STATE OF NEW MEXICO

ENERGY, MINERALS AND NATURAL RESOURCES DEPARTMENT

OIL CONSERVATION DIVISION

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| IN THE MATTER OF THE HEARING CALLED BY THE OIL CONSERVATION DIVISION FOR THE PURPOSE OF CONSIDERING: | CASE NO. 12,888 |
| APPLICATION OF THE FRUITLAND COALBED METHANE STUDY COMMITTEE FOR POOL ABOLISHMENT AND EXPANSION AND TO AMEND RULE 4 AND 7 OF THE SPECIAL RULES AND REGULATIONS FOR THE BASIN-FRUITLAND COAL GAS POOL FOR PURPOSES OF AMENDING WELL DENSITY REQUIREMENTS FOR COALBED METHANE WELLS, RIO ARRIBA, SAN JUAN, MCKINLEY AND SANDOVAL COUNTIES, NEW MEXICO | |



REPORTER'S TRANSCRIPT OF PROCEEDINGS

EXAMINER HEARING (Volume I, Tuesday, July 9th, 2002)

BEFORE: MICHAEL E. STOGNER, Hearing Examiner

July 9th-10th, 2002

Farmington, New Mexico

This matter came on for hearing before the New Mexico Oil Conservation Division, MICHAEL E. STOGNER, Hearing Examiner, on Tuesday, July 9th, 2002, at the New Mexico Energy, Minerals and Natural Resources Department, 1220 South Saint Francis Drive, Room 102, Santa Fe, New Mexico, Steven T. Brenner, Certified Court Reporter No. 7 for the State of New Mexico.

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I N D E X

July 9th, 2002 (Volume I)
Examiner Hearing
CASE NO. 12,888



(Continued...)

BP AMERICA, INC., WITNESSES:



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# E X H I B I T S

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* * *

So with that, Mr. Kellahin?

Can I get somebody to close the doors in the back? Thank you.

MR. KELLAHIN: We're going to start on Mr. Chris Clarkson's presentation. Mr. Clarkson is a reservoir engineer with Burlington, and his responsibilities for his company involve the engineering aspects in the non-fairway coal.

CHRIS CLARKSON,

the witness herein, after having been first duly sworn upon his oath, was examined and testified as follows:

DIRECT EXAMINATION

BY MR. KELLAHIN:

Q. Mr. Clarkson, for the record, sir, would you please state your name and occupation?

A. My name is Chris Clarkson. I'm a reservoir engineer with Burlington Resources on the Fruitland Coal Team.

Q. You're going to have to speak up or pull that closer to you, sounds like it's on.

A. Is that better?

Q. Yes, sir, you're soft-spoken, so you're going to have to talk into that.

You reside here in Farmington?

A. Yes, I do.

Q. Have you been one of Burlington's representatives, technical representatives, that has participated on the Committee work for the pool?

A. Yes, I have.

Q. What has been the extent of your involvement?

A. My involvement has been to determine the reservoir-engineering data, the need for infill drilling in the underpressured envelope.

Q. Have you testified before the Division on prior occasions?

A. No, I have not.

Q. Summarize for us your education. When and where did you get your degrees?

A. I obtained a bachelor's of applied science and master's of applied science and a doctorate at the University of British Columbia in the years 1992, 1994 and 1998.

Q. Summarize for us your employment.

A. I've been employed with Burlington Resources for the last four years in the capacity as a reservoir engineer, specializing in coal, Fruitland Coal.

Q. As part of that specialization, do you utilize any of the disciplines or skills associated with reservoir simulation?

A. Yes, I have.

Q. Summarize for us what it is that you do with that aspect of engineering.

A. We have utilized reservoir simulation to determine the appropriateness of infill drilling in portions of the Fruitland Coal as well as projecting estimated recoveries for the existing spaced wells.

Q. If I were to call Burlington here in Farmington and ask for the simulation expert for the coal in the underpressured area, who would I talk to?

A. That would be me.

Q. Have you participated, then, on behalf of Burlington with the study of the engineering aspects for the five pilot projects in the non-fairway properties?

A. Yes, I have.

Q. What has been that involvement?

A. My involvement has been to perform the -- or to oversee the reservoir testing of those five infill pilot wells, as well as perform reservoir simulation of the pilot wells, and immediate offset wells to those pilot wells.

Q. What position did Burlington take concerning the Committee work product that now is before Mr. Stogner as an Application for a rule change?

A. Burlington Resources supports the Committee's Application.

Q. As part of that Committee process, what portion of the presentation did Burlington commit to present to Mr. Stogner?

A. Burlington Resources has committed to present information on the underpressured portion of the Fruitland Coal Pool.

Q. Have you had sufficient data in order to study that area and reach engineering conclusions?

A. Yes, we do.

Q. And have you reached those conclusions?

A. Yes, we have.

Q. Are we about to see a presentation that includes those conclusions?

A. Yes, sir.

MR. KELLAHIN: We tender Mr. Clarkson as an expert reservoir engineer.

EXAMINER STOGNER: Any objection?

MR. HALL: No objection.

EXAMINER STOGNER: Mr. Clarkson, on your educational, is that a bachelor of science in engineering?

THE WITNESS: Oh, I'm sorry, it's applied science or engineering, yes, sir.

EXAMINER STOGNER: And you got your PhD at British Columbia in what discipline?

THE WITNESS: Geological engineering.

EXAMINER STOGNER: Dr. Clarkson is so qualified.

Q. (By Mr. Kellahin) Let's turn to your first slide, Mr. Clarkson, and let's start with a summary so that Mr. Stogner has an outline of where you're going with your presentation.

A. Yes, sir, I will begin with a brief outline of the subject matter that I will talk about today.

I will start with a summary which includes the four key conclusions that we have obtained from the infill pilot study that Burlington Resources has implemented, along with a recommendation regarding the need for increased density in the underpressured envelope.

I will then present a series of exhibits that support those key conclusions.

The next topic will be an overview of the pilot well testing program, followed by a discussion of the well testing simulation and economic results. Specifically, we will talk about three of the pilot wells that we drilled, the Huerfano Unit 258S, the Davis 505S, and the San Juan 28-and-6, 418S. I will go into detail only with the Huerfano Unit well to illustrate the types of testing and reservoir simulation that we performed in the infill pilot study. I will then summarize the results of the Davis 505S and the San Juan 28-and-6 Unit 418S.

The next subject will be -- I'm trying to understand the transfer of pilot well results to the underpressured envelope. I will demonstrate that we can take the pilot well results and extrapolate those to the rest of the underpressured envelope.

And finally, I will finish up with some conclusions regarding the study.

Q. You have performed simulation studies of three of the five pilot areas?

A. Yes, sir.

Q. What happened to the other two?

A. The three pilot wells -- or pilot areas that we did simulate represented the range in testing that we had obtained for the underpressured envelope. The two wells that were left out of the study or the simulation work were the Turner Federal 210S and the San Juan 28-and-5 201S. The purpose of leaving those out was that we believe them to be analogous to the Davis 505S in terms of depletion characteristics and the performance of the offset producing wells, so we chose to model only the Davis 505S.

Q. Let's turn to your summaries. When we do all the work and get to the conclusion, let's talk about the conclusions now.

A. The four main conclusions that we have obtained as a result of the infill pilot study was that current well density in the underpressured portion of the pool results in inadequate recovery. Stated differently, we expect a relatively low recovery of the in-place resource in the underpressured envelope.

The second conclusion is that pilot wells demonstrate inadequate drainage in some or all of the coal layers as inferred from data, measured pressure data, that we obtained at those infill pilot wells.

The third conclusion is that additional completions -- in this case, one per spacing unit -- will result in additional recovery of reserves.

And lastly, the final conclusion is that pilot well results are transferable to the rest of the underpressured envelope.

Q. Let's turn to the locator map that shows the Division the location of these pilot areas in relation to other markers.

A. Sure. This is a locator map that shows the location of the five infill pilot wells that the NMOCD granted us approval to drill last year. The wells are located here. This is the Davis 505S, the Turner Federal 210S, the Huerfano Unit 258S, the San Juan 28-and-6 418S, and the San Juan 28-and-5 201S.

Other prominent markers on this map include the City of Farmington, which is located here, the Cities of Aztec and Bloomfield. The Colorado-New Mexico border is located here.

Q. Let's turn to the next display. Are you working with a geologist on this project?

A. Yes, I am.

Q. And who is the geologist?

A. Mr. Steve Thibodeaux.

Q. Mr. Thibodeaux testified this morning that his work product resulted in the preparation for your further use of a Fruitland original-gas-in-place map?

A. Yes, sir.

Q. We're now looking at a map that shows us recovery factors?

A. Yes.

Q. Before we get to the recovery factor, do you have to start with a gas-in-place map?

A. Yes, you do, a geologic model needs to be constructed in order that an original gas-in-place map be created. Mr. Thibodeaux has created such a geologic model.

Once that is completed, the use of additional adsorption isotherm data or gas-content data is used in the calculation of an original-gas-in-place map.

Q. In your engineering opinion, was Mr. Thibodeaux's work suitable for your use?

A. Yes, sir.

Q. And were you able to create a map that showed the original gas in place for the entire pool?

A. Yes, we did.
Q. And that was one of the last displays Mr. Thibodeaux showed?
A. Yes, sir.
Q. All right. Now, let's look at this one. Your work was focused on the non-fairway coals?
A. That is correct.
Q. And so what we see is a result of that work summarized on this map?
A. Yes, sir.
Q. Why is the white area or the fairway excluded from this presentation?
A. At this point in time, Burlington Resources does not have sufficient data at their disposal to create an accurate recovery-factor map for the fairway.
Q. Let's go back and talk about what the data is, and what the engineering methodology is, that distinguishes the fairway analysis from what you have available to work with in the non-fairway properties.
A. The two components, the key components that are required for the generation of a recovery-factor map are an estimation of the estimated ultimate recovery of the wells, as well as an original-gas-in-place calculation for a 320-acre-spaced location.
The fairway differs from the underpressured

envelope in that historically Burlington Resources has used material balance methods to calculate the estimated ultimate recovery in the fairway. Because of the lack of pressure data that we have available to us, we simply cannot generate estimated ultimate recovery maps for the entire overpressured fairway.

In addition to that, original-gas-in-place maps for the fairway have not typically been used by Burlington Resources as an estimate -- or as a tool for estimating the ultimate recoveries. We are currently in the process of generating those original-gas-in-place maps and have not completed that study at this point in time.

Q. The engineering study that Burlington has ongoing in the fairway --

A. Yes.

Q. -- is done by an engineer other than you?

A. That is correct. We have a staff reservoir engineer dedicated to that task.

Q. Are Burlington's conclusions, engineering conclusions, about the fairway any different than Amoco's engineering conclusions brought to the Committee?

A. No, they are not.

Q. You agree that there's additional opportunity for infill wells in the fairway?

A. Yes, we do.

Q. Describe for me now what engineering data you have available to you to calculate estimated ultimate recoveries from the non-fairway properties, and then by subtraction of gas in place get you to the remaining gas to be recovered.

A. The underpressured envelope has -- basically, we have access to well production data throughout the underpressured interval. Conventional decline-curve analysis is appropriate for the estimation of estimated ultimate recoveries in the nonprolific or the underpressured portion of the pool.

We have calculated estimated ultimate recoveries using those techniques for a well population of approximately 1270 wells in the underpressured envelope, hence we feel that we have a very good representation of the underpressured envelope in terms of estimated ultimate recovery.

Q. Are you aware, Mr. Clarkson, that the Division has determined by their pool orders that conventional decline-curve analysis cannot be used as an engineering tool to determine estimated ultimate recoveries in the fairway?

A. Yes, I am aware of that.

Q. And at this point you continue to develop with other engineers the pressure data to look at opportunities for drilling additional wells in the fairway?

A. That's correct.

Q. All right. Let's look at, then, your work product in the nonfairway properties.

A. All right.

Q. What have you concluded?

A. Before we leave this map, I would like to point out a couple of additional points.

The five infill-well locations are spotted on this map with red squares. One of the reasons that we have chosen the infill-well locations we have is that they represent the range in expected recovery that we would see in the underpressured envelope.

For example, the Davis 505S, Turner Federal 218S and the 28-and-5 wells are located in areas where we expect the range of recovery factors to be between zero and 20 percent of the original gas in place. The San Juan 28-and-6-Unit location is spotted in an area where we expect the recovery factors to range from 20 to 40 percent. And finally, the Huerfano unit pilot is spotted in a more prolific area where we expect the offsetting producing wells to recover between 40 and 70 percent of the original gas in place. Hence, we believe we have represented the range of recoveries that one would see in the underpressured envelope.

Q. All right, sir. What have you concluded?

A. Our first conclusion is that current density results in inadequate recovery. What we are showing here is a pie chart that demonstrates the recovery of original gas in place with the current well spacing for a population of approximately 1270 wells, assuming a 320-acre drainage volume.

The estimated recovery of original gas in place for this well population is only 18 percent, which means that approximately 82 percent of the resource is left in place. The specific numbers associated with this pie chart is that the original gas in place for this population of wells is approximately 5 TCF, and the estimated ultimate recovery for this population of wells is approximately .9 TCF. So this slide demonstrates the current density results in inadequate recovery.

The next series of slides that I will present illustrate conclusion number two, which is that pilot wells demonstrate inadequate drainage in some or all of the coal layers. I will show a series of bar charts that show the layer pressure data that we were able to collect for the five infill pilot locations. I will start with the Davis 505S.

The red bars represent the original pressures estimated at the infill location prior to any coal depletion in this particular area.

The blue bars represent actual measured pressures at the infill location upon the completion of drilling of the infill well.

For this particular case, it should be noted that very little pressure differential exists from initial pressure to the current pressures, which illustrates to us that very little depletion has occurred at this particular location.

I also will point out that the top pressure and the middle -- pardon me, the top measured pressure and the third measured pressure were still building when we pulled the gauges out of the hole, meaning that those pressures will probably build up to greater than what is represented here.

Q. Prior to the pilot project study, did you have this layered pressure data to work with?

A. No, sir, we did not, we only had single-layer pressures at our disposal for some areas.

Q. Please continue.

A. The next slide shows the three measured pressures or the three layer pressures for the San Juan 28-and-5 Unit 201S. The red bars again represent the original pressures estimated at this location. The blue bars represent the current measured pressures at this location.

