

UNITED STATES DISTRICT COURT
EASTERN DISTRICT OF LOUISIANA

IN RE: OIL SPILL BY THE DOCKET NO. MDL-2179
OIL RIG *DEEPWATER HORIZON* SECTION "J"
IN THE GULF OF MEXICO ON NEW ORLEANS, LA
APRIL 20, 2010 OCTOBER 17, 2013

IN RE: THE COMPLAINT AND DOCKET NO. 10-CV-2771
PETITION OF TRITON ASSET SECTION "J"
LEASING GMBH, ET AL

UNITED STATES OF AMERICA DOCKET NO. 10-CV-4536
V. SECTION "J"
BP EXPLORATION & PRODUCTION,
INC., ET AL

DAY 11 MORNING SESSION
TRANSCRIPT OF NONJURY TRIAL PROCEEDINGS
HEARD BEFORE THE HONORABLE CARL J. BARBIER
UNITED STATES DISTRICT JUDGE

APPEARANCES:

FOR THE PLAINTIFFS: HERMAN HERMAN & KATZ
BY: STEPHEN J. HERMAN, ESQ.
820 O'KEEFE AVENUE
NEW ORLEANS, LA 70113

DOMENGEAUX WRIGHT ROY & EDWARDS
BY: JAMES P. ROY, ESQ.
556 JEFFERSON STREET, SUITE 500
POST OFFICE BOX 3668
LAFAYETTE, LA 70502

1 APPEARANCES CONTINUED:

2
3 LEVIN PAPANTONIO THOMAS MITCHELL
4 RAFFERTY & PROCTOR
5 BY: BRIAN H. BARR, ESQ.
6 316 SOUTH BAYLEN STREET, SUITE 600
7 PENSACOLA, FL 32502

8 WEITZ & LUXENBERG
9 BY: ROBIN L. GREENWALD, ESQ.
10 700 BROADWAY
11 NEW YORK CITY, NY 10003

12 IRPINO LAW FIRM
13 BY: ANTHONY IRPINO, ESQ.
14 2216 MAGAZINE STREET
15 NEW ORLEANS, LA 70130

16 LUNDY, LUNDY, SOILEAU & SOUTH
17 BY: MATTHEW E. LUNDY, ESQ.
18 501 BROAD STREET
19 LAKE CHARLES, LA 70601

20 MORGAN & MORGAN
21 BY: FRANK M. PETOSA, ESQ.
22 188 EAST CAPITOL STREET, SUITE 777
23 JACKSON, MS 39201

24 FOR THE STATES'
25 INTERESTS:

ALABAMA ATTORNEY GENERAL'S OFFICE
BY: COREY L. MAZE, ESQ.
WINFIELD J. SINCLAIR, ESQ.
500 DEXTER AVENUE
MONTGOMERY, AL 36130

1 APPEARANCES CONTINUED:

2

3 FOR THE STATE OF
4 LOUISIANA:

4

STATE OF LOUISIANA
BY: JAMES D. CALDWELL,
ATTORNEY GENERAL
1885 NORTH THIRD STREET
POST OFFICE BOX 94005
BATON ROUGE, LA 70804

5

6

7

8

9

KANNER & WHITELEY
BY: ALLAN KANNER, ESQ.
DOUGLAS R. KRAUS, ESQ.
701 CAMP STREET
NEW ORLEANS, LA 70130

10

11

12

13 FOR THE UNITED STATES
14 OF AMERICA:

U.S. DEPARTMENT OF JUSTICE
TORTS BRANCH, CIVIL DIVISION
BY: STEPHEN G. FLYNN, ESQ.
POST OFFICE BOX 14271
WASHINGTON, DC 20044

15

16

17

18

U.S. DEPARTMENT OF JUSTICE
ENVIRONMENT & NATURAL RESOURCES
DIVISION
ENVIRONMENTAL ENFORCEMENT SECTION
BY: THOMAS BENSON, ESQ.
STEVEN O'ROURKE, ESQ.
SCOTT CERNICH, ESQ.
A. NATHANIEL CHAKERES, ESQ.
ANNA CROSS, ESQ.
BETHANY ENGEL, ESQ.
RICHARD GLADSTEIN, ESQ.
JUDY HARVEY, ESQ.
SARAH HIMMELHOCH, ESQ.
P.O. BOX 7611
WASHINGTON, DC 20044

19

20

21

22

23

24

25

1 APPEARANCES CONTINUED:

2

3 FOR BP EXPLORATION &
4 PRODUCTION INC.,
5 BP AMERICA PRODUCTION
6 COMPANY, BP PLC:

LISKOW & LEWIS
BY: DON K. HAYCRAFT, ESQ.
ONE SHELL SQUARE
701 POYDRAS STREET
SUITE 5000
7 NEW ORLEANS, LA 70139

8

9

KIRKLAND & ELLIS
BY: J. ANDREW LANGAN, ESQ.
10 HARIKLIA KARIS, ESQ.
11 PAUL D. COLLIER, ESQ.
MATTHEW T. REGAN, ESQ.
BARRY E. FIELDS, ESQ.
12 300 N. LASALLE
CHICAGO, IL 60654

13

14

15

16

17

KIRKLAND & ELLIS
BY: MARTIN BOLES, ESQ.
333 SOUTH HOPE STREET
LOS ANGELES, CA 90071

18

19

20

21

KIRKLAND & ELLIS
BY: ROBERT R. GASAWAY, ESQ.
JOSEPH A. EISERT, ESQ.
BRIDGET K. O'CONNOR, ESQ.
655 FIFTEENTH STREET, N.W.
WASHINGTON, DC 20005

22

23

24

25

COVINGTON & BURLING
BY: ROBERT C. "MIKE" BROCK, ESQ.
1201 PENNSYLVANIA AVENUE, NW
WASHINGTON, DC 20004

26

1 APPEARANCES CONTINUED:

2
3 FOR TRANSOCEAN HOLDINGS
4 LLC, TRANSOCEAN
5 OFFSHORE DEEPWATER
6 DRILLING INC., AND
7 TRANSOCEAN DEEPWATER
8 INC.:

FRILOT
BY: KERRY J. MILLER, ESQ.
ENERGY CENTRE
1100 POYDRAS STREET, SUITE 3700
NEW ORLEANS, LA 70163

9
10 SUTHERLAND ASBILL & BRENNAN
11 BY: STEVEN L. ROBERTS, ESQ.
12 1001 FANNIN STREET, SUITE 3700
13 HOUSTON, TX 77002

14 MUNGER TOLLES & OLSON
15 BY: MICHAEL R. DOYEN, ESQ.
16 BRAD D. BRIAN, ESQ.
17 LUIS LI, ESQ.
18 GRANT A. DAVIS-DENNY, ESQ.
19 ALLEN M. KATZ, ESQ.
20 335 SOUTH GRAND AVENUE, 35TH FLOOR
21 LOS ANGELES, CA 90071

22 FOR HALLIBURTON
23 ENERGY SERVICES,
24 INC.:

25 GODWIN LEWIS
BY: DONALD E. GODWIN, ESQ.
JENNY L. MARTINEZ, ESQ.
BRUCE W. BOWMAN, JR., ESQ.
PRESCOTT W. SMITH, ESQ.
SEAN W. FLEMING, ESQ.
RENAISSANCE TOWER
1201 ELM STREET, SUITE 1700
DALLAS, TX 75270.

1 APPEARANCES CONTINUED:

2
3 GODWIN LEWIS
4 BY: R. ALAN YORK, ESQ.
5 GWENDOLYN E. RICHARD, ESQ.
6 1331 LAMAR, SUITE 1665
7 HOUSTON, TX 77010

8 FOR ANADARKO
9 PETROLEUM CORPORATION,
10 ANADARKO E&P COMPANY LP:

11 KUCHLER POLK SCHELL
12 WEINER & RICHESON
13 BY: DEBORAH D. KUCHLER, ESQ.
14 1615 POYDRAS STREET, SUITE 1300
15 NEW ORLEANS, LA 70112

16
17 BINGHAM MCCUTCHEN
18 BY: WARREN A. FITCH, ESQ.
19 KY E. KIRBY, ESQ.
20 2020 K STREET, NW
21 WASHINGTON, DC 20006

22 OFFICIAL COURT REPORTER:

23 SUSAN A. ZIELIE, RMR, CCR
24 CERTIFIED REALTIME REPORTER
25 REGISTERED MERIT REPORTER
500 POYDRAS STREET, ROOM HB406
NEW ORLEANS, LA 70130
(504) 589-7781
susan_zielie@laed.uscourts.gov

26 PROCEEDINGS RECORDED BY MECHANICAL STENOGRAPHY. TRANSCRIPT
27 PRODUCED BY COMPUTER.

I N D E X

1
2
3 *Testimony of:*

4 **MICHAEL ZALDIVAR (Cont)**

5 Redirect by Mr. Fields 2873

6 Cross by Mr. Chakeres 2775

7
8 **SRDJAN NESIC**

9 Direct by Mr. Brock 2843

10 Cross by Ms. Cross 2903

P-R-O-C-E-E-D-I-N-G-S

OCTOBER 17, 2013

M O R N I N G S E S S I O N

(COURT CALLED TO ORDER)

8:00 A.M.

08:07AM 6

08:07AM 7

THE COURT: Good morning, everyone.

08:07AM 8

08:07AM 9

Looks like our government workers will be paid after all. The other side of the table is probably very happy. These people down here are happy. At least until January when we have the next crisis.

08:07AM 10

08:07AM 11

08:07AM 12

Okay.

08:07AM 13

08:07AM 14

MR. FIELDS: Your Honor, just one administrative matter. Barry Fields on behalf of BP.

08:07AM 15

08:07AM 16

I have in my possession a list of the exhibits that were used during the examination of Dr. Robert Zimmerman.

08:07AM 17

08:08AM 18

That list of exhibits was circulated to the parties a couple of days ago. We did not receive an objection. So, at this time, we would offer those exhibits into evidence.

08:08AM 19

08:08AM 20

MS. HIMMELHOCH: No objections.

08:08AM 21

08:08AM 22

THE COURT: Very well. Without objection, those will be admitted.

08:08AM 23

(Exhibits admitted.)

