

Interference Study in Shale Plays

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Outline

- Introduction
- Objectives
- Assumptions
- Approach
- Results and discussion
- Conclusions

Introduction

- Fracturing of infill wells in Shale Plays causes constructive or destructive production interference in offset wells.
- Data from 179 wells within 100 square miles in a Shale play were collected to study these impacts.
- These results can be used to optimize the locations and spacing of future infill wells.

Objectives

- To quantify impacts by examining the gas lost as well as fluid recovery from adjacent wells as a function of distance from the infill well
- To find the preferential direction of the impact
- To compare production performance of infill well with the surrounding wells

Objectives

- To relate fracturing parameters to the extent of impact
- To establish relationship between intensity of impact and age of a well and to determine the probability of a well being impacted based on it's age
- To determine the probability of a well being impacted by an infill well based on the distance between the two wells

Assumptions

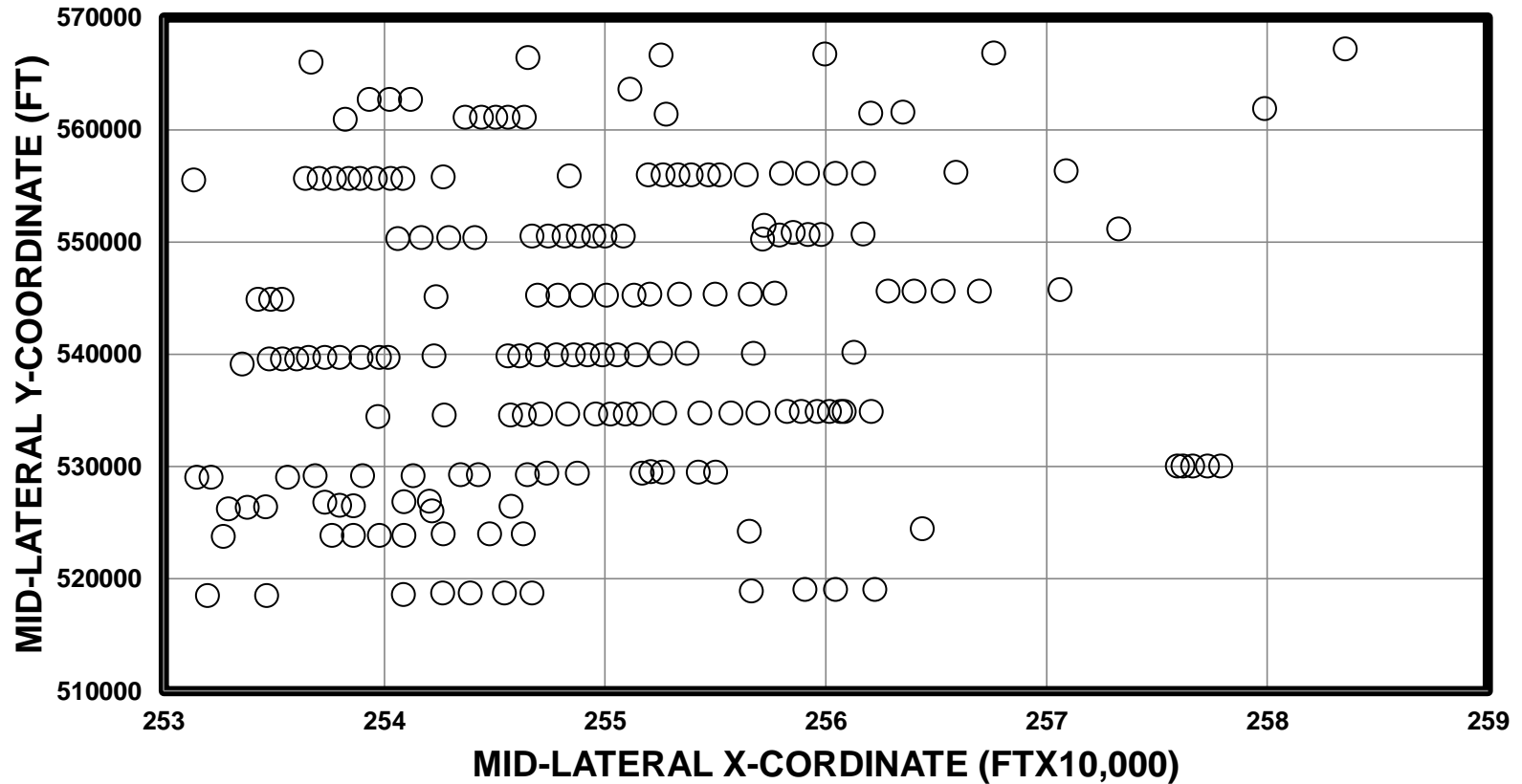
- The mid-lateral coordinate of horizontal wells was used to determine the direction and distance between two wells
- Sixty days initial production was used as a proxy for production potential from any well
- Water recovered from impacted wells, sixty days after the impact, is attributed to fracturing fluid from infill wells

Assumptions

- Sixty days Initial potential (IP) per lateral length or gross perforated interval is used to represent the performance of a well rather than the IP of the well.
- For wells on a pad, infill well that caused impact is assigned to the well closest to the impacted producer

Identification of Impact

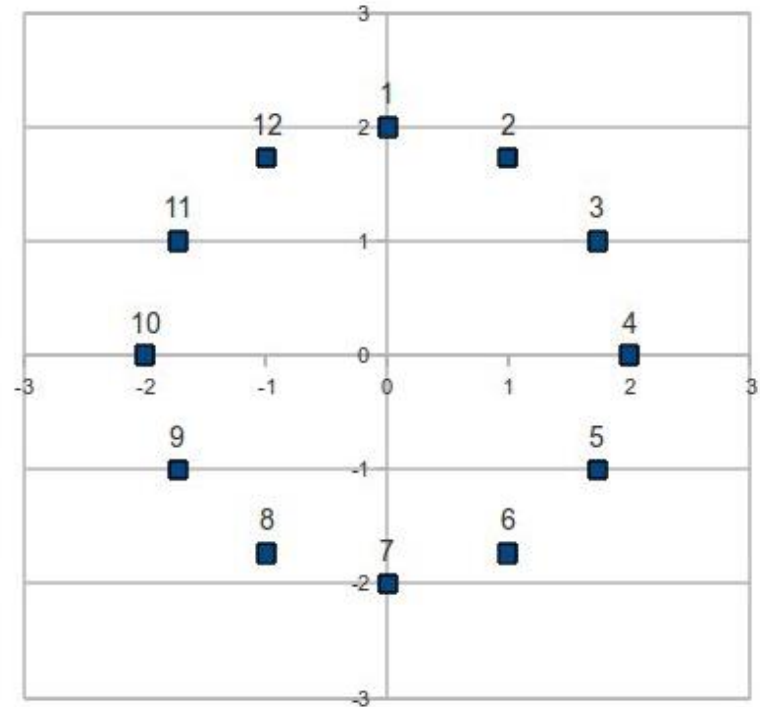
Approach – 100 square mile area used



Approach – Bearing and Distance

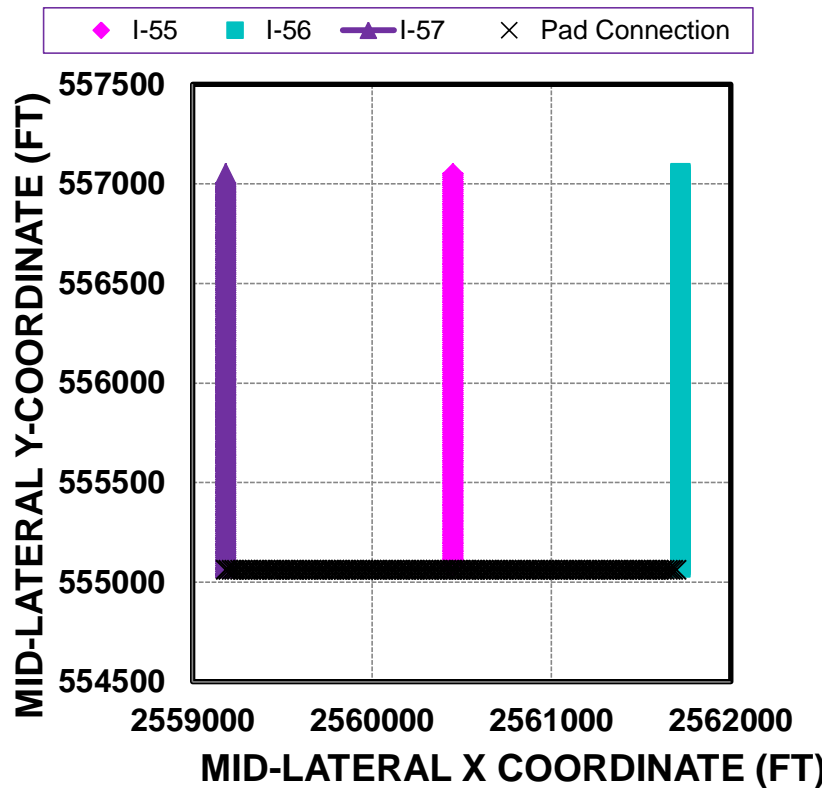
$$\Delta s = \sqrt{(x_w - x_i)^2 + (y_w - y_i)^2}$$

$$\theta = a \tan 2[(y_w - y_i), (x_w - x_i)]$$

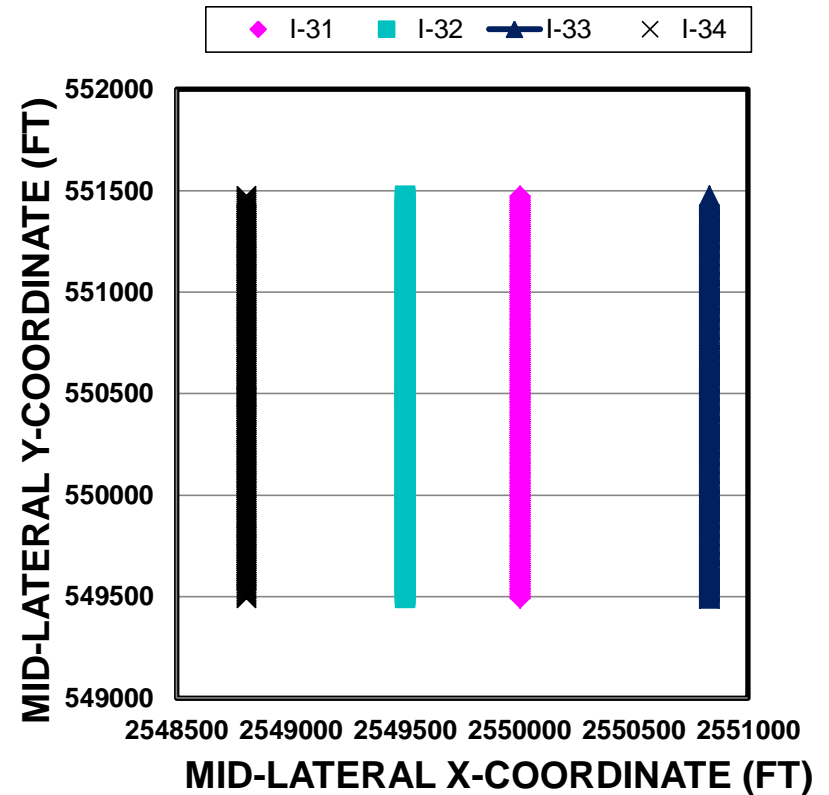


Approach – Drilling Pattern

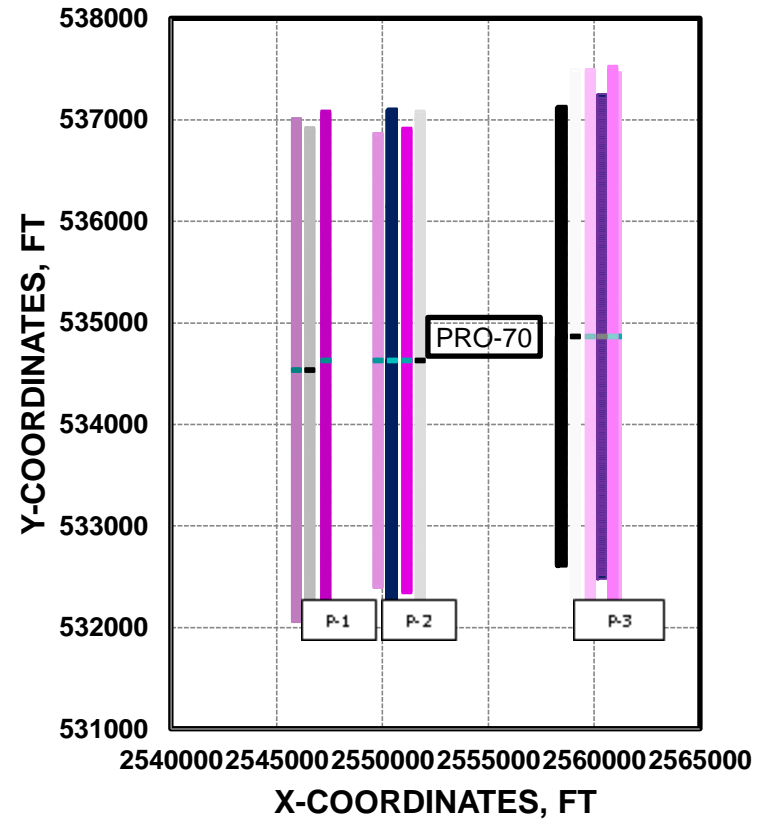
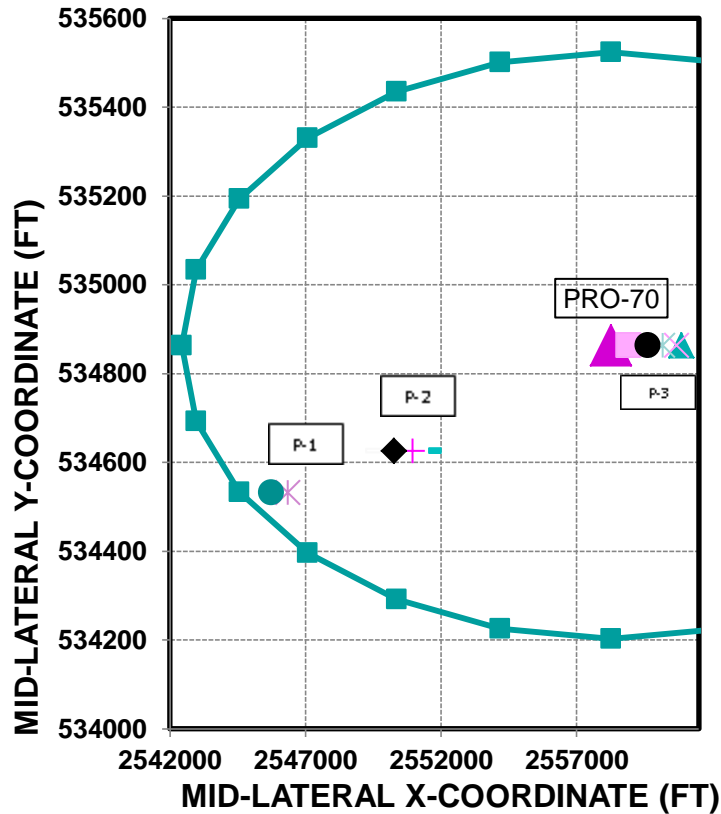
Pad Drilling (Same Pad)



