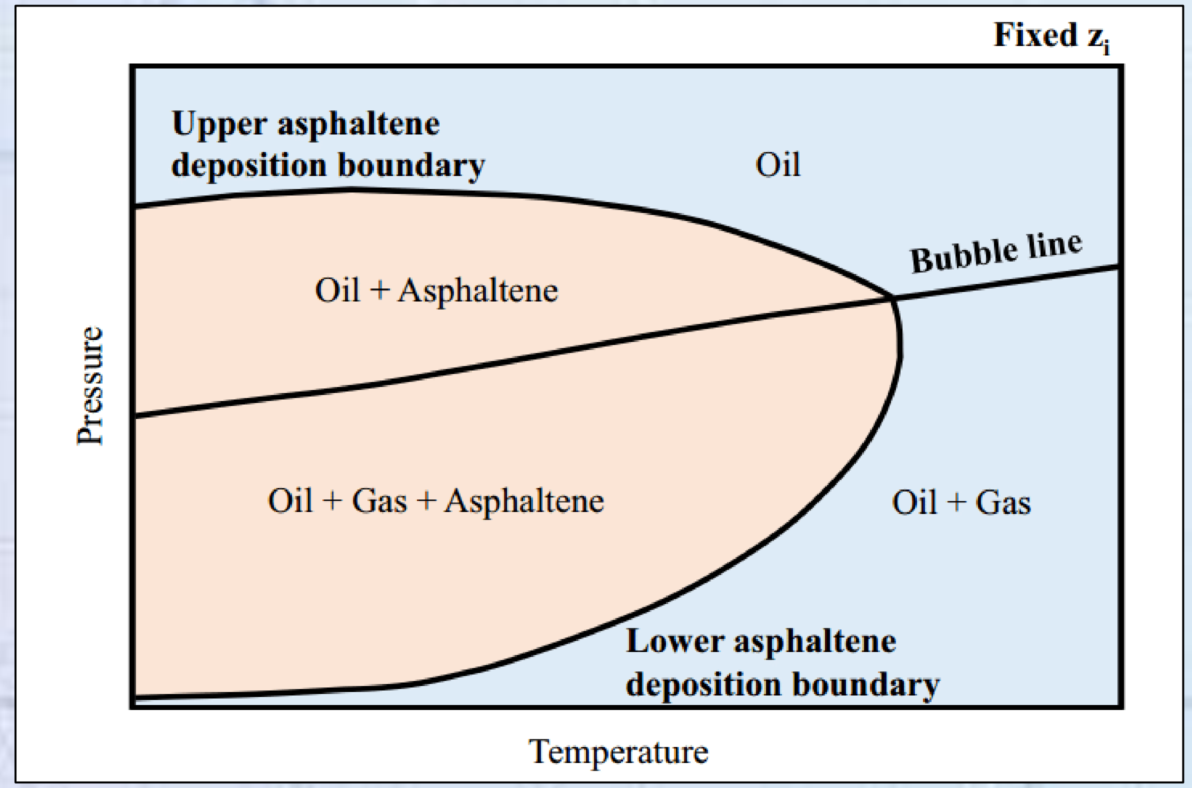
- Due to high velocity of gas, it blocks the passage of oil creating different flow regimes and ultimately reducing production

III. THERMAL EFFECTS

- As the temperature decreases the amount of wax formation increases
- The temperature below which the wax starts appearing is the WAT



WAX PRECIPITATION



ASPHALTENE PRECIPITATION ENVELOPE

- The amount of precipitated asphaltene increases as pressure decreases from the upper onset pressure to the saturation pressure of the oil.
- The precipitation reaches a maximum value at the saturation pressure and decreases as pressure decreases below the saturation pressure.

INPUT TOOLS & FUNCTIONS

STEP 1 - INPUT DATA IN MODEL BROWSER

STRUCTURAL	• MATERIAL • WALL
CASE DEFINITION	• PVT FILE • WAX FILE • ASPHALTENE FILE
FLOW COMPONENT	• MASS FLOW RATE • TEMPERATURE • PRESSURE
OUTPUT	• INTEGRATION TIME • VARIABLES • PROFILE DATA • TREND DATA

General	
LABEL	**MATER-1**
CAPACITY	**500 [J/kg-C]**
CONDUCTIVITY	**50 [W/m-C]**
DENSITY	**7850 [kg/m3]**
TYPE	***SOLID***

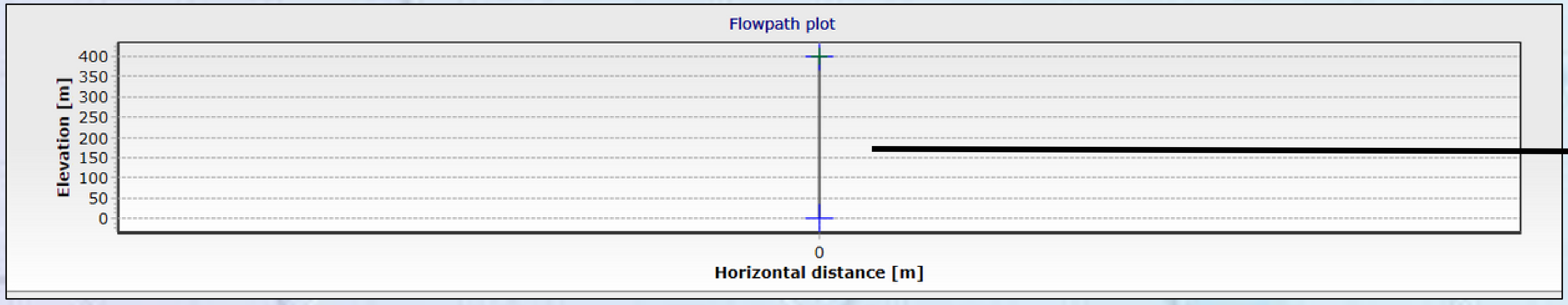
	OVERALL	GAS	LIQUID1	WAX
Mw	85.66303243	27.1498373	226.9844404	595.1194637
Z (Fugacity Model)	0.7091193695	0.9950427947	0.0108651935	0.0263988779
Volume (m^3/mol)	0.01745653922	0.02449517574	0.0002674707316	0.0006498666759
Density (mol/m^3)	57.2851232	40.8243652	3738.726829	1538.777163
H (J/mol)	-21297.85411	50.53558478	-72354.27071	-325659.3463
S (J/mol/K)	-26.28254898	11.70898135	-116.6977827	-672.3792225
G (J/mol)	-13413.08941	-3462.158821	-37344.93591	-123945.5795

General	
LABEL	**OUTLET**
X	***0 [m]***
Y	***0 [m]***
Z	***0 [m]***
TEMPERATURE	**22 [C]**
PRESSURE	**700 [psig]**
TIME	***0 [s]***
FLUID	**1**

General	
ENDTIME	**60 [h]**
MAXDT	**5 [s]**
MAXTIME	***0 [s]***
MINDT	**0.01 [s]**
MINTIME	***0 [s]***
RUNTIMESTEPAGAIN	***TRUE***
NSIMINFO	***-1***
MININCRFACT	***1.1111111***
MAXINCRFACT	***1.3333333***
STARTTIME	**0 [s]**
DTSTART	**0.01 [s]**