08:08AM 24

MR. FIELDS: Thank you, Your Honor.

08:08AM 25

MS. HIMMELHOCH: Your Honor, Sarah Himmelhoch for the

08:08AM 1 United States. Another short housekeeping matter.

08:08AM 2 Last night, BP filed an offer of proof reasserting
08:08AM 3 their arguments on the surrebuttal motion. It is my
08:08AM 4 understanding that we are not supposed to respond to that, but I
08:08AM 5 wanted direction from the Court as to whether you expected a
08:08AM 6 response.

08:08AM 7 THE COURT: I haven't even seen that, so I have no idea
08:08AM 8 what that's about.

08:08AM 9 MS. HIMMELHOCH: Okay. We'll await an order from the
08:08AM 10 Court before filing a response, sir.

08:08AM 11 THE COURT: All right.

08:08AM 12 MS. PENCAK: Good morning, Your Honor. Erica Pencak
08:08AM 13 for the United States. Just one more preliminary matter. I
08:08AM 14 have list of the United States call-outs, demonstratives, and
08:08AM 15 exhibits used in the United States' examination of Drs. Merrill,
08:08AM 16 Gringarten, and Zimmerman.

08:08AM 17 We've circulated these lists to the parties and
08:09AM 18 received no objections.

08:09AM 19 THE COURT: Okay. Any remaining objections?

08:09AM 20 Hearing none, those are admitted.

08:09AM 21 (Exhibits admitted.)

08:09AM 22 MS. PENCAK: Thank you, Your Honor.

08:09AM 23 THE COURT: All right. According to our timekeepers,
08:09AM 24 United States has used 16 hours, 33 minutes. There's 28:27
08:09AM 25 remaining. BP has used 21 hours and 49 minutes. They have

08:09AM 1 23:11 remaining.

08:09AM 2 Good morning, Dr. Zaldivar. You're still under
08:09AM 3 oath.

08:09AM 4 THE WITNESS: Yes.

08:09AM 5 MR. CHAKERES: Your Honor, may it please the Court?

08:09AM 6 THE COURT: Go ahead.

08:09AM 7 CROSS EXAMINATION

08:09AM 8 BY MR. CHAKERES:

08:09AM 9 Q Nat Chakeres on behalf of the United States. Dr. Zaldivar,
08:09AM 10 I have you on cross examination.

08:09AM 11 Dr. Zaldivar, your model is a one-dimensional
08:09AM 12 model; correct?

08:09AM 13 A That's correct.

08:09AM 14 Q The results that come out of your modeling that will you
08:09AM 15 present to the Court are mass flow rates; right?

08:09AM 16 A Those aren't the only results. What I presented to the
08:10AM 17 Court yesterday were volumetric flow rates.

08:10AM 18 The model itself works in a basis of units that is
08:10AM 19 mass based.

08:10AM 20 Q Are stock tank barrels a defined unit of mass or a defined
08:10AM 21 unit of volume?

08:10AM 22 A That's a unit of volume. That's a volumetric flow rate.

08:10AM 23 Q You used a single stage flash process to convert the total
08:10AM 24 mass flow rate in your model for stock tank barrels; correct?

08:10AM 25 A That's correct.

08:10AM 1 Q Before we get too far along, I wanted to make sure we have
08:10AM 2 some terms and definitions out there. That, we're speaking the
08:10AM 3 same language.

08:10AM 4 You had a demonstrative yesterday where you
08:10AM 5 described different flow patterns.

08:10AM 6 Do you remember that?

08:10AM 7 A Yes, I do.

08:10AM 8 Q It included stratified flows, stratified wavy flow, slug
08:10AM 9 flow, and other types of flow patterns; right?

08:10AM 10 A Yes, that's correct.

08:10AM 11 Q I might at some point call those flow regimes; that the same
08:10AM 12 sort of thing?

08:10AM 13 A Flow patterns and flow regimes are two commonly used words,
08:11AM 14 yes, that's correct.

08:11AM 15 Q Thank you, sir.

08:11AM 16 Now, I want to go back to this mass flow rate
08:11AM 17 issue. For a single phase fluid, we'll stick with that, can we
08:11AM 18 say that mass flow rate is equal to the density of the fluid
08:11AM 19 times its mean velocity times the area through which it's
08:11AM 20 flowing? Is that a definition of mass flow rate?

08:11AM 21 A Could you repeat that?

08:11AM 22 Q Yes.

08:11AM 23 And, actually, I've got a demonstrative just so we
08:11AM 24 don't have to keep all this stuff in our head.

08:11AM 25 MR. CHAKERES: If we could pull up demonstrative

08:11AM 1 D-0221.

08:11AM 2 BY MR. CHAKERES:

08:11AM 3 Q And, again, we'll stick with single phase flow right now.

08:11AM 4 Is this an accurate representation and equation of
08:11AM 5 mass flow rate along one dimension?

08:11AM 6 A Yes, that's correct.

08:11AM 7 Q Okay. And, for multiphase flow, you had multiphase flow in
08:11AM 8 your model; correct?

08:11AM 9 A That's also correct.

08:11AM 10 Q We would have to make this a little bit more involved;
08:11AM 11 right? We would have a mass flow rate for gas phase and a mass
08:12AM 12 flow rate for the liquid phase; right?

08:12AM 13 A Yes, that's correct.

08:12AM 14 Q And the mass in both the gas phase and the liquid phase
08:12AM 15 would have their own densities; right?

08:12AM 16 A Yes.

08:12AM 17 Q And both would have their own velocity; right?

08:12AM 18 A Yes, that's correct.

08:12AM 19 Q And then we would have an area for flow for each of them;
08:12AM 20 right?

08:12AM 21 A Yes. That's also correct.

08:12AM 22 Q And, before we get too far along, you've spoke in your
08:12AM 23 deposition about something called superficial velocity; right?

08:12AM 24 A Um-hum.

08:12AM 25 Q Is it fair to say that, if we are using the word superficial

08:12AM 1 velocity, that's just the velocity of that phase, and then we
08:12AM 2 don't have to worry about how much of the area is taken up for
08:12AM 3 that phase?

08:12AM 4 A It's the average phase velocity.

08:12AM 5 Q The average phase velocity averaged across the entire flow
08:12AM 6 area?

08:12AM 7 A Averaged across the area that it's flowing, yes.

08:12AM 8 Q So this equation is the definition of mass flow rate, but we
08:13AM 9 have mass flow rates for both phases in a multiphase
08:13AM 10 environment; correct?

08:13AM 11 A Yes. You also have the total mass flow rate, so that --

08:13AM 12 Q And that is the sum of the mass flow rate for each phase;
08:13AM 13 right?

08:13AM 14 A Yeah. That equation could apply to the multiphase flow if
08:13AM 15 the velocity itself was the average mixture velocity.

08:13AM 16 Q I appreciate that. Thanks. We can take down that
08:13AM 17 demonstrative.

08:13AM 18 Now, your flow rate estimate that you presented to
08:13AM 19 the Court consists of an estimate of flow out the end of the
08:13AM 20 riser and an estimate of flow out of the kink leaks; correct?

08:13AM 21 A That's correct.

08:13AM 22 Q And you described yesterday how you went through arriving at
08:13AM 23 both of those estimates.

08:13AM 24 For the estimate of the flow out of the riser, you
08:13AM 25 used LedaFlow to predict the flow rates at which observed slug

08:13AM 1 behavior took place; right?

08:13AM 2 A That's correct.

08:13AM 3 Q You looked at two points in time, May 13th and May 16th;
08:13AM 4 correct?

08:13AM 5 A Yes, that's also correct.

08:13AM 6 Q And you also looked at the period after May 20th to see what
08:14AM 7 flow rates would result in the riser being flat along the floor
08:14AM 8 of the ocean; correct?

08:14AM 9 A No. That's not precisely correct.

08:14AM 10 Q How is that not correct?

08:14AM 11 A I didn't model any time period past May 20th.

08:14AM 12 I did look at that period with respect to looking
08:14AM 13 at ROV videos to ensure that slug flow was not present after May
08:14AM 14 20th.

08:14AM 15 Q Thanks for that clarification.

08:14AM 16 Now, you don't opine anywhere in your report that
08:14AM 17 the flow out of the end of the riser was changing between May
08:14AM 18 13th and May 20th; do you?

08:14AM 19 A No, I do not.

08:14AM 20 Q You provide the same estimate for each of the days, May 13th
08:14AM 21 through 20th, at the end of the riser; correct?

08:14AM 22 A I provide the same best estimated flow rate, but I do
08:14AM 23 provide a range of flow rates over the full period.

08:14AM 24 Q Okay. Thank you.

08:14AM 25 Now, you testified yesterday about something

08:14AM 1 called a hydraulic diameter, and I'd like to go into that a
08:14AM 2 little bit now.

08:15AM 3 Now, the diameter of the flow path in your model
08:15AM 4 was what you were referring to as the hydraulic diameter;
08:15AM 5 correct?

08:15AM 6 A Yes, that's correct.

08:15AM 7 Q So, in your model, the information you gave LedaFlow about
08:15AM 8 the size of the flow path was the hydraulic diameter; correct?

08:15AM 9 A Yes. That's an input -- you have to input the diameter into
08:15AM 10 the model, and that's the diameter that I used.

08:15AM 11 Q And you testified yesterday that the hydraulic diameter is a
08:15AM 12 standard geometric transform that you use when you have a
08:15AM 13 noncircular flow path; is that correct?

08:15AM 14 A A standard geometric transformation. But, yes, that's
08:15AM 15 correct.

08:15AM 16 Q It's standardly used in fluid mechanics problems; correct?

08:15AM 17 A Yes.

08:15AM 18 Q And it's been used in steady state flow problems; correct?

08:15AM 19 A Yes.

08:15AM 20 Q It's been used in transient flow problems; correct?

08:15AM 21 A Yes, that's correct. Also correct.

08:15AM 22 Q It's used in single phase flow problems; correct?

08:15AM 23 A Yes, that's correct.

08:15AM 24 Q It's used in multiphase flow problems; is that correct?

08:16AM 25 A Yes, that's correct.

08:16AM 1 Q It's used in problems where there's constant density;
08:16AM 2 correct?