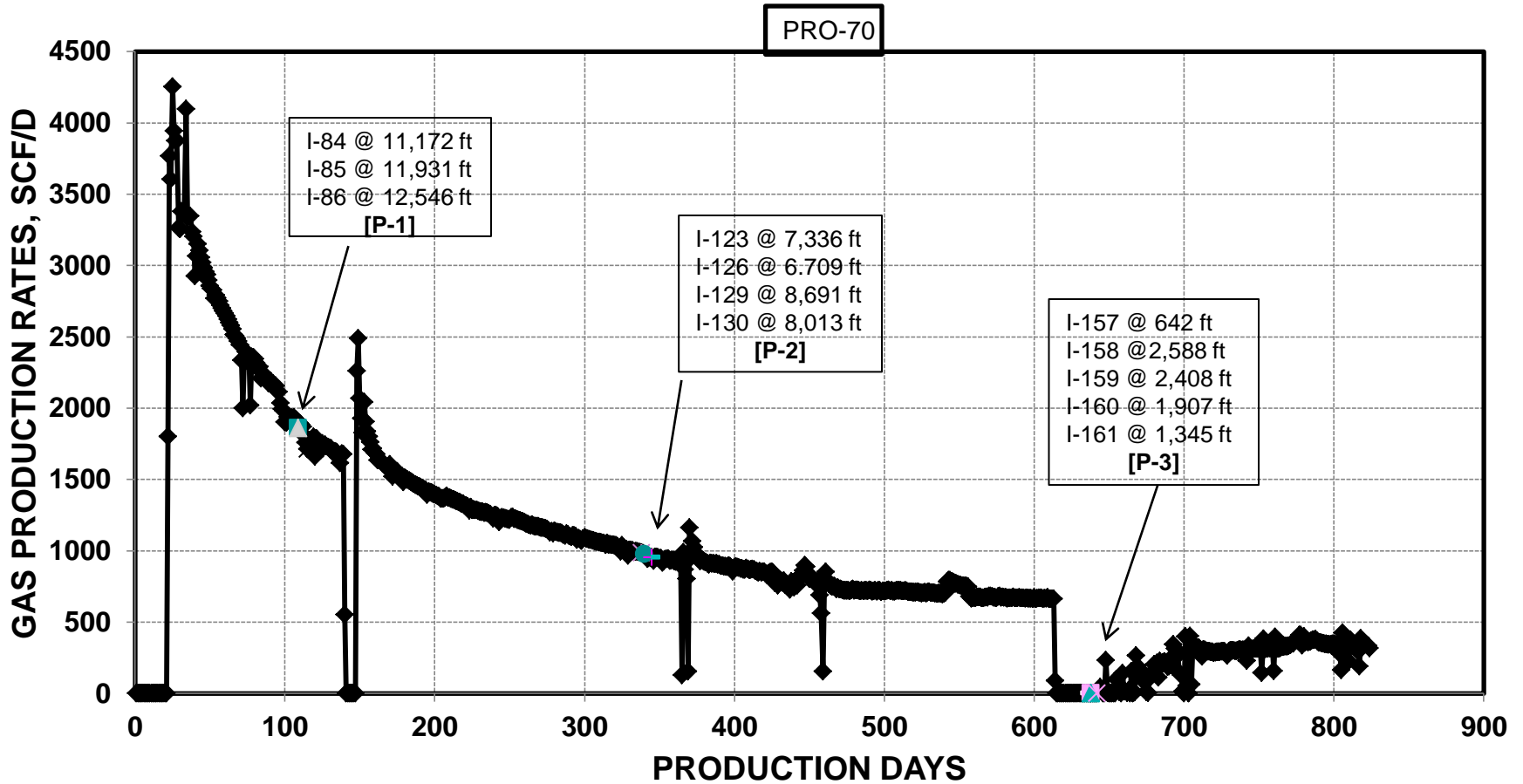
Pad Drilling (Single Wells)