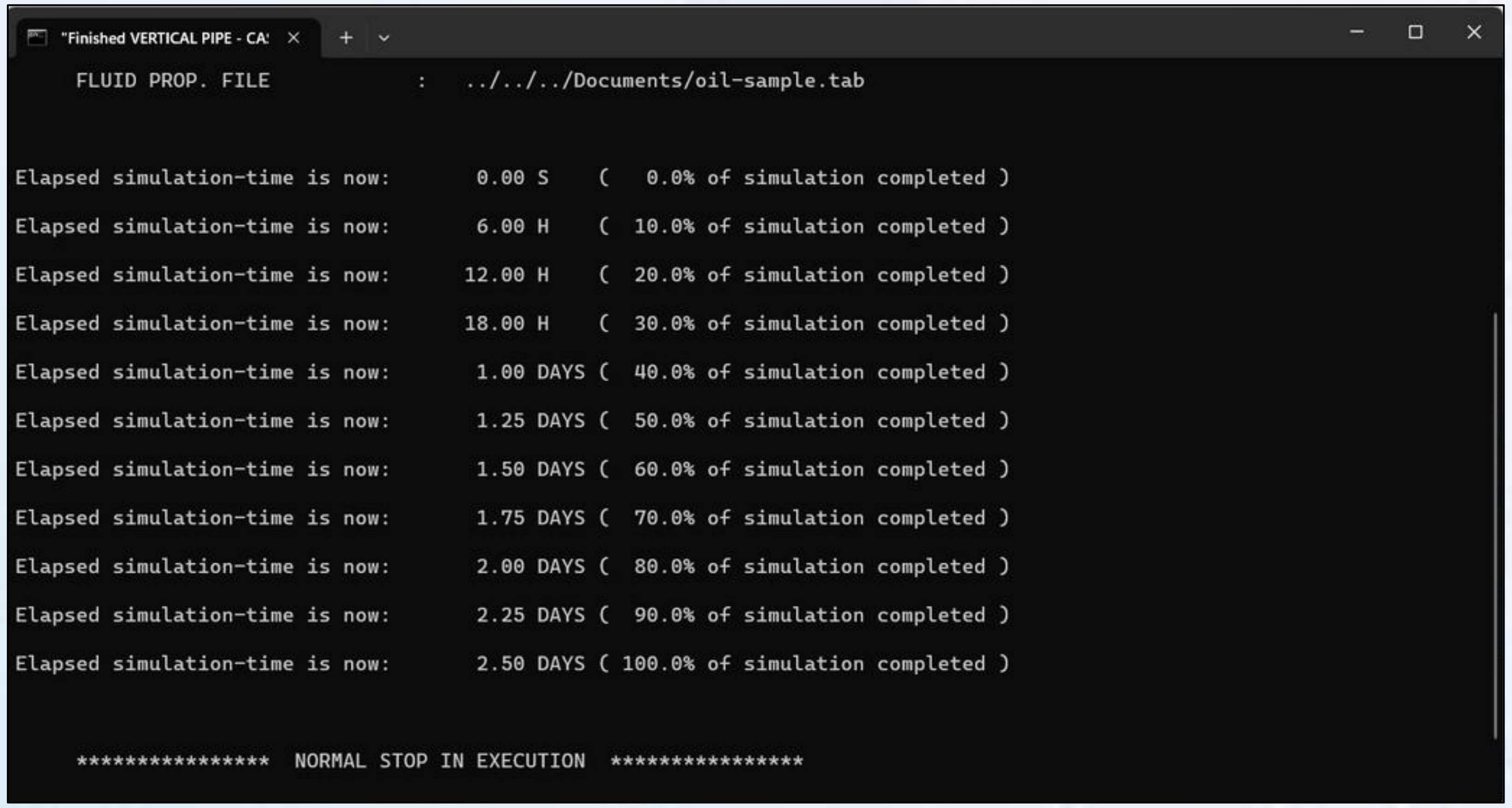
STEP 2 - DEFINE FLOWLINE GEOMETRY

LENGTH	400 m
ELEVATION	400 m
SECTIONS	1
DIAMETER	0.12 m
ROUGHNESS	5 x 10^-5 m



VERTICAL FLOWLINE

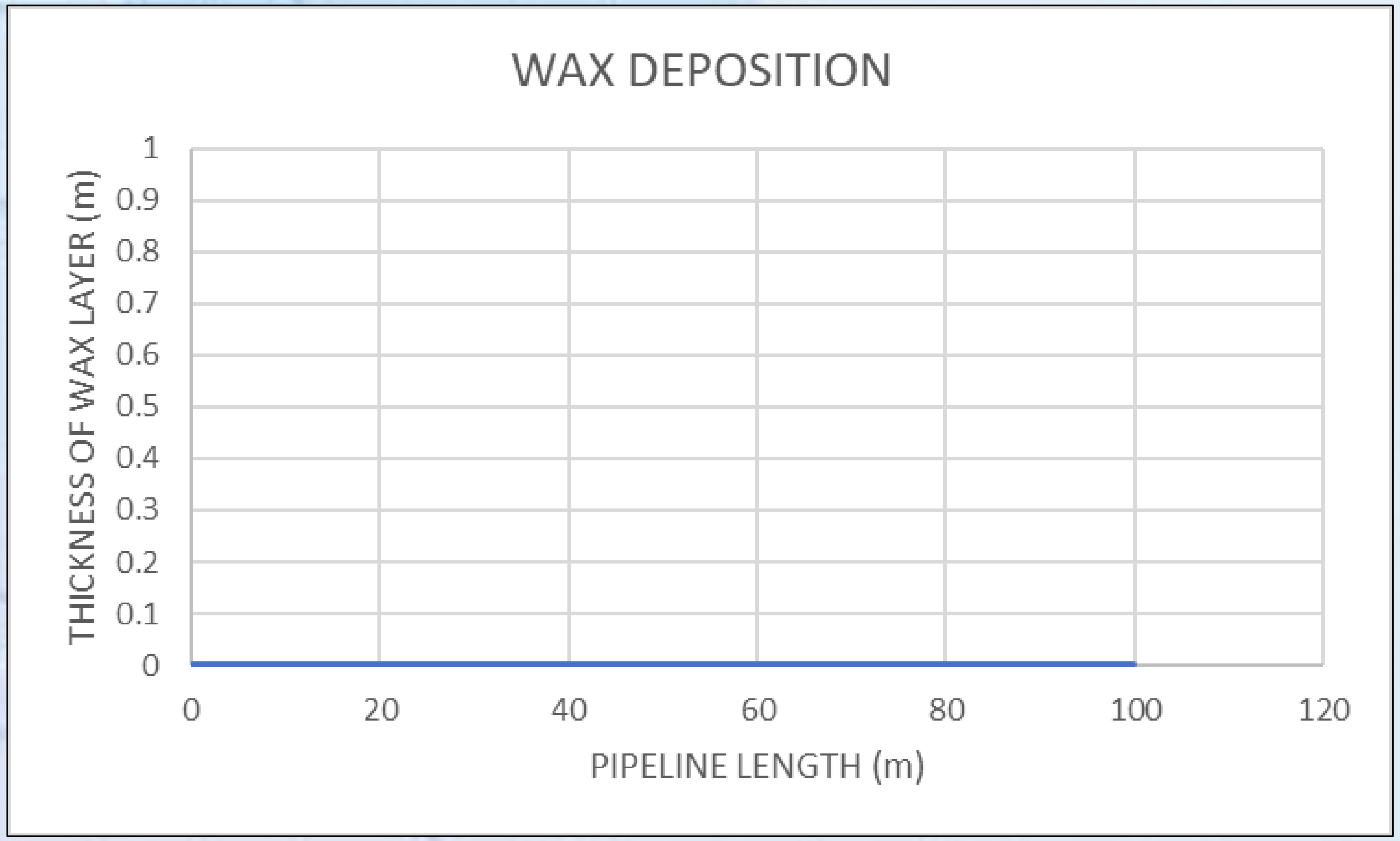
STEP 3 - RUN SIMULATION

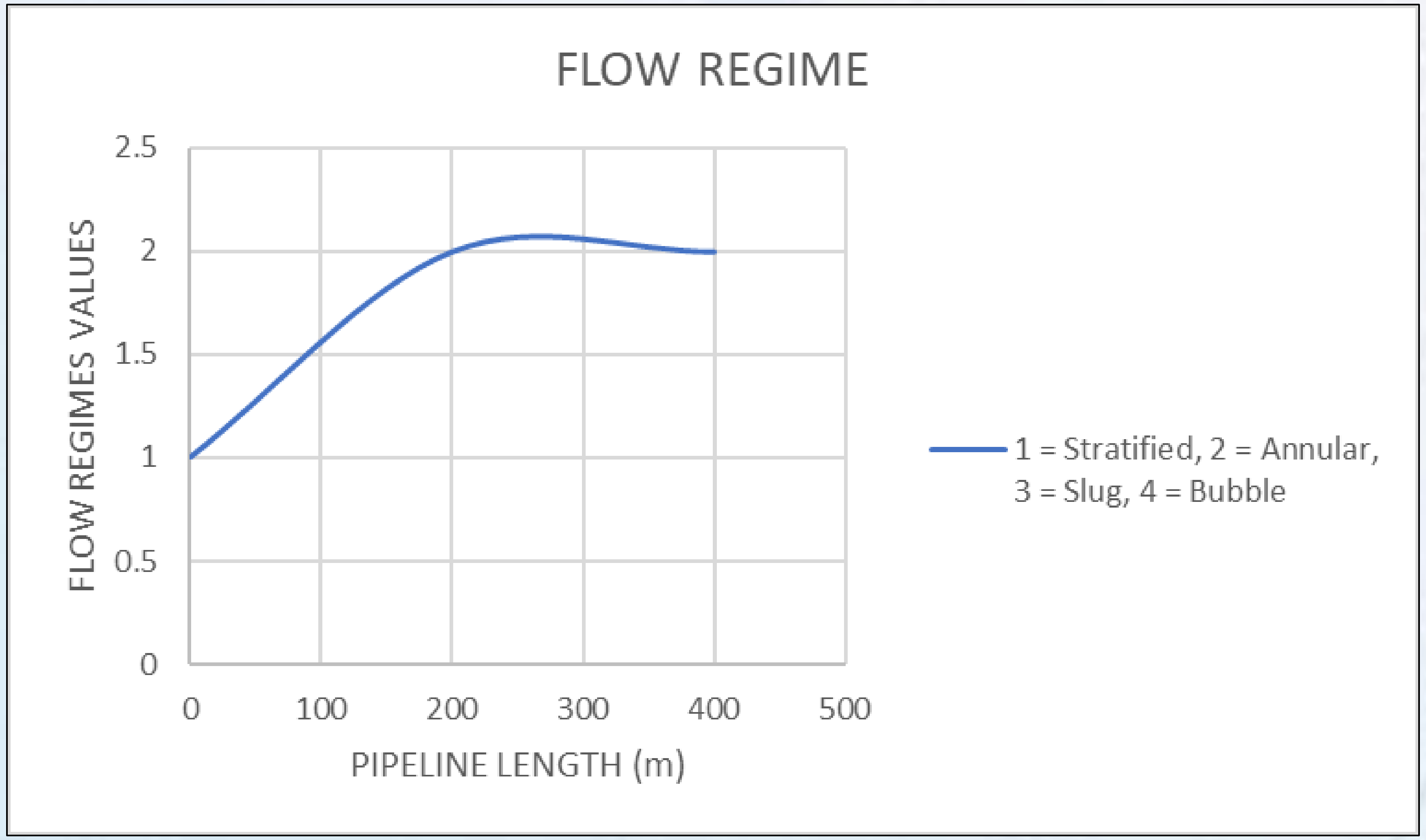


Simulation time: 60 hrs

OBSERVATIONS

CASE 1 - VERTICAL PIPE + SAMPLE A (NO N - PARAFFINS)