08:16AM 3 A Most of the time that you're modeling flow, certainly if
08:16AM 4 you're looking at large-scale flow phenomenon, you would expect
08:16AM 5 that the density would be changing because pressure and
08:16AM 6 temperature would be changing.

08:16AM 7 I am sure that it probably has been used; but,
08:16AM 8 certainly, the problems that I'm most familiar looking at are
08:16AM 9 large-scale problems, so you wouldn't presume that the density
08:16AM 10 doesn't change over the model itself.

08:16AM 11 Q Thank you.

08:16AM 12 And my question was just, if I were to perform --
08:16AM 13 look at a problem where, say, it was an incompressible fluid and
08:16AM 14 I didn't have to worry about density changes, you would expect
08:16AM 15 the hydraulic diameter concept to still apply in those types of
08:16AM 16 problems?

08:16AM 17 A I would expect that to be true. But, to be clear, this
08:16AM 18 particular problem is compressible fluid. Gas is quite
08:17AM 19 compressible, and multiphase flow is considered a compressible
08:17AM 20 flow problem.

08:17AM 21 Q I appreciate that.

08:17AM 22 MR. CHAKERES: Now, if we could go to demonstrative
08:17AM 23 D-22210.

08:17AM 24 BY MR. CHAKERES:

08:17AM 25 Q You talked about this a little bit yesterday, and I just

08:17AM 1 wanted to go through it again. So I have here on the left a
08:17AM 2 pipe that has the drill pipe inside it.

08:17AM 3 Do you see that?

08:17AM 4 A I do.

08:17AM 5 Q And, for your model of the riser, the large -- there are
08:17AM 6 several different segments that have different diameters of the
08:17AM 7 drill pipe inside of it; right?

08:17AM 8 A Yes, that's correct. The drill pipe did not have the same
08:17AM 9 diameter down the length of the riser.

08:17AM 10 Q The large majority of the riser, though, had 6.625 inch
08:17AM 11 drill pipe inside of it; right?

08:17AM 12 A By large majority, about three-quarters of the riser, or
08:17AM 13 near that amount, had that specific drill pipe diameter.

08:17AM 14 Q We'll take that.

08:18AM 15 And the general form of the equation for a
08:18AM 16 hydraulic diameter is four times the area through which the
08:18AM 17 fluid is flowing divided by perimeter, the wetted perimeter;
08:18AM 18 correct?

08:18AM 19 A That's correct.

08:18AM 20 Q And you describe that in your report; correct?

08:18AM 21 A I do.

08:18AM 22 Q And, specifically for an annular flow, you derived sort of a
08:18AM 23 shortcut, which is true for all annular flows, which the
08:18AM 24 hydraulic diameter is equal to the diameter of the big pipe, the
08:18AM 25 inner diameter of the big pipe, minus the outer diameter of the

08:18AM 1 little pipe; is that correct?

08:18AM 2 A Yeah. I wouldn't describe it as a shortcut. If you apply
08:18AM 3 the formula $4A$ over P and you simplify that formula, you can
08:18AM 4 simplify it to that specific relationship for flow in any
08:18AM 5 annulus.

08:18AM 6 Q It means the exact same thing as $4A$ over P for annular flow
08:19AM 7 path; doesn't it?

08:19AM 8 A Yes, that's correct.

08:19AM 9 Q And, if we were to pretend the drill pipe were perfectly
08:19AM 10 centered in the riser, the hydraulic diameter is equal to double
08:19AM 11 the gap between the inner pipe and the outer pipe; isn't it?

08:19AM 12 A Could you repeat that?

08:19AM 13 Q Yes.

08:19AM 14 So presuming the drill pipe is perfectly centered,
08:19AM 15 there's a gap between the drill pipe and the riser; right?

08:19AM 16 A That's correct.

08:19AM 17 Q And the hydraulic diameter would be double that gap; right?

08:19AM 18 A So, if you're asking me in this specific example that if
08:19AM 19 12.875 minus 6.625 is approximately two-thirds, so there would
08:19AM 20 be half of it on both sides, yes, that's correct.

08:19AM 21 Q That wasn't quite my question.

08:19AM 22 My question was, so you have -- the derivation of
08:19AM 23 the hydraulic diameter is the big pipe diameter minus the small
08:20AM 24 pipe diameter; right?

08:20AM 25 A That's correct.

08:20AM 1 Q Half of that would then be the big pipe radius minus the
08:20AM 2 small pipe radius; right?

08:20AM 3 A Half of what specifically?

08:20AM 4 Q Half of the hydraulic diameter.

08:20AM 5 A Half of 12.875 is 6.4 something.

08:20AM 6 Q And I'm not trying to say that this is one-third of the
08:20AM 7 whole thing.

08:20AM 8 I'm saying, for any annular flow path, the gap
08:20AM 9 between the drill pipe and the riser times two is the hydraulic
08:20AM 10 diameter; right?

08:20AM 11 A I am not sure that that's generally true without deriving
08:20AM 12 it. Certainly, you could imagine a pipe that's very small --
08:20AM 13 yeah, it might be true, though.

08:20AM 14 Q So this formula -- and we'll look at that again. So this
08:20AM 15 formula, it's not true just for the annular flow path that you
08:20AM 16 modeled; right? It's true for any annular flow path. That's
08:21AM 17 the hydraulic diameter for that annular flow path; right?

08:21AM 18 A That is true.

08:21AM 19 Q Okay. We can pull that demonstrative. We'll come back to
08:21AM 20 that in a minute.

08:21AM 21 Now, you testified in your deposition that the
08:21AM 22 reason why you use a hydraulic diameter as opposed to the actual
08:21AM 23 -- or the diameter relating to the actual flow area is because
08:21AM 24 you want to maintain the ratio between the cross-sectional area
08:21AM 25 of the flow and the wetted perimeter; correct?

08:21AM 1 A That's correct.

08:21AM 2 Q And is it correct to say that the reason you do this is
08:21AM 3 because the cross-sectional area for flow is proportional to the
08:21AM 4 driving force, there's a pressure drop for the pipe, and the
08:21AM 5 wetted perimeter is proportional to the frictional force acting
08:21AM 6 against flow?

08:21AM 7 A Yes. I would generally agree with that. I don't know that
08:21AM 8 I would say that they're directly proportional, but there is a
08:21AM 9 relationship between those.

08:21AM 10 Q And that relationship is why you need to maintain the ratio
08:22AM 11 between the area in the wetted perimeter; right?

08:22AM 12 A Yeah. In order to correctly capture the relationship
08:22AM 13 between pressure drop and volumetric flow rate or flow rate
08:22AM 14 period.

08:22AM 15 Q Now, you testified in your deposition that LedaFlow uses the
08:22AM 16 hydraulic diameter and calculates the pressure drop based on
08:22AM 17 velocities and frictional losses associated with those
08:22AM 18 velocities; correct?

08:22AM 19 A That's correct.

08:22AM 20 Q And so the fluid velocities in the system are used in
08:22AM 21 conjunction with the hydraulic diameter to calculate pressure
08:22AM 22 drops; correct?

08:22AM 23 A Yes, that's correct.

08:22AM 24 Q You want to accurately capture the pressure drops in the
08:22AM 25 system; right?

08:22AM 1 A That's correct.

08:22AM 2 Q And that's why you used the hydraulic diameter; correct?

08:22AM 3 A That's also correct.

08:22AM 4 Q You also want the velocities in your model to be correct;
08:22AM 5 correct?

08:22AM 6 A No, that's not correct.

08:22AM 7 Q You do not want the velocities in your model to be accurate?

08:22AM 8 A I think, ideally, I would want to capture the correct two
08:22AM 9 representation of the velocities.

08:22AM 10 However, when you make a geometric transformation,
08:23AM 11 such as the hydraulic diameter geometric transformation,
08:23AM 12 essentially what you're doing is you're narrowing the area of
08:23AM 13 the pipe itself.

08:23AM 14 When you do that, you increase the speed of the
08:23AM 15 fluid in that pipe in order to correctly capture the
08:23AM 16 relationship between pressure dropping and flow rate.

08:23AM 17 Essentially, if you think of his demonstrative
08:23AM 18 where you have a drill pipe flowing through the center of it,
08:23AM 19 that drill pipe has -- exerts extra frictional resistance to
08:23AM 20 flow.

08:23AM 21 And what the hydraulic diameter does, is it takes
08:23AM 22 a smaller pipe so that you get the same resistance to flow and
08:23AM 23 then the fluid flows faster.

08:23AM 24 Q So it's your testimony that the velocities in your model
08:23AM 25 were not the accurate velocities that were present in the

08:23AM 1 Macondo riser?

08:23AM 2 A Yes, that's correct. What my model captures correctly is
08:23AM 3 the volumetric flow rate and pressure drops.

08:24AM 4 Q Now, you testified in your deposition that you ran your
08:24AM 5 model for a while, an hour, two hours, to stabilize the velocity
08:24AM 6 profiles, the pressure profiles, temperature profiles, and the
08:24AM 7 density profiles before you imposed the oscillation of the
08:24AM 8 riser. Do you remember that?

08:24AM 9 A I do.

08:24AM 10 Q And you testified that you wanted to have your velocity
08:24AM 11 profiles that were as near as the actual conditions as possible
08:24AM 12 before starting to move the riser; do you recall that?

08:24AM 13 A I do.

08:24AM 14 MR. FIELDS: Your Honor, may I be heard? Barry Fields.

08:24AM 15 The one issue I have is, it's not really
08:24AM 16 appropriate to talk about what he testified in his deposition.
08:24AM 17 You can ask a question and get an answer here, but that's not a
08:24AM 18 proper --

08:24AM 19 THE COURT: That's correct. Wait a minute. Ask the
08:24AM 20 witness a question, and obviously you can phrase your question
08:24AM 21 based on something that was said in the deposition. But phrase
08:24AM 22 it as a question.

08:24AM 23 If he gives an answer that you think is contrary
08:24AM 24 to what he said in his deposition, then you can use his
08:25AM 25 deposition; okay?

08:25AM 1 MR. CHAKERES: I will do so, Your Honor.

08:25AM 2 BY MR. CHAKERES:

08:25AM 3 Q So, when you ran your model, you ran it at a steady state
08:25AM 4 for a certain period of time in order to allow it to stabilize
08:25AM 5 before oscillating the riser; correct?

