Waihapa – A New Look at an Old Oil Field

Petroleum Club Meeting

Wednesday 22nd May 2019

Mike Adams – CEO

NEW ZEALAND ENERGY CORP.

CAUTIONARY NOTES

FORWARD-LOOKING INFORMATION

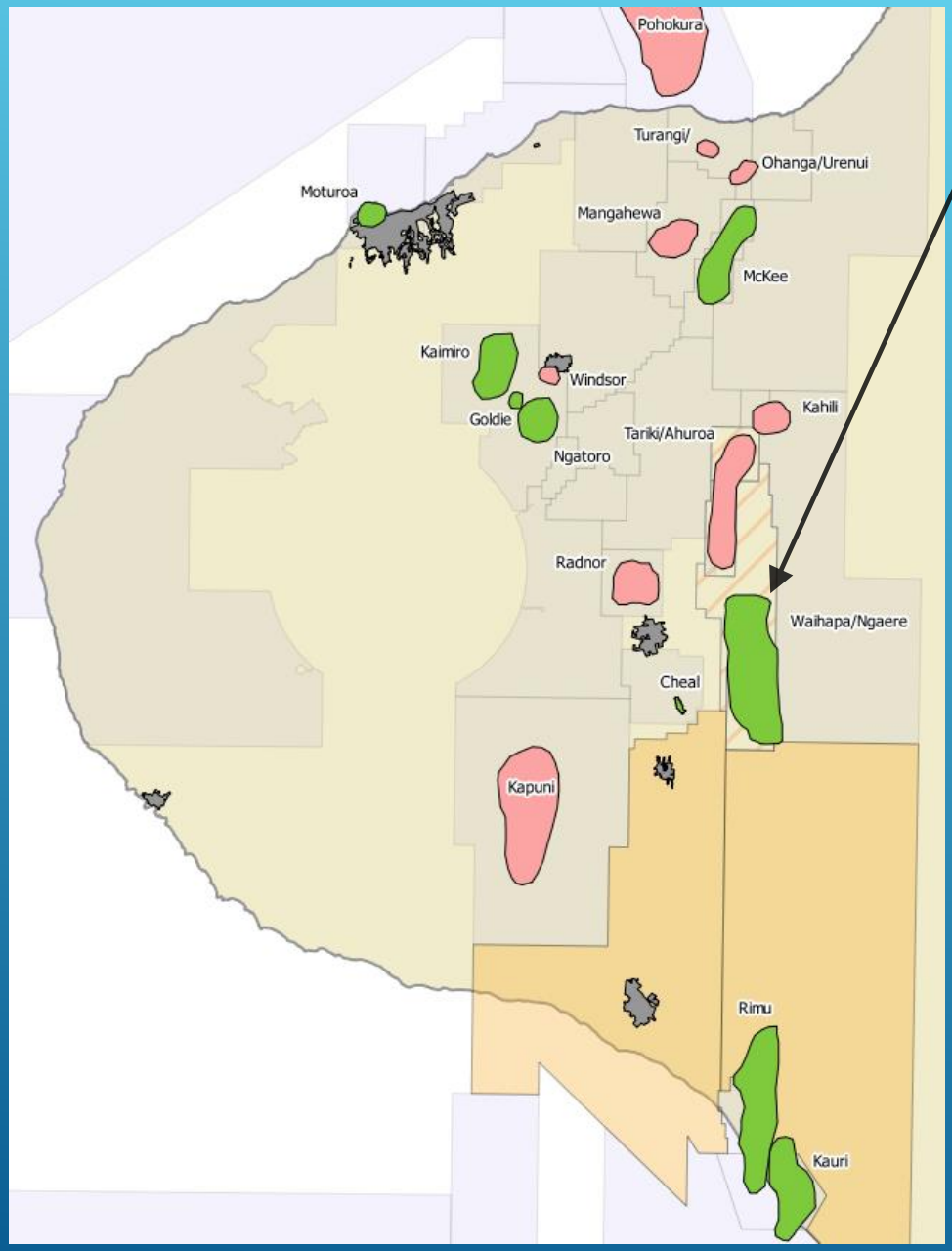
This document contains certain forward-looking information and forward-looking statements within the meaning of applicable securities legislation (collectively "forward-looking statements"). The use of any of the words "will", "objective", "plan", "seek", "expect", "potential", "pursue", "subject to", "can", "could", "hopeful", "contingent", "anticipate", "look forward", and similar expressions are intended to identify forward-looking statements. These statements involve known and unknown risks, uncertainties and other factors that may cause actual results or events to differ materially from those anticipated in such forward-looking statements. Such forward-looking statements should not be unduly relied upon. The Company believes the expectations reflected in those forward-looking statements are reasonable, but no assurance can be given that these expectations will prove to be correct.

Actual results could differ materially from those anticipated in these forward-looking statements as a result of the risk factors set forth below and elsewhere in the document, such as the speculative nature of exploration, appraisal and development of oil and natural gas properties; uncertainties associated with estimating oil and natural gas resources; changes in the cost of operations, including costs of extracting and delivering oil and natural gas to market, that affect potential profitability of oil and natural gas exploration; operating hazards and risks inherent in oil and natural gas operations; volatility in market prices for oil and natural gas; market conditions that prevent the Company from raising the funds necessary for exploration and development on acceptable terms or at all; global financial market events that cause significant volatility in commodity prices; unexpected costs or liabilities for environmental matters; competition for, among other things, capital, acquisitions of resources, skilled personnel, and access to equipment and services required for exploration, development and production; changes in exchange rates, laws of New Zealand or laws of Canada affecting foreign trade, taxation and investment; failure to realize the anticipated benefits of acquisitions; and other factors. This document includes references to management's forecasts of future development, probability of success, production and cash flows from such operations, which represent management's best estimates at the time. The forward-looking statements contained in the document are expressly qualified by this cautionary statement. These statements speak only as of the date of this document and the Company does not undertake to update any forward-looking statements that are contained in this document, except in accordance with applicable securities laws.