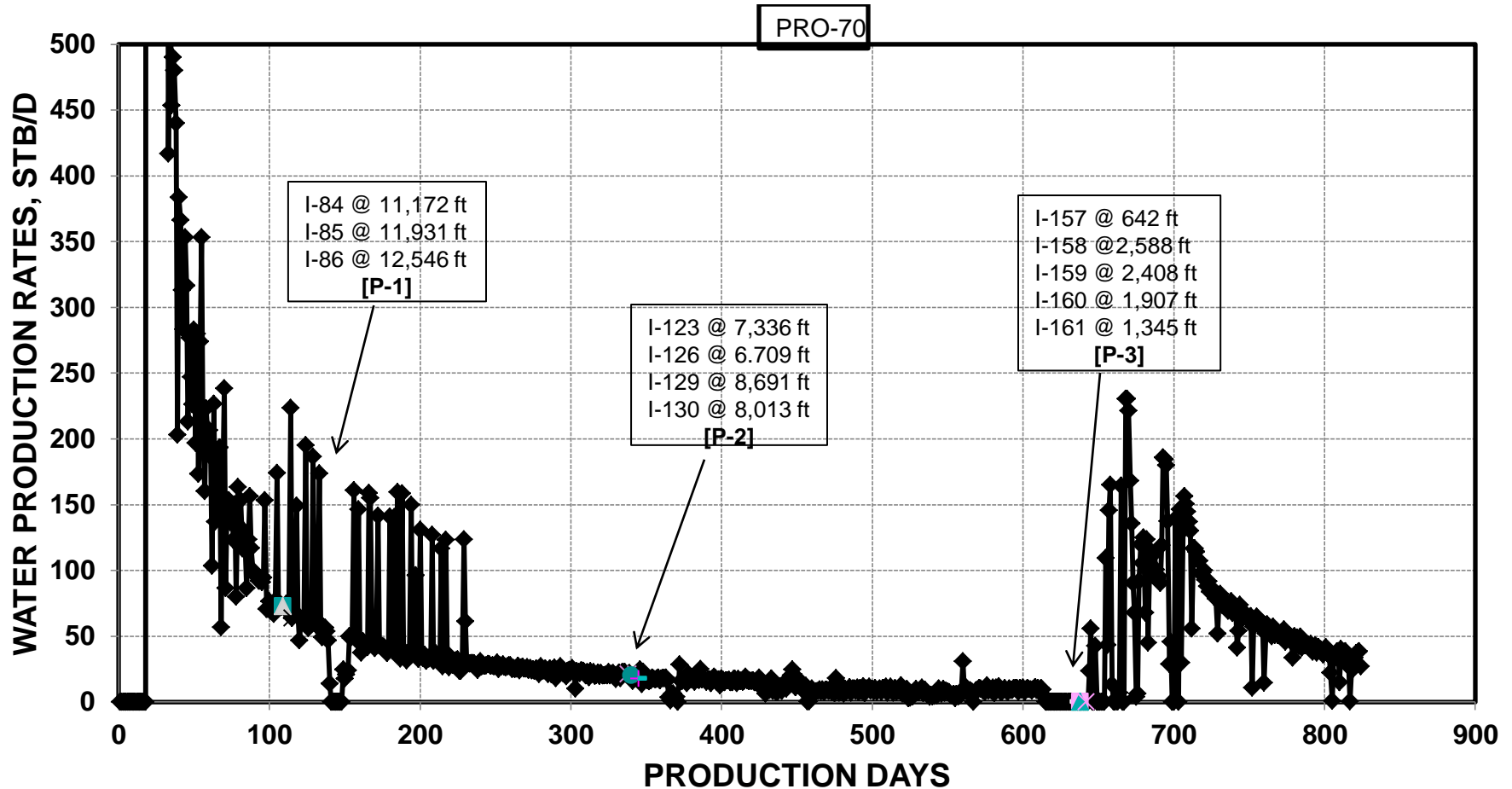
Approach – Identifying Impacts



Inspect: Gas Production History

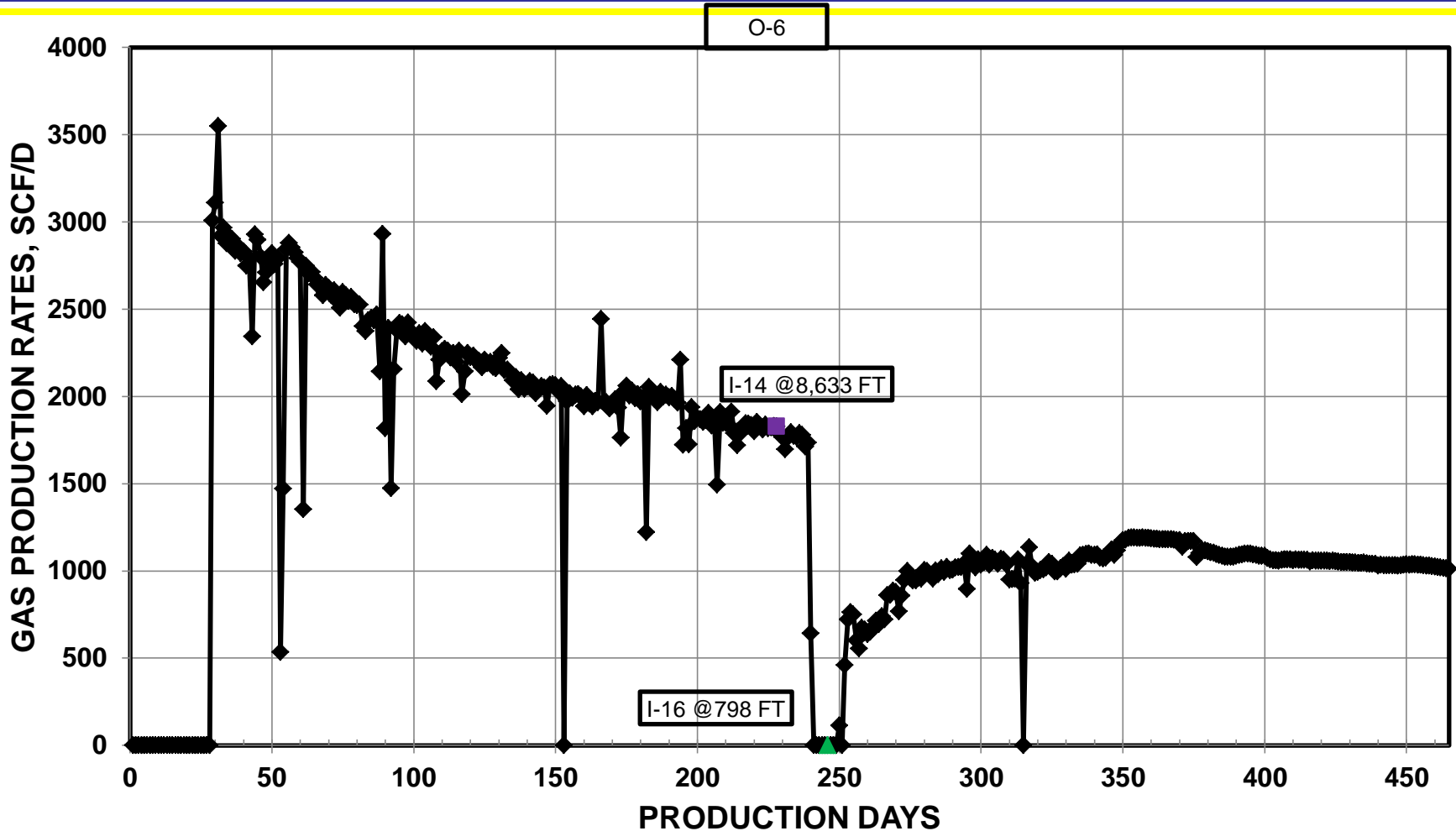


Inspect: Water Production History

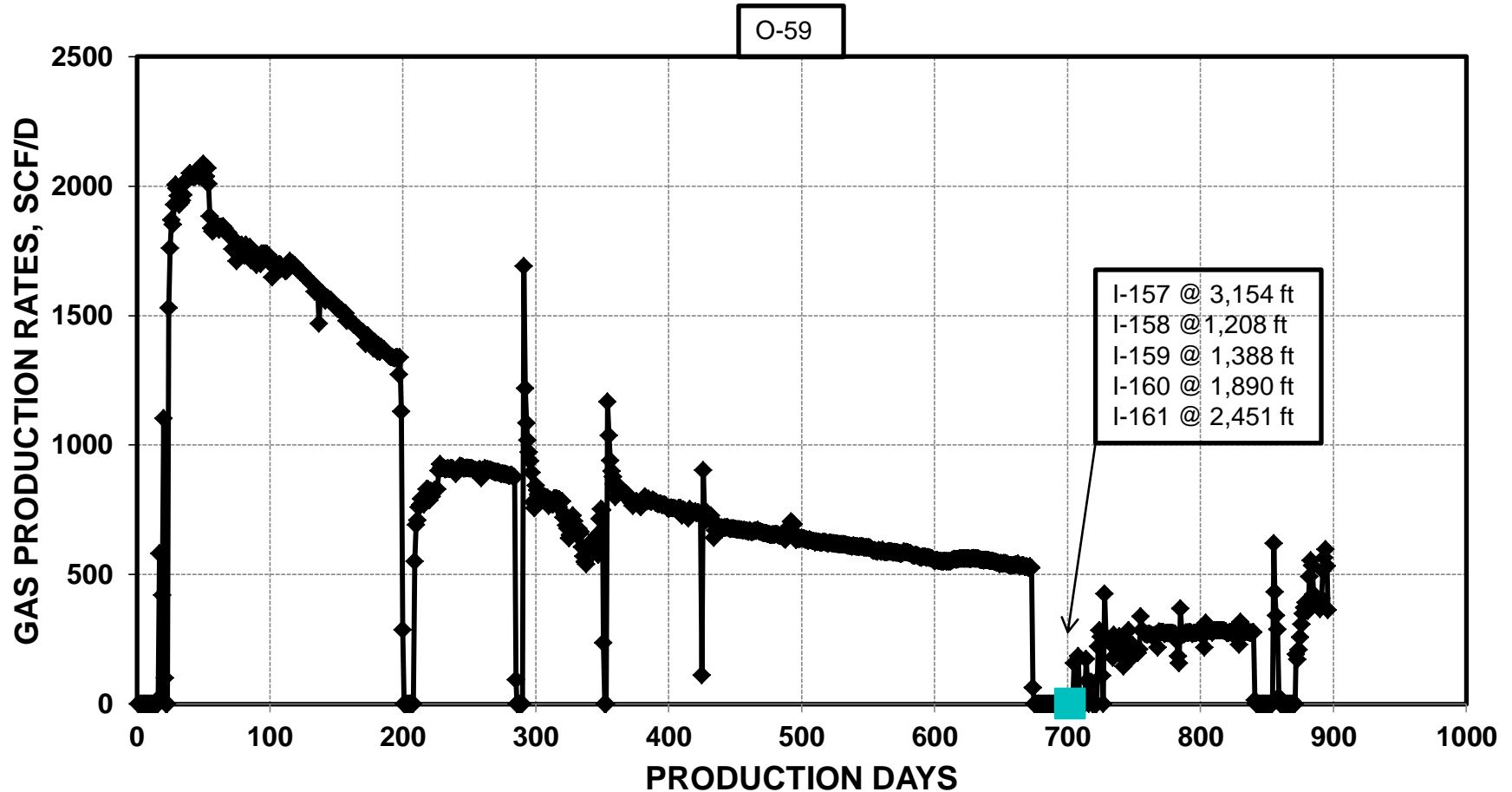


Quantification of Impact

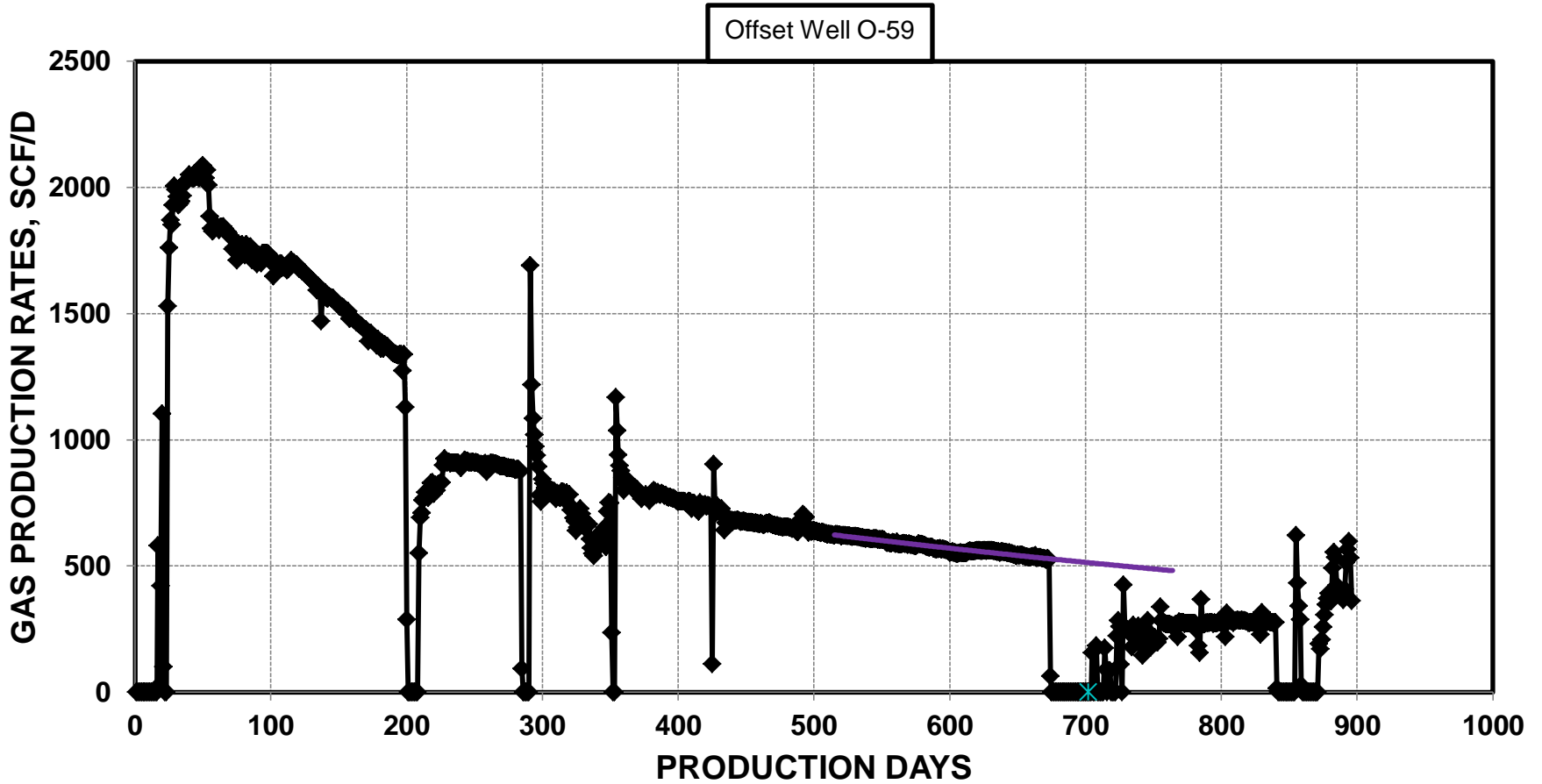
Assigning Distance : Single Infill



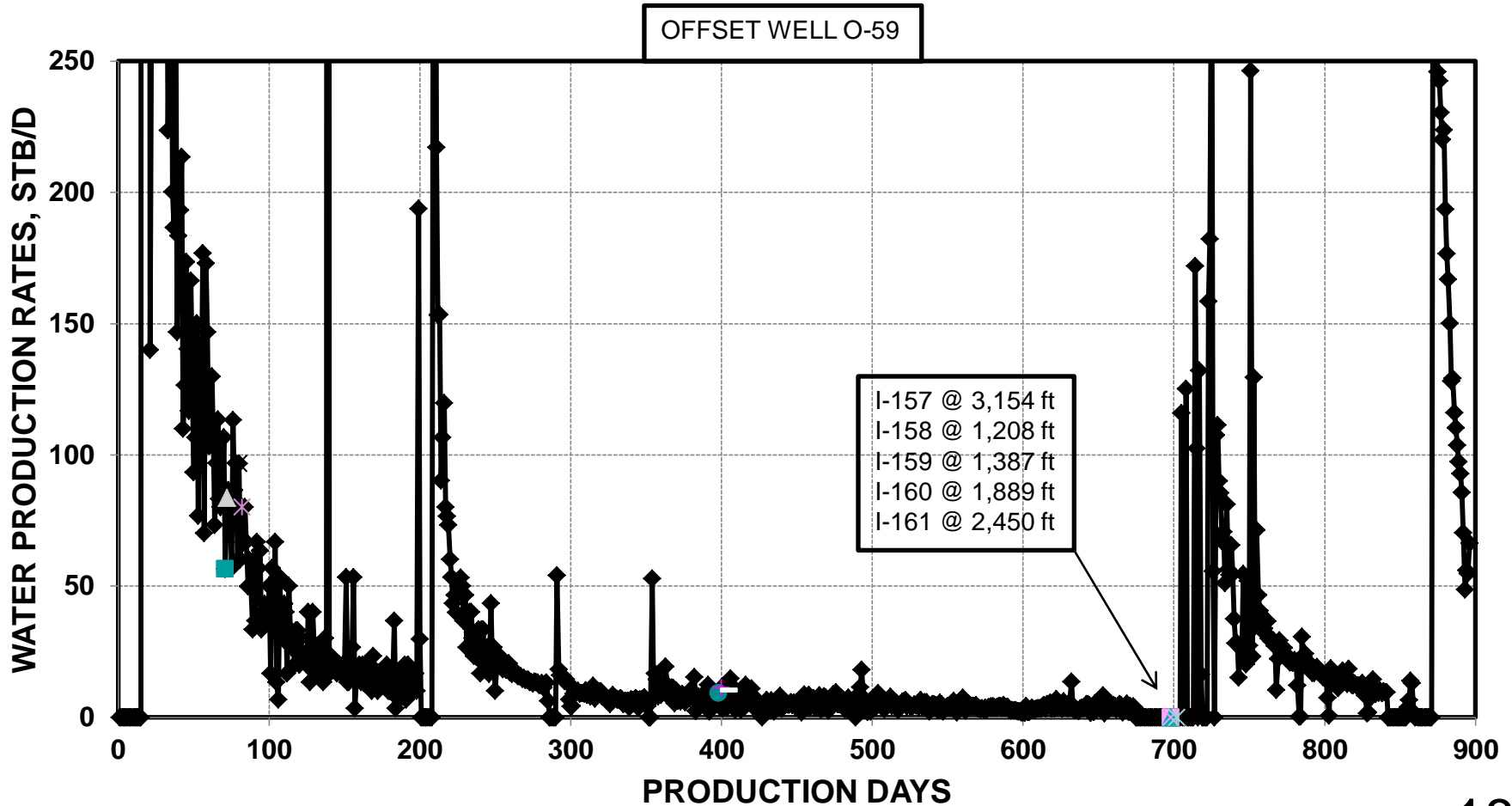
Assigning Distance: Pad Infill Wells



Quantifying Impact – Predicted Rates



Quantifying Impact – Water Rates



Quantifying Impact – Variables

- From the predicted rates, percentage change in gas rate for 60 days from the date of impact was computed as below:

$$\% \Delta = \left(\sum_{aqi=1}^{60} q_{aqi} - \sum_{pqj=1}^{60} q_{pqj} / \left(\sum_{pqj=1}^{60} q_{pqj} \right) \right) * 100$$