08:25AM 6 A That's correct.

08:25AM 7 Q And the reason you did that was because you wanted to get
08:25AM 8 representative temperature profiles, pressure profiles, density
08:25AM 9 profiles and velocity profiles that were as near the actual
08:25AM 10 conditions as possible before you started to move the riser;
08:25AM 11 correct?

08:25AM 12 A Yes. So, when you start one of these models, you have to
08:25AM 13 spend some time allowing the model to stabilize. Because, when
08:25AM 14 you jump into the Macondo well on May 13th, well, it had been
08:25AM 15 flowing for some time, which means that it had temperature
08:25AM 16 profiles across the walls. As I described earlier, you have the
08:25AM 17 riser, and there's a temperature gradient; and then there's the
08:25AM 18 buoyancy model, and there's a temperature gradient. And all of
08:25AM 19 those materials hold heat.

08:26AM 20 And so, when you build a model, you run it to
08:26AM 21 steady state or you run it until all the conditions stabilize so
08:26AM 22 that you do have these stable representative pressure profiles
08:26AM 23 and temperature profiles throughout the model.

08:26AM 24 Q But your testimony now is that your velocity profile is not
08:26AM 25 representative of what was actually in the riser; correct?

08:26AM 1 A It wasn't the true velocity. It was a representative
08:26AM 2 profile of a stable profile for those conditions. Yes, that's
08:26AM 3 correct.

08:26AM 4 Q And those conditions means a smaller pipe than what was
08:26AM 5 actually in the Macondo riser; right?

08:26AM 6 A It means, yeah, I used the geometric transformation for
08:26AM 7 hydraulic diameter. And, in doing so, I have to allow my model
08:26AM 8 to stabilize. I have to allow it to start from something that
08:26AM 9 would represent those conditions that Macondo was in, yes.

08:26AM 10 Q Now, yesterday you testified a little bit about flow
08:27AM 11 patterns; right?

08:27AM 12 A I did.

08:27AM 13 Q And you stated -- and if we could pull up -- well, we'll
08:27AM 14 keep going along.

08:27AM 15 You stated that if you have stratified flow, that
08:27AM 16 corresponds to slow gas flow and slow liquid flow; right?

08:27AM 17 A I don't think I used those exact words.

08:27AM 18 Stratified flow is the velocities, we're talking
08:27AM 19 about superficial velocities or average phase velocities, and it
08:27AM 20 generally is present when the ratio between the gas velocities
08:27AM 21 and the liquid velocities are near each other.

08:27AM 22 It could be moving quite fast. But, if the gas is
08:27AM 23 moving faster than the liquid, you would see waves or ripples on
08:27AM 24 the surface of the liquid.

08:27AM 25 If they're moving at the same speed, you're going

08:27AM 1 to see liquid at the bottom of the pipe with gas on the top of
08:27AM 2 the pipe, and you won't see much rippling in the surface.

08:28AM 3 THE COURT: No matter what the speed?

08:28AM 4 THE WITNESS: No matter what the speed.

08:28AM 5 BY MR. CHAKERES:

08:28AM 6 Q So, if both of them were moving, say, one meter per year,
08:28AM 7 very, very slowly, right, you would not see the ripples on the
08:28AM 8 waves; right?

08:28AM 9 A Not if they were moving at the same speed, no.

08:28AM 10 Q Then let's double the gas to two meters per year. That's
08:28AM 11 still very, very slow; right?

08:28AM 12 A Just the gas portions of the liquid?

08:28AM 13 Q The liquid is still moving at one meter per year.

08:28AM 14 A Yes.

08:28AM 15 Q And the gas is now moving at two meters per year. Very,
08:28AM 16 very slow. Are you going to be seeing waves kicking up there?

08:28AM 17 A I would guess not likely.

08:28AM 18 Of course, to know the answer to that, you would
08:28AM 19 need to model the specifics of the fluid. You'd need to know
08:28AM 20 something about the interfacial friction; you'd need to know
08:28AM 21 something about the particular fluid viscosity. The thicker
08:28AM 22 fluids tend not to ripple as easily.

08:28AM 23 So there's lots of sophistication and complexity
08:28AM 24 to multiphase flow. In that particular example with very
08:29AM 25 slow-moving fluids, I would say it's unlikely. But, without a

08:29AM 1 specific example, I don't know that.

08:29AM 2 I can generally answer that question for all
08:29AM 3 problems.

08:29AM 4 Q Now let's assume the fluids were moving at 10 meters per
08:29AM 5 second. Both the gas and the liquid are moving at 10 meters per
08:29AM 6 second. Are you with me?

08:29AM 7 A I am.

08:29AM 8 Q Much faster flow through the riser; right?

08:29AM 9 A That's correct.

08:29AM 10 Q Now we double the gas velocity there from 10 meters per
08:29AM 11 second to 20 meters per second.

08:29AM 12 Do you think it's going to be the same change in
08:29AM 13 flow patterns as you had when the flows were thousands of times
08:29AM 14 smaller?

08:29AM 15 A No, probably not. Again, you have to look specifically at
08:29AM 16 the fluid conditions in order to draw general conclusions.

08:29AM 17 MR. CHAKERES: Let's look at demonstrative D-2205.

08:29AM 18 BY MR. CHAKERES:

08:30AM 19 Q Now, we have here -- over here on the left is the actual
08:30AM 20 riser. We have the outer diameter of 915.5 inches, or diameter
08:30AM 21 of the outer pipe 915.5 inches, diameter of the inner pipe 6.625
08:30AM 22 inches.

08:30AM 23 Do you see that?

08:30AM 24 A I do.

08:30AM 25 Q And now we have your model. It's got a hydraulic diameter

08:30AM 1 of 12.875 inches; right?

08:30AM 2 A That's correct.

08:30AM 3 Q Now, I'll just throw out a hypothetical here. I've
08:30AM 4 multiplied my -- the riser by 3, but I've maintained the
08:30AM 5 difference between the diameter of the outer pipe and the inner
08:30AM 6 pipe. So I have the same hydraulic diameter. And we can
08:30AM 7 subtract these if you want. But those should come out to 12.875
08:30AM 8 inches.

08:30AM 9 Do you see that?

08:30AM 10 A I do.

08:30AM 11 Q The flow area for this large pipe is about 1050 square
08:30AM 12 inches.

08:30AM 13 Do you see that?

08:30AM 14 A I do.

08:30AM 15 Q The flow area for your model is about 130 square inches.

08:31AM 16 Do you see that?

08:31AM 17 A I do.

08:31AM 18 Q Now, we have the same hydraulic diameter in both of these
08:31AM 19 cases; don't we?

08:31AM 20 A Yes. That's precisely the point.

08:31AM 21 Q Precisely the point. I'm sorry. Let you finish.

08:31AM 22 A You can't think of this in terms of -- I mentioned this as a
08:31AM 23 counterintuitive phenomenon. I mean, if you think about it --
08:31AM 24 unfortunately, everything in science isn't intuitive. This is
08:31AM 25 one of those situations where it's not the most intuitive

08:31AM 1 situation.

08:31AM 2 But, in this particular example, yes, it's exactly
08:31AM 3 the same hydraulic diameter. If you have a straw with an
08:31AM 4 obstruction and you're trying to suck fluid into your mouth,
08:31AM 5 that straw requires you to exert more effort.

08:31AM 6 You can take a smaller straw and exert the same
08:31AM 7 amount of effort and get the exact same amount of fluid in your
08:31AM 8 mouth.

08:31AM 9 If you have a big, big straw with a big, big straw
08:31AM 10 in the center of it, in terms of the amount of force to get the
08:32AM 11 same fluid, or the volumetric flow rate, it's the exact same
08:32AM 12 force.

08:32AM 13 Q Well, it's not really counterintuitive when we say that
08:32AM 14 we're maintaining the velocities across these; is it?

08:32AM 15 Because we have here about the same distance from,
08:32AM 16 you know, the inner wall and the outer wall, so we're
08:32AM 17 maintaining the relationship between the area for flow and the
08:32AM 18 wetted perimeter.

08:32AM 19 So, if we say that the frictional pressure drop
08:32AM 20 versus velocity relationship stays the same across all of these,
08:32AM 21 it's not so counterintuitive; is it?

08:32AM 22 A It may not be counterintuitive to you, but it would also be
08:32AM 23 incorrect to do so.

08:32AM 24 Q So is it your testimony that, for a given pressure drop,
08:32AM 25 same pressure drop across each of these three examples -- same

08:32AM 1 fluid, same temperature, everything -- for the same pressure
08:32AM 2 drop, you are going to get the same amount of flow through each
08:32AM 3 of these?

08:32AM 4 A Not the same velocity; but you will get the same volumetric
08:32AM 5 flow rate, yes, that's correct.

08:33AM 6 Q So I can keep expanding this riser over here. I can push
08:33AM 7 this riser out to a thousand; and, as long as I have the same
08:33AM 8 hydraulic diameter, just by pushing my inner pipe out in the
08:33AM 9 same way, I can increase my area for flow up to a thousand.

08:33AM 10 I have the same pressure drop pushing flow through
08:33AM 11 this giant riser as I do through your little model, and I'm
08:33AM 12 going to get the same amount of flow through there?

08:33AM 13 A Well, I don't agree with the premise that you can extend
08:33AM 14 this model to infinity. At some point, and you might actually
08:33AM 15 be approaching that point in this particular example, you
08:33AM 16 approach what's called flow between two parallel plates.

08:33AM 17 But, in general, despite the fact that it's
08:33AM 18 counterintuitive, it is correct.

08:33AM 19 Q If I extend this thing out to a thousand, if I am
08:33AM 20 maintaining a relationship between the velocity and the pressure
08:33AM 21 drop, because every bit of flow has got a similar amount of drag
08:33AM 22 because it's got a similar amount of space to flow through, it's
08:34AM 23 not really counterintuitive if I maintain the velocity but I
08:34AM 24 allow my mass flow rates or volumetric flow rates to vary in
08:34AM 25 this case; is it?

08:34AM 1 A Yeah. But, unfortunately, that's not what the science tells
08:34AM 2 us to be true.