CAUTIONARY NOTE REGARDING RESERVE & RESOURCE ESTIMATES

The oil and gas reserves calculations and income projections were estimated in accordance with the Canadian Oil and Gas Evaluation Handbook ("COGEH") and National Instrument 51-101 ("NI 51-101"). The term barrels of oil equivalent ("boe") may be misleading, particularly if used in isolation. A boe conversion ratio of six Mcf: one bbl was used by NZEC. This conversion ratio is based on an energy equivalency conversion method primarily applicable at the burner tip and does not represent a value equivalency at the wellhead. Reserves are estimated remaining quantities of oil and natural gas and related substances anticipated to be recoverable from known accumulations, as of a given date, based on: the analysis of drilling, geological, geophysical, and engineering data; the use of established technology; and specified economic conditions, which are generally accepted as being reasonable. Reserves are classified according to the degree of certainty associated with the estimates. Proved Reserves are those reserves that can be estimated with a high degree of certainty to be recoverable. It is likely that the actual remaining quantities recovered will exceed the estimated proved reserves. Probable Reserves are those additional reserves that are less certain to be recovered than proved reserves. It is equally likely that the actual remaining quantities recovered will be greater or less than the sum of the estimated proved plus probable reserves. Revenue projections presented are based in part on forecasts of market prices, current exchange rates, inflation, market demand and government policy which are subject to uncertainties and may in future differ materially from the forecasts above. Present values of future net revenues do not necessarily represent the fair market value of the reserves evaluated. The report also contains forward-looking statements including expectations of future production and capital expenditures. Information concerning reserves may also be deemed to be forward looking as estimates imply that the reserves described can be profitably produced in the future. These statements are based on current expectations that involve a number of risks and uncertainties, which could cause the actual results to differ from those anticipated. Contingent resources are those quantities of oil and gas estimated on a given date to be potentially recoverable from known accumulations using established technology or technology under development, but which are not currently considered to be commercially recoverable due to one or more contingencies. Contingencies may include factors such as economic, legal, environmental, political and regulatory matters, or a lack of markets. Prospective resources are those quantities of oil and gas estimated on a given date to be potentially recoverable from undiscovered accumulations. The resources reported are estimates only and there is no certainty that any portion of the reported resources will be discovered and that, if discovered, it will be economically viable or technically feasible to produce.

Waihapa – Where is it?



Location

Waihapa/Ngaere lies ~8km SE of Stratford. The field is in the eastern Taranaki thrust zone – the most oil productive trend yet discovered onshore in NZ.

Waihapa – What is it?

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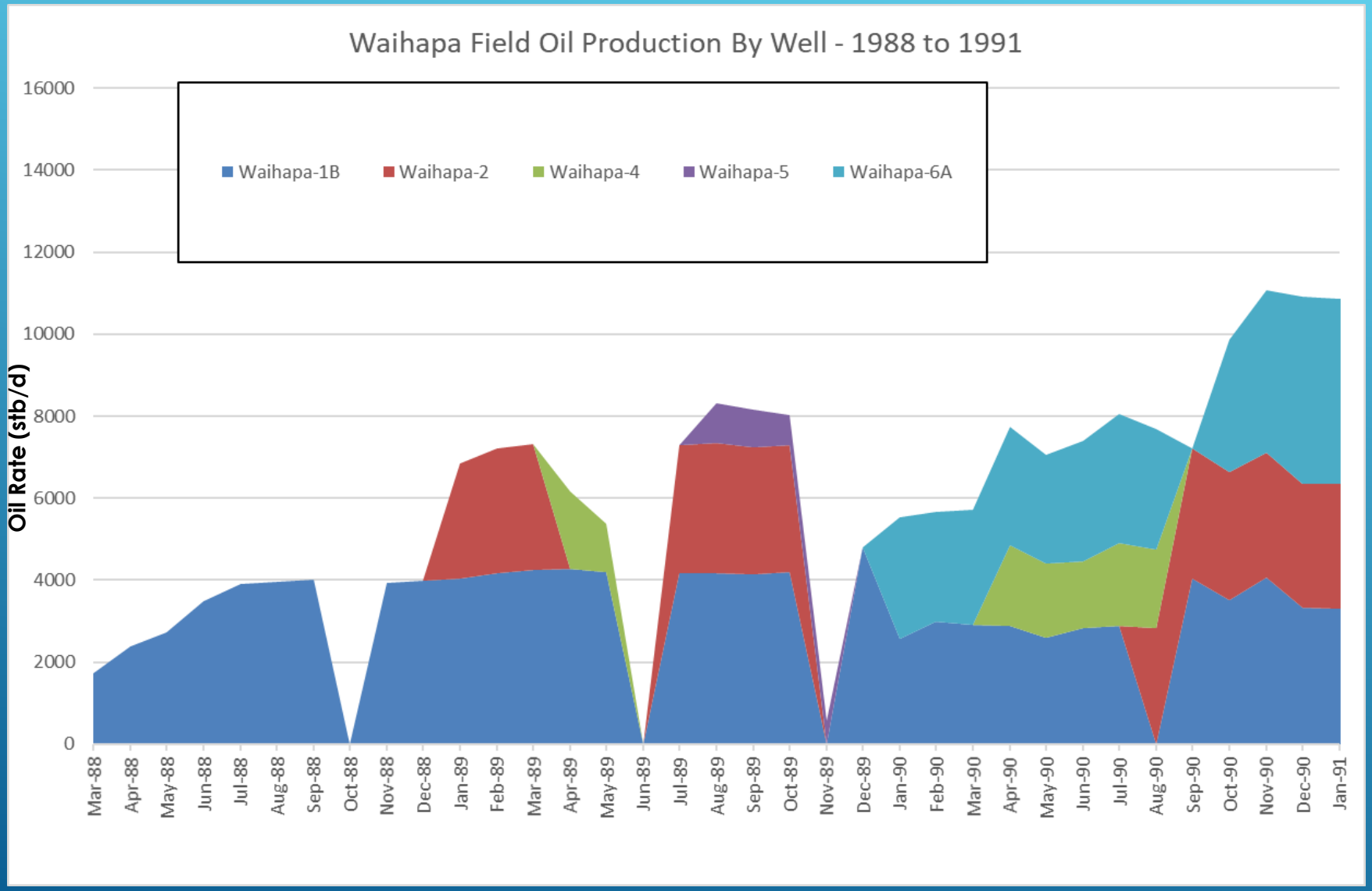
- Onshore oil field first discovered in 1988.
- 1988 - Waihapa-1B Discovery well tested at ~4500 bopd on natural flow
- 1989
  - Waihapa-2 Appraisal well at ~4000 bopd
  - Waihapa-4 Appraisal well at ~2000 bopd
  - Waihapa-5 ~1000 bopd
  - Waihapa-6A ~3000 bopd
- Follow-up wells to the north Ngaere area deferred pending PML
- Cumul. Production to YE 2018 ~24 mmstb oil
- Peak Oil Production >15,000 bopd

Waihapa – What is it?

- First three years OIL production history



Waihapa – What is it?

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- The reservoir at Waihapa is the Tikorangi Limestone at ~2500 mTVSS.
- Unique in NZ - Naturally Fractured Reservoir with No Matrix storage or contribution
- Reserves challenges
  - Traditional Volumetrics didn't work as fractures are not uniformly sized or distributed.
  - Material balance preferred method in early time but good data required to constrain
  - Resolve by collecting high quality pressure, rate, fluid and fracture geometry data. For the latter both image logs and (oriented) cores used.

Waihapa – Where is the oil stored?