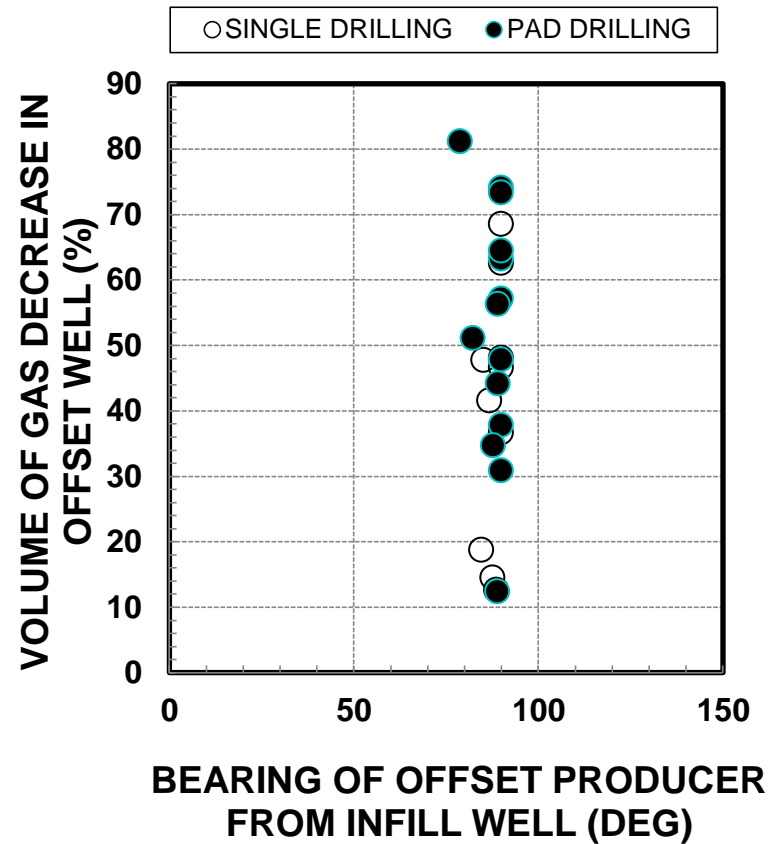
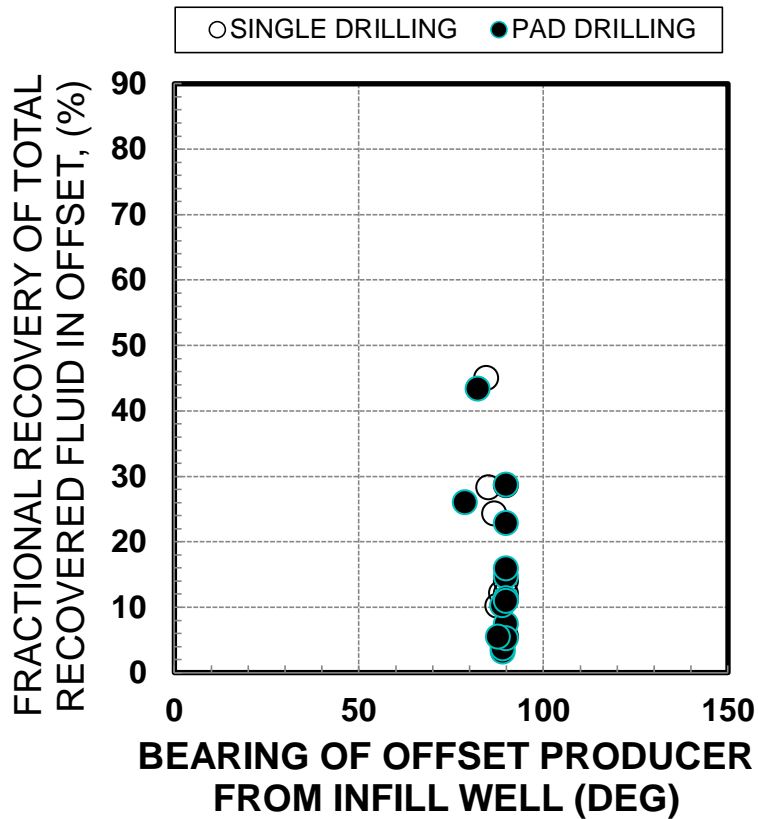
- Fractional recovery of total recovered fluid [FRTRF(%)], 60 days after impact:

$$FRTRF (\%) = \left(\left(\sum_{aqwi=1}^{60} q_{aqwi} \right) / \left(\sum_{iqwj=1}^{60} q_{iqwj} + \sum_{aqwi=1}^{60} q_{aqwi} \right) \right) * 100$$

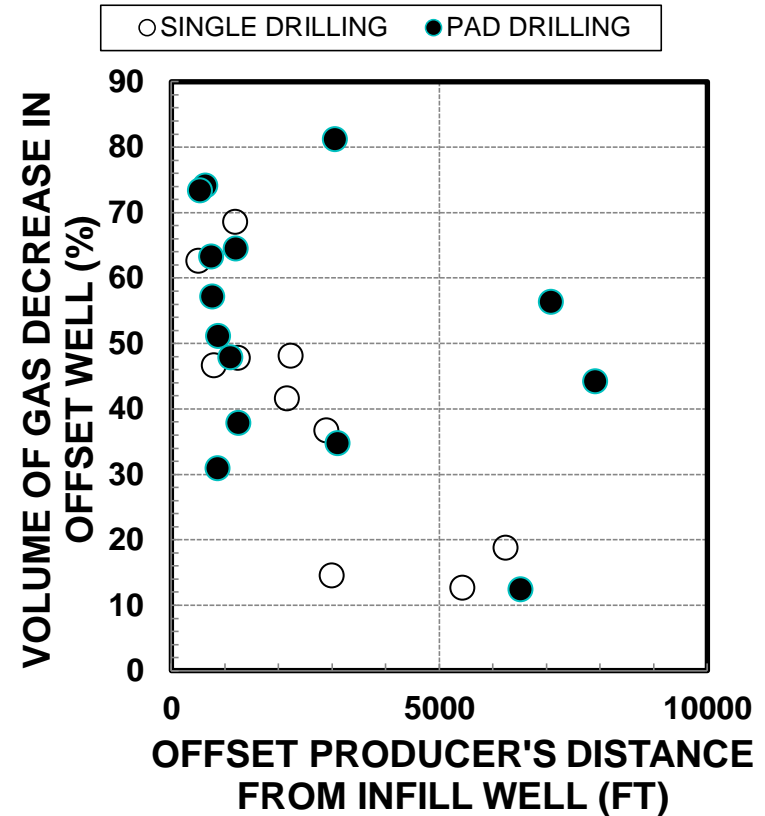
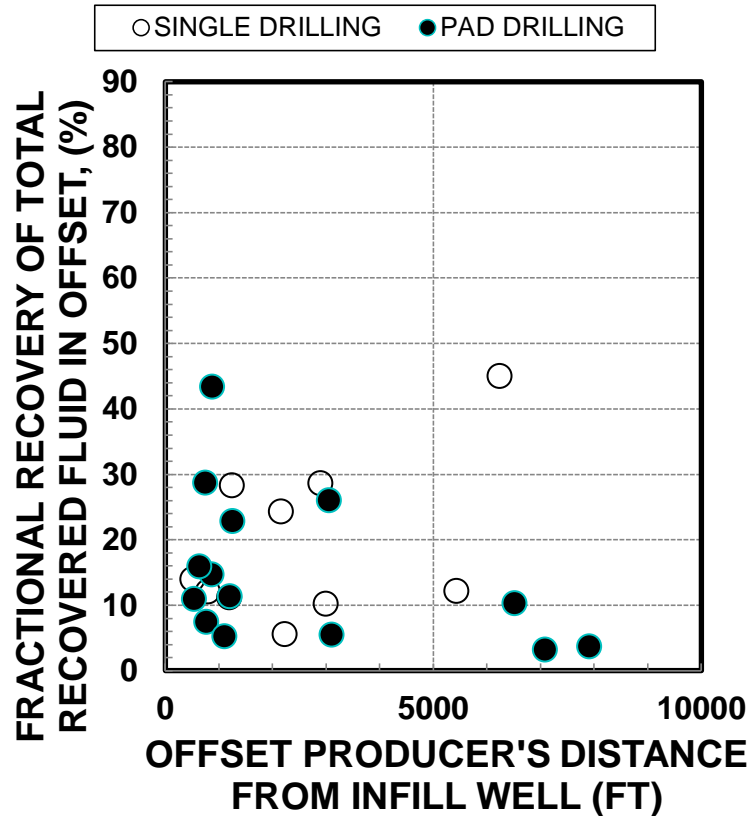
Results and Discussion

- 24/179 wells inspected had negative gas and water impact up to 60 days, 14/24 of the impacts were due to pad drilling.
- 1/179 wells was positively impacted: Impact of infill well I-49 on offset well O-4 at 2,482 ft.
- Only negatively impacted offset producers were analysed.

Results and Discussion



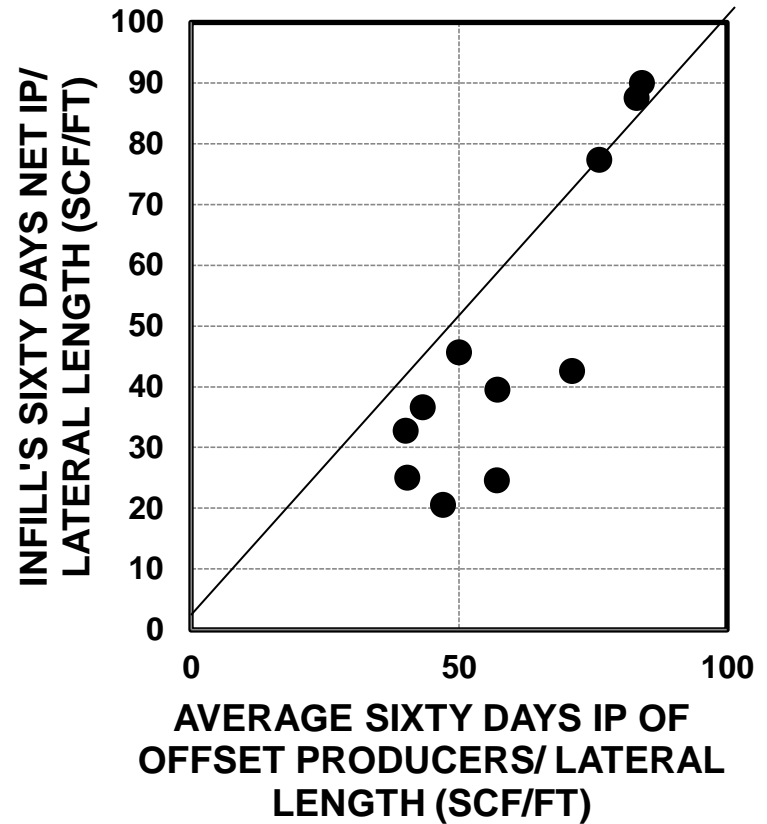
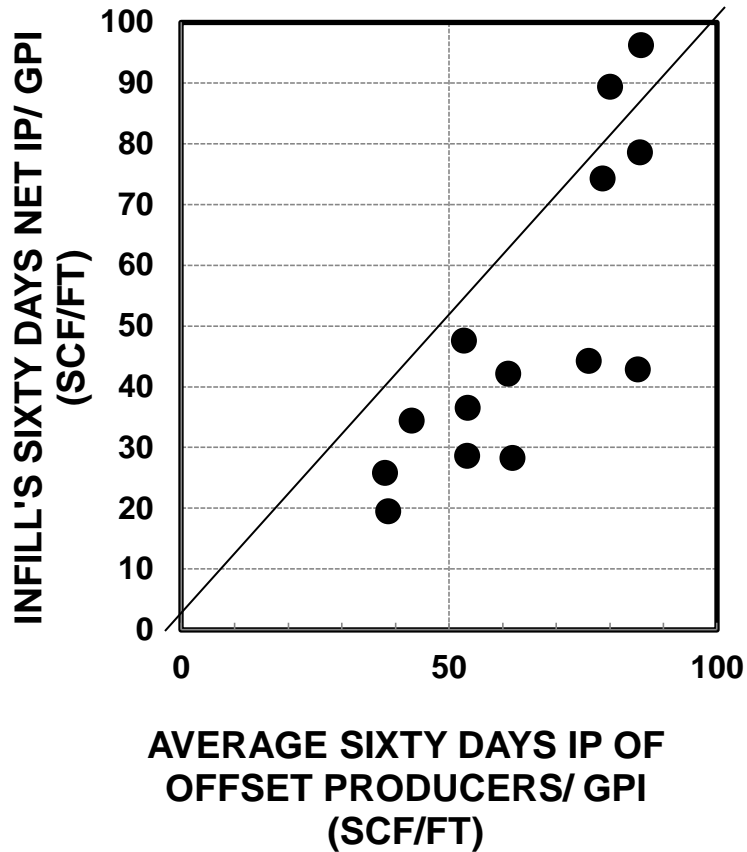
Effect of Distance on Frac Fluid Recovery and Lost Production