08:34AM 3 Q So you think the hydraulic diameter concept breaks down
08:34AM 4 around here, but it's still okay over here?

08:34AM 5 A No. I think it's probably okay in the 3X scenario; however,
08:34AM 6 you cannot extend this riser out bigger and bigger and bigger.
08:34AM 7 Eventually, you're going to get to a situation where the fluid,
08:34AM 8 for instance at the top of the pipe, has no interaction with the
08:34AM 9 fluid at the bottom of the pipe.

08:34AM 10 It would be the equivalent of imaging a pipe the
08:34AM 11 size of the earth with a tiny little layer. Well of course the
08:34AM 12 fluid here would have no idea what the fluid there is doing.

08:34AM 13 There are specific ratios where when you extend
08:34AM 14 this out to large, large system with very large inner pipes
08:34AM 15 where hydraulic diameter is not considered the correct geometric
08:35AM 16 transformation.

08:35AM 17 But, for the purpose of the demonstration, I'm
08:35AM 18 going with it. It is counterintuitive; and, yes, this model is
08:35AM 19 the correct answer.

08:35AM 20 Unfortunately, no, it doesn't give you the true
08:35AM 21 velocities, but it does give you the correct relationship
08:35AM 22 between pressure drop and flow rate.

08:35AM 23 Q So let's go to an expert report from one of your colleagues.
08:35AM 24 It's Exhibit 11488. Page 24.

08:35AM 25 BY MR. CHAKERES: If we could call out figure 9.

08:35AM 1 BY MR. CHAKERES:

08:35AM 2 Q Did you read the expert report of Adrian Johnson?

08:35AM 3 A I did not.

08:35AM 4 Q Do you recognize this as a flow regime map?

08:35AM 5 A I do.

08:35AM 6 Q Now, this represents where flows are going to be in
08:35AM 7 different flow regimes, which we described earlier is going to
08:35AM 8 be something similar to flow patterns.

08:36AM 9 Do you see that?

08:36AM 10 A I do.

08:36AM 11 Q It's a little hard to read, so we can pull out some of the
08:36AM 12 language if we need to.

08:36AM 13 Now, let's look at the axes.

08:36AM 14 We have here on the bottom something called, I
08:36AM 15 believe it's ρ liquid/ v liquid squares.

08:36AM 16 Do you see that?

08:36AM 17 A I do.

08:36AM 18 Q And then, on the y-axis, we have a ρ gas/ v gas squared;
08:36AM 19 right?

08:36AM 20 A I do.

08:36AM 21 Q And we can pull out the page. Dr. Johnson was kind enough
08:36AM 22 to define for us what ρ and v represent here.

08:36AM 23 If we could go out to the main page. We see here,
08:36AM 24 ρ liquid is density of the liquid. v liquid is the
08:36AM 25 superficial liquid velocity. U_G is the superficial gas

08:36AM 1 velocity. Right?

08:36AM 2 Do you see that?

08:36AM 3 A I do.

08:36AM 4 Q Let's go back to the flow regime map. This map tells us
08:37AM 5 what flow regime we're in based on the velocities and the
08:37AM 6 densities that we have, not a ratio of them that you're allowed
08:37AM 7 to scale by whatever factor you want; right?

08:37AM 8 It's the actual velocities and the actual
08:37AM 9 densities of each fluid that determine what flow regime you're
08:37AM 10 in; isn't it true?

08:37AM 11 A It's, in fact, kind of the ratio. But, yes. I'm not sure
08:37AM 12 exactly where this map was taken from. I'm not familiar with
08:37AM 13 Hewitt-Roberts.

08:37AM 14 But these maps, generally speaking, are built for
08:37AM 15 particular angles. They have a very specific. You often see
08:37AM 16 the x-axis and y-axis to be a series of nondimensional terms.

08:37AM 17 But, in general, what you're comparing is what is
08:37AM 18 the relative gas velocity to the relative liquid velocity, and
08:37AM 19 that says something about the flow regime.

08:37AM 20 Q Right. The relative velocities. It's not the ratios of the
08:37AM 21 velocities. If both of them are one meter per year, you are
08:38AM 22 going to wind up somewhere way down here, even if one of them is
08:38AM 23 ten times the other.

08:38AM 24 But, if you start getting over in the actual
08:38AM 25 velocity of the gas is something much greater, then the same

08:38AM 1 ratio might do something different in terms of what flow regime
08:38AM 2 you're in; won't it?

08:38AM 3 A Yeah, that's correct. And that's consistent with what I
08:38AM 4 said earlier. If I have used the term ratio, I've used it to
08:38AM 5 represent this chart itself.

08:38AM 6 But, in your specific example, you asked me if a
08:38AM 7 ratio at a very low speed was likely to be stratified smooth,
08:38AM 8 and then you took that same ratio and scaled it up to a high
08:38AM 9 speed. Then I said it is likely to result in stratified wavy.
08:38AM 10 So it is consistent with what I've said to you.

08:38AM 11 MR. CHAERES: If we could go back to demonstrative
08:38AM 12 D-2205.

08:38AM 13 MR. CHAERES:

08:38AM 14 Q So, in this case, you're saying that, for a given pressure
08:38AM 15 drop, the velocity up here is going to be different from your
08:39AM 16 model by a factor of 8; right?

08:39AM 17 For a given pressure drop, same hydraulic
08:39AM 18 diameter. You're saying the velocity in this larger shape is
08:39AM 19 going to be 8 times less than the velocity in the model; right?

08:39AM 20 A I didn't say anything about velocity.

08:39AM 21 Q Well, for a given pressure drop, what do you think is going
08:39AM 22 to happen to the velocities between, say, a model with the same
08:39AM 23 hydraulic diameter as this shape right here?

08:39AM 24 A I would need to do some math here. I'm presuming that the
08:39AM 25 ratio of 1053 to 130 is somewhere near 8, which is how you're

08:39AM 1 coming up with this 8 times velocity.

08:39AM 2 Surely, what I'm saying is that the velocity and
08:39AM 3 modeled riser in this example would result in a substantially
08:39AM 4 higher velocity than the velocity in 3 times the riser.

08:40AM 5 And, again, we're really talking about the average
08:40AM 6 mixture velocity. Remember, in multiphase flow, there are
08:40AM 7 multiple different velocities. The gas is moving at a different
08:40AM 8 speed.

08:40AM 9 But, yes, the average velocity certainly is going
08:40AM 10 to be significantly faster in the modeled riser, as you've got
08:40AM 11 it termed.

08:40AM 12 Q The very crux of what you're trying to do in this case is
08:40AM 13 you're trying to provide the Court with an estimate of flow
08:40AM 14 rates based on what flow patterns you observed; correct?

08:40AM 15 A That's correct.

08:40AM 16 Q And the flow patterns that you're determining are based on
08:40AM 17 the velocities, among other things, are based on the relative
08:40AM 18 velocities of each phase; correct?

08:40AM 19 A In general, that is a true statement. But you have to be
08:40AM 20 very careful with these flow regime maps.

08:40AM 21 So what these flow regime maps focus on
08:40AM 22 specifically is what I was talking about, hydrodynamic slugging,
08:41AM 23 which is when slug flow is determined based on those ratio.
08:41AM 24 And, when I described slug flow at the beginning, that's the way
08:41AM 25 I described it.

08:41AM 1 But one of the other mechanisms for slug flow is
08:41AM 2 terrain-induced slugging, which is slugging that's determined
08:41AM 3 based on the position of the riser. So liquid tends to move to
08:41AM 4 the low spots in the riser, and it accumulates there; and then,
08:41AM 5 occasionally, it will burp out liquid in these system.

08:41AM 6 What we have in this particular case is sort of a
08:41AM 7 modification of terrain-induced slugging. So you wouldn't see
08:41AM 8 on a flow map that it would be in the slug flow regime. What
08:41AM 9 would you see is it would likely be in the stratified flow
08:41AM 10 regime.

08:41AM 11 If we can put up video -- I don't know if we can
08:41AM 12 do this. But, yesterday, one of the slugs actually looks quite
08:42AM 13 like stratified flow. It is oil dominant, but it does still
08:42AM 14 have a gas layer flowing across the top.

08:42AM 15 And so we're really talking about a very unique
08:42AM 16 mechanism of slug flow behavior. We're certainly not talking
08:42AM 17 about hydrodynamic slugging or these flow regime maps or what
08:42AM 18 you get from these flow regime maps.

08:42AM 19 Q Appreciate that. You are still -- you need to wind up in
08:42AM 20 the stratified flow regime ballpark upstream of the buoyant
08:42AM 21 riser in order to model the slugs that you observed; correct?

08:42AM 22 A That's correct.

08:42AM 23 Q The relative velocities of the phases are still relevant to
08:42AM 24 whether you're in a stratified flow regime or flow pattern
08:42AM 25 upstream of the buoyant riser; correct?

08:42AM 1 A That's also correct.

08:42AM 2 Q And the relative velocities of the phases is also important
08:42AM 3 in determining whether the gas can push the oil slugs all the
08:43AM 4 way up the buoyant riser, or you get something to break and you
08:43AM 5 create a double peak; isn't that correct?

08:43AM 6 A That's also correct.

08:43AM 7 Q So the actual relative velocities of both phases is very
08:43AM 8 important in determining whether the slug behavior observed
08:43AM 9 matches your flow rates; right?

08:43AM 10 A Yes, that's correct. We looked specifically at the flow
08:43AM 11 regimes in this particular case. We see almost the entire riser
08:43AM 12 sits in -- when you look at that traditional flow regime map,
08:43AM 13 almost the entire riser sits in a stratified flow.

08:43AM 14 Q And it's your testimony, just so I'm clear, that instead of
08:43AM 15 using the hydraulic diameter to get the right velocity profile,
08:43AM 16 you believe that the hydraulic diameter maintains mass flow
08:43AM 17 rates or volumetric flow rates, and so your model will predict
08:43AM 18 velocities that are incorrect; right?

08:43AM 19 A It's not just what I believe. That's what the science tells
08:43AM 20 us. But, yes, that's also what I believe.

08:44AM 21 Q Okay. Now, let's look at another example. Let's go to the
08:44AM 22 kink leaks for a little while.