It is important to note that the original pressures estimated for this area are somewhat smaller than the actual measured pressures, and the reason for this is that those pressures, initial pressures, are estimated from the original pressures from offset producing wells, and there are some cases where the pressures of the offset producing wells may not have built up to their full pressure. This is a very low-permeability area, and it takes a substantial period of time for pressures to build up. Hence the discrepancy between the original pressures and the current pressures.

However, in this example it is clear that the current pressures are illustrative of very little depletion at this particular location.

The next slide shows the four-layer pressures for the Turner Federal 210 S, again the original pressures being red, current pressures being blue.

This well in this area, we have the same situation as the San Juan 28-and-5 Unit in that our estimated original pressures are somewhat lower than the current measured pressures.

Also, I will point out that in the top zone we were not able to get a good pressure. Our first pressure built up to about 52 p.s.i. We re-perforated this zone and still got the same pressure. So this is somewhat of an anomalous point.

The rest of the pressures built up to similar to the original pressures in the well.

The next slide illustrates the layer pressures associated with the San Juan 28-and-6 Unit 418S. In this particular case is an example of significant differential depletion between layers.

The top zone, as you'll notice, the pressure built up to very close to what the original pressure was calculated to be, whereas the three bottom zones showed a substantial amount of depletion. This indicates that there appears to be inadequate drainage in at least one of the coal layers, whereas the other three coal layers appear to be depleting.

Our final example is from the Huerfano Unit 258S well. This example is similar to the 28-and-6 in that the top layer pressure appears to show very little depletion, whereas the middle pressure shows a substantial amount of depletion from original pressure. The third pressure, we were unable to obtain a reasonable pressure estimate on this zone.

Q. You've got some layered pressure data for all five pilot wells now?

A. Yes, we do.

Q. And having looked at that engineering data, what does it tell you about well density?

A. This data supports increased density in the underpressured envelope in that some, if not -- or many coal layers show very little or no depletion at the infill locations.

Q. What's the next part?

A. This next slide supports our conclusion number three, which is that additional completions result in additional recovery. What we have shown here is a bar chart that shows the recovery of original gas in place for the three modeled pilot areas. The red portion of the bar represents the recovery of original gas in place for the current spacing. The blue portion of the bar represents the incremental recovery we would expect for infill drilling.

For example, with the Huerfano Unit 258S, we expect the parent wells or the currently spaced wells to recover approximately 57 percent of the original gas in place. The infill wells will increase that recovery to approximately 65 percent of original gas in place. This represents a 15-percent increase in recovery for this area.

Q. In the absence of the infill well, then, you would not get this additional 15 percent?

A. That is correct.

Q. So the 15 percent in the Huerfano study represents additional recovery from the pool that you would not otherwise achieve?

A. That is correct.

Q. Okay. What happens in the 28-and-6 Unit?

A. In the 28-and-6 area, we expect somewhat more incremental recovery. The 28-and-6 unit parent wells are projected to recover approximately 29 percent of the original gas in place, whereas infill drilling should increase that recovery up to approximately 40 percent of original gas in place. This represents a 37-percent increase in recovery in this particular area.

The Davis area, being the least prolific in terms of the performance of the offset producing wells, shows the most incremental recovery of the three areas, or the most relative increase in recovery.

The Davis 505 S area shows that the parent wells would recover approximately 16 percent of the original gas in place, whereas infill wells will increase that recovery to 28 percent of original gas in place, hence a 68-percent increase in recovery for this particular area.

Q. For the five pilot areas, you are now persuaded as an engineer that the infill well is going to result in the recovery of additional gas?

A. That is correct.

Q. How did you address the issue of determining whether those recoveries from the five pilot project areas are representative of the range of opportunity for the rest of the fairway -- the rest of the properties outside the fairway?

A. We will cover that with the next exhibit. What we have plotted here is the increase in recovery factor due to infill development as a function of the parent well recovery factor. And what we have spotted on this chart are the estimated increase in recovery factors for the three pilot areas that we modeled.

How one uses a graph of this sort is to estimate the recovery due to the parent wells, extrapolate up to the curve and then extrapolate over to the Y axis. That will tell you the percentage increase in recovery that one would expect associated with the infill wells.

Q. Let me see if I understand how this works. Where on this curve or line do you plot the results of the other two pilots that are not shown on this curve?

A. The other two pilots would be more similar to the Davis area, in that the parent well recoveries are in the same range of parent well recoveries, and hence we would expect similar types of increase in recovery due to infill drilling.

Q. Let me have you explain how to make the curve work. Let's assume I have a parent well.

A. Uh-huh.

Q. I can determine its recovery factor in a conventional way with decline-curve analysis?

A. That is correct.

Q. I can do that? And let's say I can determine, based upon the original-gas-in-place map, that my parent well's recovery is going to be 40 percent.

A. That is correct.

Q. I'll start at the 40-percent line.

A. Okay.

Q. And I read up to the red line where they intersect.

A. That is correct.

Q. Now, I go over to the left margin and I can know now what portion of my cumulative production from the two wells now will represent the incremental increase in recovery because of infill?

A. That is correct, the increase in recovery factor that one would expect with infill is read off of the left axis, the Y axis, if you will.

Q. And if I'm in an area that looks like the Davis example, what happens with the results of my infill effort?

A. We would expect, if one extrapolates over to the curve, recoveries in the range of, say, 60 to 80 percent, incremental recoveries -- recovery-factor increases of 60 to 80 percent, in that area.

Q. And if I'm down in Huerfano where a part of that area is the darker red, where I'm achieving better recovery with the parent well, is there still an opportunity for incremental recovery with the infill well?

A. There is still opportunity for incremental recovery, yes.

Q. And what is that on this display?

A. With the Huerfano it would be approximately 15-percent increase.

Q. Let's go back and fill in the pieces. You've given us your conclusions. Let's go back through the pieces of the study so Mr. Stogner can look at the engineering data and the details of how you modeled the reservoir and how you got to your conclusions.

Let's talk about the test program.

A. I will now overview the pilot -- well, pardon me, the pilot-well testing program, we have drilled, Burlington Resources has drilled five pilot wells in geologically diverse areas of the underpressured envelope as outlined by Mr. Thibodeaux earlier. We also chose these pilot wells to represent the range in production performance and estimated ultimate recovery for the offsetting producing wells.

We as part of this program collected coal cuttings from the infill well locations for up to five coal layers. These coal cuttings were then tested for coal quality -- in other words, the inorganic/organic content of the coals -- using a procedure referred to as proximate analysis.

We also performed adsorption isotherm testing on those coal-cutting samples from the wells in order that we may determine the gas content of those individual coal horizons. We then used those gas-content data to calculate original gas in place for the coal layers at the infill locations.

We then ran open-hole logs over the coal intervals for the purposes of estimating coal density, which was coupled with the gas-content results to determine the original gas in place per layer.

We then collected multiple pressures, layer pressures at the infill locations, in this case up to four pressures at the infill location. Upon completion of drilling of the well we perforated and isolated individual coal zones so that we may determine what their current pressure is. We used that pressure data to determine the degree of coal-layer depletion at the infill locations.

The final step was to fracture-stimulate the infill wells using techniques very similar to the offset producing wells, and we produced the wells for a period of up to 180 days. And the purpose of that was to compare the production performance of the infill wells with the offset producing wells, as well as for data that would be input -- or would be modeled in a reservoir-modeling approach.

Q. Let me take you to the end of the book, and look at Exhibit Tab 15 for a moment. If you turn to 15, flip past the cover sheet and you're going to get into a pilot area for the Davis study?

A. That's correct, yes.

Q. And you have these plats or maps for each of the simulated model areas?

A. Yes, we do.

Q. So if Examiner Stogner wants to see the configuration and well locations, it's in the exhibit book?

A. That is correct.

Q. All right, you now have your test program described for us, Mr. Clarkson. Let's move beyond Exhibit Tab 7 and go to 8. Let's have you talk about your pilot simulation economic results.

A. I will now summarize the pilot well testing/ simulation/economic results.

Burlington Resources drilled five pilot wells. We tested these wells, stimulated them and produced them. All five pilot wells, as we showed earlier, contained some coal layers with little depletion as inferred from pressure data.

As we also stated earlier, only three of the pilot areas were modeled: the Huerfano, the Davis and the San Juan 28-and-6 Unit. The reason why the San Juan 28-and-5 and Turner Federal was left out of the modeling effort is that they are believed to be analogous to the Davis in that they demonstrate a lack of depletion and poor production performance of the offset producing wells.

Q. Let's start with the Huerfano Unit, that pilot study in the Huerfano with that well. We're going to go through that one from start to finish, and then you can summarize what happens with the others.

A. Yes, sir.

Q. Yeah, let's go through the steps, then. Let's talk about the summary for the Huerfano, and then we'll talk about the parts.

A. For the Huerfano Unit 258S, sufficient data was collected to evaluate the pilot area for infill. In other words, sufficient pressure, gas content and production data were acquired for the purposes of evaluating this area for infill.

For reference, the original gas in place on a 320-acre basis is 3.3 BCF for the Huerfano area, which represents the lowest gas in place of the three areas that we modeled.

Three layer pressures were collected, and as we showed in an earlier slide the top layer here shows little depletion. The middle layer shows a substantial amount of depletion. And the bottom coal layer pressure, we were unable to obtain a reasonable pressure for that zone.

A successful history match was obtained using a numerical simulator of the infill well layer pressures and the flowing pressures for eight offset producing wells.

We then built a scaled-up model in order to perform sensitivities for 160-acre infill and in order to determine the incremental reserves associated with 160-acre infill in this area. Those stimulation results show that there is an increase in reserves for this pilot area.

The final summary bullet point here is that the infill recompletes are economic in this particular area, although this is the least economic area compared to the other two pilot areas that we studied.

I will now show a location map that shows the location of the Huerfano Unit 258S pilot well, with respect to the offset producing wells. The infill test well -- the pilot test well, is located approximately in the center of the area that we studied or modeled. The offset producing wells are shown with purple diamonds and triangles, and they represent existing producing coalbed methane wells.

I will also point out that the simulation area that we modeled corresponds to this rectangle, showing that we modeled not only the infill well but the eight offset producing wells in the area.

Q. Why did you choose a simulation grid boundary of this size?

A. We chose a model of this size to represent the variability that we see in the production performance of the offset producing wells. We also wanted to try and eliminate boundary effects that are often associated with a smaller simulation model.

Q. And did you do that here?

A. Yes, we did.

Q. Please continue.

A. I will now describe to you in fair detail the steps that were used in the reservoir simulation procedure. I will use the example of the Huerfano Unit 258S, although we used the same procedures for the other two pilot areas that we modeled.

The first step was the incorporation of pilot well and offset well test data into the reservoir simulation. We obtained open-hole logs from the infill well location that was used to complete a pilot area geologic model, which Mr. Thibodeaux was responsible for. This geologic model is 16 sections in extent and includes coal layer thicknesses and bulk densities that were ultimately incorporated into the simulation model.

The next step was to take the adsorption isotherm data that we had collected and the coal density information that we had obtained to develop a correlation between isotherm parameters and coal density. The purpose of this was to calculate original gas in place by layer at each of the infill well locations.

The third step was to collect multi-layer pressures, which were then used as a parameter in the history-matching effort. In other words, we history-matched the multi-layer pressures at the infill well location. We also used the pilot well production data as a parameter to history-match in the simulation.

Lastly, we used pilot well offset data in the form of type-curve analysis to generate permeability and skin-factor estimates for the offset producing wells. The importance of this is that we used these estimates to constrain the permeabilities that we ultimately used in the simulation model.

Q. You've set up the simulation to match known production and to match known pressure points.

A. Actually, we used the simulation to match pressures at the infill well location and flowing pressures of the offset producing wells. The simulation model was actually driven with historical gas rate; that was an input into the simulator.

Q. At this point, then, you tried to run the model, the computer model, to match known history points?

A. Yes.

Q. And the known data you're matching is the pressure data and the production --

A. Yes.

Q. -- of the study area?

A. The pressure data -- the flowing pressure data, and in the multi-well simulation, which we'll get into in a minute, we matched the flowing pressures of the wells and the infill pilot pressures.

The first step, however, was to use single-well models and input the type-curve derived permeability and skin estimates to obtain a production match of the offset producing wells.

So sorry, there's two --

Q. Is this methodology consistent with conventional engineering modeling of a reservoir by simulation?

A. Yes, it is.

Q. In order to make the match, are there any reservoir parameters that you adjust in order to make the simulation perform like the existing data shows it should perform?

A. Yes, in the multi-well simulation that we will show here shortly, the permeability by layer was adjusted to match the flowing pressures and the pressures at the infill well location.

Q. Are you satisfied that your adjustments of the permeability stayed within reasonable ranges of engineering expectations for wells like this?

A. Yes, we are.

Q. What's the range of permeability you're using?

A. In the case of the Huerfano area, the permeabilities by layer range from approximately .6 millidarcies to approximately 52 millidarcies. The composite perm, which is obtained by basically summing up the permeabilities for those four layers, is 14 1/2 millidarcies, which is consistent with the type-curve results that we obtained from offset producing wells.

Q. All right, let's go to the next display.

A. This next display shows that once we input type-curve-estimated permeability and skin information into a single well model, we are able to reproduce the production performance of that well.

This is a specific example of the Huerfano Unit 255, whereby we used a single-well model which predicts the gas rate as a function of time, gas rate being in MCF a day, as a function of time.

The blue dots represent the production performance, the actual data for the well. The red line represents the predicted production performance for this well, using the type-curve-derived permeability and skin numbers.

This is a validation of the permeability and skin numbers that were derived from type-curve analysis.

Q. Once you've calibrated your model and you can simulate known history, then you're able to use that simulation to forecast what would happen in the future for that well?

A. That is correct.

Q. And when we look at this display, once we get to the right of the circles, we're now forecasting what will happen to this production as we move through time?

A. That is correct.

Q. Go ahead.

A. The next step in the history -- or pardon me, in this reservoir simulation procedure, was to history-match pilot offset wells, in this case a multi-well simulation using Eclipse numerical reservoir simulator.

I will now talk about some of the specifics of the model.

The model parameters included a model grid that was a 47 by 57 by 3, in other words, a model grid that had three vertical layers of an average grid block size of approximately 200 by 200. The model area in the case of the Huerfano area was 2561 acres, which incorporated the eight offset producing wells plus the infill well in the simulation.

It's important to note that each of the vertical grid blocks in the simulator correspond to the coal layer pressures that were measured at the infill location, so that the model reflects the data that was actually collected.