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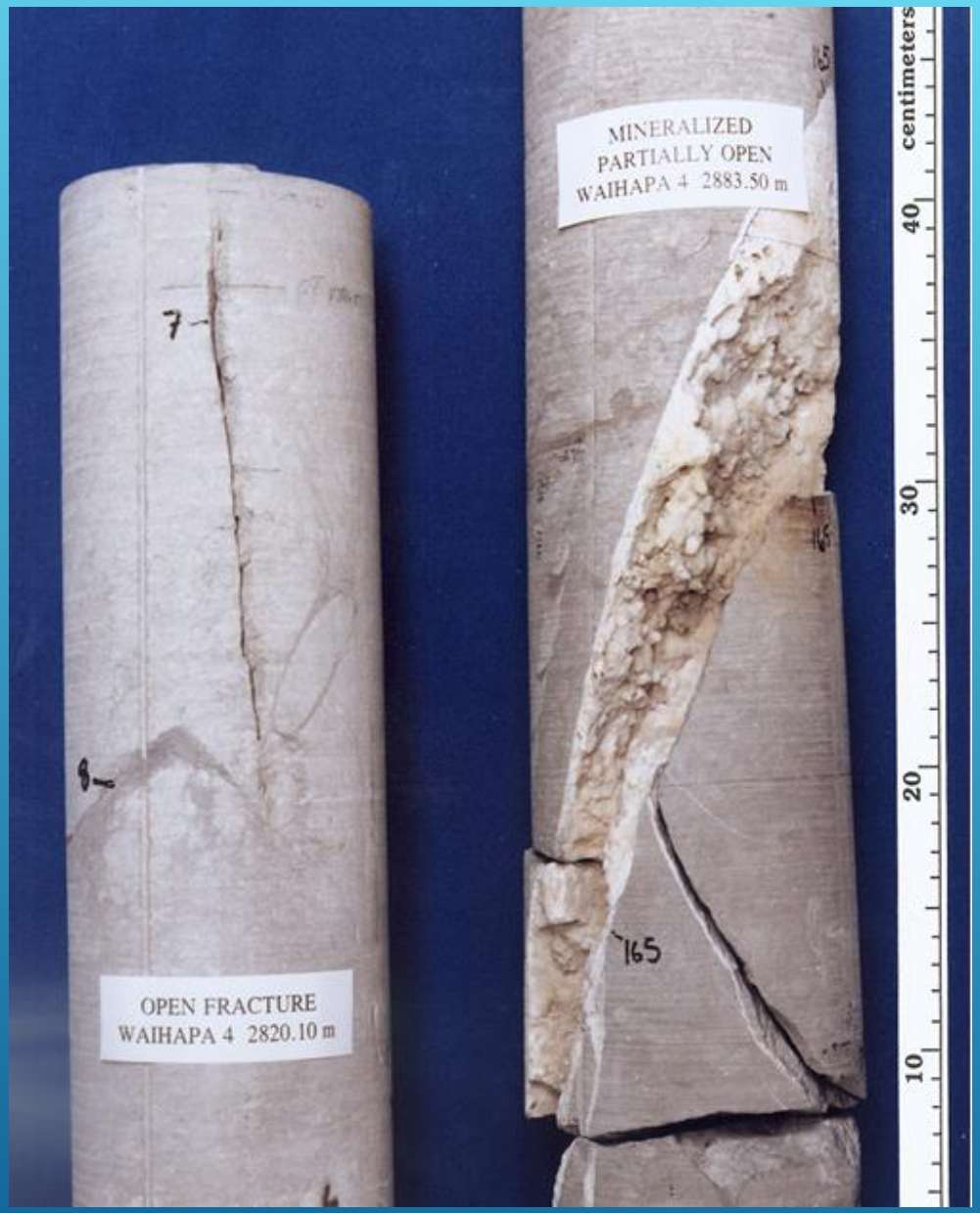
Core recovered in Waihapa-2, -4, -5 and -6.

- Fracture Porosity
  - Large near vertical open fractures with permeability >10 Darcy
  - Small scale fractures with permeabilities <0.1 Darcy (100 mD)
- Limestone matrix average ~5% porosity and 0.01mD permeability. No hydrocarbons detected in the matrix pores.
- All storage AND flow is via fractures!



Waihapa – Where is the oil stored?

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Schematic cross-section of the fractured Tikorangi reservoir