08:44AM 23 Now, you also use hydraulic diameters for the kink
08:44AM 24 leaks; correct?

08:44AM 25 A That's correct.

08:44AM 1 Q And, before we get too much farther, there were several
08:44AM 2 leaks that you modeled. There was the leak that you called leak
08:44AM 3 B; correct?

08:44AM 4 A Yes.

08:44AM 5 Q And there was leak D; correct?

08:44AM 6 A Yes.

08:44AM 7 Q And then there are two other leaks that you combined; isn't
08:44AM 8 that right?

08:44AM 9 A No, that's not correct.

08:44AM 10 Q How did you model the other two leaks?

08:44AM 11 A Well, just to be clear, the three leaks or four potential
08:44AM 12 holes that were present were holes B and C. And then D and E
08:44AM 13 were the holes that were, if you remember the drawing, they're
08:44AM 14 almost touching each other. There's a very small sliver of the
08:44AM 15 riser between the two holes.

08:45AM 16 Q Okay. And how did you model those two that were very close
08:45AM 17 to each other?

08:45AM 18 A So I consulted Nestic, and he provided area and wetted
08:45AM 19 perimeter for those holes so that I could calculate the
08:45AM 20 hydraulic diameter for those holes.

08:45AM 21 Q Did you sum the areas and sum the perimeters?

08:45AM 22 A Again, Nestic provided that information.

08:45AM 23 Q Understood.

08:45AM 24 A I got a total area for those holes and a wetted perimeter.

08:45AM 25 Q Okay. And, the total area, did you understand that to be

08:45AM 1 the area of one hole plus the area of the other hole?

08:45AM 2 A I have presumed so, yes.

08:45AM 3 Q And, likewise for the perimeter, it was the perimeter on one
08:45AM 4 hole plus the perimeter of the other hole?

08:45AM 5 A Again, I presume so.

08:45AM 6 Q I'd like to flip to the ELMO and ask you about another
08:45AM 7 hypothetical.

08:45AM 8 And, again, it's your understanding that, using
08:45AM 9 the hydraulic diameter, that will -- well, let me rephrase that.

08:46AM 10 It's your testimony that, for a given pressure
08:46AM 11 drop, two flow paths with the same hydraulic diameter will give
08:46AM 12 the same flow rate; right?

08:46AM 13 A Could you just repeat it just to make sure that I
08:46AM 14 understand?

08:46AM 15 Q Yes.

08:46AM 16 For a given pressure drop, two flow paths with the
08:46AM 17 same hydraulic diameter will give the same flow rate.

08:46AM 18 That's your testimony; right?

08:46AM 19 A Yeah, that the relationship between pressure drop and flow
08:46AM 20 rate is the same.

08:46AM 21 Q It's not your testimony. You're rejecting the idea that,
08:46AM 22 for a given pressure drop, two shapes of the same hydraulic
08:46AM 23 diameter provide the same velocity; right?

08:46AM 24 A Yes, that's correct.

08:46AM 25 Q Okay. I'd like to go through another example.

08:46AM 1 So I'm attempting to draw a water tank. Do you
08:46AM 2 see that? And let's put a little leak at the bottom of the
08:47AM 3 water tank. We'll make it a square of 1 inch area on the side.

08:47AM 4 And so, for this square, the hydraulic diameter is
08:47AM 5 4 times the area over the perimeter; correct?

08:47AM 6 A That's correct.

08:47AM 7 Q And the area would be 1 inch times 1 inch; right?

08:47AM 8 A That's correct.

08:47AM 9 Q And the perimeter would be 4 inches; right?

08:47AM 10 A That's correct.

08:47AM 11 Q Okay. So that comes out to 1 inch for the hydraulic
08:47AM 12 diameter; right?

08:47AM 13 A That's correct.

08:47AM 14 Q And, assuming this is water, if we know the height of the
08:47AM 15 water, we can calculate the flow rate out of that leak. That's
08:47AM 16 a straightforward calculation; right?

08:47AM 17 A I'm sorry. What's the premise, that the tank is --

08:47AM 18 Q We know the height of the fluid, we know the size of the
08:47AM 19 leak, we can calculate the flow out of the leak; right?

08:47AM 20 A Yes.

08:47AM 21 Q What if I were to go in there with a grinder and I'm going
08:47AM 22 to expand the size of this leak into a circle that had a
08:48AM 23 diameter of 1.

08:48AM 24 What's the hydraulic diameter of the circle of
08:48AM 25 diameter 1?

08:48AM 1 A 1.

08:48AM 2 Q So those two shapes have the same hydraulic diameter, the
08:48AM 3 square and the circle; right?

08:48AM 4 A That's correct.

08:48AM 5 Q And, putting aside jokes about squares and circles, the area
08:48AM 6 of the circle is more than 20 percent greater than the area of
08:48AM 7 the square; right?

08:48AM 8 A I will take your word that it's 20 percent. I would have to
08:48AM 9 do calculations to be certain of that.

08:48AM 10 Q It's roughly something related to the ratio between Pi and
08:48AM 11 4.

08:48AM 12 Now, is it your testimony that the flow rate out
08:48AM 13 of the circle is going to be the same as the flow rate out of
08:48AM 14 the square?

08:48AM 15 A In this particular case, if you were using the hydraulic
08:48AM 16 diameter, they would result in the same flow rate given the same
08:48AM 17 pressure drop, yes.

08:48AM 18 Q Well, I understand that if you're using the hydraulic
08:48AM 19 diameter, because we just stated that they have the same
08:49AM 20 hydraulic diameter.

08:49AM 21 My question to you is, what's happening in
08:49AM 22 reality. Do these two orifices have the same flow rate coming
08:49AM 23 out of them for the given pressure drop?

08:49AM 24 A I think the answer is yes. I haven't looked specifically at
08:49AM 25 this problem; but, when you have a square hole, you've

08:49AM 1 introduced a very different frictional relationship between flow
08:49AM 2 out the bottom of that tank.

08:49AM 3 What the science says is that, yes, they would
08:49AM 4 result in the same fundamental flow rate despite the fact that
08:49AM 5 the area is bigger. I know it's counterintuitive, but that
08:49AM 6 doesn't make it incorrect.

08:49AM 7 Q Okay. It's not so counterintuitive if we just say that the
08:49AM 8 velocities through both of these are the same, and the area
08:49AM 9 change is changing the flow rates; is it? That's not so
08:49AM 10 counterintuitive?

08:49AM 11 A It may not be counterintuitive to you, but it would be
08:49AM 12 incorrect.

08:49AM 13 MR. CHAERES: We're going to label this as
08:49AM 14 demonstrative D-22485.

08:50AM 15 I'd like to draw one more water tank, with the
08:50AM 16 Court's indulgence.

08:50AM 17 BY MR. CHAERES:

08:50AM 18 Q Again, we have a gap, a leak, with a 1 inch square. Do you
08:50AM 19 see that?

08:50AM 20 A I do.

08:50AM 21 Q And we've established the hydraulic diameter of this leak is
08:50AM 22 1 inch; right?

08:50AM 23 A Yes.

08:50AM 24 Q Okay. Now, let's say we plunk a hole on the opposite side
08:50AM 25 of this tank, same size. Hole's on the opposite side of the

08:50AM 1 tank.

08:50AM 2 Is the flow rate going to stay the same?

08:50AM 3 A When you mean on the opposite side of the tank --

08:51AM 4 Q On the other side of the tank, a hole of the same size.

08:51AM 5 A Is that whole hole at the bottom?

08:51AM 6 Q Both of these holes are at the bottom of the tanks of water.

08:51AM 7 A I guess, if you could draw it. I'm not sure what you mean.

08:51AM 8 But, yes, if you add another hole --

08:51AM 9 Q We'll add another hole here on the side.

08:51AM 10 A -- you'll have additional volume or fluid leaking out of the
08:51AM 11 tank.

08:51AM 12 Q Okay. What if I move that hole right next to our hole?

08:51AM 13 Would we have additional flow coming out of the tank?

08:51AM 14 A Yes, you do.

08:51AM 15 Q Okay. And, this hole, let's say this is 1 inch. Okay?

08:51AM 16 Now, if we wanted to use a hydraulic diameter to
08:51AM 17 calculate the flow out of these orifices, if they're right next
08:51AM 18 to each other, we can use a hydraulic diameter to do that.

08:51AM 19 That's what you did with two of the leaks on the
08:51AM 20 kink; right?

08:51AM 21 A I did.

08:51AM 22 Q Okay.

08:52AM 23 A Now, please bear in mind, this was an exceptionally
08:52AM 24 conservative assumption of mine. Again, when we looked at the
08:52AM 25 kink leaks, we were focused on maximum flow rates. We used very

08:52AM 1 conservatively -- since it wasn't clear which hole or if both
08:52AM 2 holes were present, we used both holes in that scenario or the
08:52AM 3 area and wetted perimeter for both holes.

08:52AM 4 Q Appreciate that.

08:52AM 5 But the use of the hydraulic diameter for two
08:52AM 6 holes that were near each and saying they're combined areas and
08:52AM 7 they're combined perimeters, could be used to make one hydraulic
08:52AM 8 diameter. That's what you did in your model for those holes;
08:52AM 9 right?

08:52AM 10 A I did.

08:52AM 11 Q And you believe that the science supports you in that;
08:52AM 12 right?

08:52AM 13 A It does.

08:52AM 14 Q Now, let's figure out what the hydraulic diameter of these
08:52AM 15 two holes is. It's 4 times the area over the perimeter; right?

08:52AM 16 You agree?

08:52AM 17 A Yeah. That's the formula for hydraulic diameters.

08:52AM 18 Q Now, the area we multiply by 2, so it's going to be 2 square
08:52AM 19 inches now; right?

08:53AM 20 A You're calculating -- sorry, the hydraulic diameter for
08:53AM 21 those combined holes?

08:53AM 22 Q Yes. Yes.

08:53AM 23 A That's not what was provided to me.

08:53AM 24 Q That's not what was provide to you.

08:53AM 25 A I was provided a combined area and a combined wetted

08:53AM 1 perimeter. I then took the irregular-shaped hole and converted
08:53AM 2 that into a circular hole which is required by the models in
08:53AM 3 order to accurately characterize the volume of flow out of the
08:53AM 4 riser in this case.