I. CHEMICAL COMPOSITION

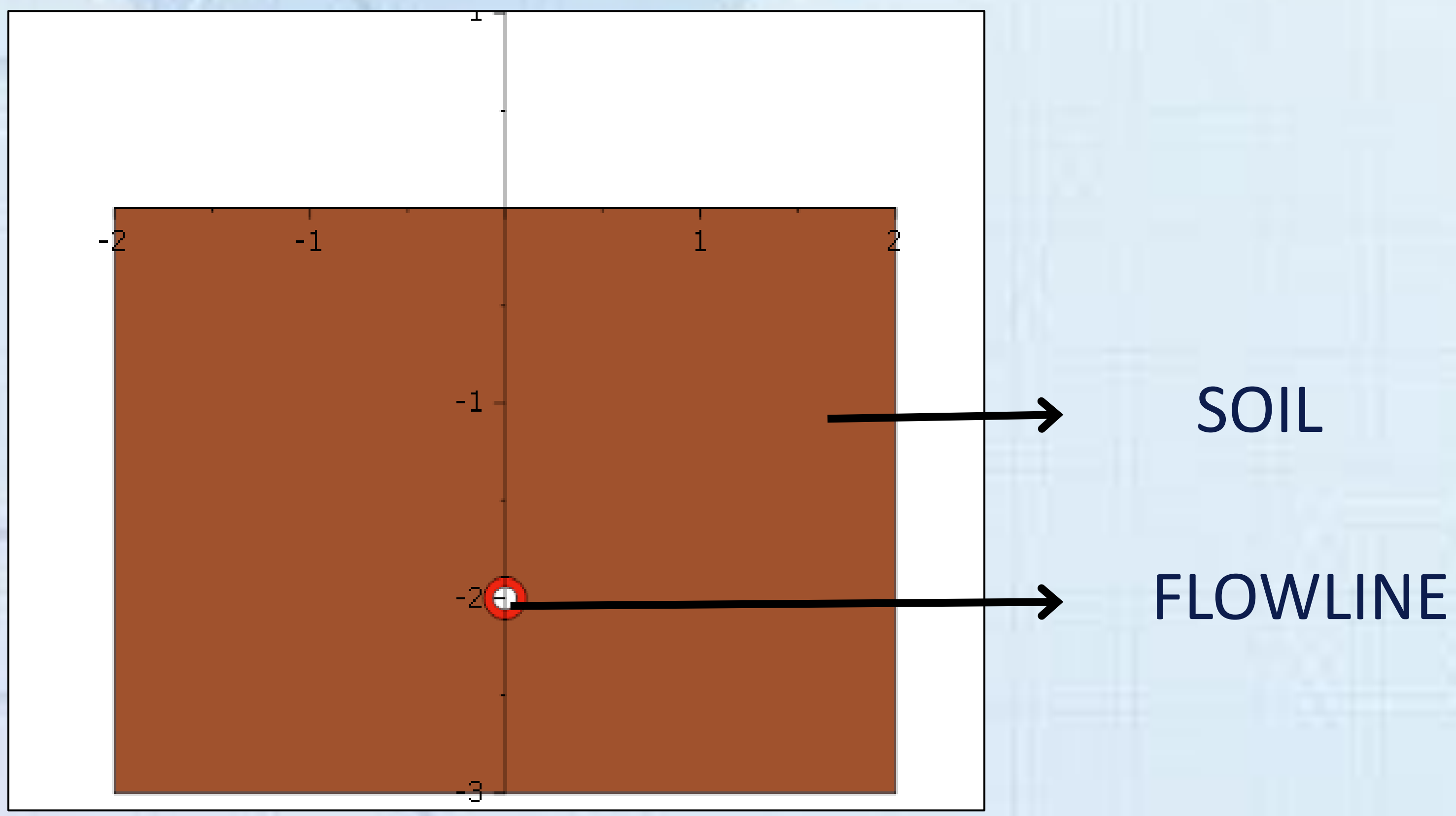
II. MULTIPHASE FLOW

- No wax deposition is observed - no n paraffin compounds are present
- The flow regime lies between stratified flow and annular flow - indicating two phase (oil and gas) inside the flowline

OBSERVATIONS

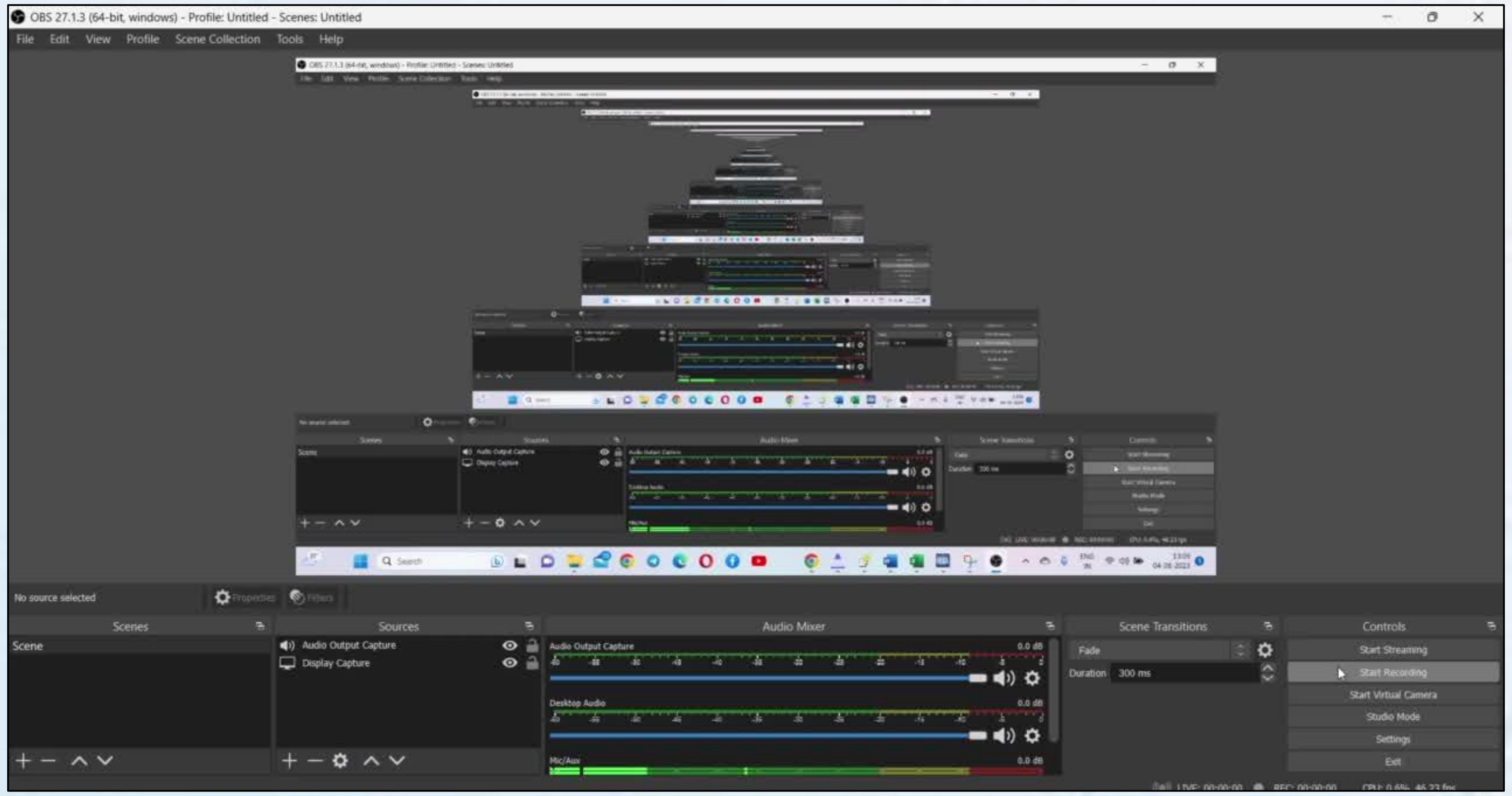
III. THERMAL EFFECT

SUB CASE I - FLOW LINE UNDER THE SOIL



FLOWLINE BURRIED UNDER THE SOIL

HEAT TRANSFER COEFFICIENT (W/m^2)