The next step in the multi-well reservoir simulation included the input of reservoir parameters. In this case, the coal layer original-gas-in-place numbers were calculated from an isotherm-versus-coal-density relationship that we were able to obtain from pilot-well-adsorption-isotherm data. We then assumed a relationship between coal-layer permeability and coal density to obtain a permeability estimate for each of the coal layers, using the average density for that layer.

The permeability in coal is assumed to be a function of the coal density in that typically the lowest-density coals are the most highly fractured and hence the most permeable. So we assumed a relationship between those two parameters.

The other reservoir properties that were used in the model included data from core data and literature values.

Q. Does Burlington maintain a library of isotherms in the coal?

A. Yes, we do.

Q. Of that population, how did you select the appropriate isotherm that's applicable to this well?

A. We actually collected isotherm data from each of the individual coal wells or infill wells by layer. We then used that data from all the pilot wells and created a correlation between the isotherm parameters and density of the coal, which was then used in the calculation of original gas in place for each of the pilot areas, and in fact the entire underpressured coal envelope.

Q. What do you use an isotherm for? What's the point?

A. An adsorption isotherm is a measure of the gas content, is a measure of pressure for coal. If one knows the initial pressure and the isotherm parameters, one can calculate the gas content for a particular coal under initial conditions.

Q. Do you have an example of an isotherm on the next page?

A. This is actually an example of the correlation between an adsorption isotherm parameter and the coal density that was used for the pilot well modeling.

What this is is a plot of the Langmuir volume, which is an adsorption isotherm parameter, which is a function of coal density of the coal. The Langmuir volume is one of the two parameters that are used in the Langmuir equation, which is commonly used to correlate experimental adsorption isotherm data.

How this is used is, if one knows the average density of a particular coal, one extrapolates up to the curve and then over to the left-hand axis to obtain an estimate of the Langmuir volume. That is then input into the adsorption isotherm equation, and combined with pressure will give you a gas-content estimate for this particular coal.

Q. How do you construct the red line?

A. That is simply a linear correlation to the data, a single -- using a correlation.

Q. Now, what do you do with this information?

A. This information is used to calculate the gas content by layer in the coal. The gas contents are then coupled with coal-density and thickness information to calculate an original gas in place for each of the layers in the coal.

Q. All right. What happens next?

A. The next step or the next slide here shows how the history match was achieved for the multi-well simulation. The simulation was driven by historical monthly gas rates, and as I mentioned earlier, the flowing pressures of the offset producing wells and the pressures at the pilot infill well location were predicted with the simulation model. In this case, we assumed single-phase flow, in that there's a lack of historical water production in this particular area.

The permeability-versus-coal-density relationship was adjusted to match the pressures at the infill location as well as the flowing pressures of the offset producing wells. It's important to note, however, that the composite permeabilities that were derived from this estimate were constrained to be within the range that one observes for the offset producing wells.

There was also some adjustment in skin factor in order to achieve a flowing bottomhole pressure match.

This next slide illustrates the relationship between permeability and coal density that was used in the Huerfano area to achieve the history match that I discussed earlier.

The top layer permeability, as I mentioned earlier, is approximately .6 millidarcies and this is consistent with the fact that this top layer is the least-depleted layer at this location.

The middle layer is a 24-millidarcy layer, and the bottom coal layer is 52 millidarcies. The composite layer, as I mentioned earlier, is 14 1/2 millidarcies, which is consistent with the offset producing wells in the area.

I will now show you the two parameters that were history-matched in this simulation model, the first being the multi-layer pressures that were observed at the infill well location.

What I've shown here is, the red bars represent the original pressures at the infill location, prior to offset well production. The dark blue bar represents the actual measured pressure at the infill location, upon completion of the drilling of that well. The light blue bar represents the simulated pressure at this infill location at the end of history match, and one can observe that we have obtained a fairly good match to those pressures. The bottom zone, as I mentioned earlier, we were unable to obtain a reasonable pressure for that zone.

The one other data point that we have on here is the green bar which represents the post-fracture-stimulation dip in pressure that was taken just prior to first delivery of this particular well.

Some additional data that I've put in the slide for reference includes the total layer thickness associated with each of the pressure zones that were measured in this well. I note that the top zone is the thickest layer at 27 feet thick, the bottom two zones are somewhat smaller or thinner zones, representing nine feet and six feet thickness.

I've also shown the original gas in place calculated for each of those layers. This is a model average original gas in place on a 320-acre basis. The top zone, of course, being the thickest, has the most original gas in place, whereas the bottom two zones have substantially less original gas in place.

I have also shown the remaining gas in place associated with each of those layers, and as I mentioned earlier, the top zone appears to be the least depleted, whereas the bottom two zones do show some depletion.

The second history match parameter in the simulation model included the flowing bottomhole pressures for the eight offset producing wells to the pilot infill well.

This is an example, again, using the Huerfano Unit 255, which shows the flowing bottomhole pressure as a function of time. The blue dots represent the actual flowing pressures at this infill location, or -- or pardon me, this offset producing well location. The red line represents the simulator-predicted flowing bottomhole pressure. This demonstrates that there's a reasonable match of the simulator to actual data and that the permeability or composite permeabilities that we used in the simulator are reasonable.

The next step in the simulation procedure was to use the model that we used to history-match the offset producing wells to predict what the well production would be for the infill well location, and this was done for the Huerfano area.

In this case, we drove the simulator using scheduled flowing pressure, which was estimated from the measured casing pressure of the well. In this case also, the skin factor was adjusted to be consistent with the range of the offset producing wells.

I will now show a plot that shows the history match of the infill well production data. This plot shows the gas rate in MCF a day as a function in time for the Huerfano Unit 258S infill location. The blue dots represent actual production data for this well. The red line represents the simulator-predicted production rates for this infill location. And as you can see, it is a very good match.

The next and final step in the simulation modeling procedure was to build larger scale models, in this case 16 sections in area, to forecast infill well, incremental and accelerated reserves. The purpose of building a larger scale model was to reduce any battery effects that may be associated with a smaller model, as well as to represent the parent and infill locations on a regular spacing.

The model grid in this case is a 40-by-40-by-3, again, three vertical layers in the simulation model, consistent with the history-match model. The model area, as I mentioned earlier, is 16 sections so that there were 32 parent wells and 32 infill wells that were simulated using a regular pattern.

The reservoir parameters that were used in the scaled-up model are identical to those that were used in the history-match model. Coal layer thickness, permeability and all other properties were set equal to the history match model.

The forecasting of the parent and infill wells was achieved using the following procedure. The scale-up model started basically at the end of the history match of the offset producing well such that the initial pressures in the model were the same as the pressures achieved at the end of the history match.

The parent wells were then forecast, assuming that no infill development occurred, were forecast out to the year 2033. Infill wells were scheduled during a separate run in the year 2003, and then forecast out to the year 2033, again forecast out for a 30-year time-frame.

The simulation in this case was driven by flowing bottomhole pressure, and it's important to note that the flowing bottomhole pressure profile for all the wells in the model were identical.

I will now show the increased density recovery profile for the Huerfano unit area for the years 2003 to 2033. This plot will require a little bit of explanation.

The left-hand axis represents the cumulative gas production, the right-hand axis represents an incremental gas production. The bottom three curves in this plot, the red, blue and green curves, represent the cumulative gas production over that 30-year time frame for three different scenarios, which I will now describe.

The blue curve represents the cumulative production over a 30-year period for a single parent well, assuming no offset infill development.

The green curve represents the same parent well, but subject to offset infill development. In other words, we would expect some reduction in cumulative production of the parent well due to the presence of the infill well.

The difference between these two curves represents the accelerated reserves component associated with the infill well. In other words, the difference in cumulative production between the parent with no infill and the parent with infill -- the volume difference here represents gas that would have been recovered by the 320-acre-spaced well, had no infill well been drilled.

The red curve, on the other hand, represents the cumulative production from two wells, the parent plus the infill well. The difference between the red curve and the blue curve represents the incremental gas production associated with infill development. And as one can see, there's an approximate 50-50 split between incremental gas and accelerated gas associated with infill development.

The last curve, the purple curve, which is read off of the right axis, represents the incremental reserves profile associated with a single infill well, such that after 30 years the infill well would be expected to cum approximately 270 million.

We will contrast this particular slide with the Davis and the 28-and-6 areas, which show a substantially more relative incremental gas production.

Q. You have each of these type of displays for the other areas modeled?

A. Yes, we do.

Q. Let's stay on this for a second, make sure we can read it. If you start with the top purple curve --

A. Yes.

Q. -- I'm going to read the conclusions off the right axis or right margin?

A. That is correct.

Q. And if all I want to know is the additional gas to be attributed in the Huerfano area as a result of having two wells instead of one --

A. Yes, that is correct.

Q. -- that volume of gas is going to be what?

A. That incremental gas volume associated with infill drilling is 270 million, approximately.

Q. All right. If I want to look at what a single well by itself in the spacing unit would do, I'm going to look at the blue line?

A. Yes, that is correct.

Q. And to see a single well by itself as to how it will recover, I'm going to read off the left margin?

A. That is correct.

Q. I'll go over there and find what that single well will do?

A. Yes.

Q. And you recognize that when you have two wells there's going to be some overlap where those two wells are affecting each other?

A. Yes, that's correct.

Q. And so the parent well is going to be affected -- or that gas is going to be accelerated to a certain percentage?

A. Yes, that is correct.
Q. And how do I find that percentage on this display?
A. The difference between the blue curve, which represents the parent well with no infill, and the green curve, which represents the parent well with offset infill development, would be the accelerated-reserves component.
Q. And then I can read that off of the left scale?
A. That is correct.
Q. And if I want to know what the infill well is going to do, I'm going to read the red line?
A. Yes, the red line represents the total of the infill and the parent cumulative production over that --
Q. All right, so the 160 red line is the cumulative total of the two?
A. Yes.
Q. And I would read that one now off of the left axis?
A. That is correct.
Q. All right, let's look at the next slide.
A. The next slide is an illustration of the projected infill well performance for the Huerfano area. It simply is a plot of gas rate as a function of time over that 30-year time frame for a single infill well.
Notice the initial rates are projected to be just

over 200 MCF a day, declining to approximately -- just below 20 MCF a day over that 30-year period.

Q. Next slide. This is one of your conclusion slides, and it's where we started a while ago. This now shows us in these three model areas the portion of additional gas to be recovered as a result of infill drilling?

A. That is correct. This is a reproduction of a slide that we showed earlier, showing the Huerfano Unit area and the other two mottled areas and the relative increase in recovery that one would expect with infill drilling in the Huerfano area relative to the other two areas.

We note that relatively smaller percentage of incremental reserves would be yielded in the Huerfano compared to the 28-6 and the Davis areas.

Q. Mr. Hayden this morning reported to Mr. Stogner that the Committee's expectation is that they could take existing wellbores, such as Pictured Cliffs wells, and recomplete those to add coal gas production from the coal seam?

A. Yes.

Q. Do you have a series of displays where you studied that to see if it's economic --

A. Yes.

Q. -- to improve the recovery from the gas pool by recompletion?

A. Yes, we do.

Q. Let's look at that.

A. The next slide shows that infill recompletes -- in other words, if we were to recomplete an existing wellbore to the Fruitland Coal and produce the Fruitland Coal, that this recomplete would be economic in the Huerfano area.

The after-tax present value calculation for this particular area is around $13,000, discounted at 10-percent rate. This represents the poorest economics of the three areas, which we will show here in a few minutes.

The primary economic assumptions that went into this economic modeling included a gas price at $3.25 per MMBTU. This is a NYMEX average gas price for the month of June, 2002.

The operating cost assumed for this particular area was about $1000 per well per month. The capital costs were around $200,000, which include the perforation and stimulation of the coal zone within the existing wellbore.

And finally, the gross- and net-revenue interests are 100 and 84 percent respectively, which represents an average that one sees for the pilot wells that we modeled.

And what's important here is that these represent incremental economics whereby we calculated a cash flow for a 320-acre-spaced case and subtracted that from a 160-acre case to determine the incremental net present value associated with that case.

Q. Have you satisfied yourself as an engineer that there's additional gas to be recovered by an infill program?

A. Yes, we have, or I have.

Q. And the economics here are attributed to the recompletion of the Pictured Cliffs well?

A. Yes.

Q. And the $200,000 is the cost attributable to recompletion in the coal seam?

A. That is correct.

Q. And it's economic to capture that additional gas, in your opinion, using these parameters?

A. Yes, it is.

Q. Are all these within reasonable engineering expectations for the industry to apply to their own properties?

A. We believe so.

Q. Let's look at the summary now for the others, starting with the Davis. What are your conclusions about the Davis study?

A. Unlike the Huerfano area, we will not go into the simulation detail that I showed earlier, but I simply will summarize the key points associated with this area.

These points are that sufficient data was collected to evaluate the pilot area for infill development. Sufficient pressure, gas-content and production were collected for that purpose.

For reference, the original gas in place for that area is approximately 4.3 BCF for 320-acre area, which is actually higher than the Huerfano area, in part due to the higher pressures, initial pressures, that one sees in this particular area.

Four layer pressures were collected. All coal layers, as we showed earlier, show very little depletion.

A five-layer, dual-porosity simulation model was used in a history-matching effort, and we were able to successfully history-match the infill well layer pressures as well as the offset four producing well flowing pressures.

The scaled-up model again was used to calculate incremental reserves associated with 160-acre spacing, and we found that in this case incremental reserves were yielded.

Finally, infill recompletes are economic in this area as well, and in fact are somewhat better than the economics that I showed for the Huerfano area.

I will now show a representation of the increased density profile as a function of time for the Davis area, and I will not reiterate the meaning of each of these curves, other than to note that the incremental recovery associated with the Davis area is much larger than what we expected for the Huerfano area.

Incremental volume percent in this case is 81 percent, and the accelerated reserves component is only 19 percent.

Also note that the single infill well would yield a recovery of just under 500 million in incremental reserves over that 30-year period.

So contrast this with the Huerfano area, we see that there's much more incremental reserves that could be had in this area.

Q. That again is your summary slide we talked about earlier?

A. Yes.

Q. Let's look to the results of the 28-and-6 pilot.

A. With the 28-and-6 area, again, summarizing, sufficient data were collected to evaluate this area as well. The original gas-in-place estimate is somewhat larger than the other two areas at 5.6 BCF per 320-acre.

Four layer pressures were collected, the top layer showing very little depletion as we illustrated earlier, whereas the other three layers did show some depletion.