08:53AM 5 Q So you created a diameter of the actual -- you created a
08:53AM 6 hole with a diameter corresponding to the actual area for flow
08:53AM 7 for those depths?

08:53AM 8 A Yeah. Again, I was provided an actual area of those two
08:53AM 9 holes and an actual combined perimeter for those two holes. I
08:53AM 10 did not take those two holes, combine them with the hydraulic
08:53AM 11 diameter.

08:53AM 12 Q Let's walk through what you did; okay? So the area of hole
08:53AM 13 1 and the area of hole 2, you were given those as a combined
08:53AM 14 number; right?

08:53AM 15 A That's correct. I was given a combined area and a combined
08:54AM 16 wetted perimeter for those two holes. I then take that combined
08:54AM 17 area -- so, in this case, the $4A$. The A is already given and
08:54AM 18 the wetted perimeter is also given -- that is the combined area
08:54AM 19 and the combined wetted perimeter for those two holes.

08:54AM 20 Then I convert using the hydraulic diameter those
08:54AM 21 holes into a circular geometry, which is what the hydraulic
08:54AM 22 diameter transformation does. And then I was able to calculate
08:54AM 23 the flow rate using those holes.

08:54AM 24 Q Let's do that -- sorry, I didn't mean to cut you off. Were
08:54AM 25 you done?

08:54AM 1 A Yeah.

08:54AM 2 I was able to calculate the flow rate using those
08:54AM 3 holes using a multiphase flow simulator.

08:54AM 4 Q So let's walk through -- if what I'm doing over here is
08:54AM 5 incorrect, so what's the combined area of the two holes here?
08:54AM 6 If both holes have a size of 1 inch.

08:54AM 7 A I think it would be 2 inches.

08:54AM 8 Q Squared; correct?

08:54AM 9 A That's correct.

08:54AM 10 Q And what's the combined perimeter of both of these holes?

08:54AM 11 A It's going to be 8.

08:55AM 12 Q And so you took the combined area and combined perimeter and
08:55AM 13 then you calculated a hydraulic diameter using the combined area
08:55AM 14 and the combined perimeter?

08:55AM 15 A That's correct.

08:55AM 16 Q So the combined area we just said was 2 square inches;
08:55AM 17 right?

08:55AM 18 A That's correct.

08:55AM 19 Q And the perimeter you said was 8 inches; right?

08:55AM 20 A Yes, that's correct.

08:55AM 21 Q And that equals 1 inch; doesn't it? Right? For this
08:55AM 22 example, the hydraulic diameter is 1 inch; right?

08:55AM 23 A Yes, that's correct.

08:55AM 24 Q So we just doubled the size of our flow path. You just said
08:55AM 25 that if we double it we're going to increase our flow. Yet, we

08:55AM 1 have the exact same hydraulic diameters we had with just one
08:55AM 2 hole there; don't we?

08:55AM 3 A Right. But you have all of this additional frictional force
08:55AM 4 associated with the additional walls. It is unintuitive, but it
08:55AM 5 is the correct thing to do. It is the best available geometric
08:55AM 6 transformation for the modeling of the these problems.

08:55AM 7 There are numerous texts. You arguing with me
08:56AM 8 doesn't take away from the fact that there is decades of
08:56AM 9 scientists looking specifically at this geometric
08:56AM 10 transformation, and they all conclude it is the correct
08:56AM 11 geometric transformation.

08:56AM 12 Q You say it's the correct geometric transformation to get the
08:56AM 13 right velocities of out the holes; don't they?

08:56AM 14 A That is absolutely not correct.

08:56AM 15 Q I can keep on drawing these things; right? I can draw
08:56AM 16 another one over here; right?

08:56AM 17 A If you can show me one paper that says that the hydraulic
08:56AM 18 diameter, one text or any sort of body, because the science --
08:56AM 19 and I went to school studying these things -- and, really, the
08:56AM 20 science does tell you, despite the fact its unintuitive, it is
08:56AM 21 the correct answer.

08:56AM 22 Q With all due respect, sir, just answer my question.

08:56AM 23 I can put another leak over here, right next to
08:56AM 24 these other leaks; right? Same size, we'll pretend. And these
08:56AM 25 three leaks combined will have the same hydraulic diameter;

08:57AM 1 right?

08:57AM 2 A But I did not combine the holes. So, when I modeled the
08:57AM 3 kink section of the riser outside of D and E, which was provided
08:57AM 4 to me by Dr. Nestic as a combined area and perimeter.

08:57AM 5 All of the other holes were modeled independent of
08:57AM 6 one another.

08:57AM 7 Q Now --

08:57AM 8 A Now, each of those holes were converted to a circular
08:57AM 9 geometry, but they were all independently modeled.

08:57AM 10 Q But you just said that, if the holes had been close to each
08:57AM 11 other, as in fact D and E were, it would be appropriate to
08:57AM 12 combine their areas, combine their perimeters, and get a
08:57AM 13 hydraulic diameter corresponding to those areas and perimeters;
08:57AM 14 right?

08:57AM 15 A I believe that's what I said. I didn't catch the full
08:57AM 16 question. If you could repeat it just to make sure.

08:57AM 17 Q Just wanted to confirm, you said if the holes are close to
08:57AM 18 each other, you can use their combined areas and the combined
08:57AM 19 perimeters and come up with a hydraulic diameter corresponding
08:58AM 20 to the combined area and the combined perimeter; correct?

08:58AM 21 A I don't know that I made any general statements. What I
08:58AM 22 specifically did is I was provided the area and perimeter by
08:58AM 23 Dr. Nestic. It was a combined area and perimeter because these
08:58AM 24 holes were so close to one another.

08:58AM 25 I then took that area and used the hydraulic

08:58AM 1 diameter for D/E, which I correctly labeled, and I treated that
08:58AM 2 as one hole in this case.

08:58AM 3 The other holes, B and C, were modeled
08:58AM 4 independently.

08:58AM 5 Q Understood.

08:58AM 6 But, here, if all these holes are very close to
08:58AM 7 each other, I can keep on drawing holes that are very close to
08:58AM 8 each other; right? I can keep doing that for a long time. I
08:58AM 9 can put holes all the way around the bottom of our water tank,
08:58AM 10 and the combined areas and the combined perimeters will give you
08:58AM 11 a hydraulic diameter that's the same for -- it's the same as
08:58AM 12 just one hole; won't it?

08:58AM 13 A In this particular example, I did not do that. You're
08:58AM 14 asking me to indulge in your hypothetical here. If you're
08:59AM 15 asking me, if you continue to draw holes and then try to combine
08:59AM 16 them into one hydraulic diameter, yes, that's the case.

08:59AM 17 That's not what I did.

08:59AM 18 Q All I was asking you is, if you keep drawing holes, you're
08:59AM 19 not going to increase your hydraulic diameter; will you?

08:59AM 20 A In this particular case or in the *Deepwater/Macondo/Horizon*?

08:59AM 21 Q In this particular case.

08:59AM 22 A In this particular case, if you keep drawing the holes and
08:59AM 23 you keep trying to combine them and to create one hydraulic
08:59AM 24 diameter, yes, that's what will occur.

08:59AM 25 Q All right. We are going to put this as D-22486.

08:59AM 1 Let me give you one more water tank. I want to be
08:59AM 2 clean here.

09:00AM 3 So what if, instead of drawing the holes separate,
09:00AM 4 I actually bring them together, just a little bit, so it's one
09:00AM 5 hole.

09:00AM 6 You see that?

09:00AM 7 A I do.

09:00AM 8 Q And so now it's one hole with this complex geometry you're
09:00AM 9 talking about. There's all sorts of frictional interactions
09:00AM 10 going on with this complex geometry.

09:00AM 11 If I bring these holes together -- again, I can
09:00AM 12 still do the same thing. One hole now, essentially the same
09:00AM 13 hydraulic diameter is just one square; isn't it? Because the
09:00AM 14 ratio between the areas of all this space and the perimeter
09:00AM 15 stays the same; doesn't it?

09:00AM 16 A I think that would be correct, yes.

09:00AM 17 Q And is it your testimony that the flow -- I can put a ring
09:00AM 18 around the whole bottom of the tank. Is the flow rate out of
09:00AM 19 the bottom of the tank with our little daisy-chain of holes here
09:00AM 20 as it would just a 1 inch square hole?

09:00AM 21 A Again, I didn't --

09:01AM 22 THE COURT: Or a 1 inch round hole; is that what you're
09:01AM 23 equating this to?

09:01AM 24 THE WITNESS: Yes. It would be -- if you were to take
09:01AM 25 this string of holes and you were to compute the area, and then

09:01AM 1 you would take the wetted perimeter, a 1 inch round hole would
09:01AM 2 roughly calculate to be the same flow rate out of the bottom of
09:01AM 3 the tank.

09:01AM 4 Despite the fact that it's unintuitive, that would
09:01AM 5 be correct.

09:01AM 6 BY MR. CHAKERES:

09:01AM 7 Q And is that what would actually happen if I took a water
09:01AM 8 tank and I punched all these holes around slightly overlapping
09:01AM 9 with each other? Would I have the same flow rate out of the
09:01AM 10 tank as if I just punched one hole?

09:01AM 11 A Again, I've not studied this particular problem.
09:01AM 12 Intuitively, it sounds counterintuitive, but the science would
09:01AM 13 tell you that's what would happen.

09:01AM 14 Q Okay. We're going to label this as D-22487.

09:01AM 15 MR. CHAERES: Now, if we could pull up Exhibit 10650.

09:01AM 16 BY MR. CHAERES:

09:02AM 17 Q You were provided in your considered materials some
09:02AM 18 calculations that BP performed of flow out of the kink leaks
09:02AM 19 during the response; weren't you?

09:02AM 20 Let's blow up the top half of this. Call-out
09:02AM 21 10650.1.1.US.

09:02AM 22 You were provided this as part of your
09:02AM 23 consideration materials; weren't you?

09:02AM 24 A Yeah. I recognize the material.

09:02AM 25 Q Do you understand that Tim Lockett was calculating flow out

09:02AM 1 of kink leaks here?

09:02AM 2 A He appears to be, yes.