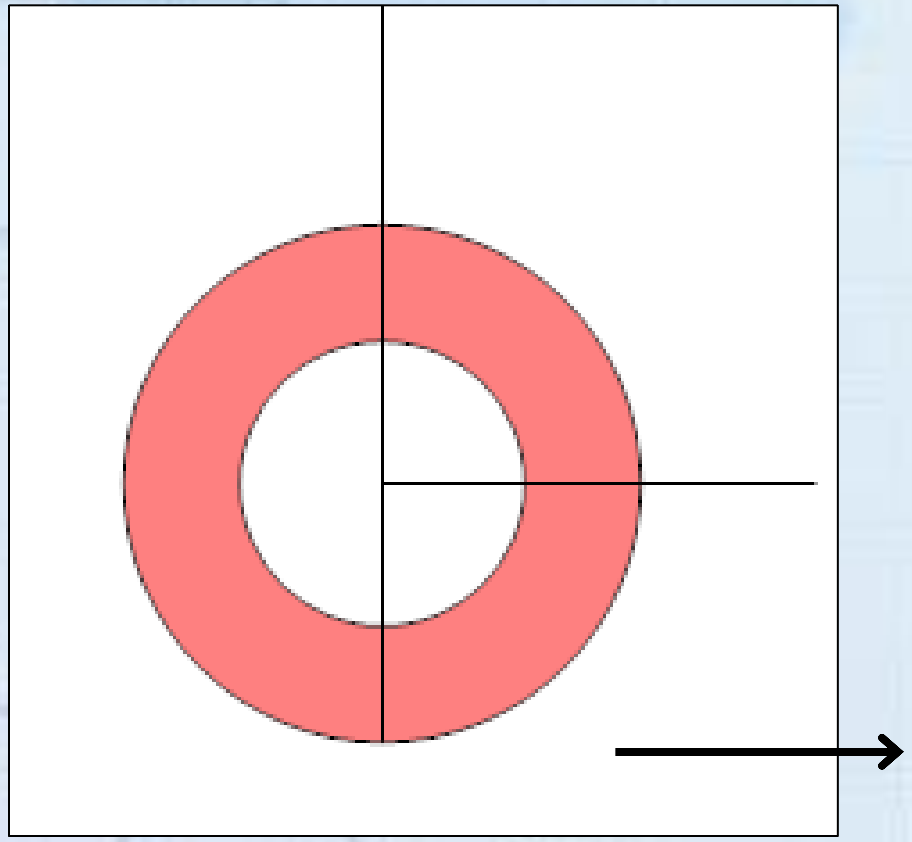
PIPELINE LENGTH (m)

- Overall Heat Transfer coefficient - combination of conduction, convection & radiation
- Increase in flow rate implies increase in velocity - increase in convective heat transfer coefficient
- Its also affected by the surrounding environment and thermal conductivity of soil

OBSERVATIONS

III. THERMAL EFFECT

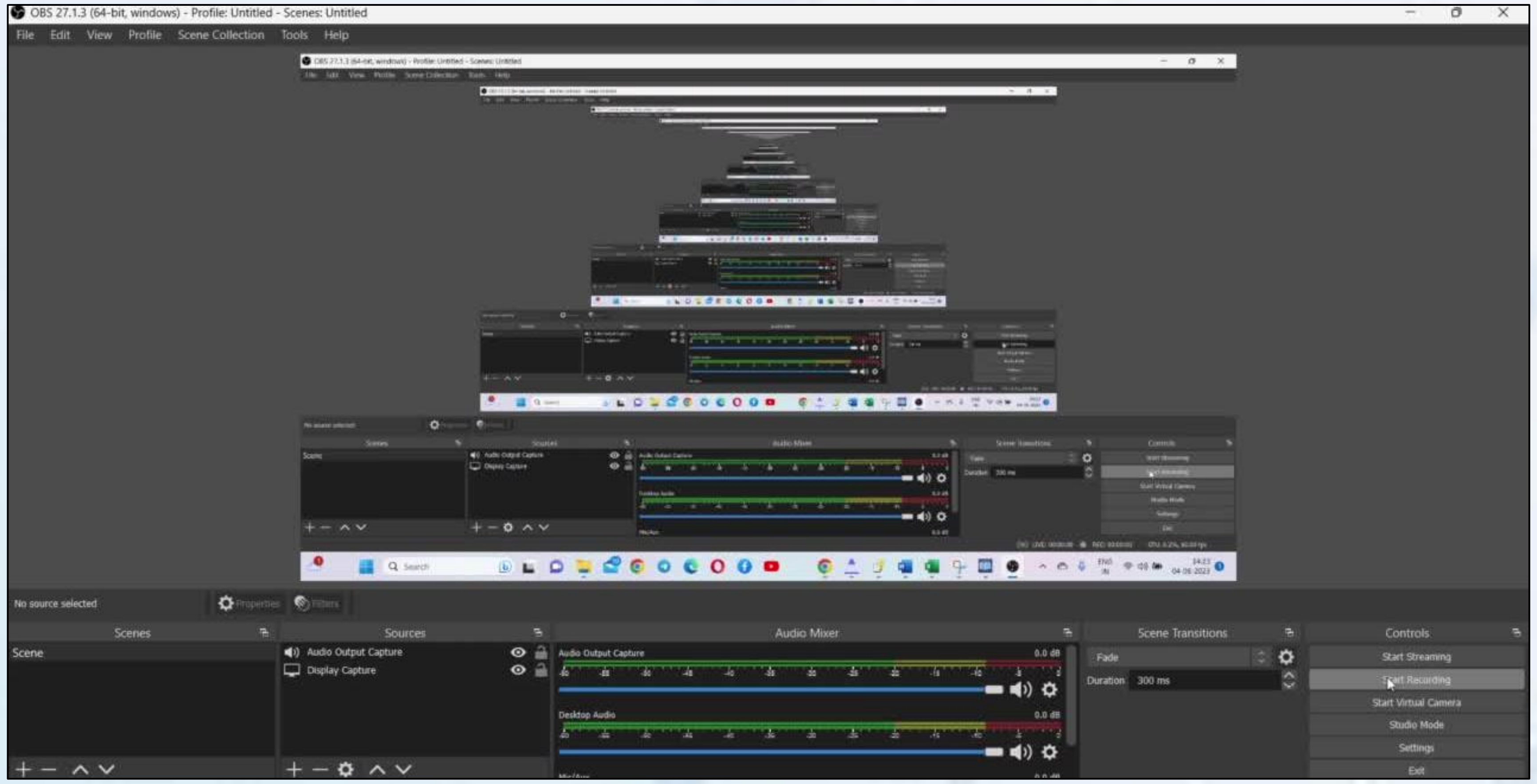
SUB CASE II - FLOWLINE ABOVE THE SOIL



No environment in contact with flowline

FLOWLINE ABOVE SOIL

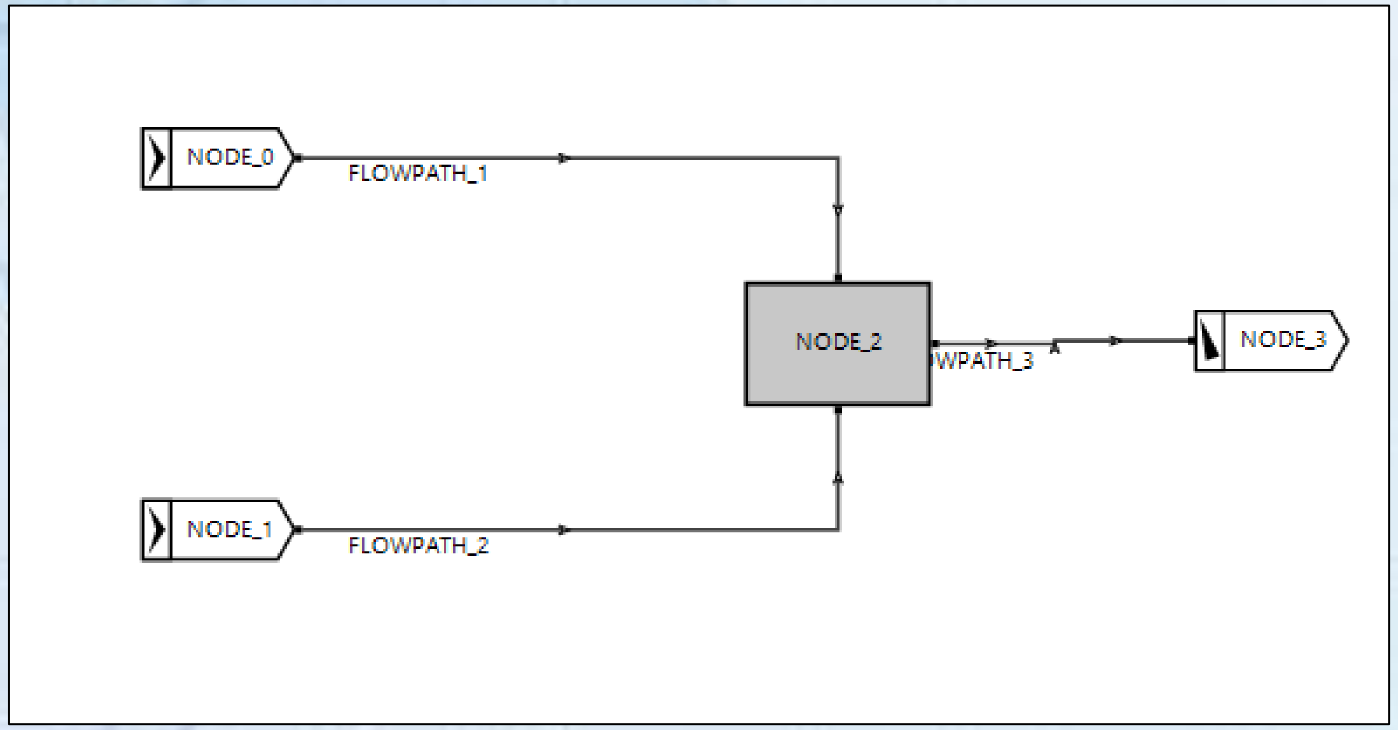
HEAT TRANSFER COEFFICIENT (W/m^2)