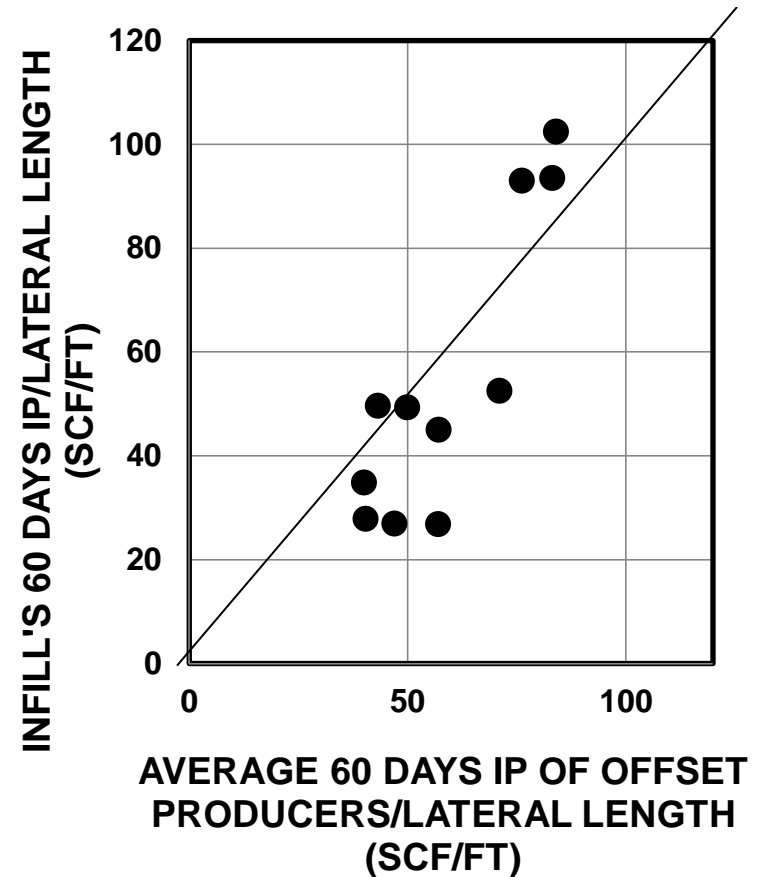
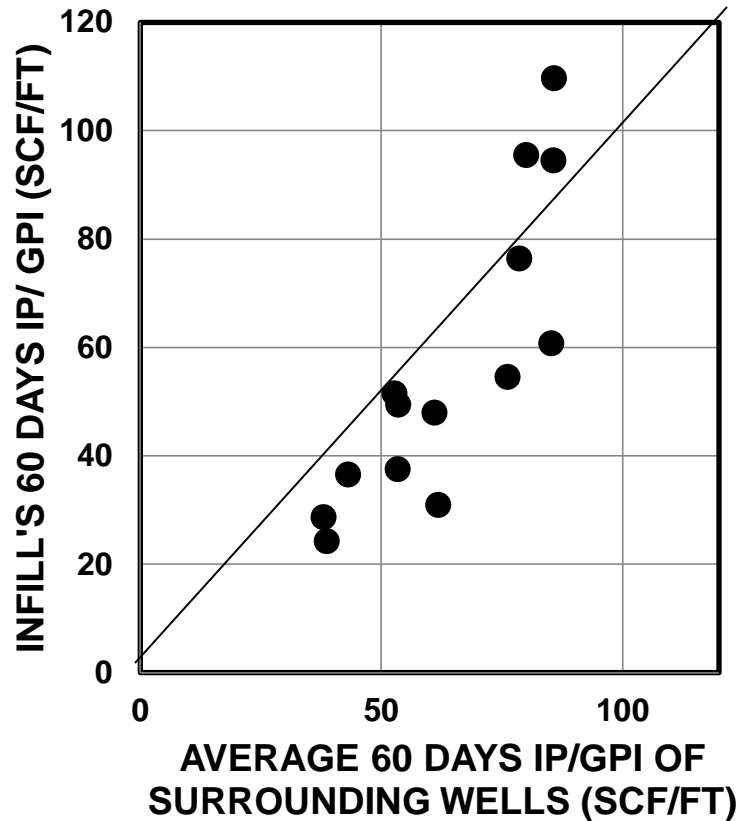
IP of Infill Wells Which Impact Other Wells

- Infill's Net sixty days IP is defined as 60 days IP in infill well less volume of gas lost in impacted producers for sixty days after being impacted
- Based on 19/24 impacts seen in one square mile, a 5,280 X 660 ft ellipse was used to compare 60 days Net IP of infill well with 60 days IP of surrounding wells

Net IP of Infill Wells vs. Surrounding Wells

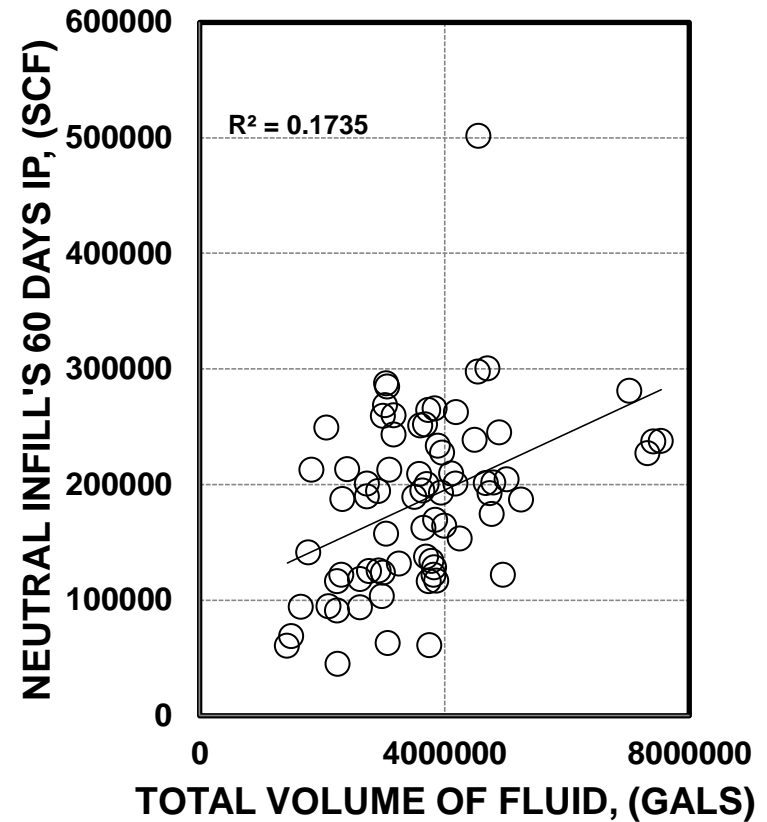
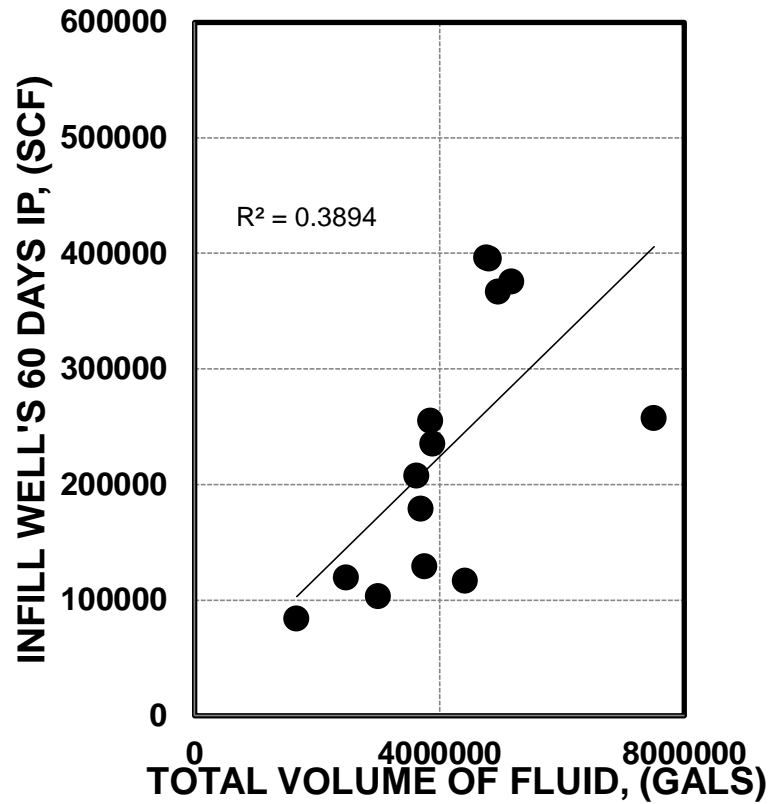


IP of Infill Wells vs. Surrounding Wells

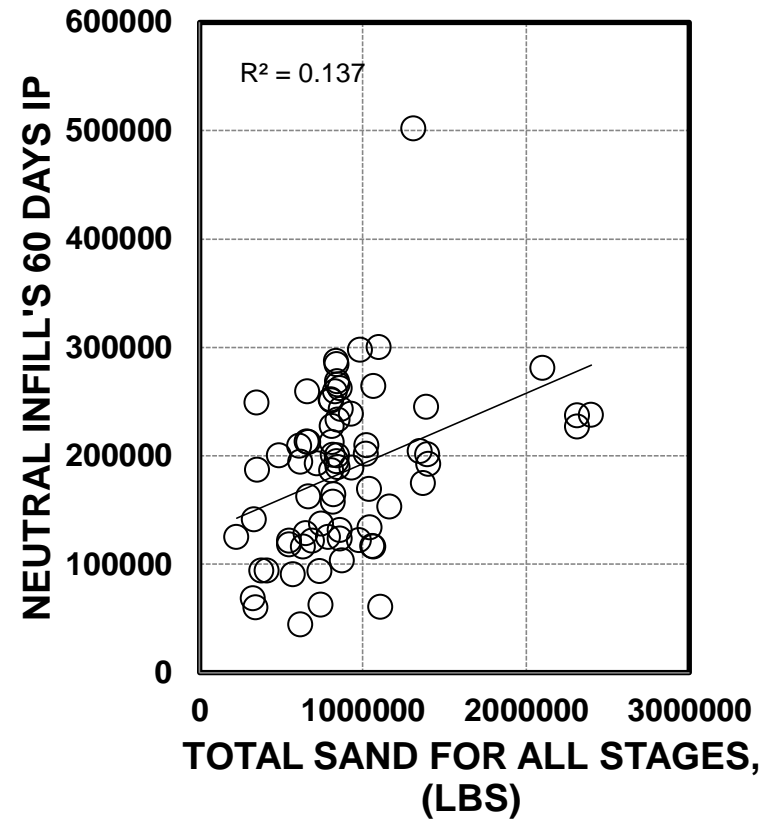
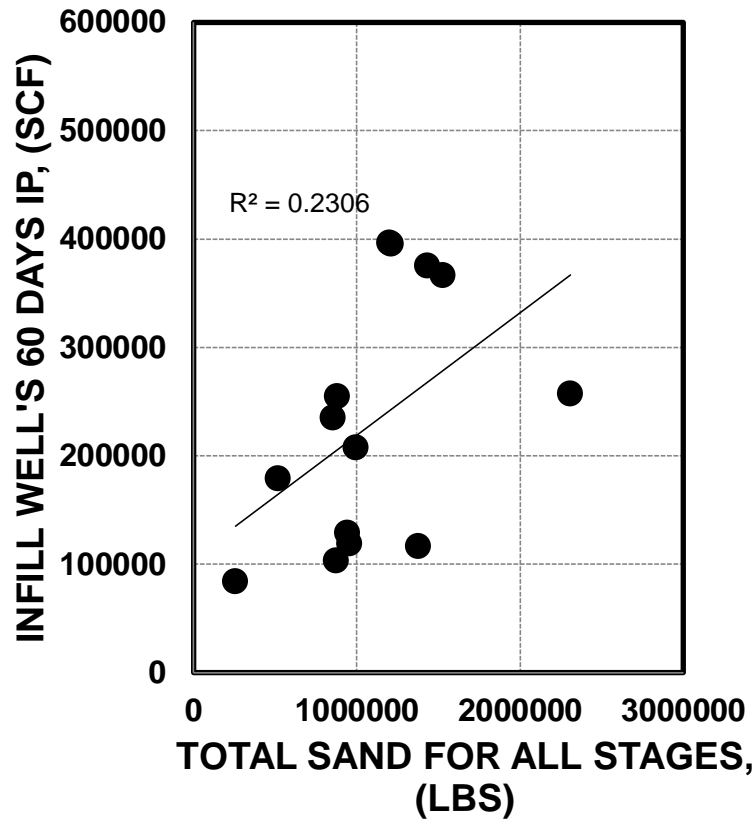