A 13-layer dual-porosity simulation model was used in this case, because the heterogeneity at this particular location was greater than our ability to measure it with pressure data, so we needed a more complex model to accurately history-match the infill well pressures.

We were able to obtain a successful history match of the infill well layer pressures and the flowing pressures of four outside producing wells.

The scaled-up modeling showed that incremental reserves would be yielded with the 160-acre program.

And finally in this case, infill recompletes are also economic. In fact, this represents the best of the three areas in terms of net present value associated with infill recompletes.

Q. The total volume expected for the incremental production as a result of infill drilling in this area is what?

A. For a single infill well, the incremental reserves are estimated to be approximately 600 million in reserves.

Q. And then again we're back to your summary slide on this area?

A. Yes, the final slide shows a bar chart that shows the incremental volumes of the 28-and-6 area relative to the other two areas, and one can see that the incremental reserves are in between the Davis and the Huerfano area in terms of percentage increase in recovery.

Q. If you'll turn to Tab 9, and let's go to the conclusions, because each of these previous three we talked about in your introduction. We talked about your method for taking the pilot study results and transferring it to the underpressured area?

A. Right.

Q. We've done that. Let's talk about your conclusions.

A. Okay.

Q. Let's go back and have you summarize your conclusions, which is the last page behind Exhibit Tab 9.

A. The four main conclusions that were obtained as a result of this infill pilot study is that current well density in the underpressured portion of the pool results in inadequate recovery. The pilot wells demonstrate that inadequate drainage occurs in some or all of the coal layers as represented by measured pressure data. Additional completions result in additional recovery in all cases that we modeled and studied. And finally, the pilot-well results are transferable to the rest of the underpressured envelope.

Q. Were the exhibits prepared under Exhibit Tab 6 through 9 plus the additional information behind 15 compiled under your supervision and direction?

A. That is correct.

Q. And that represents your work product?

A. That is right.

MR. KELLAHIN: That concludes my examination of Mr. Clarkson.

We would move the introduction of his Exhibits 6 through 9, plus 15.

EXAMINER STOGNER: Any objections?

MR. HALL: No objection.

EXAMINER STOGNER: Exhibits 6 through 9 will be admitted into evidence at this time.

Mr. Hall?

EXAMINATION

BY MR. HALL:

Q. Mr. Clarkson, let me make sure we understand the purpose for which your testimony is being offered here today.

As I understand it, your study was limited to the pilot project areas, and then you attempt to demonstrate the applicability of that study to the underpressurized area?

A. That is correct.

Q. Burlington is not recommending that your testimony be used to establish a basis for infill rules for the high-productivity area, is it?

A. This study was limited to the underpressured envelope, and the results herein are applicable to the underpressured envelope. However, Burlington supports BP's testimony, which will be shown later, and the results therein regarding the high-productivity fairway.

Q. And what is it that prevents you from applying your methodology and your analysis and your results to the high-productivity area? What data is missing?

A. We at this point in time do not have all the -- we don't feel at this point that we have enough data in the form of multi-layer pressures and reservoir simulation to comfortably extrapolate these results to the high-productivity fairway.

Q. Do you believe it would be prudent to gather additional data like that before pool rules are adopted for the high-productivity area?

A. Burlington Resources supports BP's testimony in that BP has collected the types of data that we believe allow us to make a judgment as to the applicability of the infill within the high-productivity fairway.

Q. Except for the pressure data you mentioned?

A. They do have somewhere some pressure data.

Q. But is it sufficient in your view?

A. We believe the results that they have demonstrated are sufficient to apply their results to the fairway.

Q. The 150-well Fruitland drilling program that Mr. Thibodeaux testified to earlier this morning, of those 150 locations, how many of those will be in the underpressured area?

A. The vast majority of those are actually estimated to be in the high-productivity fairway.

Q. All right. Of those locations, what percentage will be infill locations?

A. I'm not sure at this time what that percentage is.

Q. Is it a high percentage?

A. It's relatively lower percentage of underpressured wells compared to overpressured wells.

Q. In your economic analysis for the infill in the underpressured envelope area, why did you limit that analysis to just recompletions?

A. We have in fact run economics for stand-alone new drills as well. We simply showed recomplete economics because Burlington Resources will try and develop the infill program economically in the underpressured envelope, and we will in all cases look for areas where we can perform recompletes as opposed to stand-alone new drills, simply because there's some additional capital cost, as well as other issues associated with infill drilling.

So we showed recomplete economics to show that we would pursue those opportunities where they exist.

Q. Did you also do recomplete economics on recompletion targets within the high-productivity area?

A. I did not.

Q. Okay. Do you know that there are a number of recomplete targets in the high-productivity area for Burlington?

A. There are -- as Mr. Hayden testified earlier, I don't believe there's as many opportunities for recompletes in the fairway as in the underpressured envelope, simply because of the way that we complete the overpressured wells.

MR. HALL: I believe that's all I have, Mr. Examiner.

EXAMINER STOGNER: Mr. Carr, before I call you, I did fail to take into notice Exhibit Number 15, so I'll -- That has been offered and accepted.

So Mr. Carr?

MR. CARR: I have no questions of Dr. Clarkson.

EXAMINER STOGNER: Let the record show that I believe Mr. Jim Bruce and Mr. Dean are no longer here.

EXAMINATION

BY EXAMINER STOGNER:

Q. I want to refer to your recovery profile from 2003 to 2033, and I believe the one you used was the Huerfano area; is that correct?

A. Yes, sir.

Q. Okay, I want to make sure that I'm reading this correctly. Okay, the blue line is the current well within the spacing unit; is that correct?

A. That is correct.

Q. And the green line would be the infill well without the original well producing?

A. Actually, the green line represents the parent well production performance in the presence of infill well development.

MR. KELLAHIN: Mr. Clarkson, would you take a moment and find that slide so the audience --

THE WITNESS: Oh, I'm sorry.

MR. KELLAHIN: -- can see what you're talking about?

Q. (By Examiner Stogner) Okay, my question was, the blue line, that represents the current well?

A. That's correct.

Q. And the green line represents the new infill well?

A. It represents the same parent well, but with offset infill well performance. In other words, you have one existing well in the 320, and that represents -- the cumulative profile associated with that would be the blue curve, and then the green curve would be that same single well but with offset infill well development.

Q. Okay, that's where I was getting confused then.

Now, the red line would represent the infill well just in that spacing unit?

A. It would represent the two wells, the infill plus parent well.

Q. Okay. Now, I remember in your testimony there was something mentioned about the water production.

A. Yes, sir.

Q. But that was absent from the Davis area; is that correct?

A. All three areas that we modeled showed a relative lack of historical water production.

Q. Was this taken into account whenever the pilot areas were chosen, of the historical water production? I'm taking it, it's low anyway in those areas.

A. Yes, it is. For the most part, although this isn't true for the entire underpressured envelope, a lot of the wells appear to be relatively dry in that they don't produce a great deal of water. And so the pilot wells were in areas where the reservoir is relatively dry.

Q. Did you see any effect on what little water production was there from the original well versus the infill well?

A. There's a potential for whatever water production data -- or pardon me, the parent well may have produced some historical water production and hence it may have impacted the performance initially of those wells, but there does not appear to be any impact of water production performance on the infill location.

EXAMINER STOGNER: I have no other questions of this witness.

MR. BROOKS: I have nothing.

EXAMINER STOGNER: No follow-up, you may be excused.

MR. KELLAHIN: That concludes our presentation on behalf of Burlington.

EXAMINER STOGNER: Okay, let's take a 10-minute recess. And which one will go next?

MR. CARR: BP will go next, our witness will be Rusty Riese.

EXAMINER STOGNER: Okay, why don't you turn your microphones off at this time?

(Thereupon, a recess was taken at 2:40 p.m.)

(The following proceedings had at 3:00 p.m.)

# Pilot Testing/Simulation/Economic Results

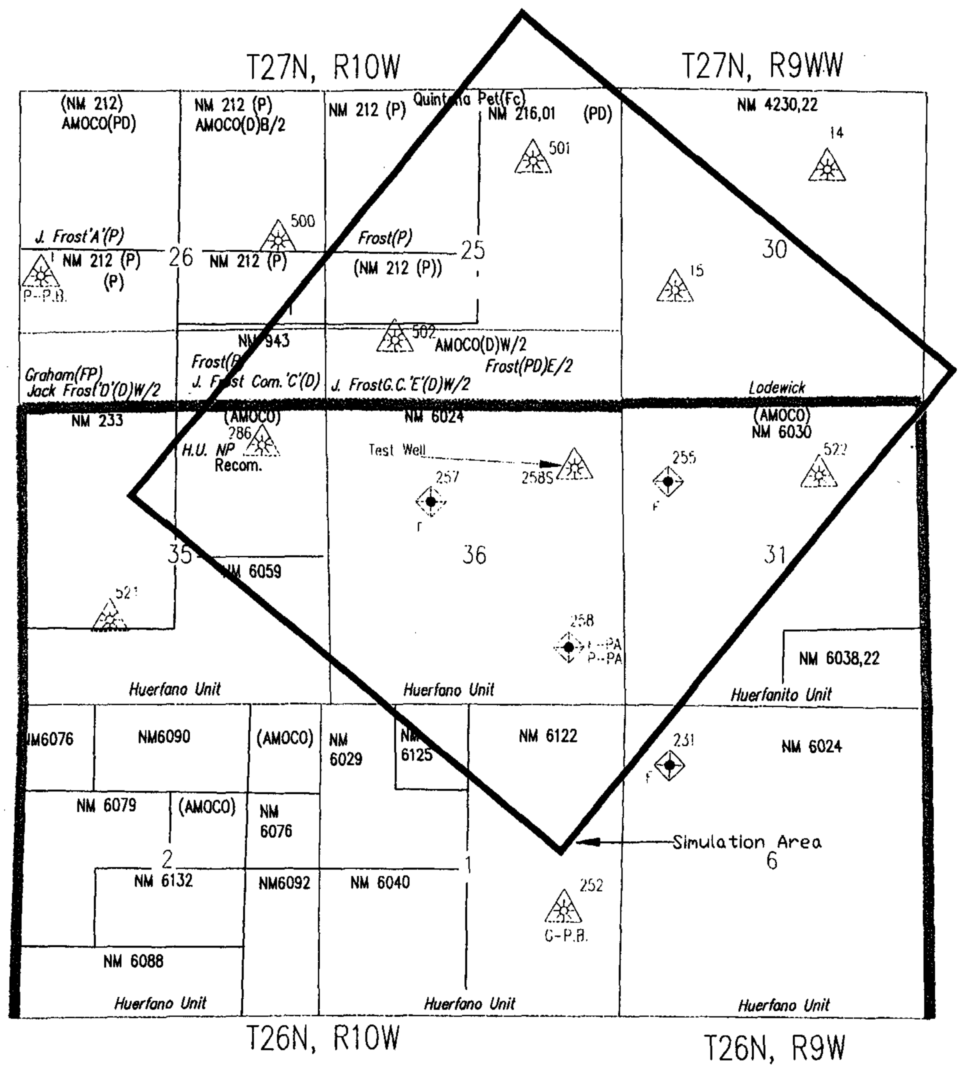
- Five pilot wells drilled, tested, stimulated and produced
- All five pilot wells contained some coal layers with little depletion (as inferred from pressure data)
- Only 3 pilot areas modeled (Huerfano, Davis, SJ 28-6)
    - SJ 28-5 and Turner Federal areas believed to be analogous to Davis – lack of depletion, poor production of offset wells

*Application of Richardson Operating Co.*
Record on Appeal, 1965.

# Pilot Testing/Simulation/Economic Results: Huerfano Unit #258S Summary

- Sufficient data collected to evaluate pilot area for infill
- Original Gas-In-Place (320-acre) = 3.3 Bcf
- 3 layer pressures collected:
  - Top coal layer shows little depletion, middle layer shows substantial depletion, bottom coal layer pressure (bad data)
- Successful history-match of infill well layer pressures and flowing pressures for 8 offset wells
- Scale-up modeling indicates 160-acre infill yields increase in reserves
- Infill recompletes are economic

# Huerfano Unit #258S Pilot Area




**Approximate Extent of Simulation Grid Boundary**

*Application of Richardson Operating Co.*
Record on Appeal, 1967.

# Pilot Testing/Simulation/Economic Results: Huerfano Unit #258S Detail

I. Incorporation of pilot well/offset well test data:

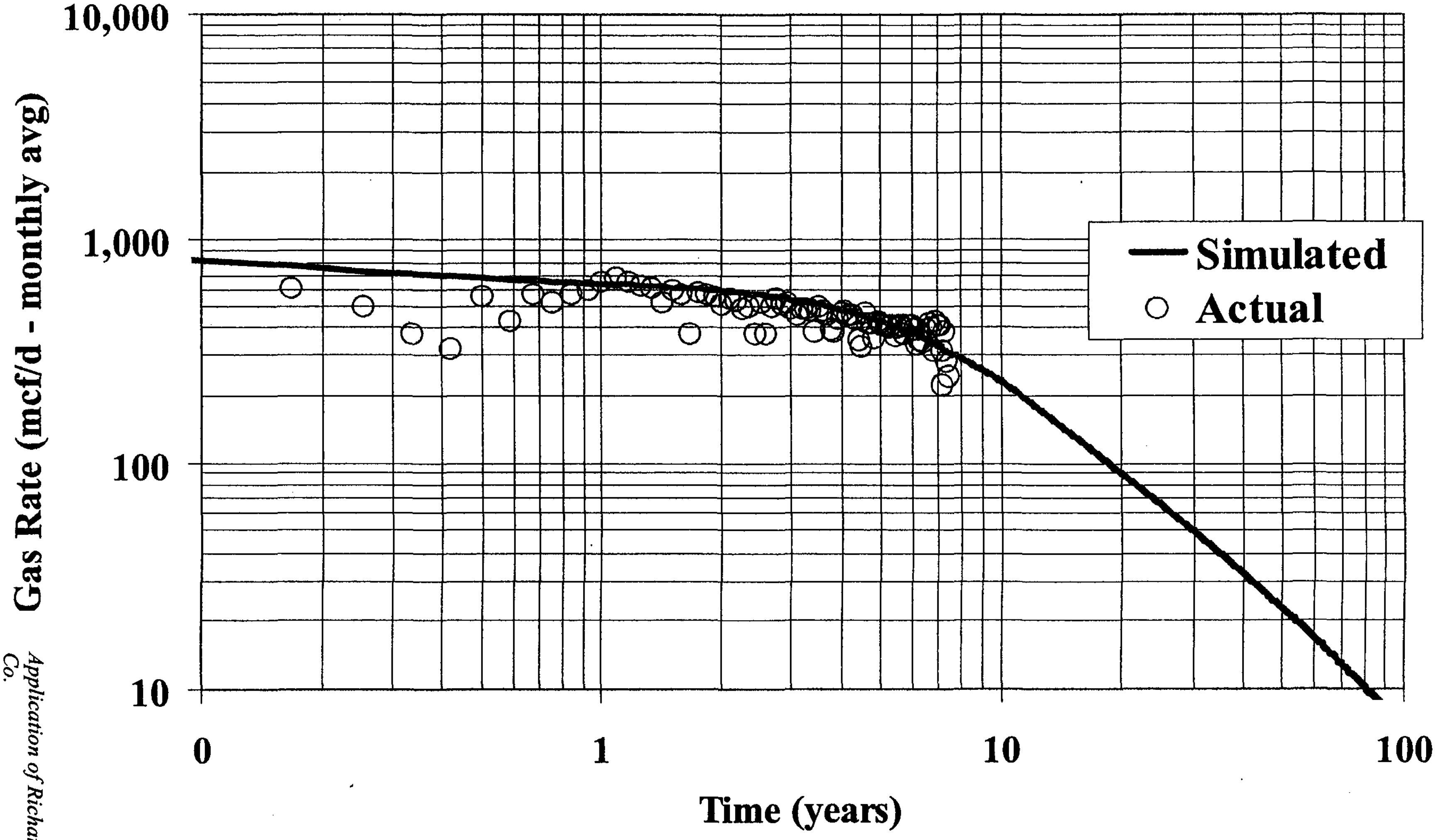
- Pilot well openhole logs used to complete pilot area geologic model – coal-layer thickness and bulk density (16-section)
- Adsorption isotherm data and coal densities used to develop correlation between isotherm parameters and coal density – OGIP calculations
- Pilot well multi-layer pressures used as parameter to history-match
- Pilot well production data used as parameter to history-match
- Pilot offset well type-curve analysis used to constrain composite permeability in simulation model