PIPELINE LENGTH (m)

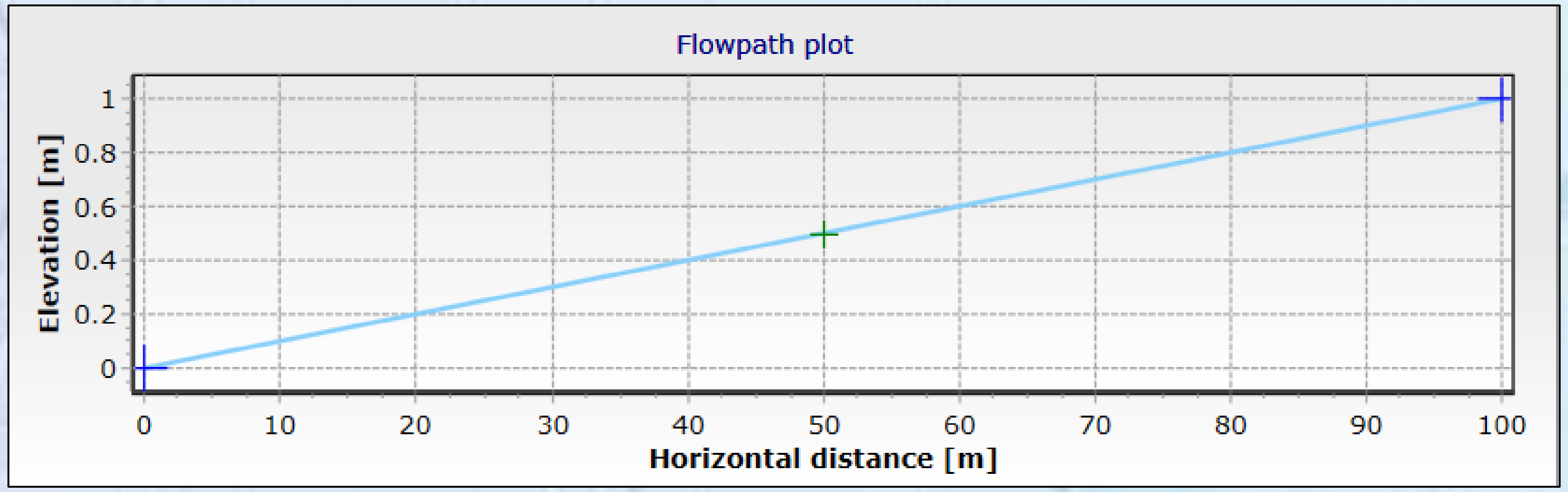
- Conductive heat transfer will be reduced due to no solid environment present in contact with pipeline
- Overall heat trasfer coefficient is contributed mostly by convection inside fluid and conduction by pipe material
- Heat transfer (under soil) > Heat Transfer (above soil)