Impact of Fracturing Parameters

Results & Discussion



Results & Discussion

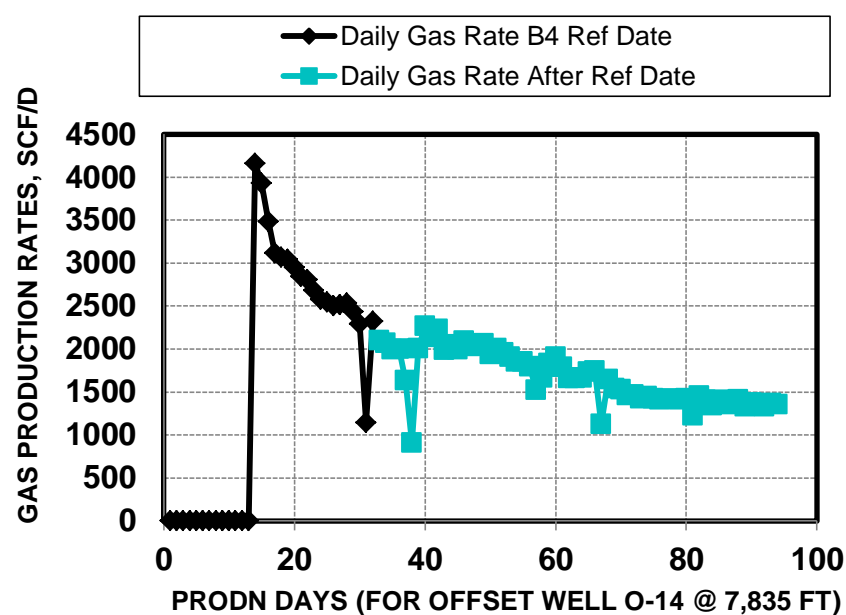
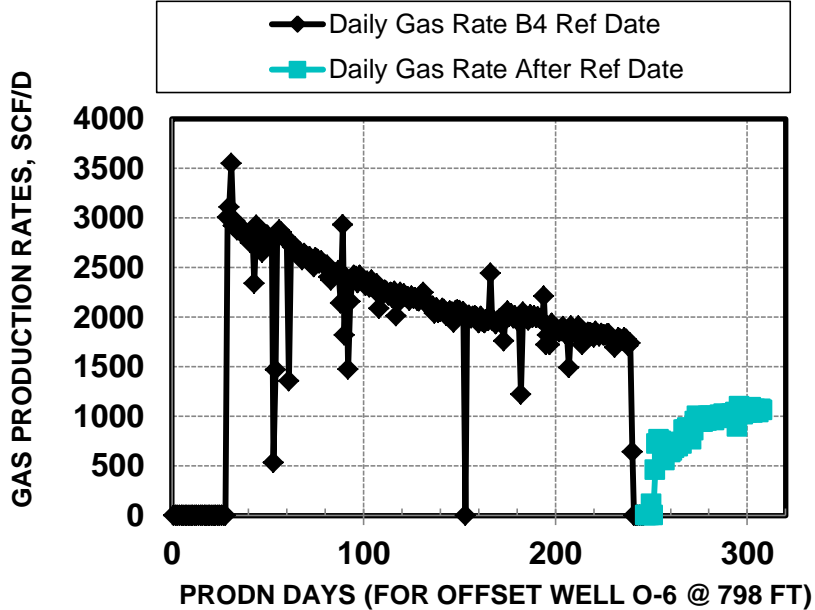
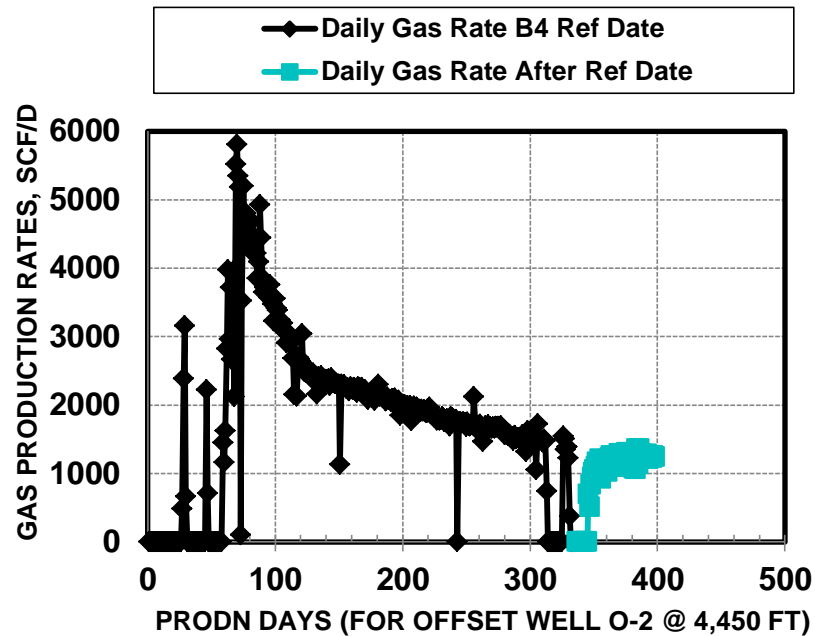
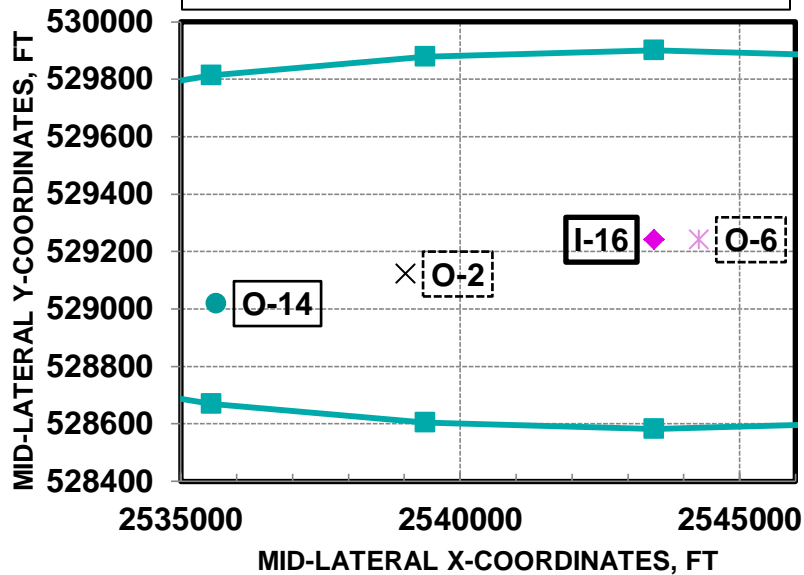


Impact and its relationship to distance and age

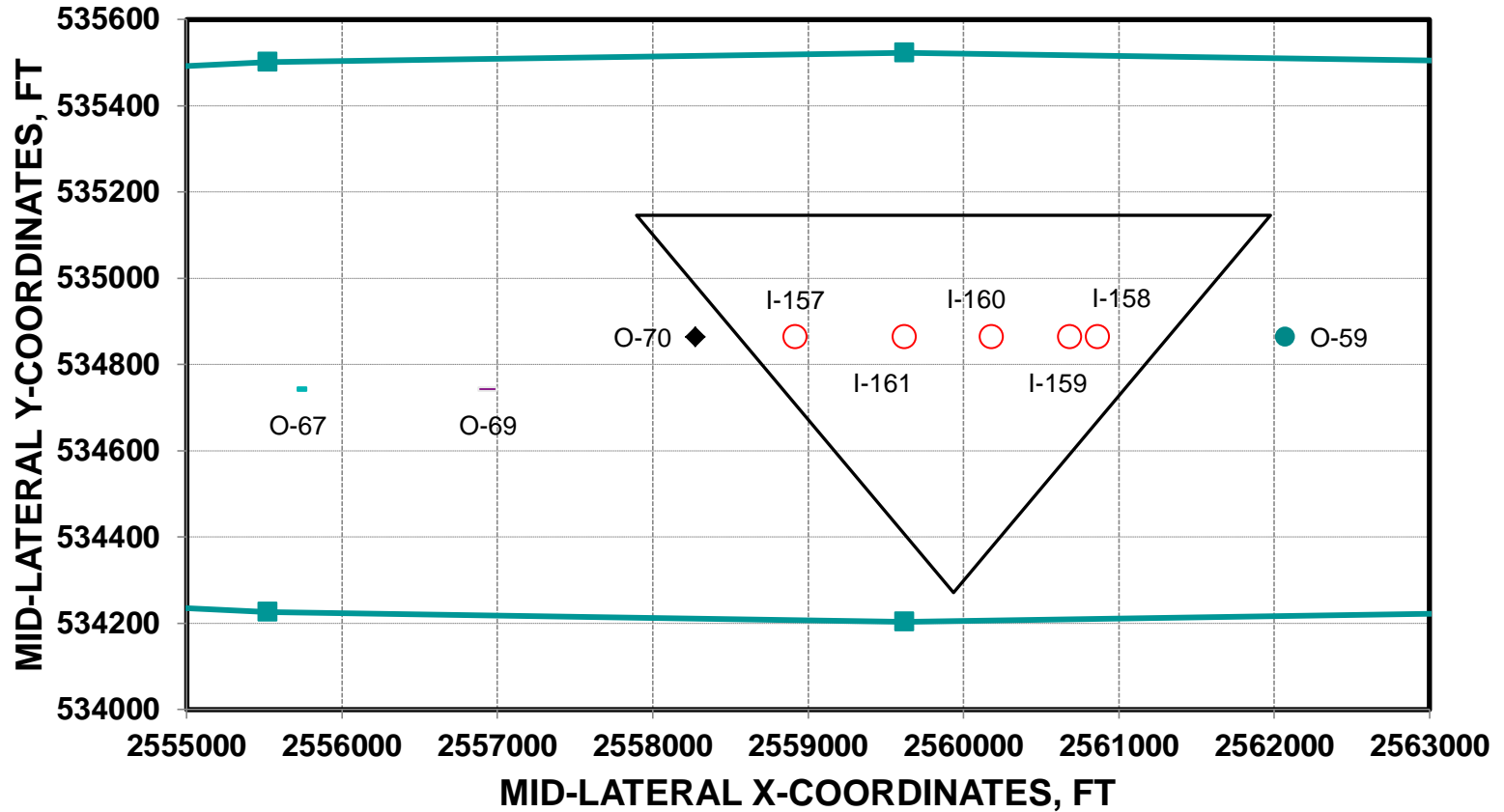
Approach – Single Infill Well

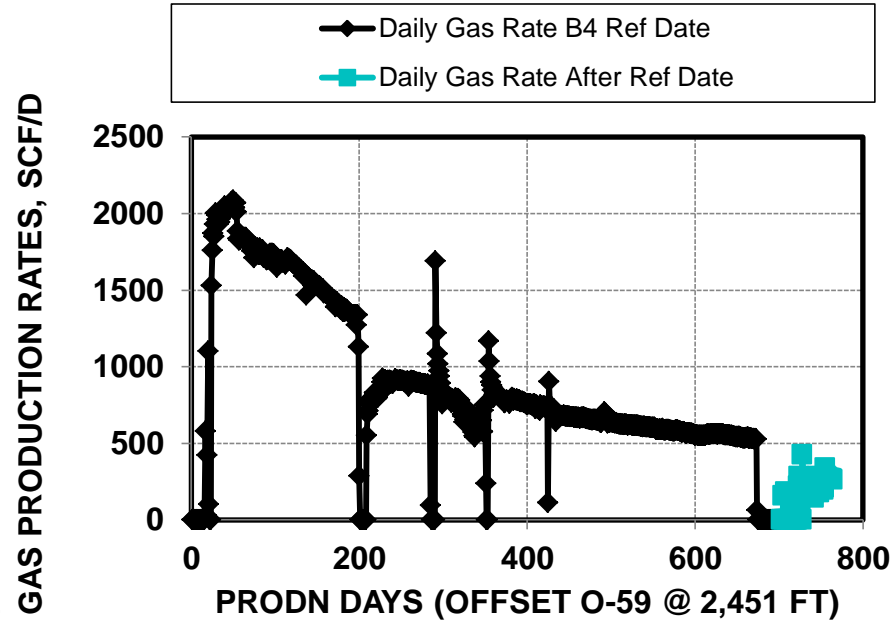
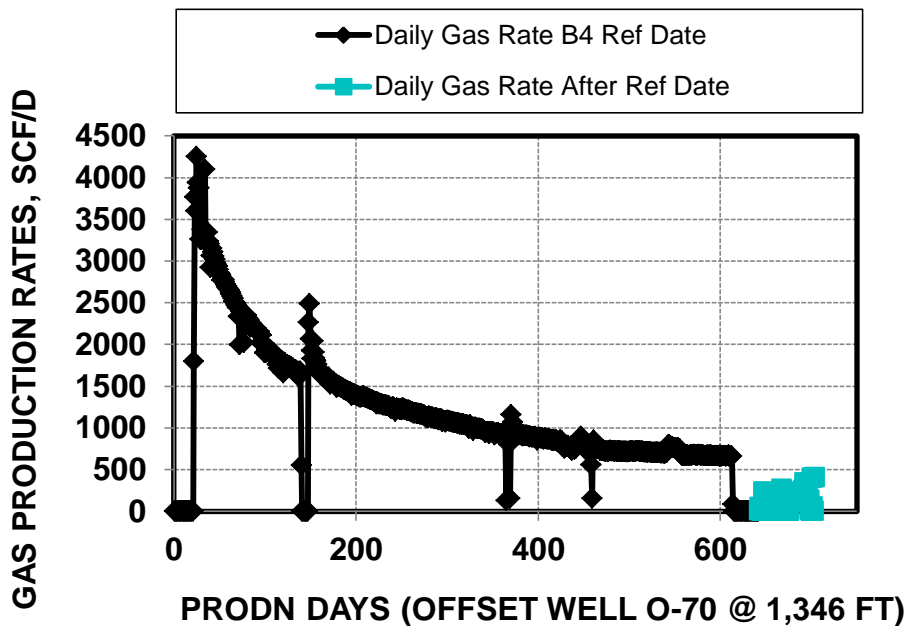
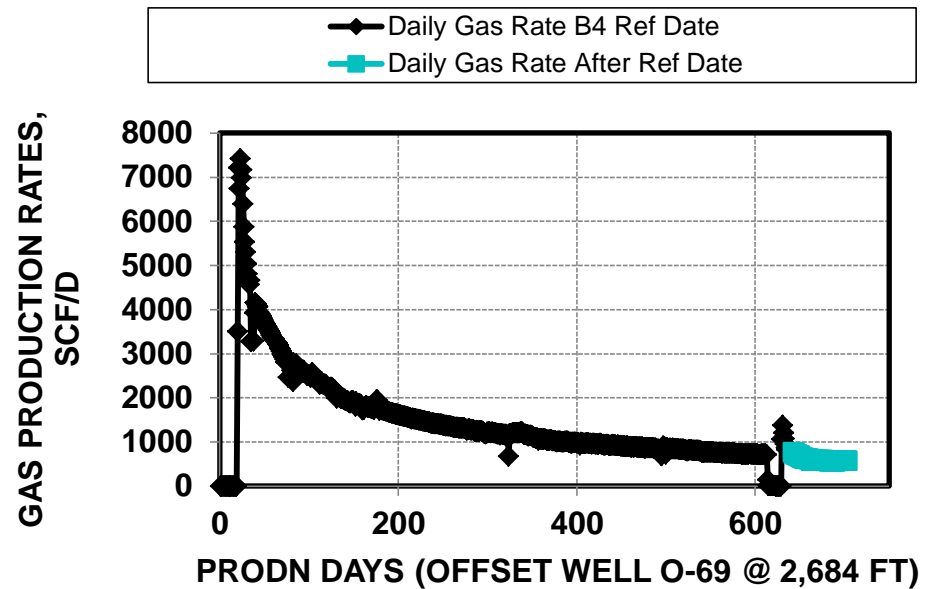
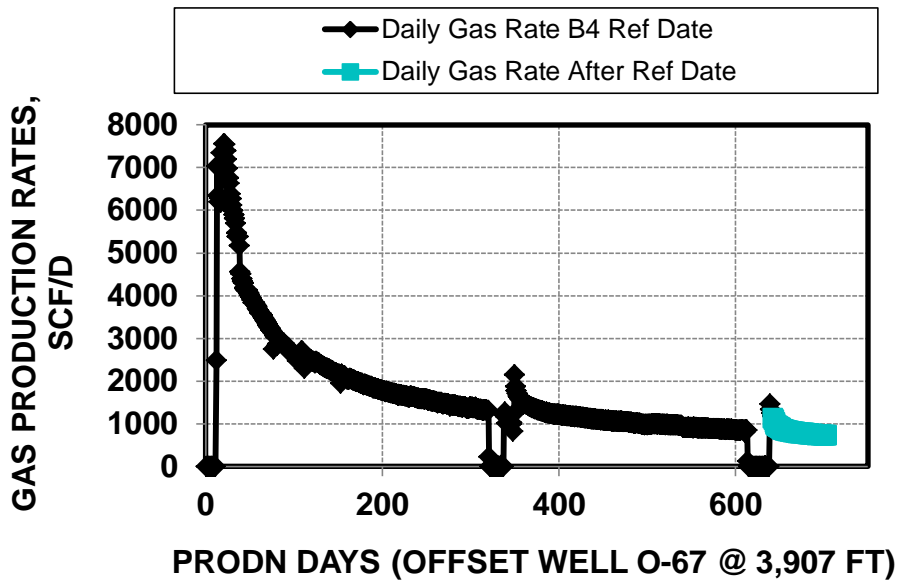
- For each single well fractured (now an infill), pre-existing wells in a 15,840 X 660 ft ellipse are identified
- Production profiles of each pre-existing well is inspected to check if they were impacted by the infill well or not (plus impacts < 60 days)
- Distance is assigned based on location of the pre-existing wells from the single infill well