# Pilot Testing/Simulation/Economic Results: Huerfano Unit #258S Detail

II. History-match pilot offset wells (single-well) using (EXCEL®) tank model and type-curve results

- ➢ Type-curve estimated composite permeability and skin factor yield reasonable performance predictions
- ➢ Constrain reservoir simulation to have composite permeability within range of type-curve estimates

# Huerfano Unit NP #255 Tank Model Match




*Application of Richardson Operating Co.*
Record on Appeal, 1970.

# Pilot Testing/Simulation/Economic Results: Huerfano Unit #258S Detail

III. History-match pilot offset wells (multi-well) using ECLIPSE® numerical reservoir simulator

***Model Parameters:***

- Model grid: 47 x 57 x 3 (3 vertical layers, dual porosity), average gridblock size = 206 ft x 202 ft
- Model area: 2561 acres, incorporating 8 offset producing wells + infill well
- Each vertical layer (3) in model corresponds to coal layer for which pressure measured at infill well

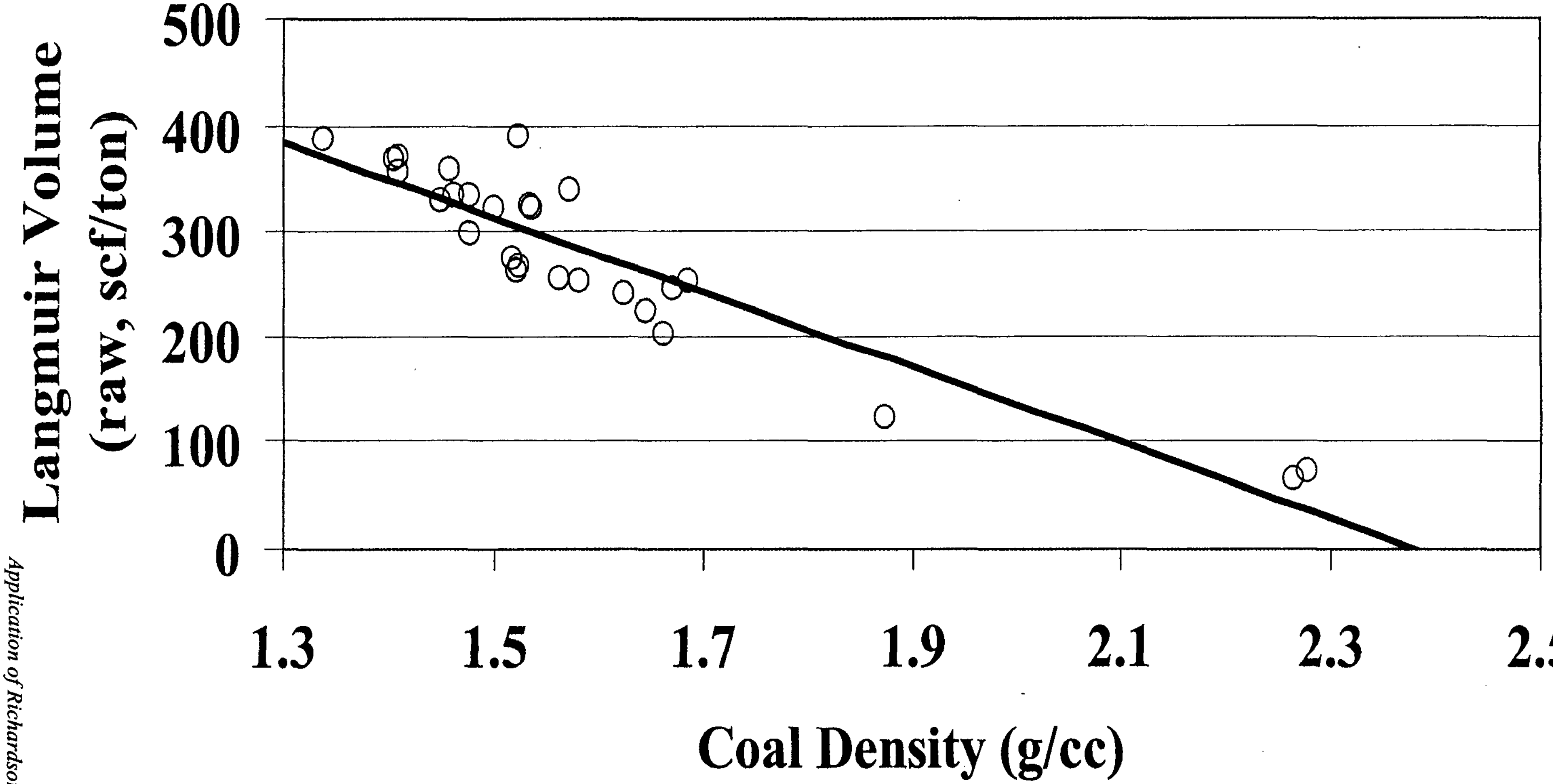
# Pilot Testing/Simulation/Economic Results: Huerfano Unit #258S Detail

III. History-match pilot offset wells (multi-well) using ECLIPSE® numerical reservoir simulator (cont'd)

***Reservoir Parameters:***

- Coal layer OGIP calculated from Isotherm vs. Coal Density Relationship, using average density for layer
- Coal layer permeability calculated from assumed Permeability vs. Coal Density relationship, using average density for Layer
- Other reservoir properties obtained from core data and literature values

# Isotherm vs. Coal Density Relationship




Average Original Gas-In-Place per 320-acre ~ 3.3 Bcf

*Application of Richardson Operating Co.*
Record on Appeal, 1973.

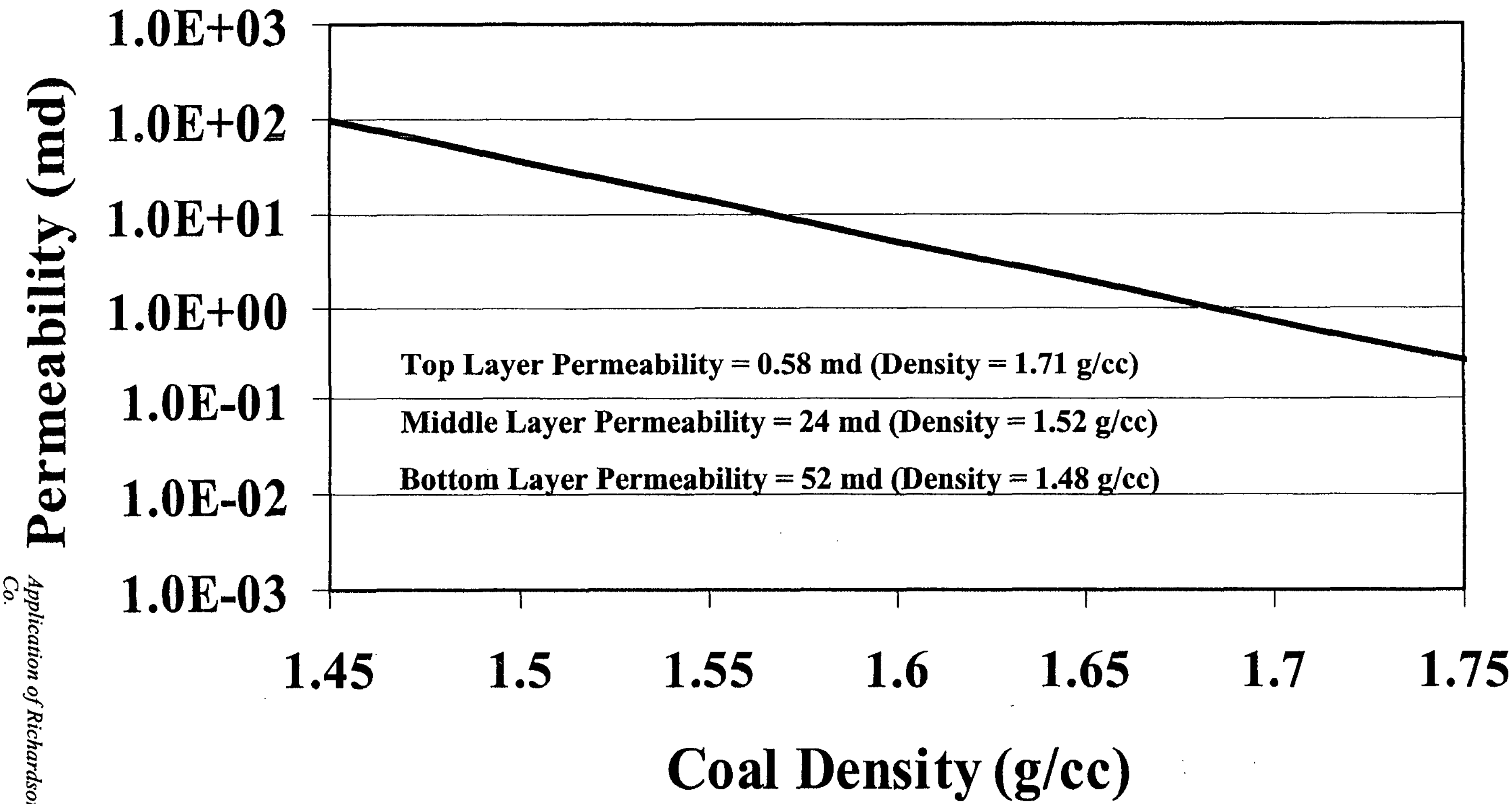
# Pilot Testing/Simulation/Economic Results: Huerfano Unit #258S Detail

III. History-match pilot offset wells (multi-well) using ECLIPSE® numerical reservoir simulator (cont'd)

***History-Matching:***

- Simulation driven by historical monthly gas rate (offset wells)
- Assumed single-phase flow
- Permeability vs. Coal Density relationship adjusted to match pressures at infill well location, and flowing pressures of offset wells
- Some skin factor adjustment also required

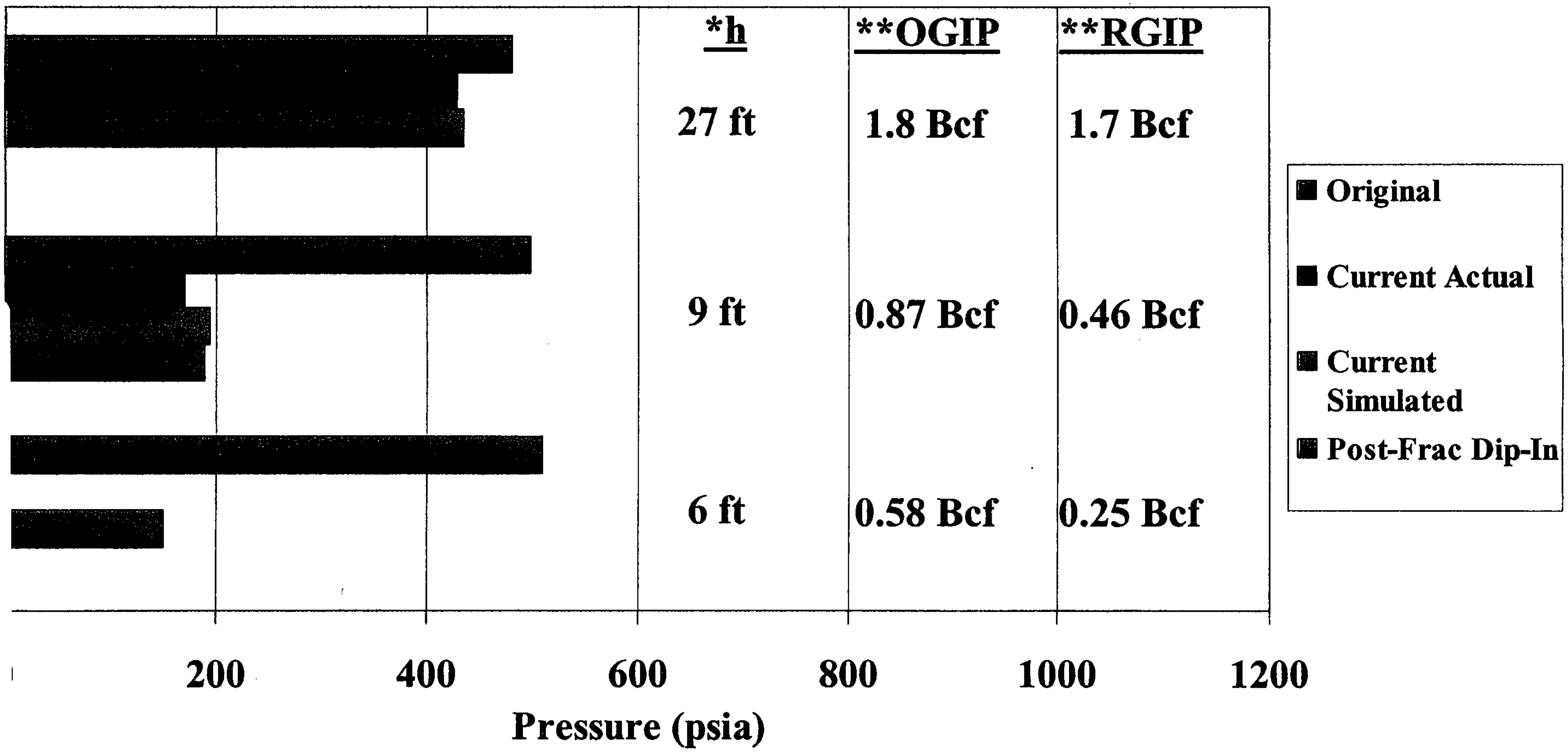
# Coal Permeability vs. Coal Density Relationship




*Application of Richardson Operating Co.*
Record on Appeal, 1975.