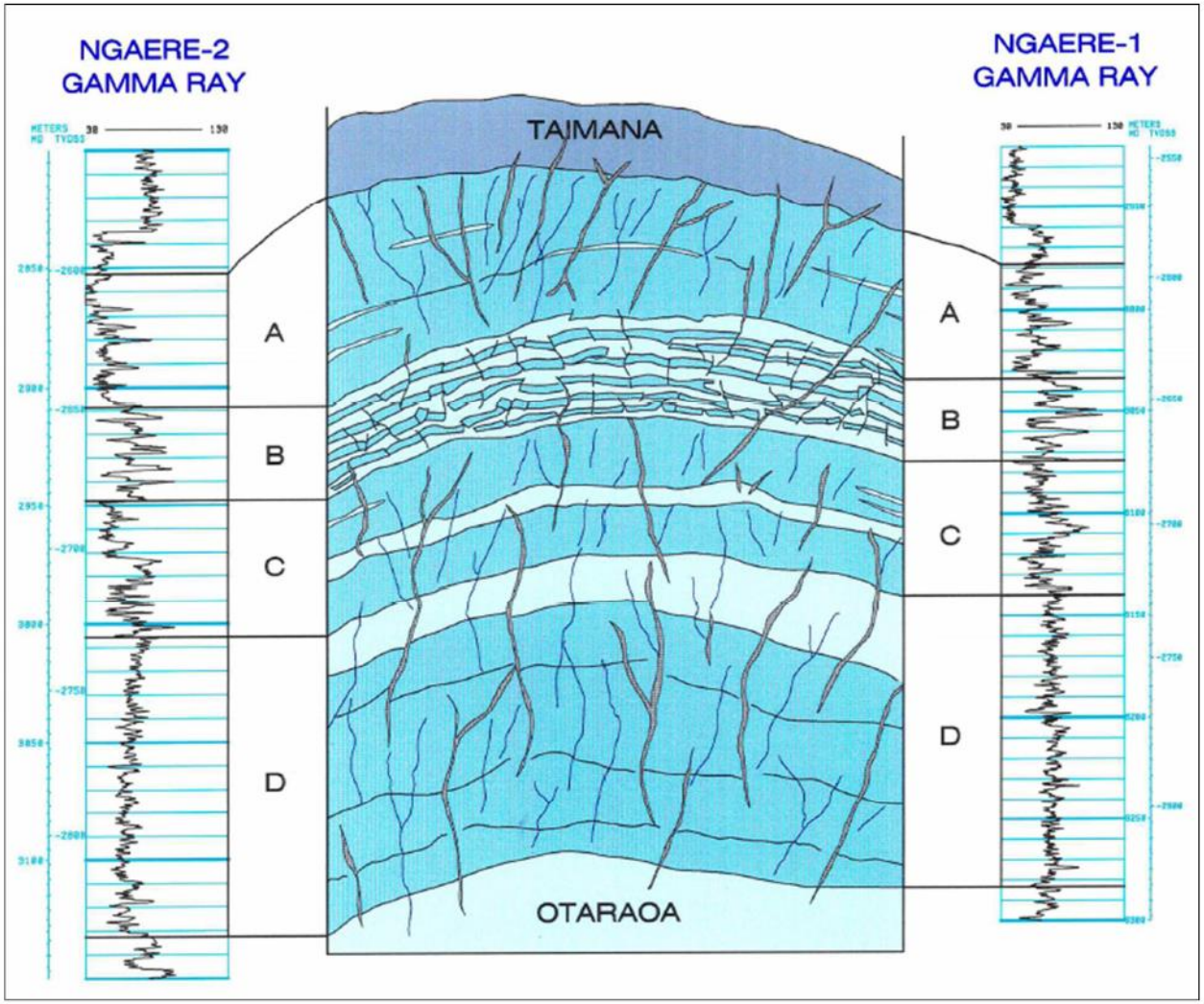

Figure 2.4. Reservoir units within the Tikorangi Formation

Waihapa – Development

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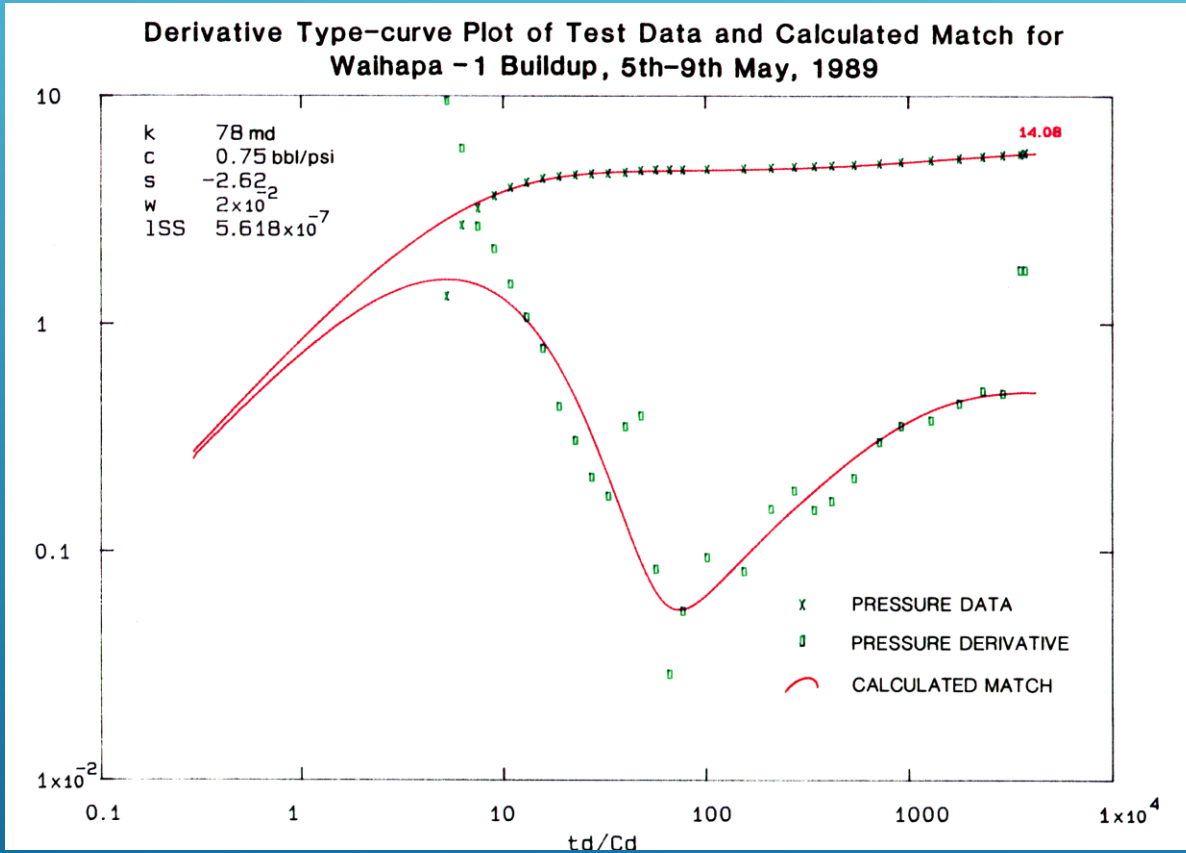
- Capital Expenditure for wells, oil and gas processing facilities and pipelines required certainty on minimum volumes.
- Development Plan FID deferred while data collected certainty increased;
  - Pressure Transient Tests
  - Interference Tests
  - OWC – established using water coning tests
  - Fractured Core analyses
  - Image Logs
  - Earth Tide Monitoring

Waihapa – Development

- **Pressure Transient Tests**
  - Measure the pressure response in a well(s) to rate changes.
  - Measures the permeability and can see shape of a reservoir. Also see if there is a second porosity/permeability system present

- **Waihapa-1B**
  - Negative skin
  - Per ~80 mD lower than expected
  - Dual porosity system evidence with primary porosity ~2% of volume and a very large permeability contrast between primary & secondary porosity systems from inter-porosity flow



Waihapa – Development

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- Interference Tests 1989 - 1993
  - Phased Testing Program between
    - W1-W2 – 510m
    - W1-W4 – 2600m
    - W1-W5 – 1325m
    - W1-W6 – 1750m