FOR SINGLE INFILL WELL I-16

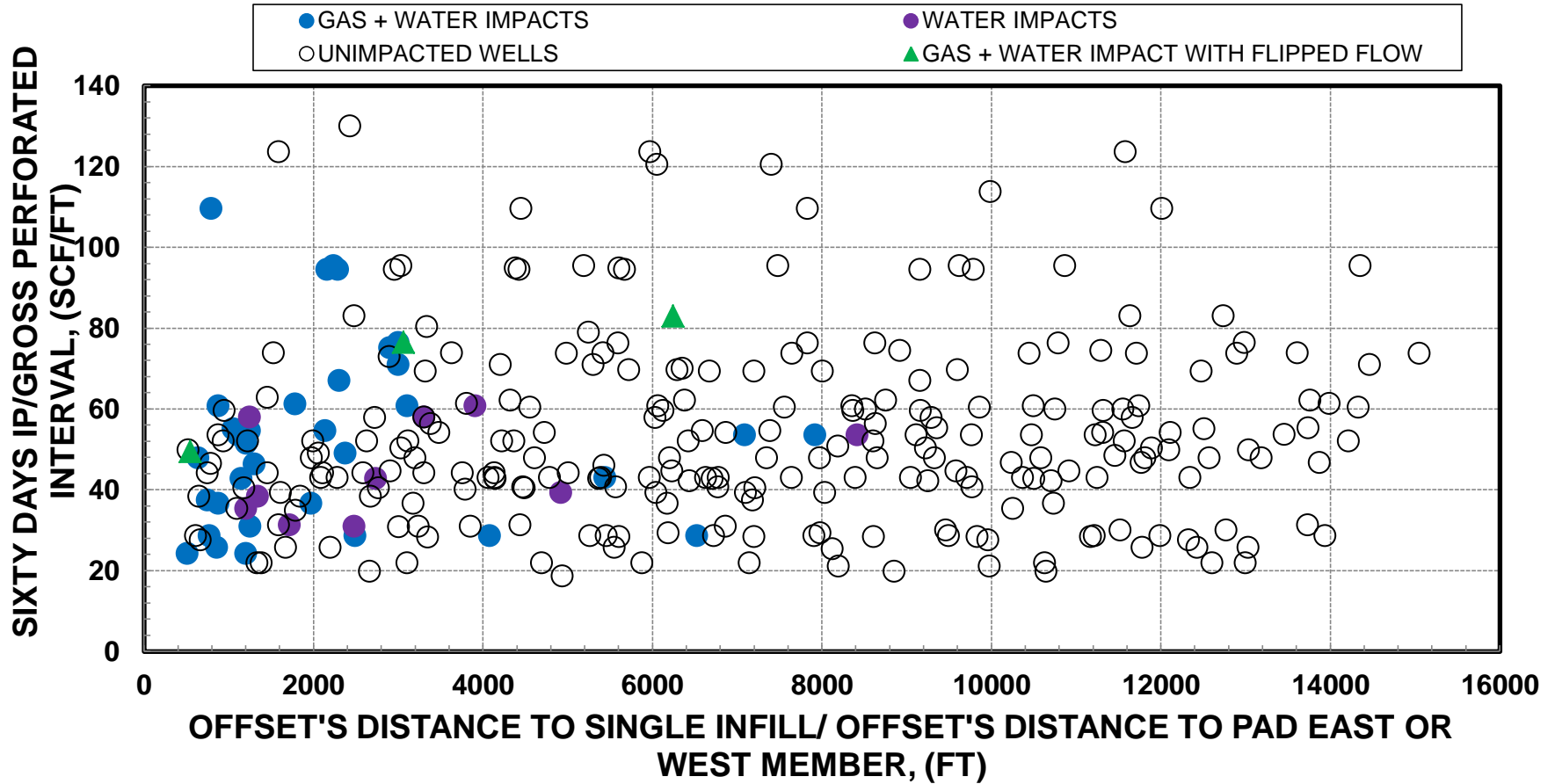


Approach - Pad Infill Wells

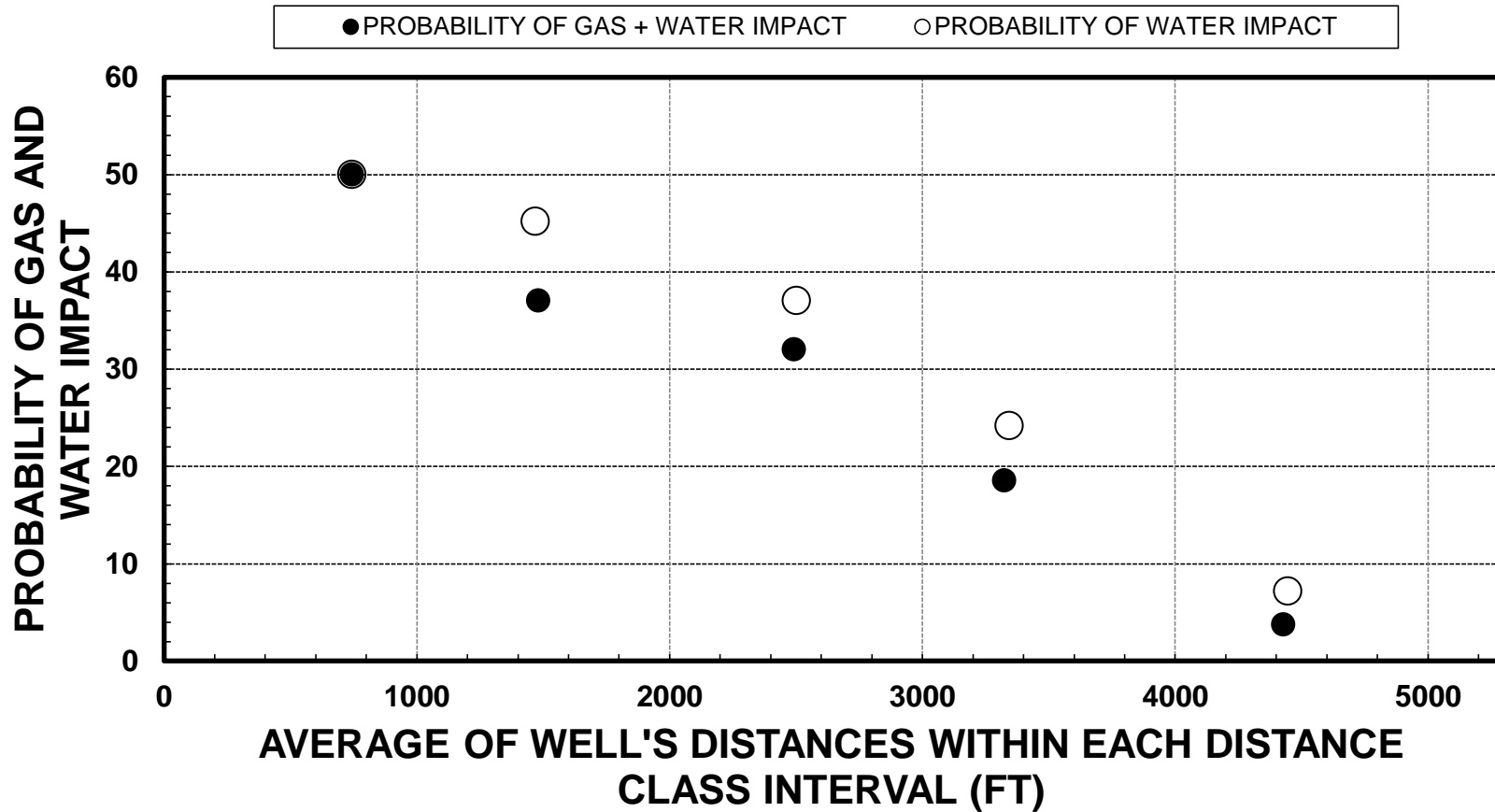




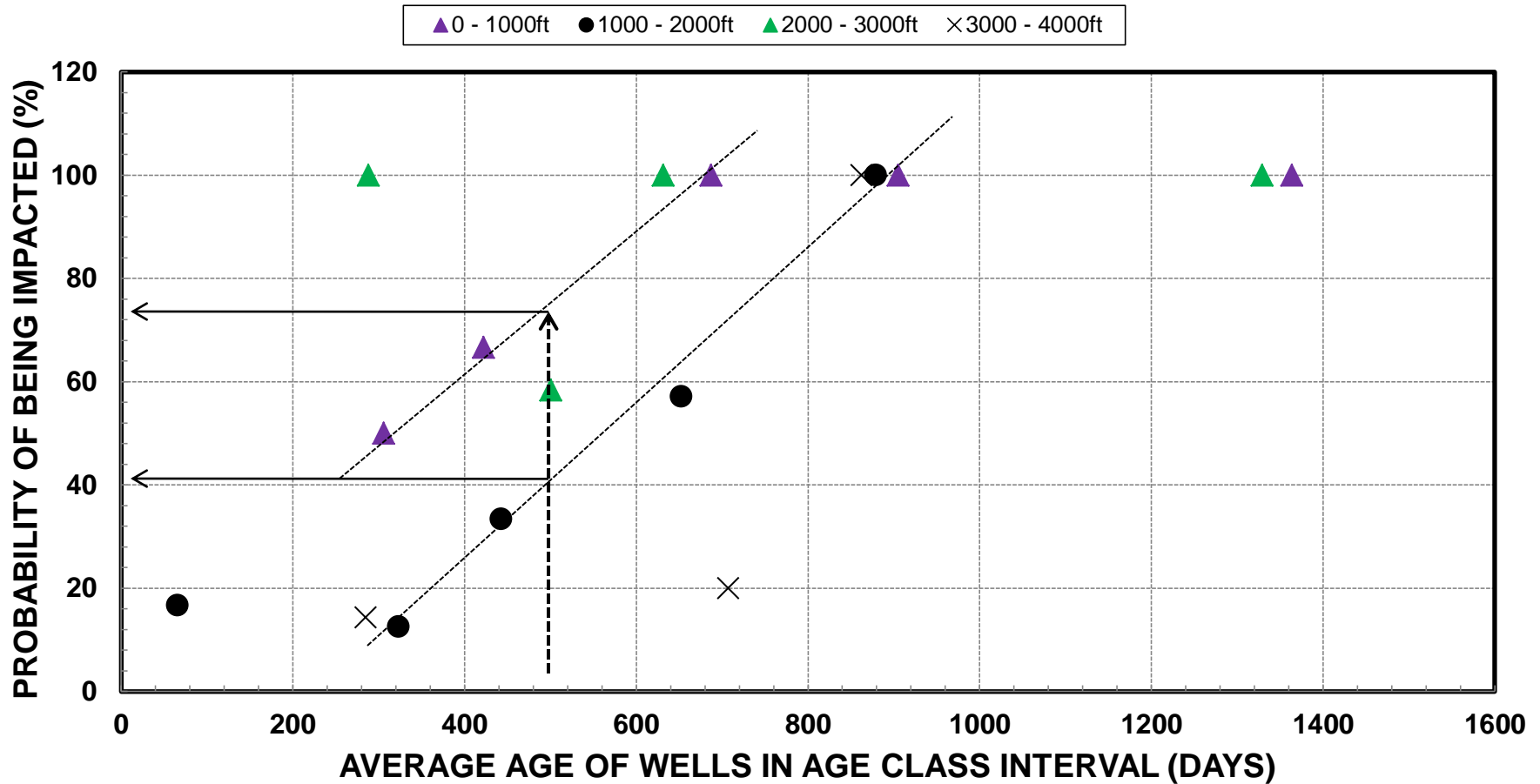
60 Days IP/GPI vs. Distance



Probability vs. Distance



Probability vs. Age (for Different Distances)