CASE II - NETWORK + WAXY CRUDE



STEP 1 - INPUT DATA IN MODEL BROWSER

INLET	2 MASS SOURCE NODES
OUTLET	PRESSURE NODE
CONNECTION	INTERNAL NODE
HEAT TRANSFER	OVERALL U VALUE



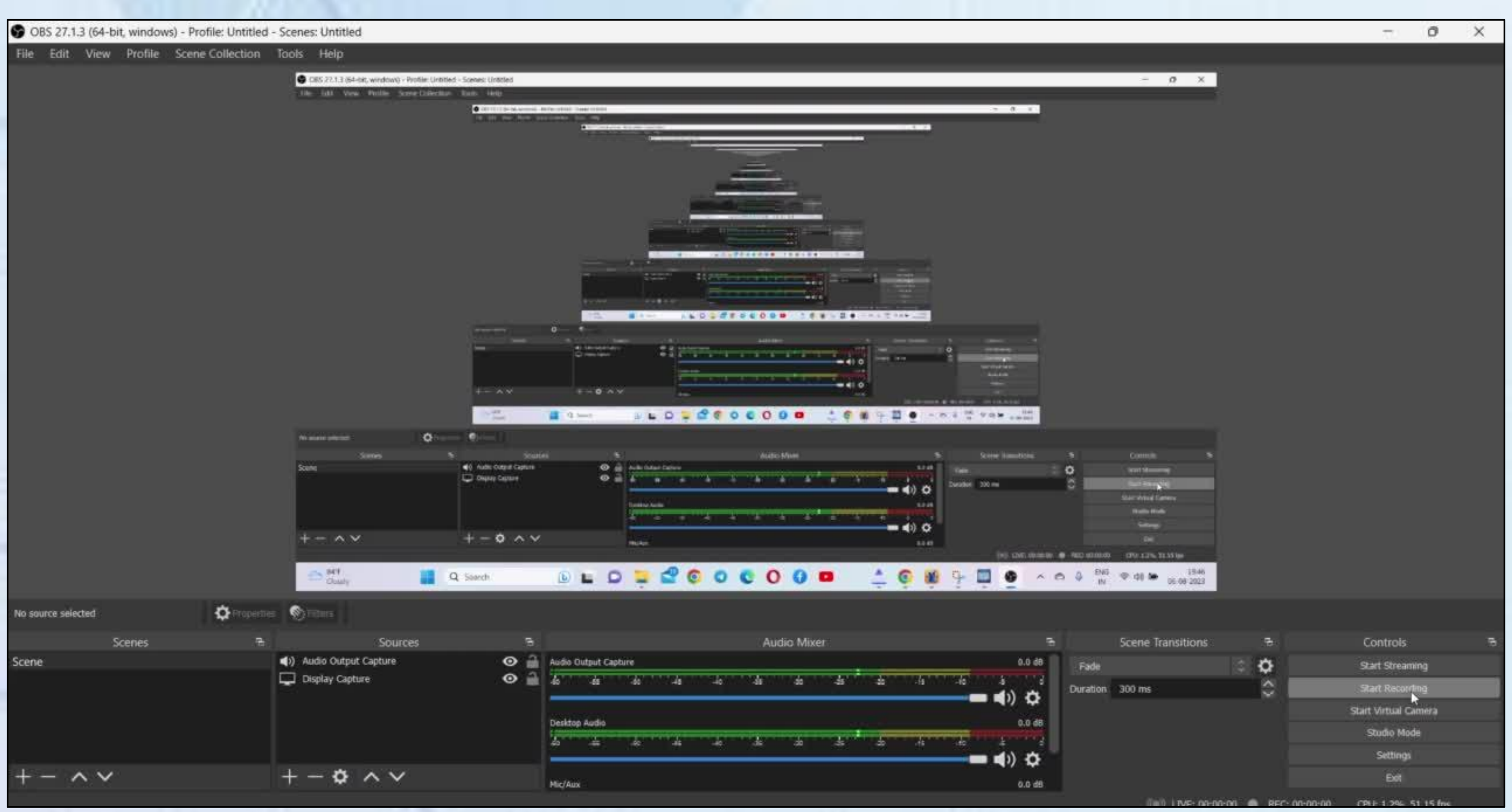
STEP 2 - DEFINE PIPELINE GEOMETRY

LENGTH OF EACH SECTION	100 m
ELEVATION	1 m

OBSERVATIONS

I. CHEMICAL COMPOSITION

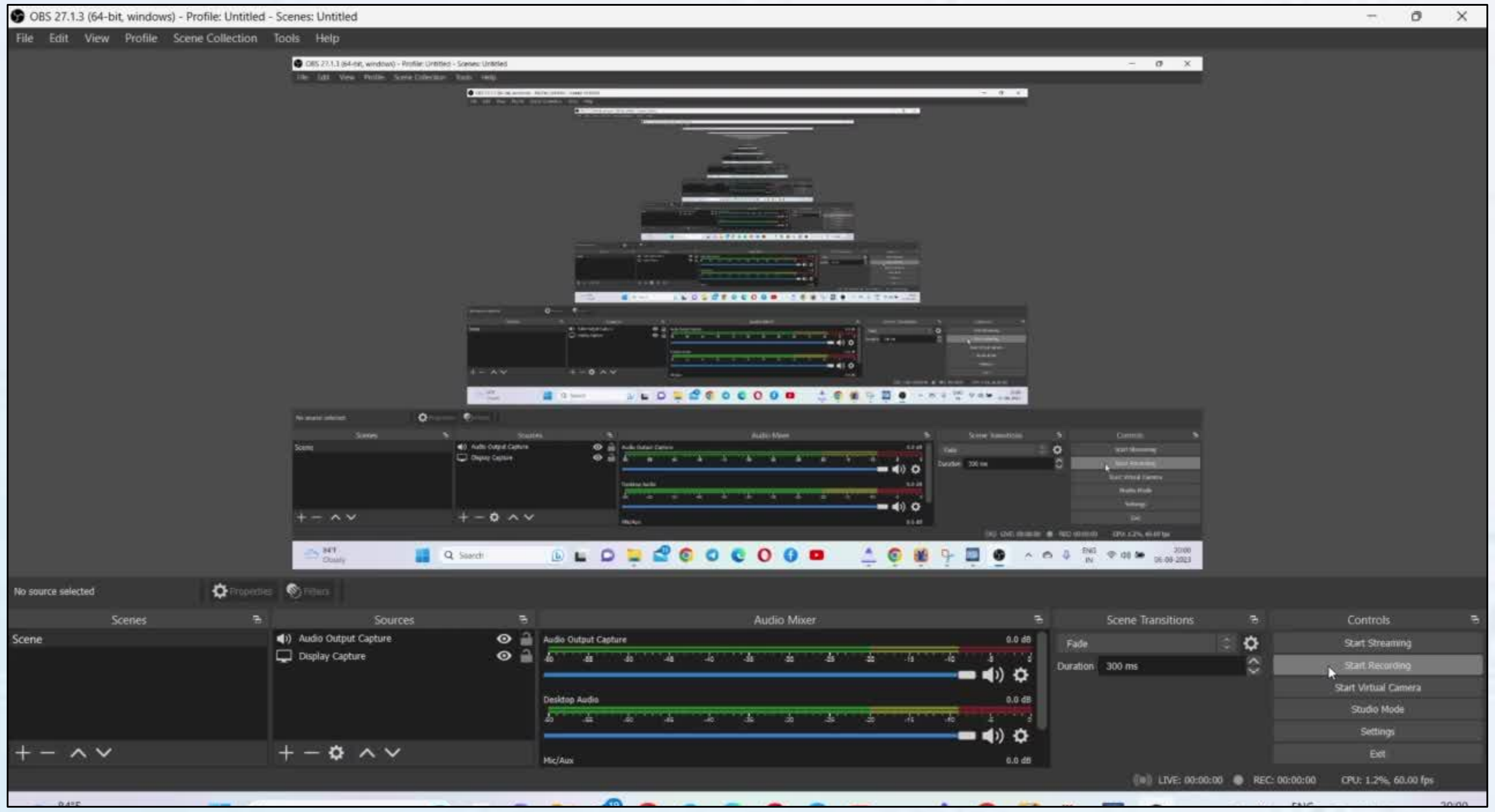
THICKNESS OF WAX LAYER (m)



PIPELINE LENGTH (m)

II. MULTIPHASE FLOW

FLOW REGIME VALUES



PIPELINE LENGTH (m)

- Wax Deposition Rate - FLOWPATH 3 > FLOWPATH 2 > FLOWPATH 1
- Flow regime constantly shifts between slug flow & stratified flow due to presence of gas

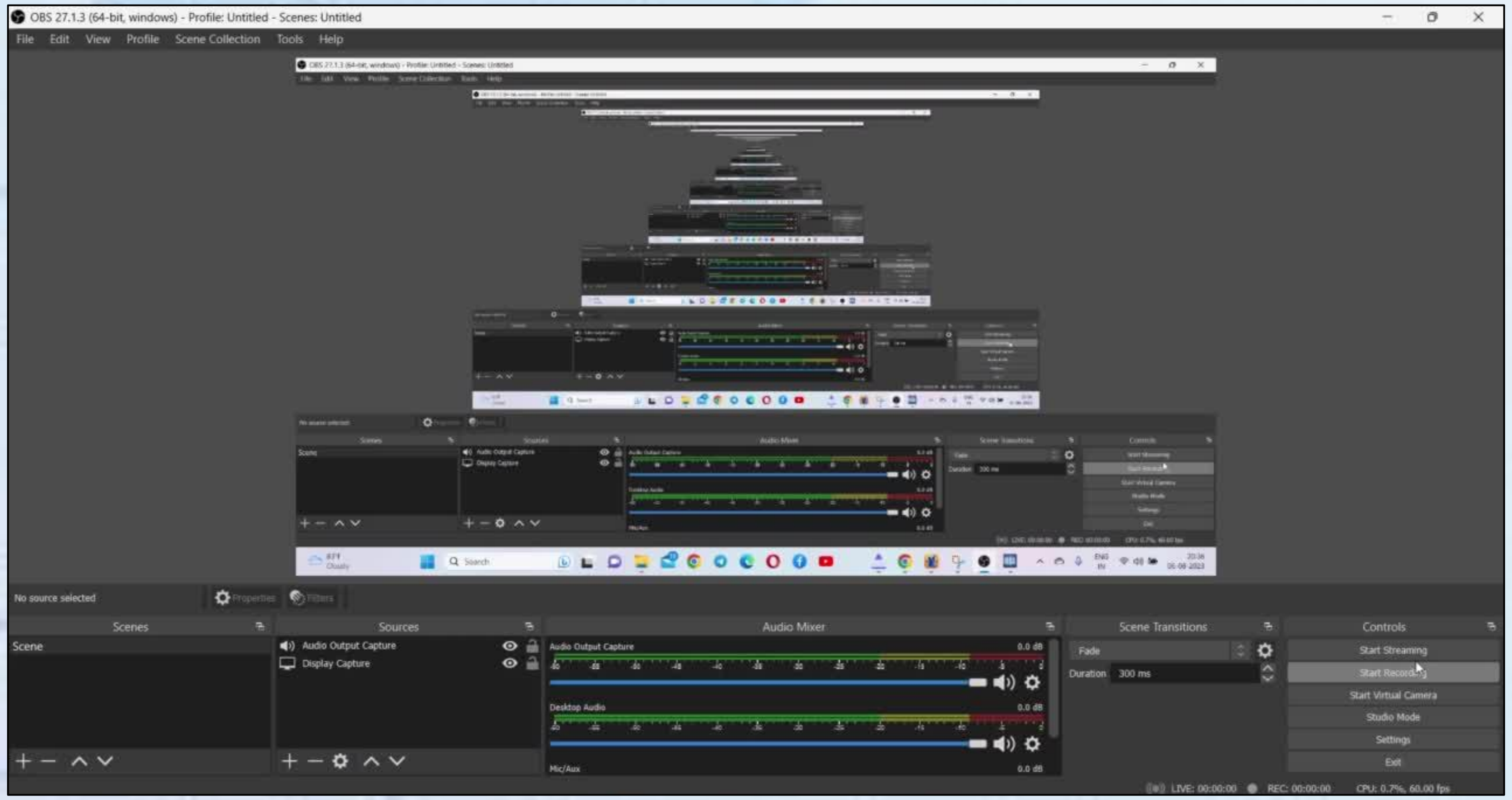
- RED LINE - WAX DEPOSITION IN FLOWPATH 1
- GREEN LINE - WAX DEPOSITION IN FLOWPATH 2
- PINK LINE - WAX DEPOSITION IN FLOWPATH 3

OBSERVATIONS

III. THERMAL EFFECT

SUB CASE I - EFFECT OF THERMAL CONDUCTIVITY (MATERIAL PROPERTY)

THICKNESS OF WAX LAYER (m)



PIPELINE LENGTH (m)

MATERIAL - I	MATERIAL - II
THERMAL CONDUCTIVITY - 50 W/m - C	THERMAL CONDUCTIVITY - 100 W/m - C
DENSITY - 7850 Kg/m^3	DENSITY - 7850 Kg/m^3
LEGEND - BLACK LINE	LEGEND - RED LINE

- FOURIER'S LAW

$$Q = KAdT/dx$$

- K -Thermal Conductivity (W/m - C)
- Q - Heat Transferred (W)
- Heat Transfer directly proportional to thermal conductivity

- The separation between the lines increases with time indicating material II is having greater wax deposition rate than material I