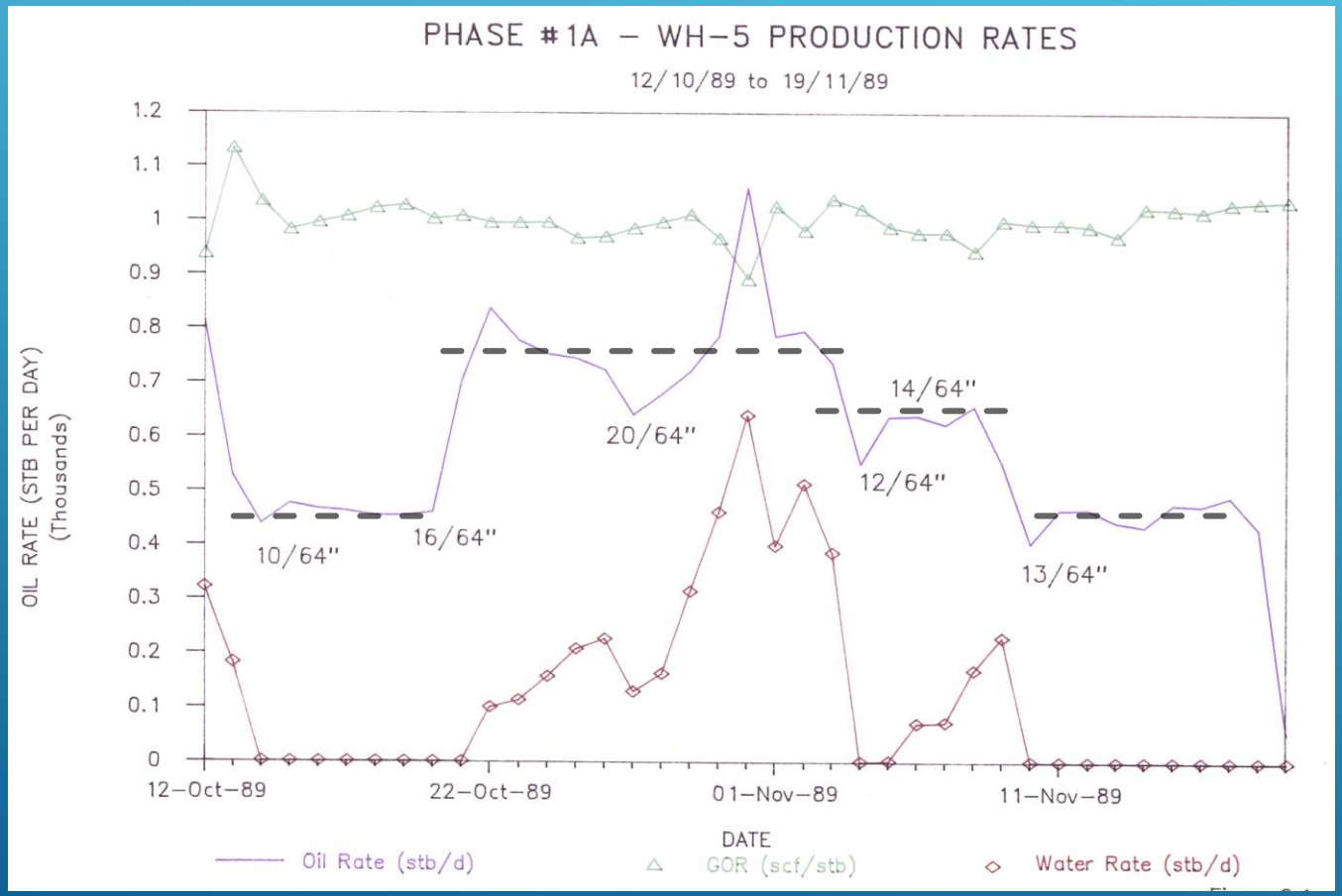
Well Pair	Date	Kh (md.ft)	K (md)	Storativity (/psi)	Porosity (based on 20e-06 /psi compress)	Comments
Waihapa-1b to 2	March 1989	116400	194	0.12E-06	0.6	WH2 observing WH1
Waihapa-2 to 4	March 1989	10200	17	0.08E-06	0.4	WH2 observing WH4
Waihapa-4 to 1 & 2	Aug 1989	5920	10	0.144E-06	0.71	WH4 observing WH1 and 2 SI
Ngaere-2 to 1	Aug 1997	174000	290	na	0.48	NG1 observing
Waihapa-6a to Ngaere-1	Aug 1997	150000	250	na	0.68	NG1 observing

- Interference testing provides estimates of the inter-well storativity (i.e the compressibility.porosity product) . An estimate of the system compressibility can derive average porosity of the system.
- In the case of Waihapa interference testing the inter-well testing gave a storativity of 0.1 to 144 x 10-6/psi. This results in total porosity estimates of 0.4% to 0.71% porosity.

Waihapa – Development

- OWC – established using water coning tests
  - Waihapa-5 exhibited water-coning behaviour very early, within days of starting at ~1000 bopd.
  - Water rate was oil rate dependent, i.e. pressure drawdown dependent.

Assume ~450 bopd gave no water (just) then Water coning calculation in open fracture gives OWC at ~2850 mTVSS



Waihapa – Development

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- **Volume Estimates – Performance Derived 1989 - 1993**

Table 7 Waihapa-Ngaere Field OIIP Estimates from Material Balance

Study	Low P90/P85 (mmstb)	Mid P50 (mmstb)	High P15/P10 (mmstb)	Comments
1989 - Wadsley	22.2	36.8	51.5	Complex porosity model. Stochastic simulation.
1989 - Wadsley	42.4	52.0	65.2	Dual Fracture model. Stochastic simulation.
1993 - Wadsley	25.4	-	76.3	Attempted pressure matches with 0.2% and 0.6% porosity models in an 11 cell material balance model. Only 0.2% model matched historical oil production (12.72

Waihapa – Production

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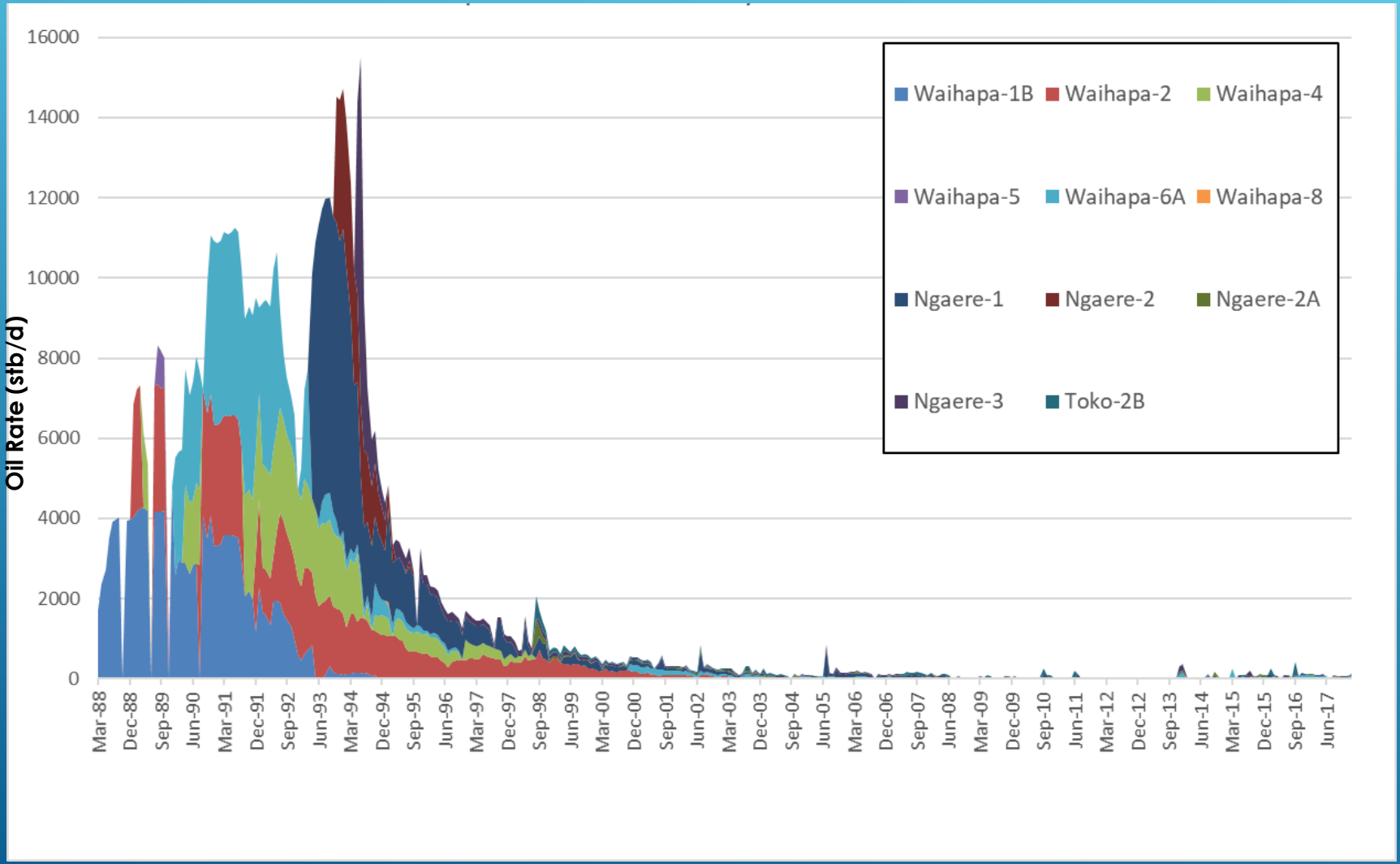
- Development Progressed
  - FID based on Performance Derived Reserves
  - Gas sales commencing 1991 and expanding 1993 to New Plymouth Power Station (via 081/082 pipeline)
  - Ngaere Permit Area wells drilled up and onstream 1993 – peak field oil rate ~15,000 bopd
  - Waihapa Production Station on stream 1993 – 18,000 bfpd
  - ESPs installed to maintain oil rates
    - W4 1996-1998
    - N1 1995 – 1998
    - N3 1995