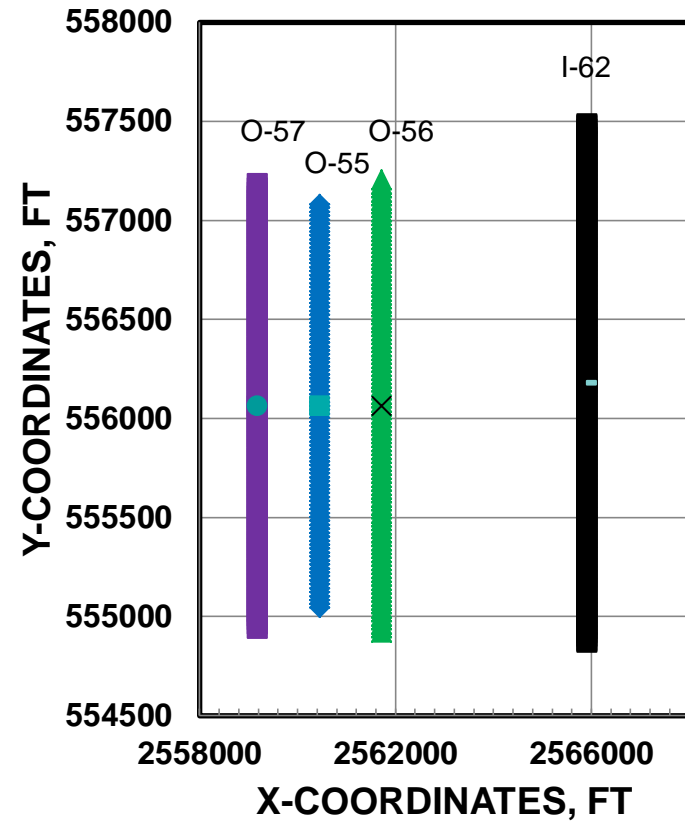
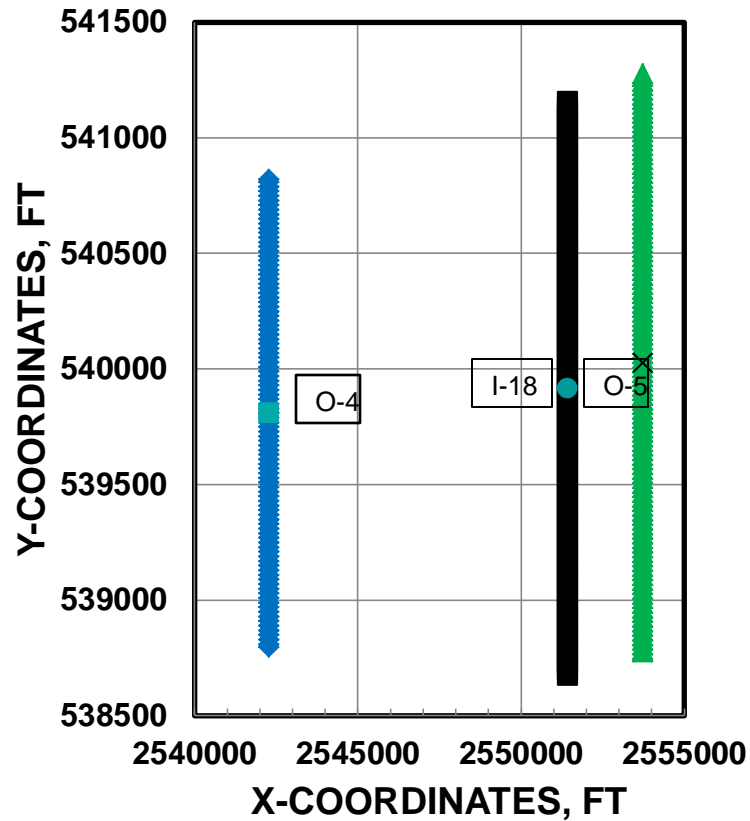


Change in IP with Spacing

Assumptions

- Wells without any existing well within 5,280 ft are considered as unbounded on both sides. If another well exists at a distance less than 5,280 ft, the well is considered unbounded on one side
- The well closest in a particular direction is considered most influential and wells beyond that distance are assumed to be screened out by the closest well.

Illustration of Assumptions Made

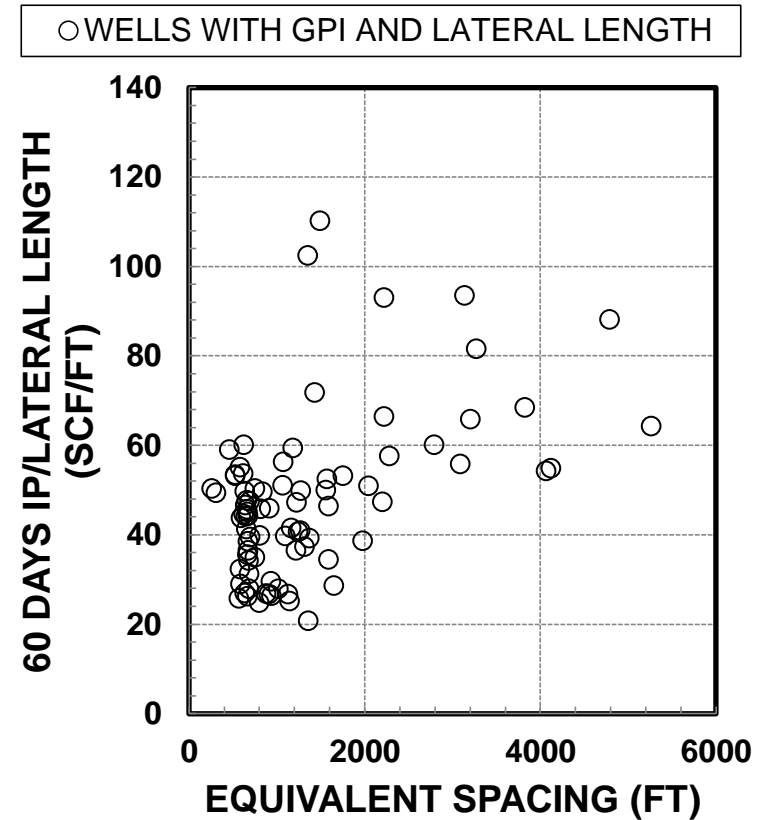
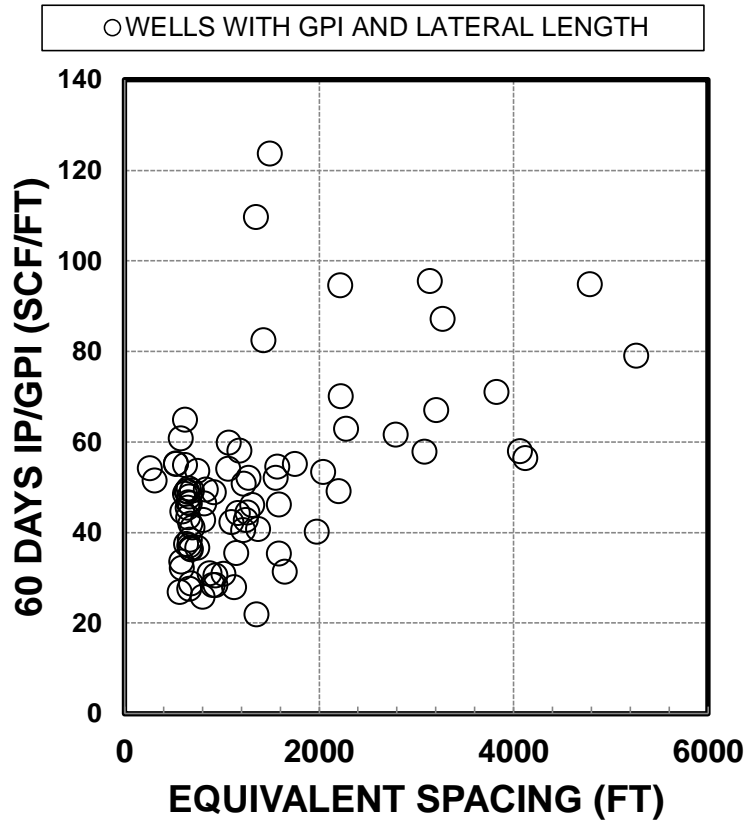


Approach

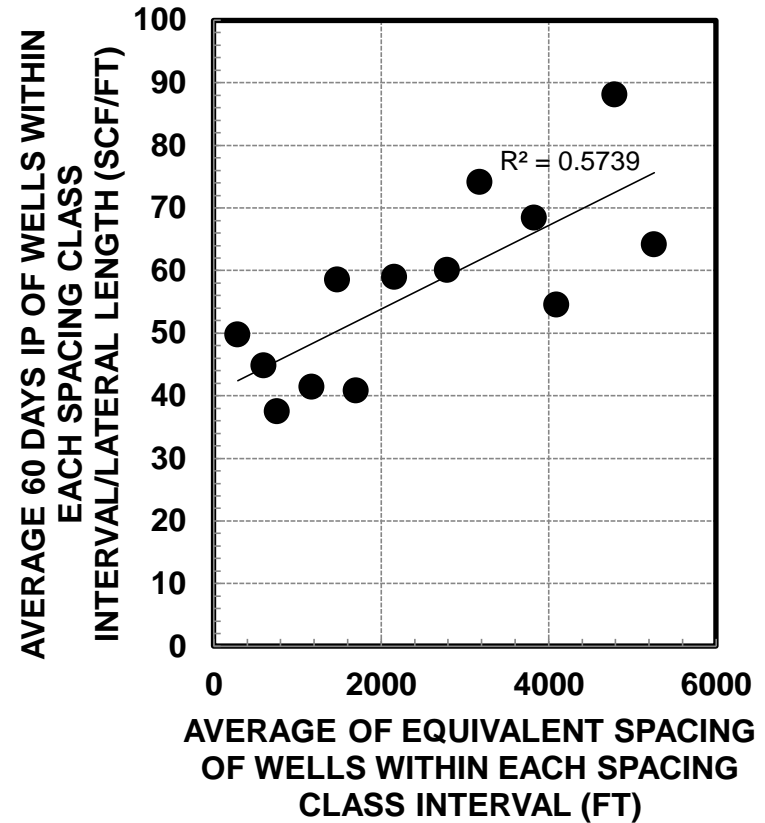
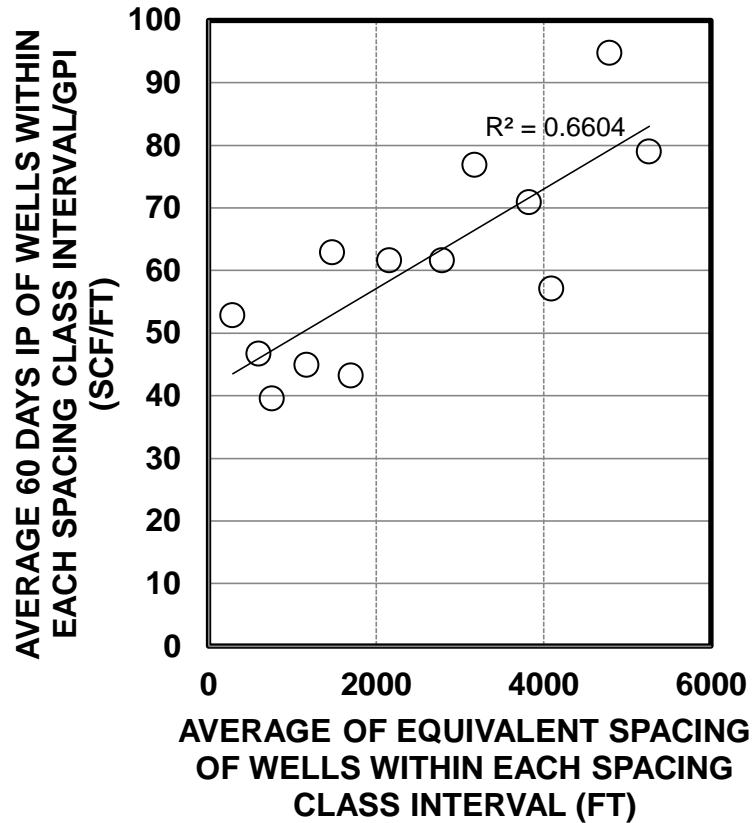
- For every infill well, the closest offset well's distance on the west and east are considered as D_1 and D_2
- An equivalent distance is then computed using harmonic average as:

$$D_{eqv} = \frac{2 * D_1 * D_2}{(D_1 + D_2)}$$

IP/GPI & Lateral Length vs. Equivalent Distance



IP/GPI & Lateral Length vs. Binned Data



Conclusions

- In Woodford Shale, the impact of surrounding infill wells on the existing producing wells can be significant
- The effect is mostly adverse and can result in increased water production and sustained reduction in gas production
- The effect is more prominent at distances less than 1000 feet.
- As the age of the producing well increases, the probability of the well being impacted increases. At the same time, the permanent impact has much more severe impact during the early stages of production
- The IP of infill wells – on an average – is less than parent wells. This is probably due to sharing of fracturing network as well as partial depletion of pressure

Interference Study in Shale Plays

Any questions?