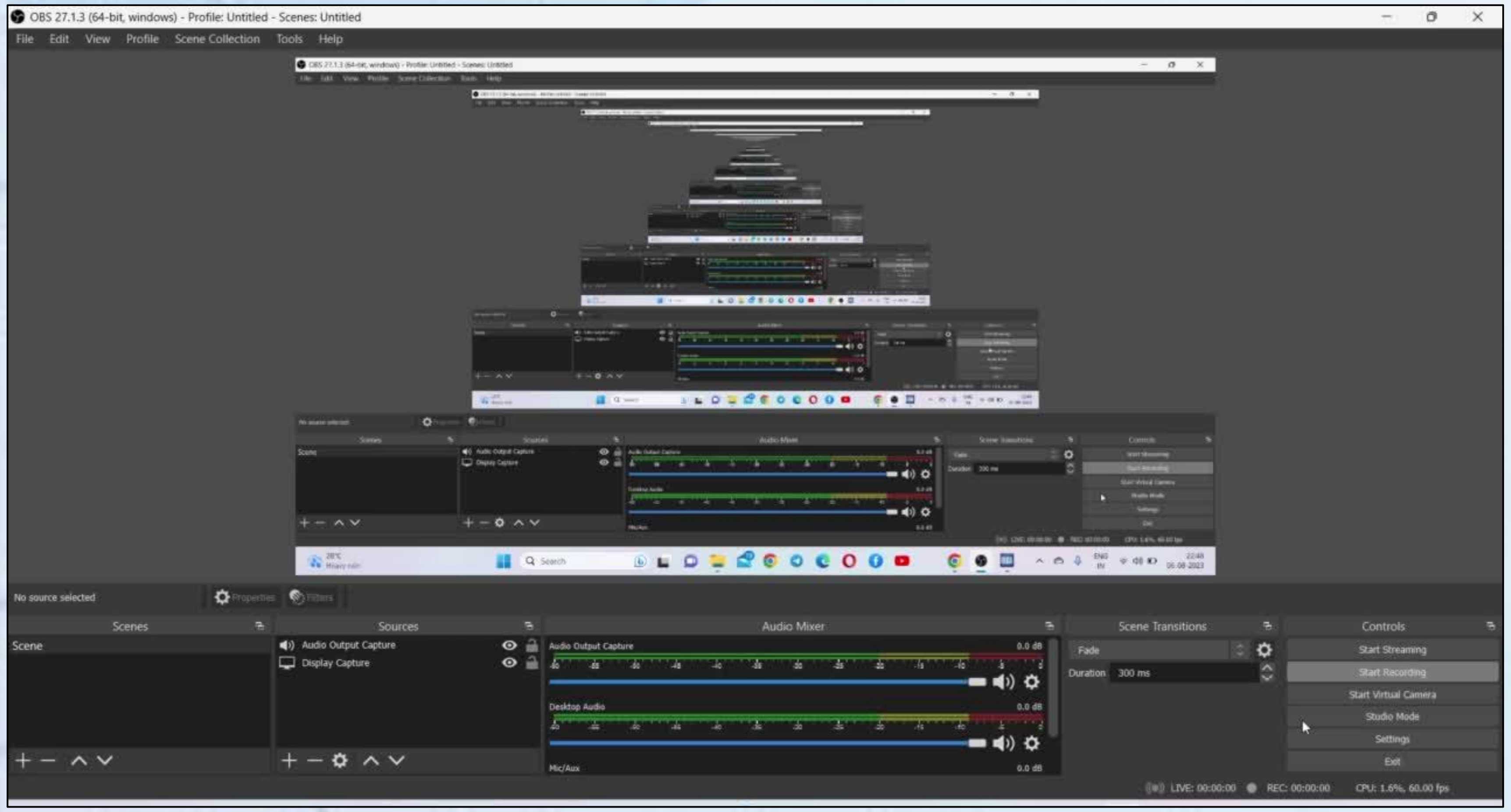
- Material with less thermal conductivity is preferred to prevent wax deposition

OBSERVATIONS

III. THERMAL EFFECT

SUB CASE II - EFFECT OF FLOWLINE THICKNESS (MATERIAL PROPERTY)

THICKNESS OF WAX LAYER (m)



PIPELINE LENGTH (m)

MATERIAL - I	MATERIAL - II
THICKNESS - 9 mm	THICKNESS - 20 mm
LEGEND - BLACK	LEGEND - RED

- Heat transfer is directly proportional to surface area, hence the thickness of the material

- Heat Transfer in Material II > Heat Transfer in Material I

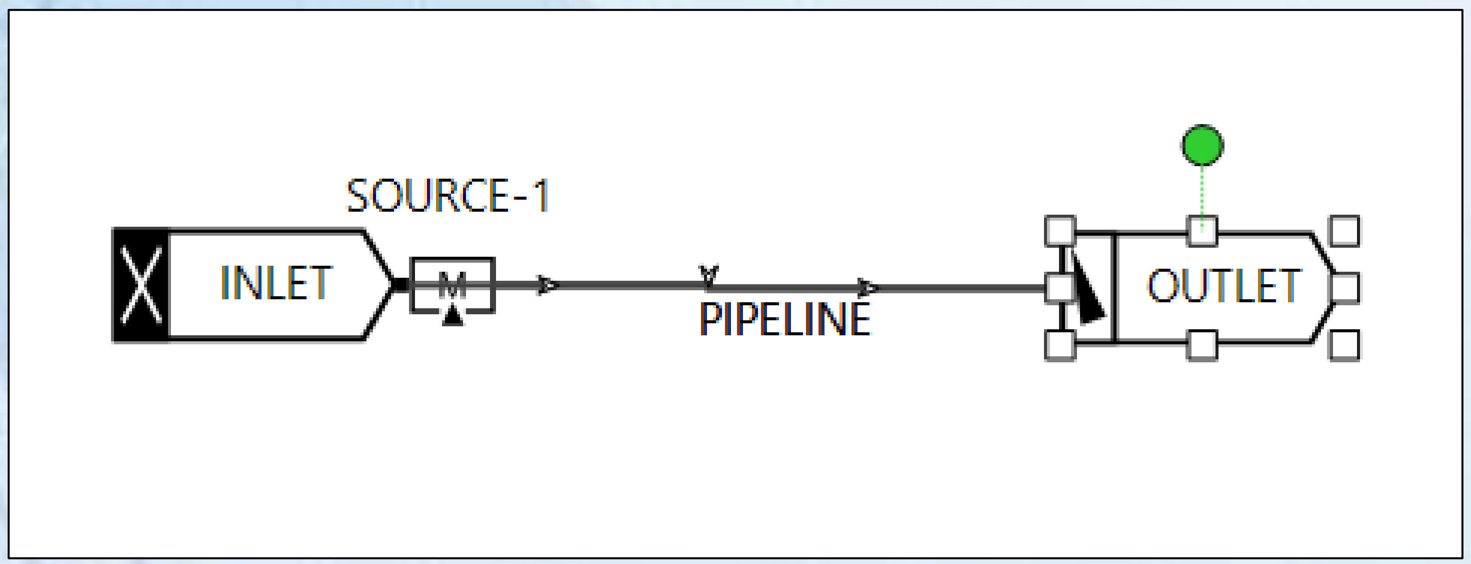
- Hence, Wax Deposition in Material II > Wax Deposition in Material I

- Heat Transfer Equation

$$Q = UA(T2 - T1)$$

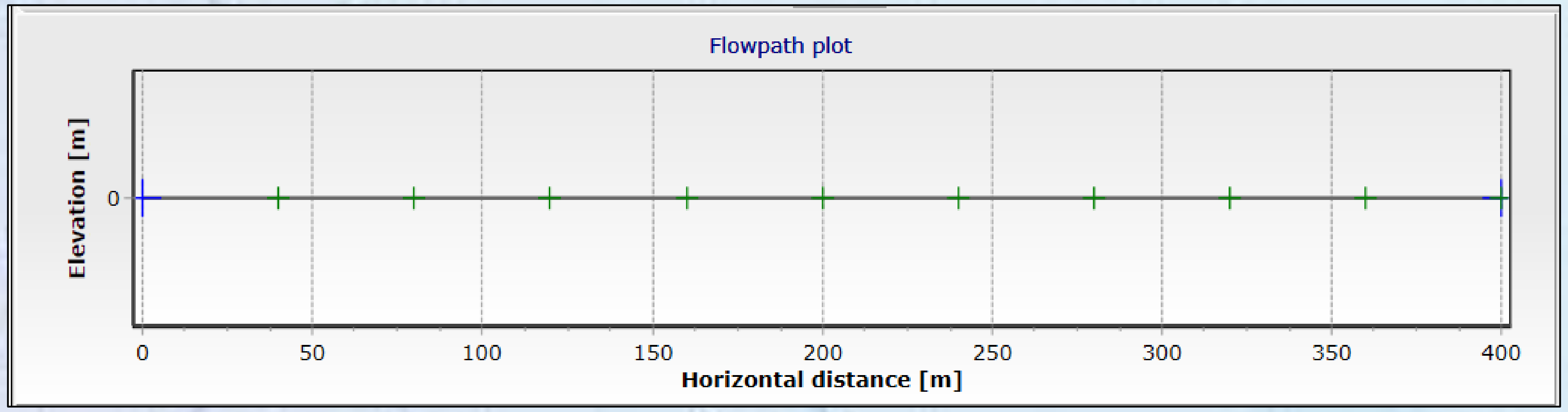
- A - Surface Area (m^2)
- U - Overall Heat Transfer Coefficient (W/m^2)
- Q - Heat Transferred (W)