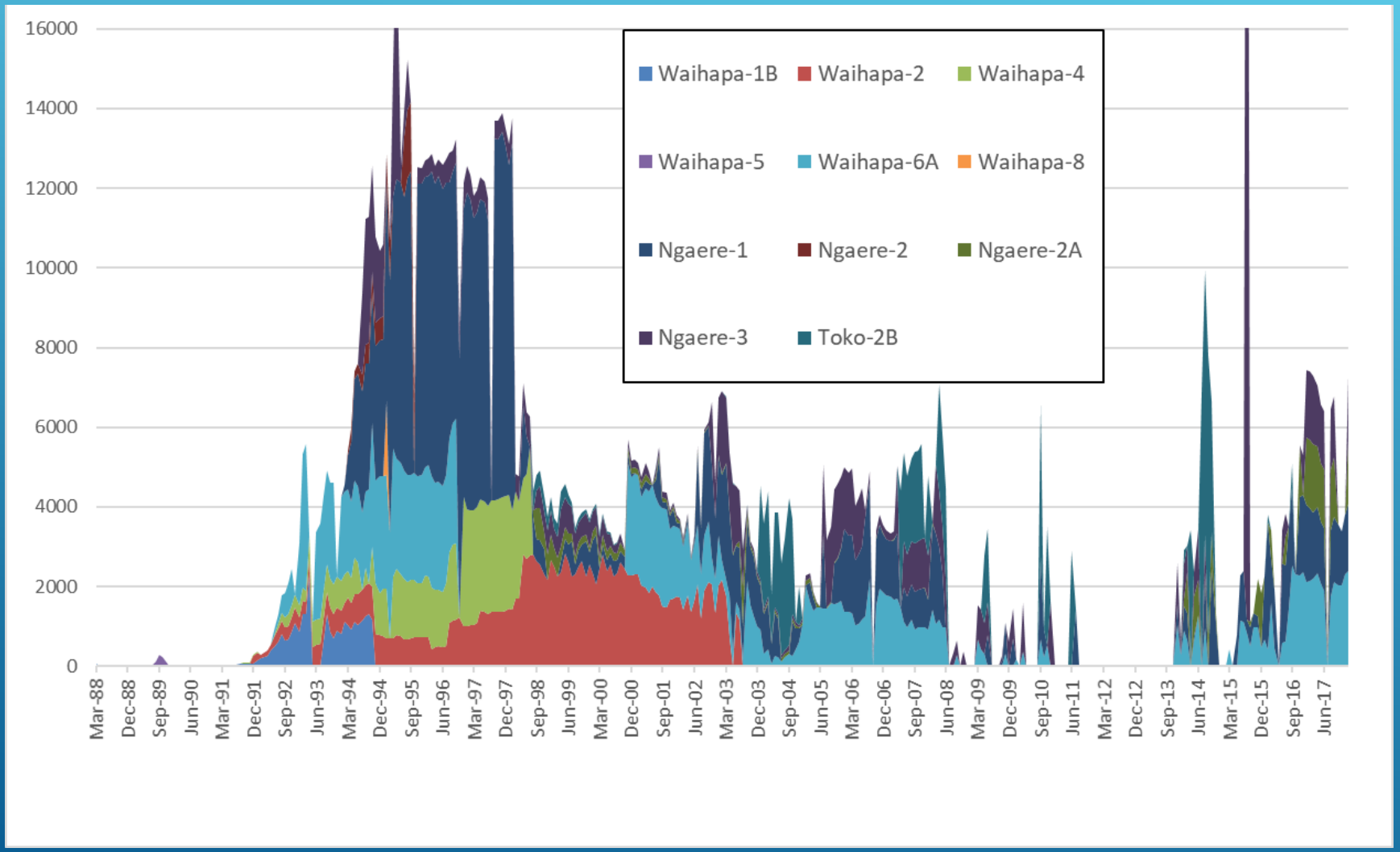
Waihapa – Production

- Full oil rate production history 1988 to 2018



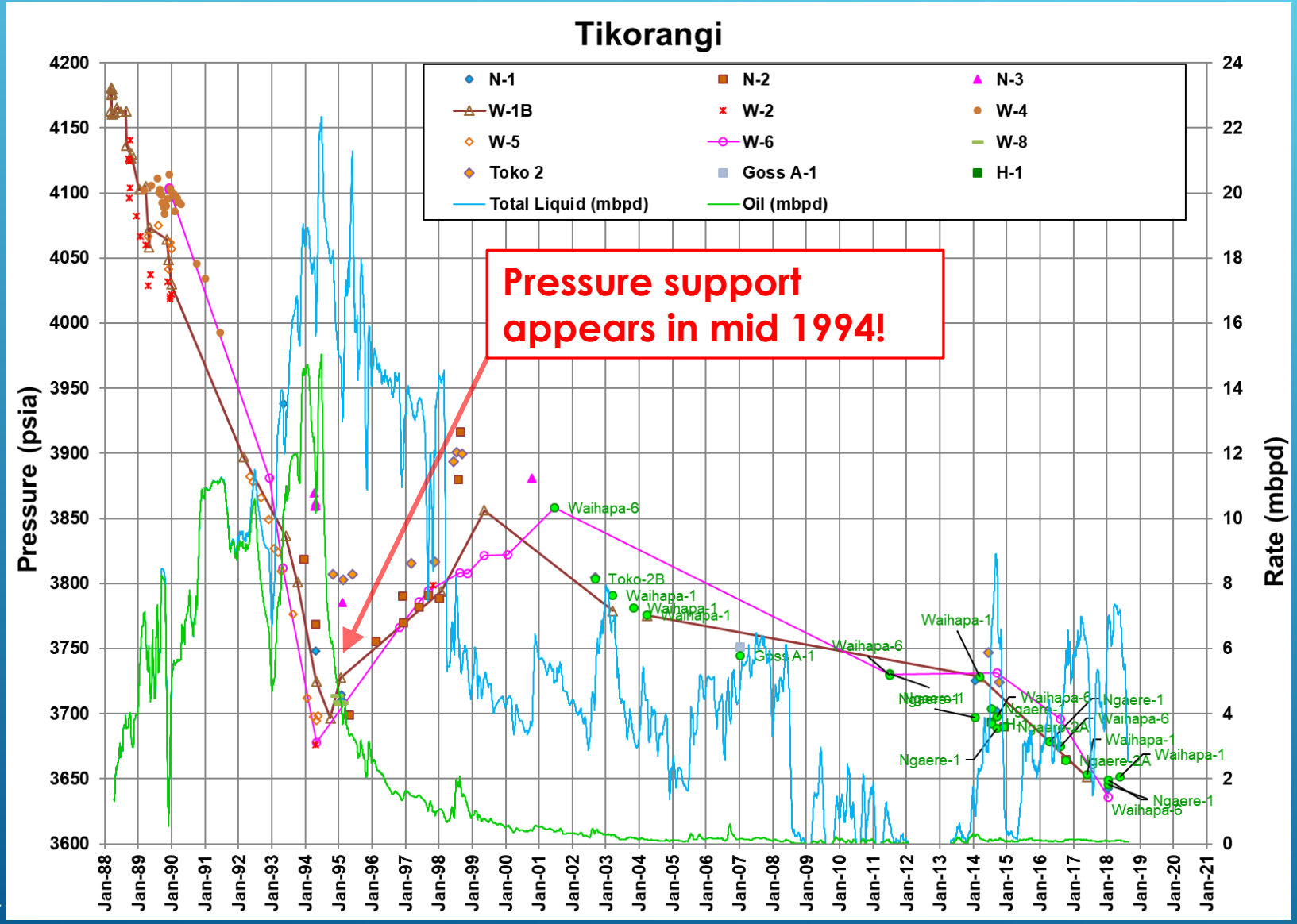
Waihapa – Production

- Full WATER production history 1988 to 2018



Waihapa – Production Understanding

- Reservoir Pressure Versus Time



Waihapa – Production Understanding

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1994 – 2015 Reservoir Performance

Assume pressure support is large aquifer that became connected via a "breach" mechanism (e.g. fault seal failure due to high pressure differential).