# Infill Well Layer Pressure Match

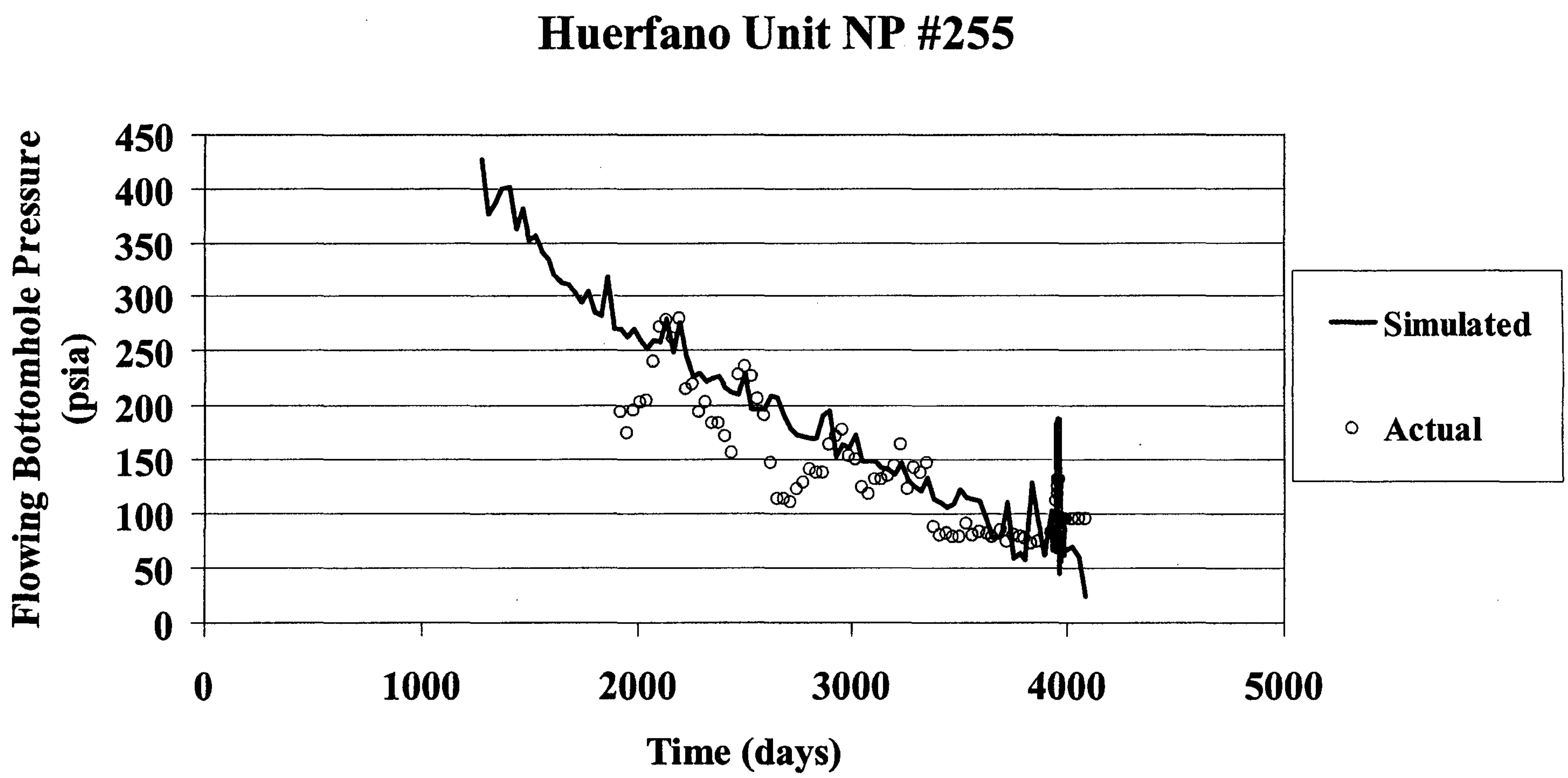
## Huerfano Unit #258S Layer Pressures




* Thickness At Infill Well **Model Average per 320

*Application of Richardson Operating Co.*
Record on Appeal, 1976.

# Offset Well Flowing Pressure Match




*Application of Richardson Operating Co.*
Record on Appeal, 1977.

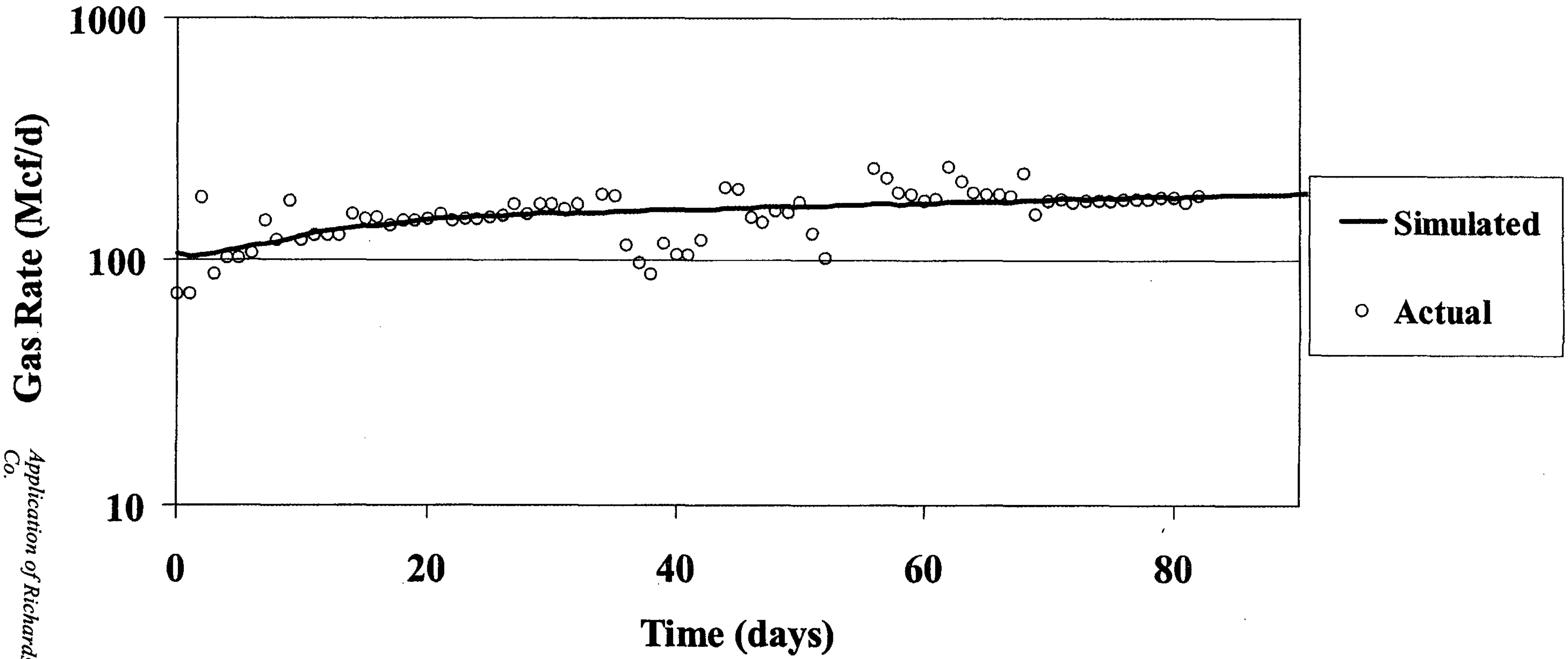
# Pilot Testing/Simulation/Economic Results: Huerfano Unit #258S Detail

IV. History-match infill well production using ECLIPSE®

- Simulation driven by scheduled flowing pressure (estimated from measured casing pressure)
- Skin factor adjusted within range of offset wells

# Infill Well Production Match

## Huerfano Unit #258S (Infill Well) Gas Production Rate




*Corrected to 24 hour flow rate

*Application of Richardson Operating Co.*
Record on Appeal, 1979.

# Pilot Testing/Simulation/Economic Results: Huerfano Unit #258S Detail

V. Use scale-up models (16-section) to forecast infill well incremental and accelerated reserves

***Model Parameters:***

- Model grid: 40 x 40 x 3 (3 vertical layers, dual porosity)
- Model area: 16 Sections (10240 acres)
- Parent (32 wells) and Infill (32 wells) follow regular pattern

# Pilot Testing/Simulation/Economic Results: Huerfano Unit #258S Detail

V. Use scale-up models (16-section) to forecast infill well incremental and accelerated reserves (cont'd)

***Reservoir Parameters:***

- Average coal layer thickness = history-match model
- Coal layer permeability = history-match model
- All other reservoir properties = history-match model

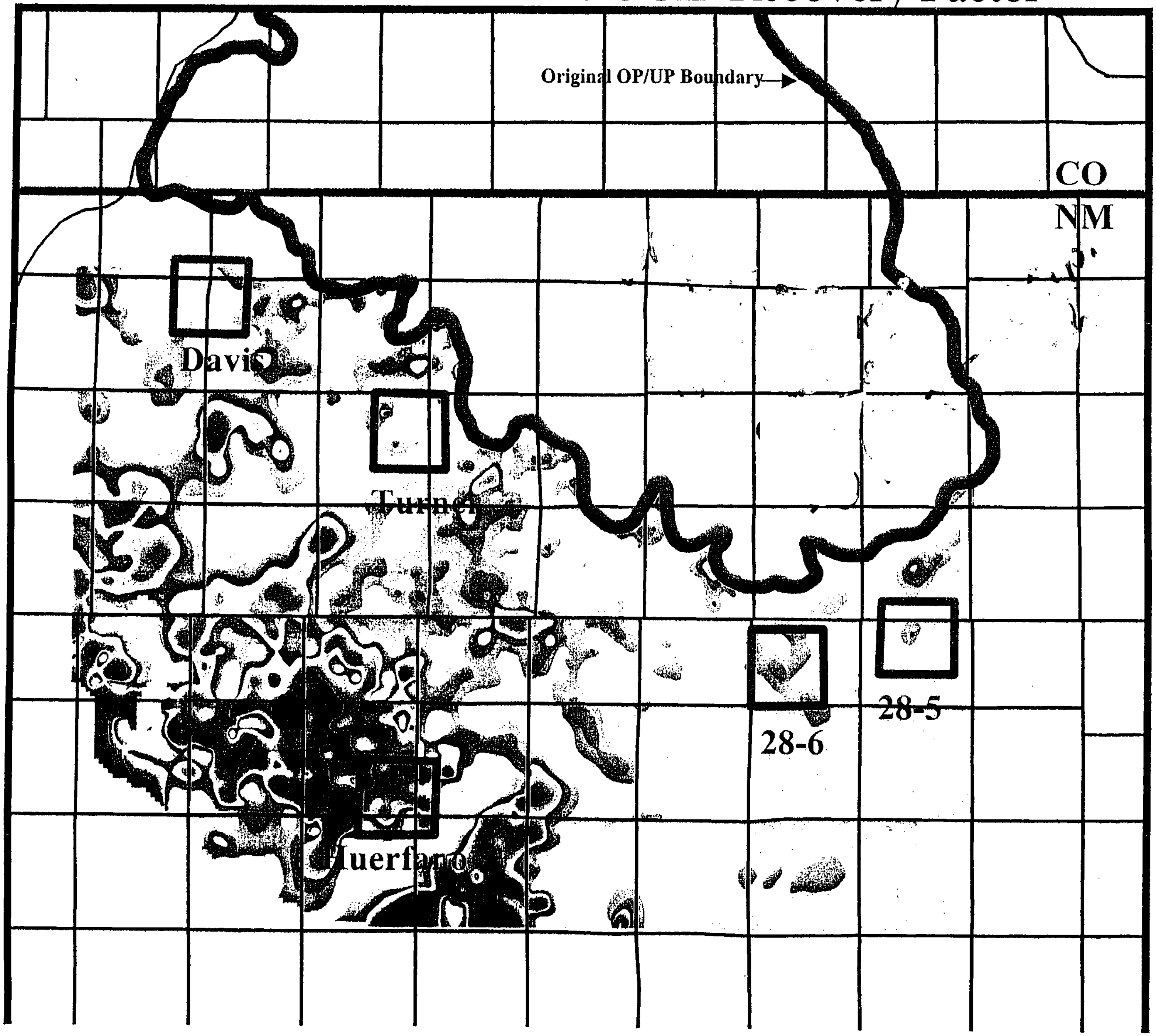
# Pilot Testing/Simulation/Economic Results: Huerfano Unit #258S Detail

V. Use scale-up models (16-section) to forecast infill well incremental and accelerated reserves (cont'd)

***Parent (320-acre) and Infill (160-acre) Forecasting:***

- Initial layer pressures = Huerfano Unit #258S (infill well) pressures at end of history-match
- Parent wells (no infill) forecast out to year 2033
- Infill + parent wells forecast out to year 2033, with infill wells starting in year 2003
- Simulation driven by flowing bottomhole pressure