CASE III – ASPHALTENE DEPOSITION + HORIZONTAL PIPE



STEP 1 - INPUT DATA IN MODEL BROWSER

INLET	CLOSED NODE
OUTLET	PRESSURE NODE
SOURCE	MASS FLOW SOURCE



STEP 2 - DEFINE PIPELINE GEOMETRY

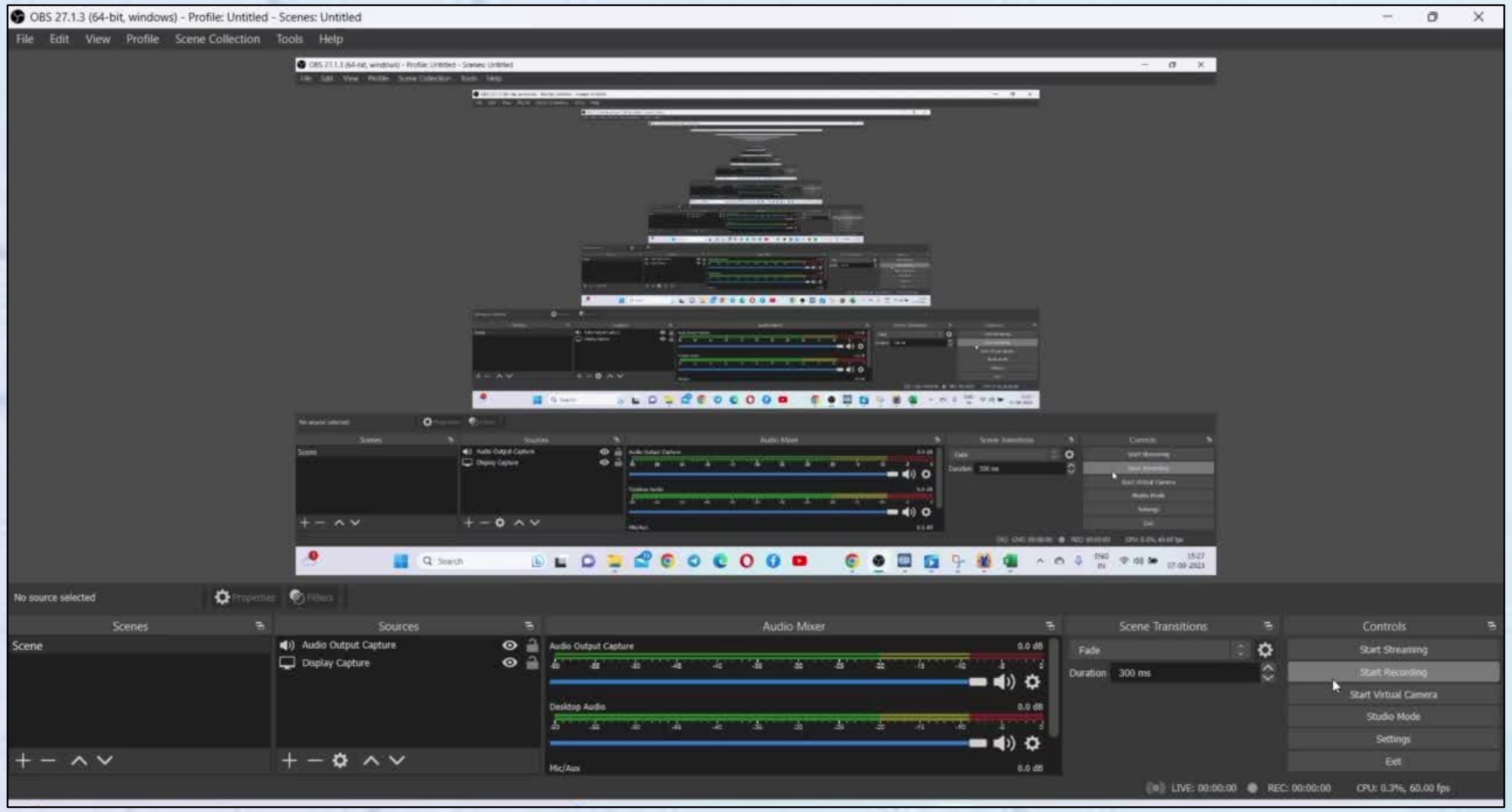
LENGTH OF PIPE	400 m
ELEVATION	0 m (HORIZONTAL PIPE)

OBSERVATIONS

I. CHEMICAL COMPOSITION

	Component	Amount (g)
20	C33-37	2.908976182
21	R33-37	0.40395505
22	R37-42	2.873154959
23	R42-48	2.423491352
24	R48-58	1.91937163
25	R58-65	0.6492232729
26	R65+	0.6563769222
27	ASPHALTENE	0.3949383511

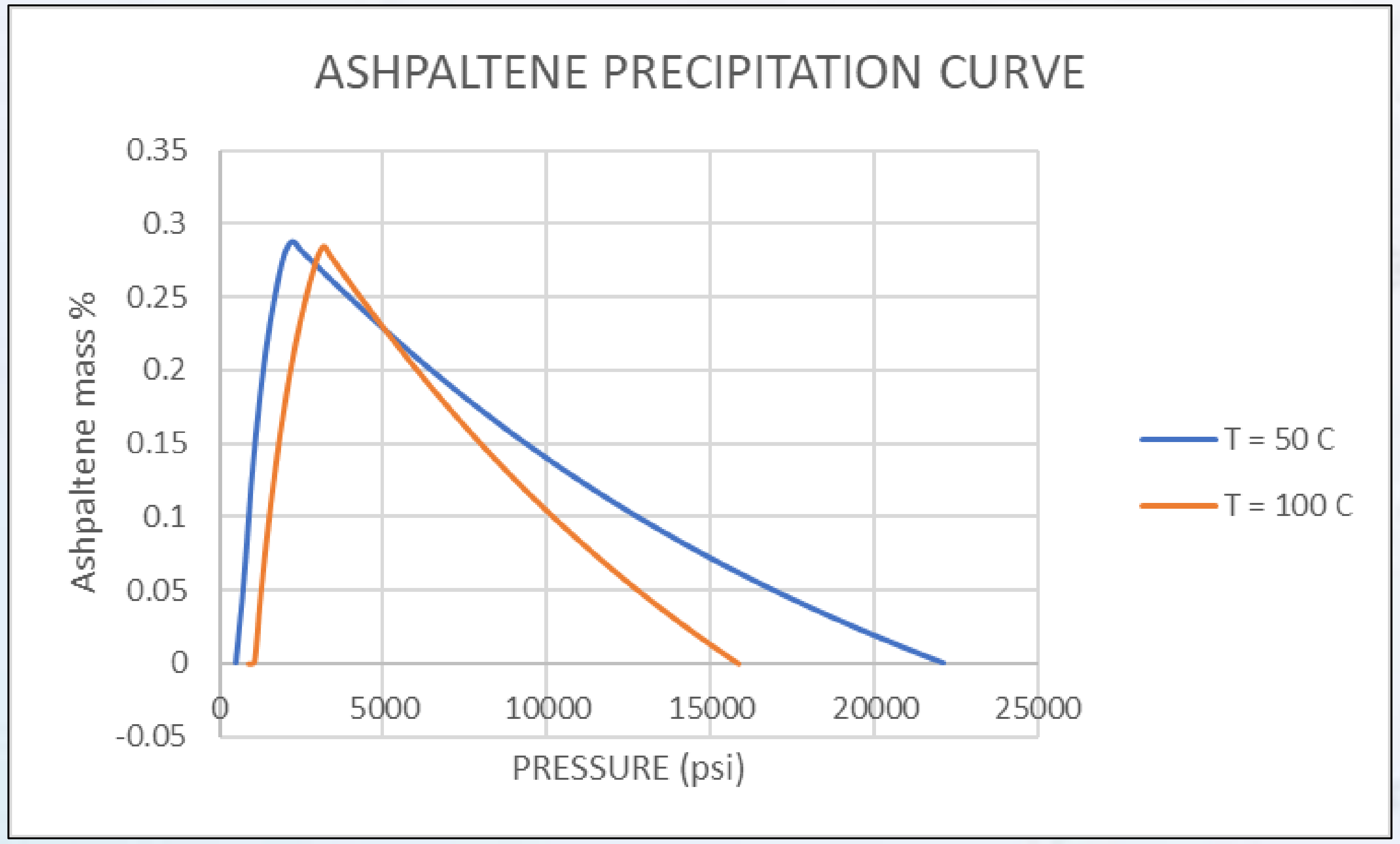
ASPHALTENE



II. MULTIPHASE FLOW

- Animated simulation of flow inside horizontal flowline

III. THERMAL EFFECT



- As the temperature increases the AOP decreases

TEMPERATURE	AOP
50 C	23000 psi
100 C	15800 psi

IMPROVEMENTS & SCOPE

- Flow assurance consists of three major analysis - Chemical composition, Multiphase flow & Heat Transfer
- It is clear that flow assurance not only depends on the pipeline design, but it's also based on the crude chemical composition, environment such as pressure and temperature, etc
- Mitigation techniques such as pigging, mechanical scrapping, chemical inhibitors, etc. can be simulated
- Further, Flow assurance simulations can be implemented in wells using the WELL EDITOR TOOLS
- PVT data, wax tables and other observations can be exported to ECLIPSE software for well & reservoir simulations

Thank You