2011 Material Balance Model

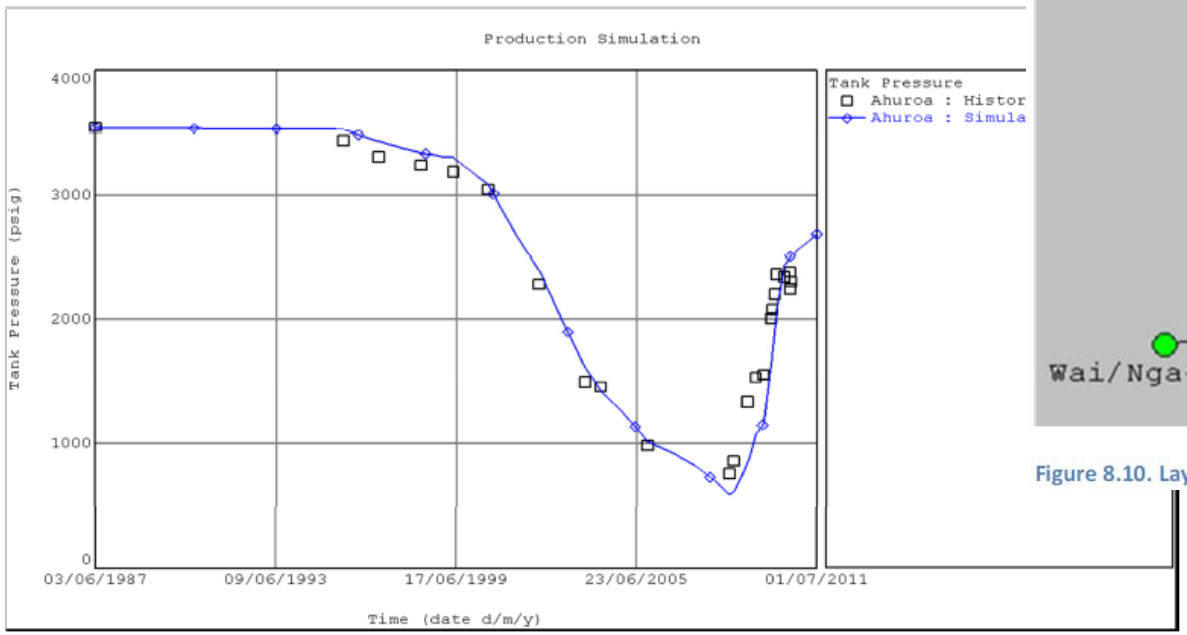

Figure 8.11. Pressure match Ahuroa tank. Integrated Wai/Nga & Ahu model (datum 2150 mTVDSS)

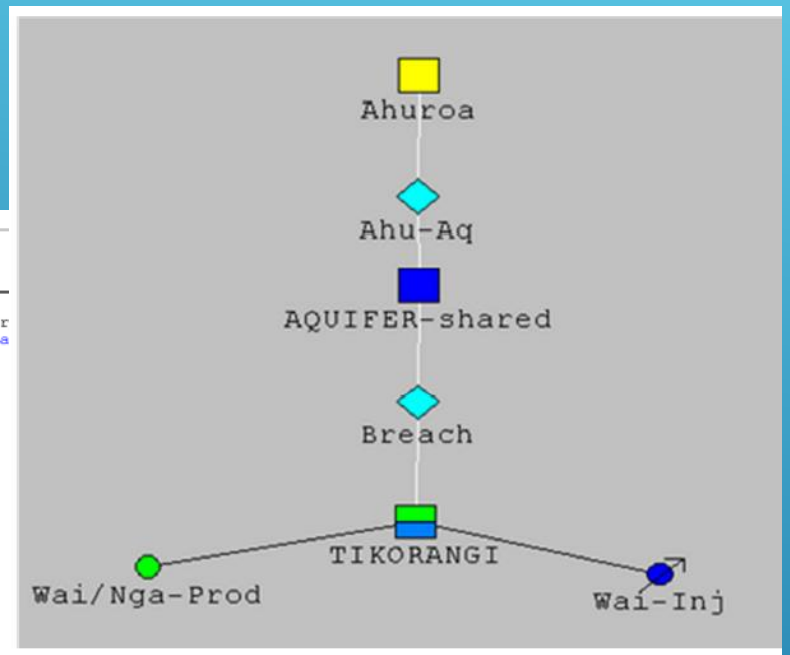

Figure 8.10. Layout of integrated Wai/Nga & Ahu model

Waihapa – Production Understanding

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2015 - 2018 Reservoir Performance

What if the "breach" assumption is incorrect – say 18 mmstb produced water was re-injected into Waihapa-5. The rest was pumped in Waihapa-7A at shallower level.