# Current 320 Acre OGIP Recovery Factor

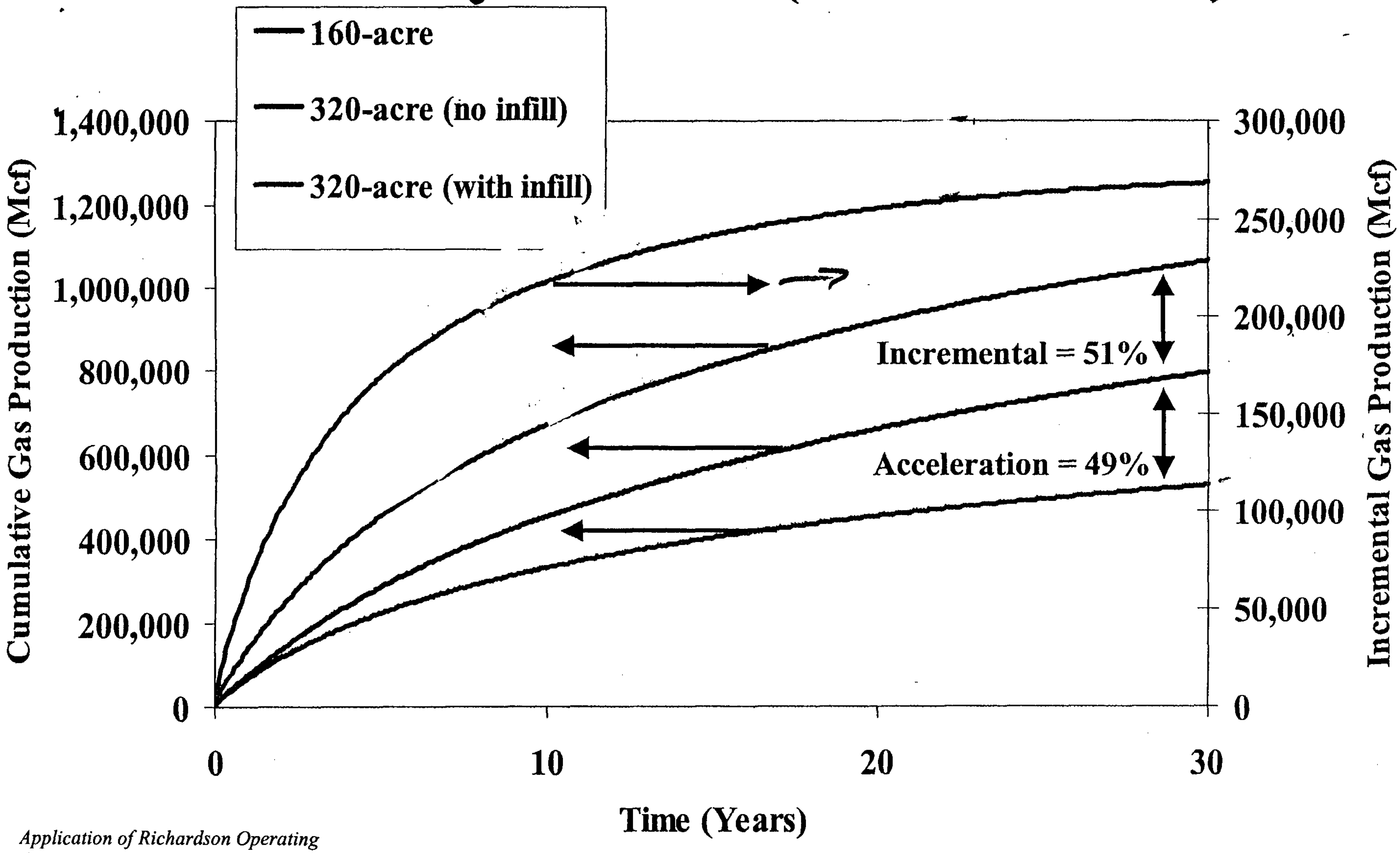



Light Blue: 0 – 20%
Dark Blue: 20 – 40%
Light Green: 40 – 70%
Dark Green: 70 – 100%
Red: > 100%

*Application of Richardson Operating Co.*
Record on Appeal, 1983.

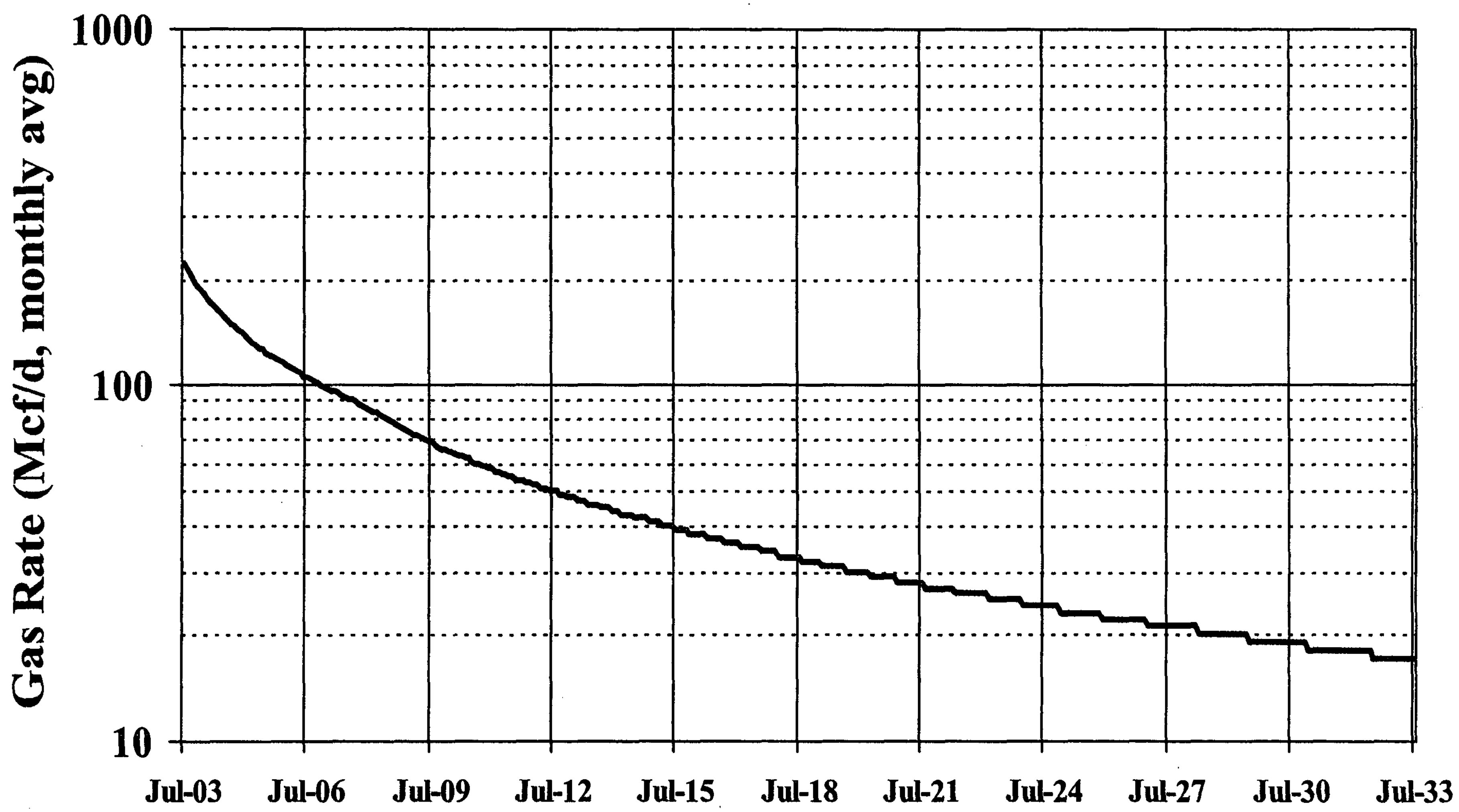
CI: 10%

# Huerfano Area Increased Density Recovery Profile (2003 – 2033)



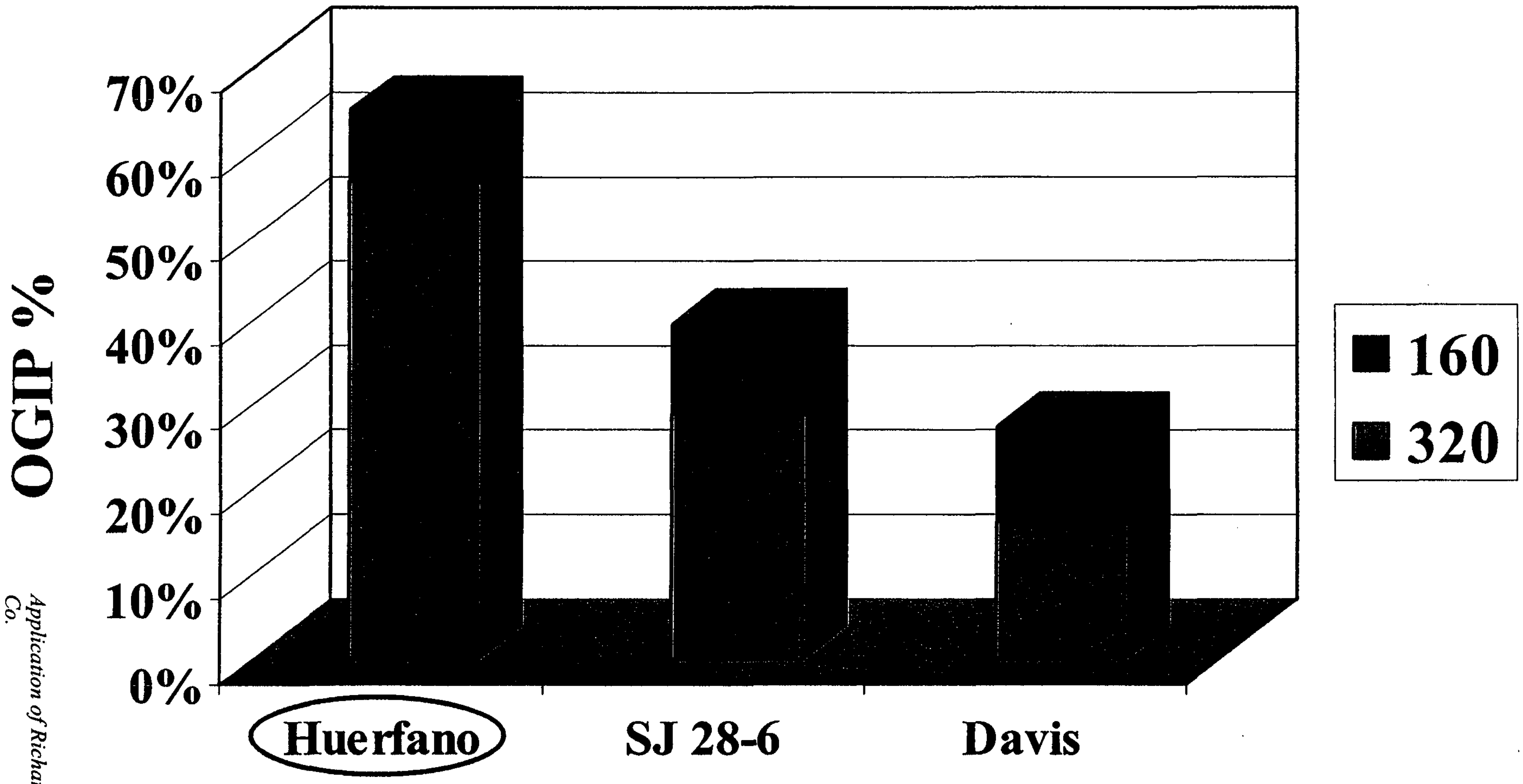

*Application of Richardson Operating Co.*
Record on Appeal, 1984.

# Huerfano Area Infill Well Projection




*Application of Richardson Operating Co.*
Record on Appeal, 1985.

# Additional Completions Result in Additional Recovery




*Application of Richardson Operating Co.*
Record on Appeal, 1986.

# Infill Recompletes Are Economic

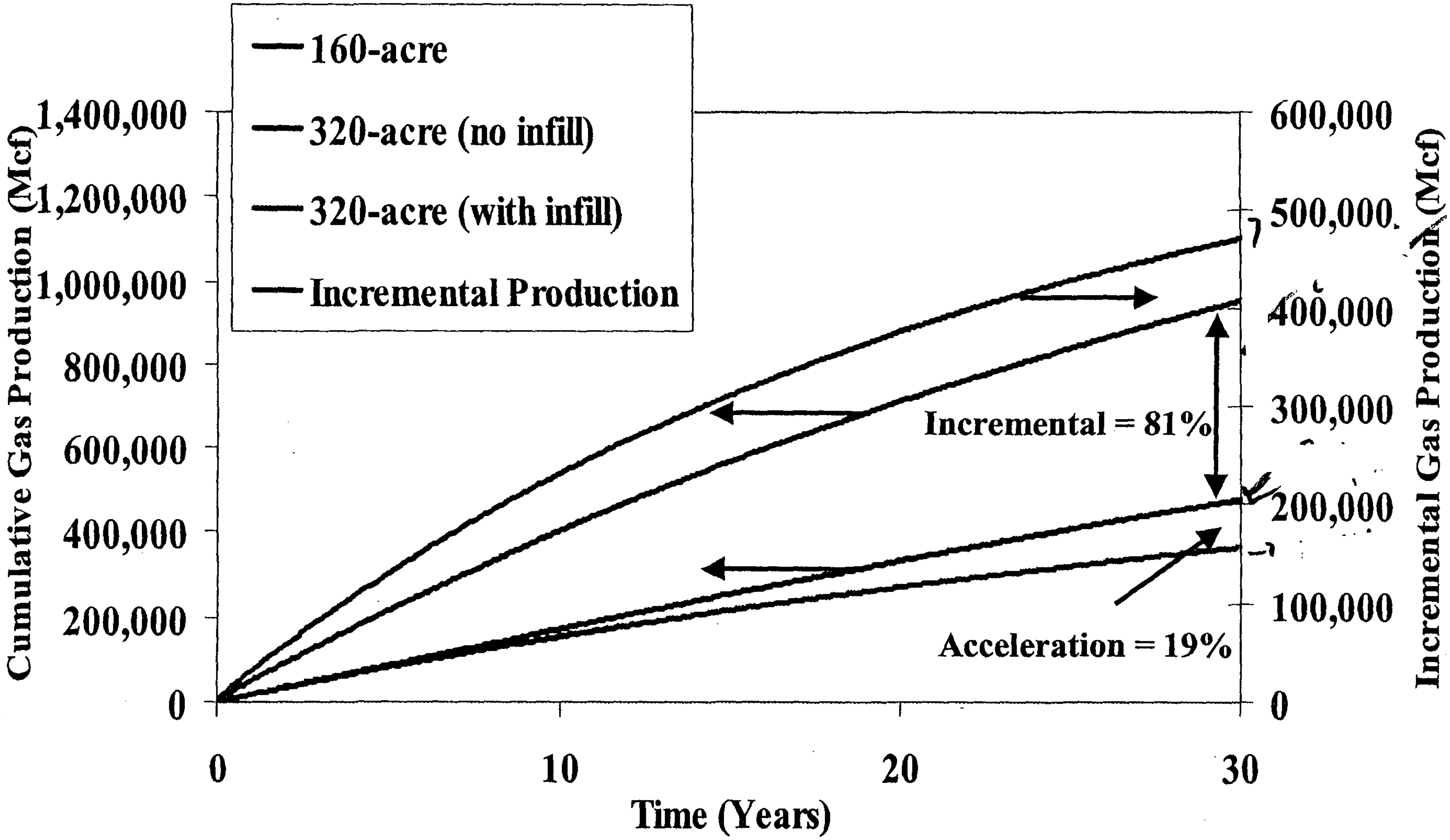
- After-tax Present Value = $13.0 M (Disc. @ 10%)
- Primary economic inputs/assumptions:
  - Incremental economics (160-acre case – 320-acre case)
  - Gas price = $3.25/mmbtu (NYMEX)
  - Operating costs = $1060/well/month
  - Capital costs = $200 M
  - GWI/NRI = 100/84

*Application of Richardson Operating Co.*
Record on Appeal, 1987.

