CHAPTER I

INTRODUCTION

Production of oil and gas is usually accompanied by the production of water. In early stages of production, water may only be a minor component of produced fluids. As the reservoirs depletes, produced water (PW) volume increases. PW is the largest single waste water stream in oil and gas production operations (Abou-Sayed, A., *et.* al, 2000). Consequently, petroleum industry has been more and more concerned about the effects of PW disposal in the environments, particularly in offshore fields.

There are a number of disposal options of PW but in offshore operations direct discharge following treatment and injection into the unusable aquifer or depleted reservoirs are usually suitable. When injection is chosen, confinement of the injected PW within the target strata is central environmental acceptability of the disposal process.

Produced water injection (PWI) and produced water re-injection (PWRI) are being increasingly applied as options which give maximum environmental protection. There are subtle differences between the two:

PWI is injecting back to disposal horizons. Here needs to ensure no chance of produced water escaping from disposal horizon (rock formation/aquifer) into sensitive aquifers, e.g. current, or possible future, sources of potable or irrigation water, nor of escape to surface.

PWRI is injecting back into the source oil reservoir. Here needs to ensure above for PWI plus no detriment to oil zone, e.g. reduced oil sweep efficiency or pressure maintenance, due to bad fractures and blockages. There exists need to additional controls of reservoir souring, due to changes in pH and SRB activity (sulphate-reducing bacteria, generating H_2S from sulphate and nutrients).

Both PWI and PWRI have been widely practiced for decades in some areas of the world, often with filtered water. However, there has been a growing trend to injection of unfiltered water and this can save considerably on both treatment costs, distribution pipelines and the number of injection wells - often the big cost item.

PW composition varies with the subsurface geology and the contents of the permeable strata through which it has percolated. Depending on the type of well, typical produced water in the Gulf of Thailand (GOT) contains dissolved and undissolved oil, heavy metals, aromatics, phenols, salts and minerals. The presence of dissolved hydrocarbon, heavy metals and other contaminants in the PW create environment impacts. Pollution of surface water supplies or fresh water aquifers has become a serious concern in recent years. In addition, tourism and fishing are critical to Thailand and therefore, environmental impact of PW is a major concern.

With the increasing amount of PW, handling of PW has become one of the main issues in the petroleum industry. Required facilities and equipments for treatment of the PW make it more expensive. Estimates of water treatment cost in the GOT are as high as \$0.2 per bbl (Hibbeler and Rae, 2005). Thus, if it is assumed that the water treatment is used on all Thailand PW (200,000 STB/D according to an informal study), the cost would be approximately \$15 million per year. Therefore, due to handling and treatment cost, water treatment is the more expensive option over time.

The aforesaid concerns have focused attention on PWI as a promising method to dispose. PWI is believed to be the best solution to eliminate the environmental impact for disposal of PW in an attempt toward zero discharge and to prevent generation of byproducts from the treatment process. The greatest environmental benefit of PWI is the potentially harmful fluids are permanently removed from direct human and indirect food chain, interaction.

Since the last decade, PWRI was successfully implemented in the GOT by Unocal Thailand, Ltd in 1997. Erawan field, in the GOT, produces approximately 20,000 STB/D and adopted re-injection to address the future environmental impact from heavy metals and other contaminants.

This thesis work investigates the PWI as disposal method in a Gas Condensate Field in the GOT. The field will be called as the M field throughout this study. To handle the PW over time PWI is selected as disposal method and implemented it in early 2008. The appropriate aquifer was selected based on high porosity, permeability and reservoir volume. Two wells namely MN-1 and MN-2 will be used to inject the

PW into shallow aquifers. It is also mentioned that both of the targeted aquifers are located above the producing formation.

1.1 OBJECTIVES OF THESIS

The main objectives of this study are:

- To investigate the disposal capacity of PW into shallow aquifer in a Gas-Condensate field in the Gulf of Thailand (GOT).
- To predict the injection performance of the aquifer under fracture pressure.

1.2 OUTLINE OF METHODOLOGY

This thesis work is to investigate the PW injection capacity and performance of shallow aquifer using reservoir simulator. The following tasks are performed:

- Collect Structural Depth Map, Well Logs, and Well Deviation Surveys to build the static model.
- Construct a static model using Structural Depth Map and Well Logs. The static model has a total of 532890 active grid blocks.
- Determined rock porosity from well logs.
- Determined rock permeability from porosity permeability correlation.
- Determined relative permeability curves by Special Core Analysis (SCAL).
- Determined PVT data from correlations.
- Initialization the model.
- Testing the model.
- Run reservoir simulator for different scenarios.
- Analyze the results and make conclusions.

In the following page, the methodology is shown by a simplified block diagram.