2018 Material Balance Model

P50 Match

OIIP 44 mmstb
WIIP 545 mmstb
FGIIP ~nil

Very similar to pre 1994 Material Balance estimates!

P50 ~20 mmstb remaining OIP. Not all recoverable!

Waihapa – Is there any Oil left?

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- The displacement efficiency of water in open fractures is ~100%.
- Any remaining oil production must be due to;
  1. Unswept oil, i.e. below attic oil that is accessed via low permeability fracture networks where significant oil saturations remain whilst the high permeability networks surrounding are swept to water.
  2. Attic or up-dip oil, i.e. oil that is trapped in fracture systems up-dip on any connection to a wellbore or an adjacent fracture system.
  3. Laterally trapped oil, i.e. oil that is trapped in fracture systems that are laterally disconnected from any wellbore.

Waihapa – Is there any Oil left?

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- **How to test these concepts?**
  1. **Unswept Oil. Low perm. network oil can test by increasing drawdown should lead to increased oil-cut.**
     - **Tested in Waihapa-6A and Ngaere-1 on gas-lift 2016-2018**
  2. **Attic or Up-Dip Oil. Look for fracture zones up-dip in existing wells and connect them, or drill up-dip. Can also create secondary gas cap to displace oil down-dip or inject gas for same.**
     - **Plan to deplete reservoir below 3500 psia (oil bubble point) by out-running aquifer influx. Have tested with high voidage rates in 2016-2018**
  3. **Laterally Trapped Oil. Drill new wells to test.**

Waihapa – Is there any Oil left?

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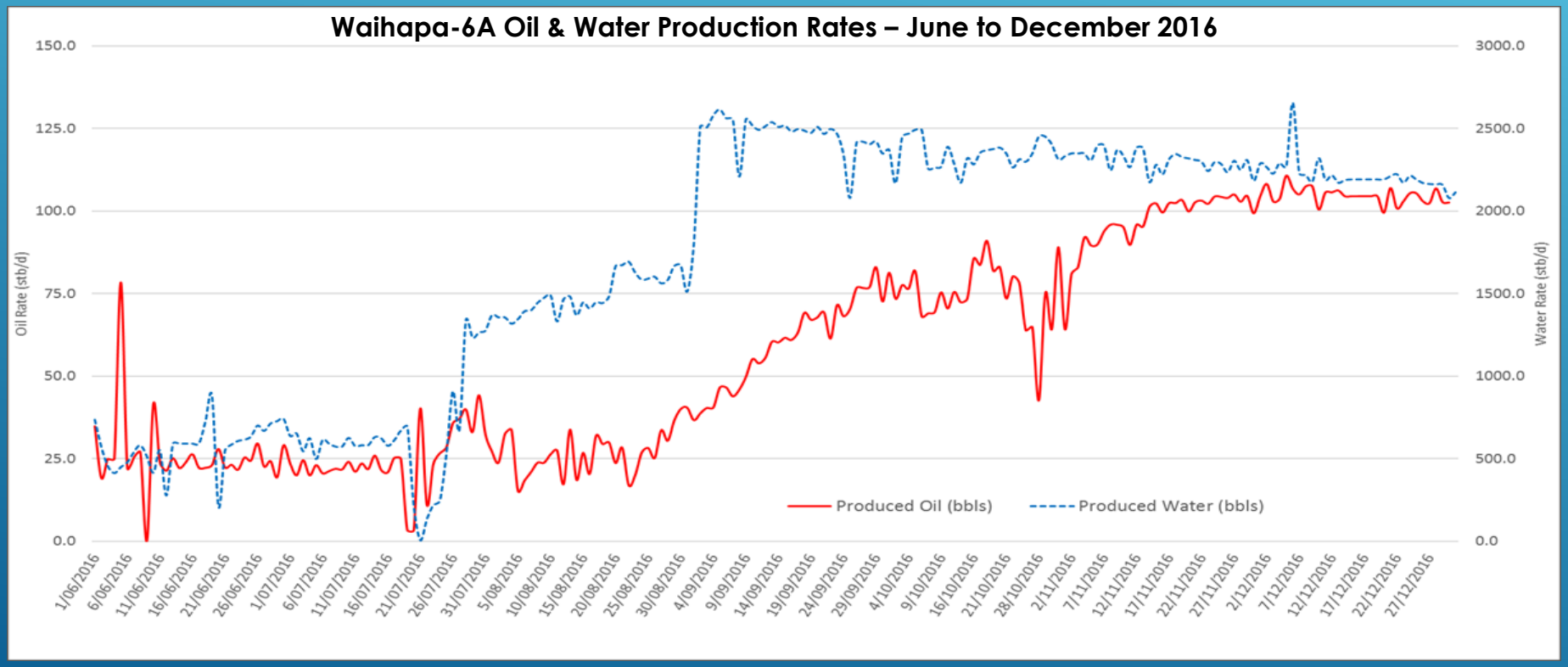
- **Unswept Oil**
  - Waihapa-6A went from ~22 bopd in July 2016 to ~100 bopd by mid November 2016
  - Oil cut went from 1.6% to 5% over 4 months
  - Confirms presence of oil remaining in less permeable fracture system



Waihapa – There is Oil left!

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- **Unswept Oil**

  Test results from Waihapa-6A and Ngaere-1 confirm;

  - **Two fracture systems present – large open fractures (k>>1000 mD) and micro-fractures (k<50mD)**
  - **Increasing drawdown on the wells, i.e. creating a lower bottom-hole pressure) increases drawdown acting on micro-fractures and results in increasing oil production**
  - **Gas-lift was used to test the concepts but requires higher gas-lift pressures and deeper GLVs to maintain rates as the reservoir pressure drops. Hence preferred high-rate lift technology is ESPs**

Waihapa – There is Oil left!

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- **Attic or Up-Dip Oil**

  High Rate flow tests using Waihapa-6A, Ngaere-1, Ngaere-2A and Ngaere-3 confirm;

  - **Ngaere-2A used as observation well to determine reservoir pressure in October 2016 and confirmed that we can out-produce the natural aquifer and depleting at ~0.6 psi/d at fluid rates of ~6500 bfpd**
  - **Rates of >~4000-4500 bfpd out produce the aquifer and start depleting the reservoir.**
  - **Pressures are currently above but close to Pb at ~3680 psia**

Waihapa – Re-Development

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Tikorangi Enhanced Oil Project	Progress
• Staged Field Re-Development in Progress	
• Testing and production increases using revised gas-lift designs	100%
• Produced gas & water handling upgrades & de-bottlenecking	100%
• Repairs to Produced Water System – new disposal strategy	90%
• Implement High Rate Artificial lift Technology in well Ngaere-1	100%
• Monitor results and evaluate second ESP well AND additional water disposal	25%
• Continuous Gas Sales commence	95%


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