# Pilot Testing/Simulation/Economic Results: Davis #505S Summary

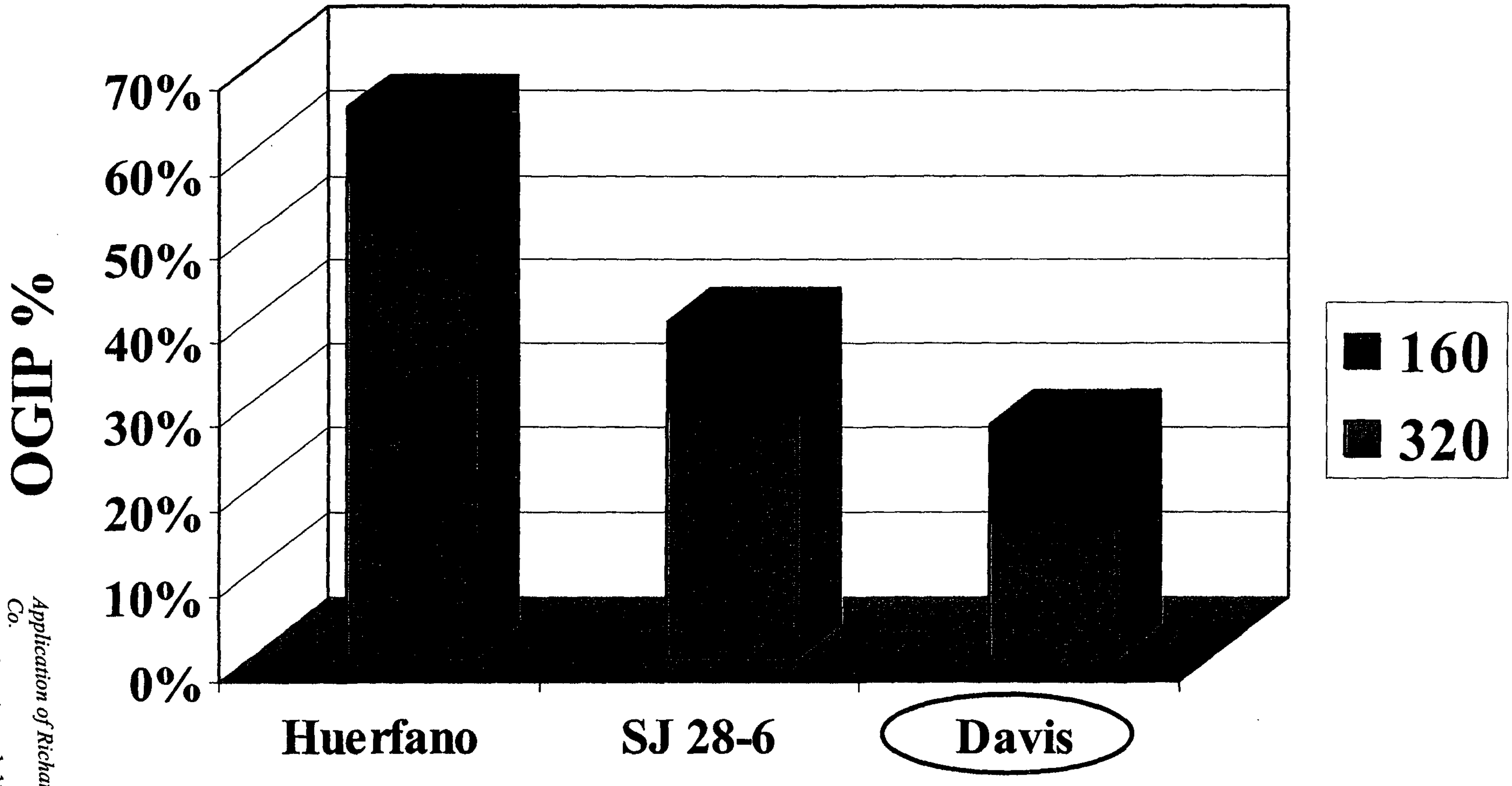
- Sufficient data collected to evaluate pilot area for infill
- Original Gas-In-Place (320-acre) = 4.3 Bcf
- 4 layer pressures collected:
  - All coal layers show little depletion
- 5-layer, dual porosity simulation model used
- Successful history-match of infill well layer pressures and flowing pressures for 4 offset wells
- Scale-up modeling indicates 160-acre infill yields increase in reserves
- Infill recompletes are economic

# Davis Area Increased Density Recovery Profile (2003 – 2033)




*Application of Richardson Operating Co.*
Record on Appeal, 1989.

# Additional Completions Result in Additional Recovery

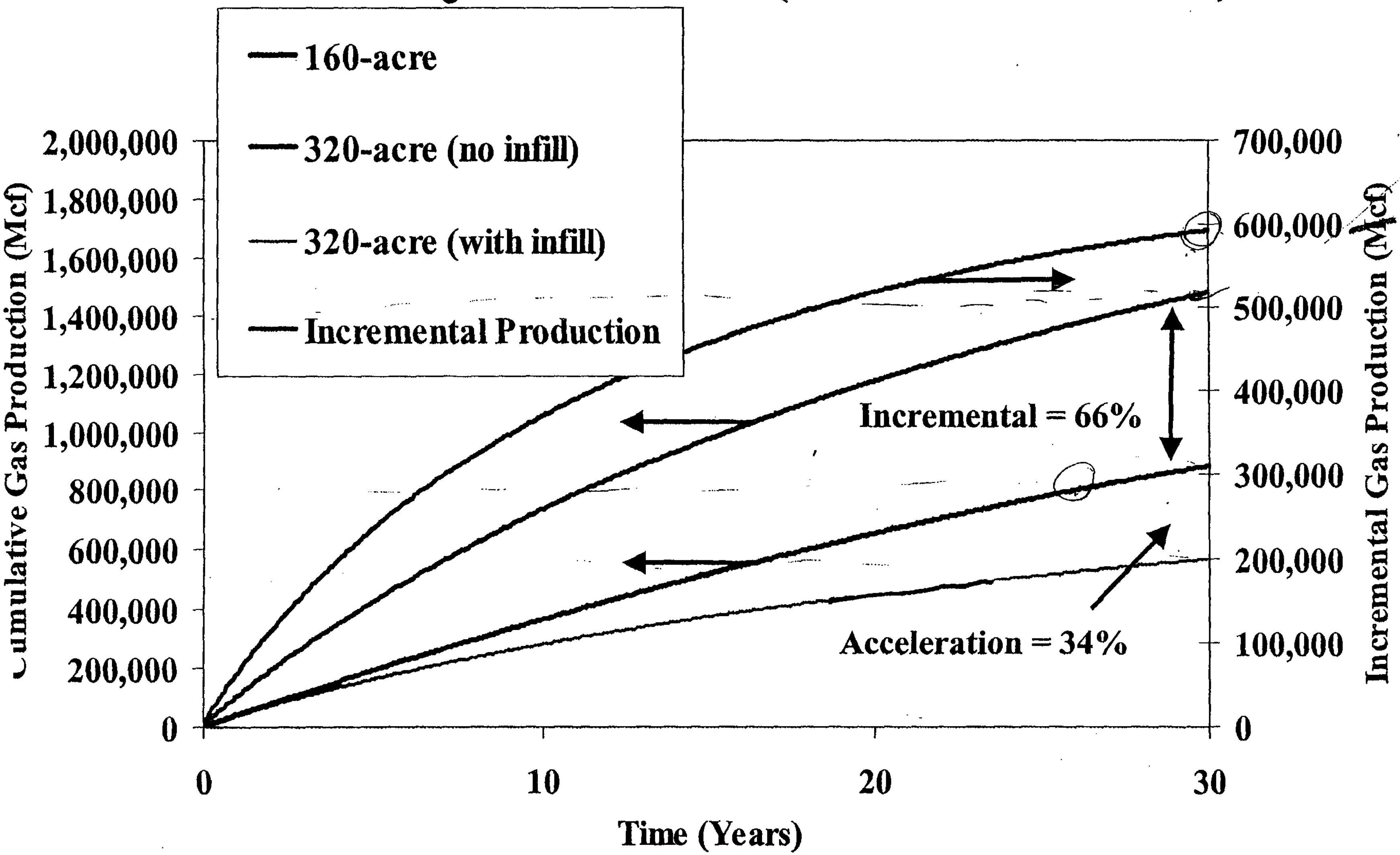



*Application of Richardson Operating Co.*
Record on Appeal, 1990.

# Pilot Testing/Simulation/Economic Results: SJ 28-6 Unit #418S Summary

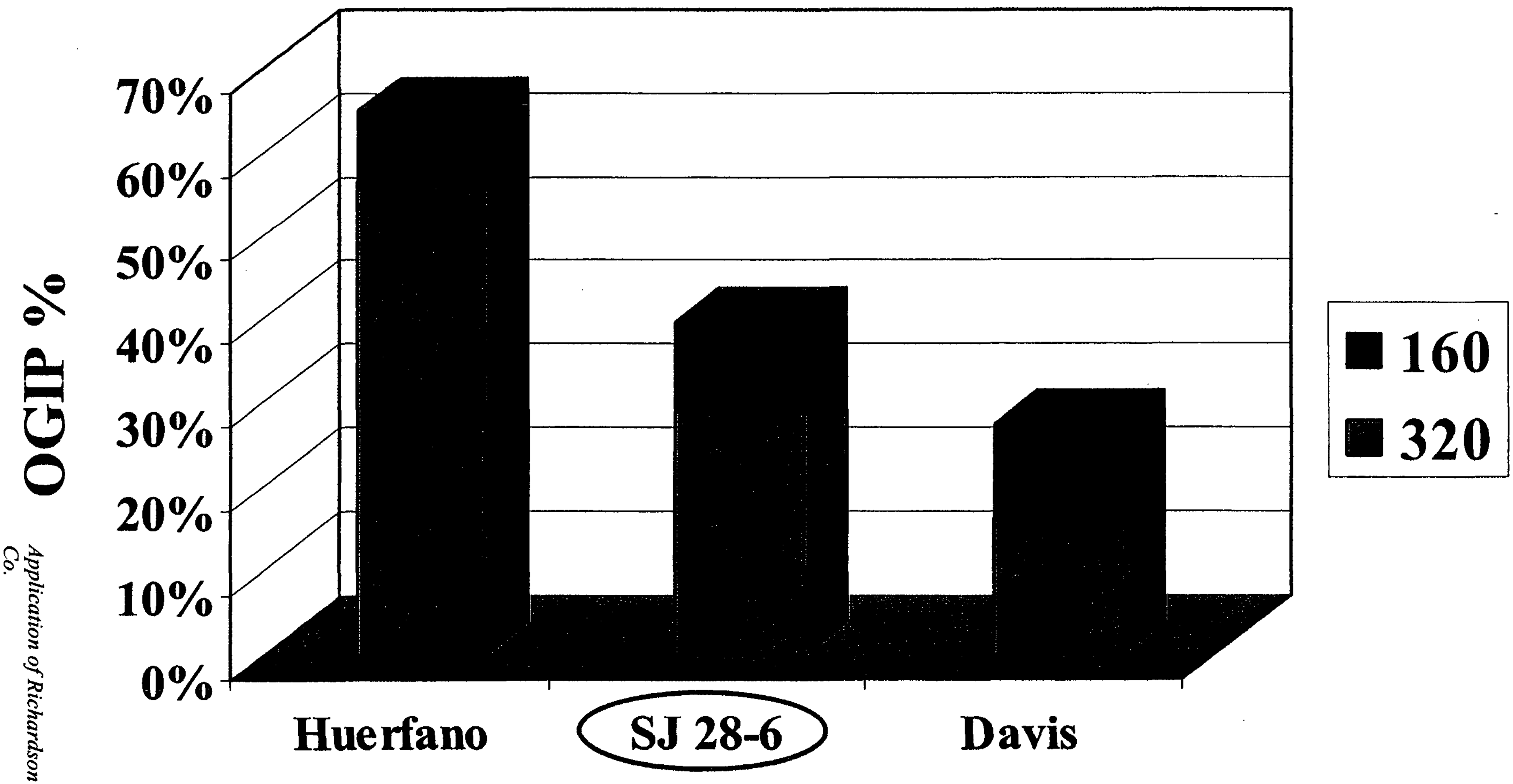
- Sufficient data collected to evaluate pilot area for infill
- Original Gas-In-Place (320-acre) = 5.6 Bcf
- 4 layer pressures collected:
    - Top coal layer shows little depletion, other 3 layers show substantial depletion
- 13-layer, dual porosity simulation model used
- Successful history-match of infill well layer pressures and flowing pressures for 4 offset wells
- Scale-up modeling indicates 160-acre infill yields increase in reserves
- Infill recompletes are economic

# SJ 28-6 Area Increased Density Recovery Profile (2003 – 2033)




*Application of Richardson Operating Co.*
Record on Appeal, 1992.

# Additional Completions Result in Additional Recovery




*Application of Richardson Operating Co.*
Record on Appeal, 1993.