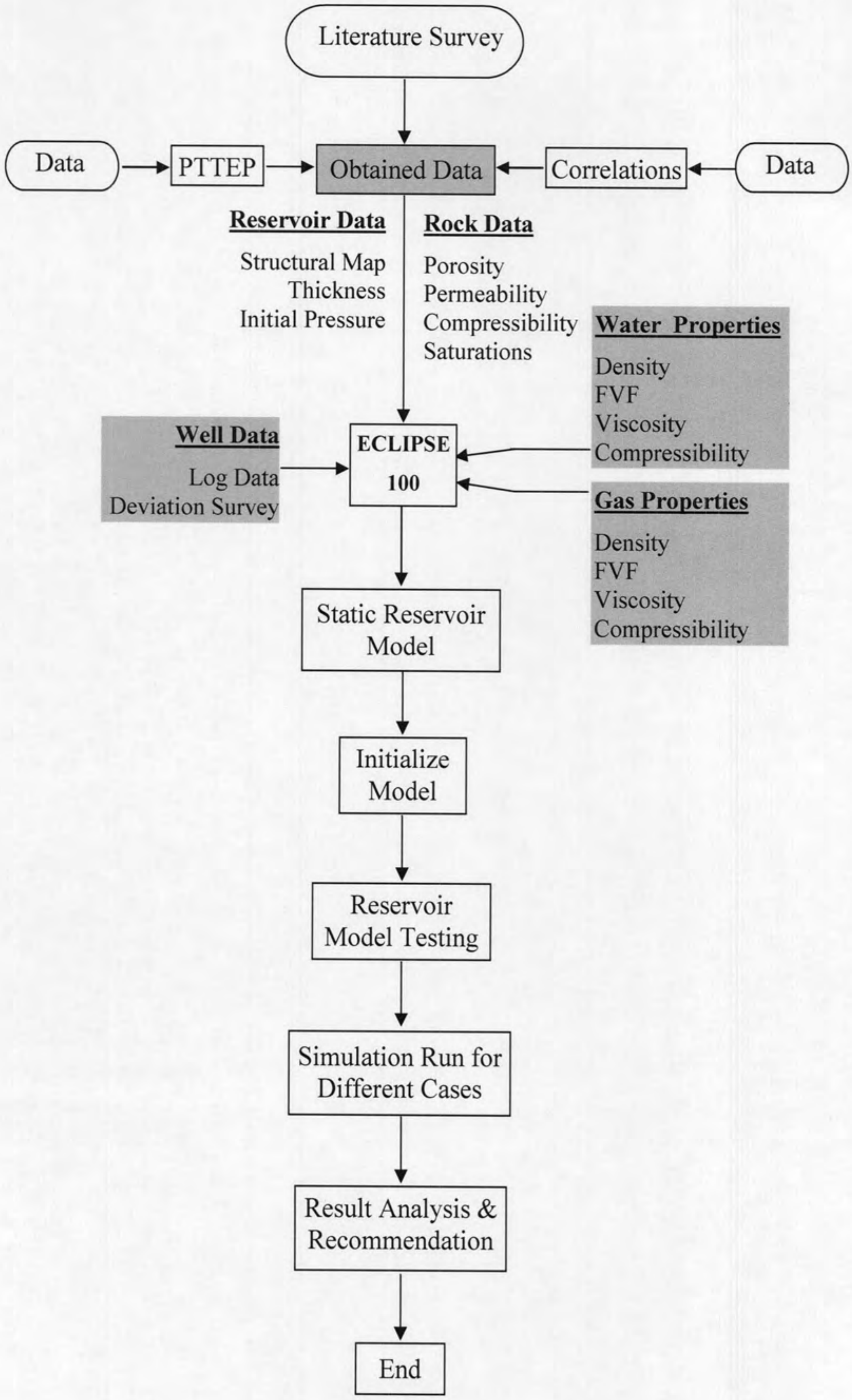

Figure 1.1: Simplified block diagram of the methodology of this research.

1.3 THESIS OUTLINE

This thesis paper consists of 6 chapters.

Chapter 1 outlines introduction and theoretical background on PWI.

Chapter 2 outlines a list of related works on PW disposal and reservoir simulation, history matching those have been conducted previously.

Chapter 3 describes the principle of reservoir simulation and its application related to this study.

Chapter 4 discusses the steps involved to build up the reservoir simulation model of the disposal aquifer. The model was constructed based on surface depth maps, well log data, and well deviation surveys. Essential parameters which are porosity and permeability were defined for each grid block.

Chapter 5 discusses different cases simulation results and makes analysis. In addition, best sand candidate in terms of cumulative injection volume is also recommended.

Chapter 6 makes conclusions and provides necessary recommendations for future works.