09:02AM 3 Q And he's calculating flow out of a circular orifice; right?
09:02AM 4 He's converting the original geometry to a circular flow path;
09:02AM 5 right?

09:02AM 6 A He appears to be, yes.

09:02AM 7 Q And the area of that circular flow path is not an area
09:02AM 8 corresponding to the hydraulic diameter, but it's actually a
09:02AM 9 circle that has the same area as what he believed the kink leaks
09:03AM 10 to have; isn't that true?

09:03AM 11 A Could you repeat the question one more time?

09:03AM 12 Q Isn't it true that the circular flow path that Tim Lockett
09:03AM 13 modeled had the same area as he believed the kink leaks actually
09:03AM 14 had?

09:03AM 15 A He seems to be taking irregular geometry holes, calculating
09:03AM 16 the cross-sectional area for those, and then converting them
09:03AM 17 into what's called an equivalent area transformation.

09:03AM 18 Q And an equivalent area transformation will give you a circle
09:03AM 19 or the diameter corresponding to a circle with the same area as
09:03AM 20 the regular geometry; right?

09:03AM 21 A That's correct.

09:03AM 22 Q Okay. We can pull that down.

09:03AM 23 And, again, it's your testimony that any two
09:03AM 24 geometries with the same hydraulic diameter will, for the same
09:04AM 25 pressure drop, give you the same flow rate; right?

09:04AM 1 A Yes, That's correct.

09:04AM 2 Q It's not your testimony that the velocities will stay the
09:04AM 3 same.

09:04AM 4 A No. The velocities certainly will not stay the same.

09:04AM 5 MR. CHAERES: Okay. Let's go to Exhibit 130712.

09:04AM 6 130712. Might be 130713.

09:04AM 7 BY MR. CHAERES:

09:04AM 8 Q Ever seen this book before?

09:05AM 9 A I have.

09:05AM 10 Q You have?

09:05AM 11 A Yes.

09:05AM 12 Q What is it?

09:05AM 13 A It's a book on flow. It's a textbook.

09:05AM 14 Q And, for your demonstrative yesterday where you posited that
09:05AM 15 hydraulic diameter maintains the relationship between flow rates
09:05AM 16 and pressure drops, this book was one of the sources that you
09:05AM 17 cited for that proposition; wasn't it?

09:05AM 18 A That's correct.

09:05AM 19 Q All right. Let's see what this book has to say about the
09:05AM 20 topic.

09:05AM 21 MR. CHAERES: If we could go to 130713, page 35.

09:05AM 22 BY MR. CHAERES:

09:06AM 23 Q Now, we're in chapter 3, calculation of system pressure flow
09:06AM 24 or size. Do you see that? It's a chapter where they tell you
09:06AM 25 how to calculate flow?

09:06AM 1 A I see this, yes.

09:06AM 2 Q Let's pull out the portion of the page under Equations For
09:06AM 3 Losses.

09:06AM 4 Now, we see here, we have equations for losses.
09:06AM 5 And you recognize delta H represents head; is that what it
09:06AM 6 appears to you?

09:06AM 7 And delta PR represents pressure?

09:06AM 8 A Yes, that's what it says.

09:06AM 9 Q Okay. And it says that delta P is equal to K times rho
09:06AM 10 times v squared over 2; right?

09:06AM 11 A That's correct.

09:06AM 12 Q And rho typically denotes density; right?

09:06AM 13 A Typically, it's density, yes, that's correct.

09:06AM 14 Q And v -- that's a term for velocity; isn't it?

09:06AM 15 A It could be.

09:06AM 16 Q Is that your understanding? Are you familiar with this
09:07AM 17 equation?

09:07AM 18 A Yeah. In this context, I suspect that it is the velocity.

09:07AM 19 Q And then we've got K over here; right? And they say K is a
09:07AM 20 loss coefficient; don't they?

09:07AM 21 A They do.

09:07AM 22 Q And, under the Loss Coefficient, they say K is equal to FL
09:07AM 23 over D; right?

09:07AM 24 A Right.

09:07AM 25 Q And D, in that loss coefficient -- if we could pull out --

09:07AM 1 let's actually go down to the equation below it.

09:07AM 2 They're talking about the hydraulic diameter with
09:07AM 3 that D with the loss coefficient; right?

09:07AM 4 A Yes, that's correct.

09:07AM 5 Q And we can actually go on to the next page, just to confirm
09:07AM 6 it.

09:07AM 7 Up here at the top, D is equal to hydraulic
09:07AM 8 diameter 4 times the cross-sectional area divided by the
09:08AM 9 perimeter; right?

09:08AM 10 A That's correct.

09:08AM 11 Q So, sure enough, as you stated, the hydraulic diameter is an
09:08AM 12 accepted principle in fluid dynamics; right?

09:08AM 13 A That's correct.

09:08AM 14 Q And it's used in this context, again, in equation relating
09:08AM 15 pressure drops to velocities; right?

09:08AM 16 A Specifically used in the frictional relationship.

09:08AM 17 Q Right.

09:08AM 18 Now, let's go ahead to page 44, 130713.44.

09:08AM 19 All right. Now let's see what the book says about
09:08AM 20 noncircular cross-sections.

09:08AM 21 MR. CHAERES: We can call out all the way down to the
09:08AM 22 bottom? Thank you.

09:08AM 23 BY MR. CHAERES:

09:08AM 24 Q Here, again, they introduce the concept of a hydraulic
09:08AM 25 diameter; don't they?

09:08AM 1 A They do.

09:08AM 2 Q And they say above it: For many noncircular cross-sections
09:08AM 3 a satisfactory procedure for calculating head losses is to
09:08AM 4 replace the pipe diameter in the friction and Reynolds number
09:09AM 5 equations by the hydraulic diameter.

09:09AM 6 You see that?

09:09AM 7 A I do.

09:09AM 8 Q And, again, this book is saying that you use the hydraulic
09:09AM 9 diameter when you want to get your frictional pressure losses
09:09AM 10 right and in the Reynolds number equation; right?

09:09AM 11 A Yes, that's correct.

09:09AM 12 Q And, the Reynolds number equation, that's one of those
09:09AM 13 dimensionless parameters you mentioned a while back; isn't it?

09:09AM 14 A Yes.

09:09AM 15 Q And the dimensionless parameters help tell you what flow
09:09AM 16 regime or flow pattern you're in if you're in multiphase flow;
09:09AM 17 right?

09:09AM 18 A The Reynolds number specifically focuses on the difference
09:09AM 19 between laminar and turbulent flow. It is not associated with
09:09AM 20 the flow patterns that we were discussing earlier.

09:09AM 21 THE COURT: Pull the microphone a little closer.

09:09AM 22 BY MR. CHAKERES:

09:09AM 23 Q Take that correction. The Reynolds number tells you how
09:09AM 24 turbulent your flow is?

09:09AM 25 A That's correct. I mean, this is all focused on single phase

09:09AM 1 flow as a context.

09:09AM 2 Q And you testified before, the hydraulic diameter concept
09:09AM 3 should apply to single phase flow just like it should apply to
09:10AM 4 multiphase flow; right?

09:10AM 5 A It's used in single phase flow, that's correct.

09:10AM 6 Q And this is a book that you cited in support of the
09:10AM 7 proposition that every geometry with the same hydraulic diameter
09:10AM 8 will have the same flow rate for a given pressure drop; isn't
09:10AM 9 it?

09:10AM 10 A I have referred to this book with regards to the use of
09:10AM 11 hydraulic diameter in industry, yes.

09:10AM 12 Q Let's skip ahead to page 46 now?

09:10AM 13 45 is a bunch of pictures with noncircular
09:10AM 14 geometries.

09:10AM 15 Let's go down here to section, all the way up to
09:10AM 16 Substituting. So, here, they're solving H - and, again, that's
09:10AM 17 head -- and they say substitute -- again, Q , that's flow rate;
09:10AM 18 right? Q is typically flow rate in these kind of equations?

09:10AM 19 A That should be the volumetric flow rate, yes.

09:10AM 20 Q And, A, we just saw in our hydraulic diameter derivation
09:10AM 21 that A is the actual cross-section area available for flow;
09:10AM 22 didn't we? It's the same A as we saw in the hydraulic diameter
09:11AM 23 equation; right?

09:11AM 24 A Yeah, that's correct. I don't know if it's the actual
09:11AM 25 cross-section in this particular section without reading it.

09:11AM 1 But I think it is; yes, that's correct.

09:11AM 2 Q They say substituting v -- which is velocity, we decided;
09:11AM 3 right?

09:11AM 4 A Yes.

09:11AM 5 So that's the definition between in single phase
09:11AM 6 flow the velocity and volumetric flow in an area.

09:11AM 7 Q When you want to solve for the flow rate instead of the
09:11AM 8 velocity in that equation we saw before, you don't divide by an
09:11AM 9 area corresponding to the hydraulic diameter, you divide by the
09:11AM 10 actual cross-sectional area; don't you?

09:11AM 11 A No, that's not correct. This is what's referred to in
09:11AM 12 science as a definition. This relates variables to one and the
09:11AM 13 other inside the context of whatever assumptions that you've
09:11AM 14 made.

09:11AM 15 So, in my model, when I used the hydraulic
09:11AM 16 diameter, you could take the velocity in that model, you could
09:12AM 17 take the area calculated by the hydraulic diameter and you could
09:12AM 18 come to the volumetric flow rate.

09:12AM 19 It's just the relationship between variables.
09:12AM 20 This is not a formula that you would use then to determine
09:12AM 21 something.

09:12AM 22 Q This is the formula you'd use to determine something; isn't
09:12AM 23 it?

09:12AM 24 A In this particular case, this is a formula that looks to be
09:12AM 25 calculating -- I'm surprised it's ΔH -- but some sort of

09:12AM 1 pressure drop with frictional and flow rate, yes.

09:12AM 2 Q And, when you stick in the flow rate, you stick in the flow
09:12AM 3 rate based on the velocity in the actual cross-sectional area;
09:12AM 4 don't you?

09:12AM 5 A No. I think, if you go back a page, actually what's
09:12AM 6 happening is they've taken a frictional relationship. Now what
09:12AM 7 they're doing is saying, Hey, we now have a relationship or a
09:12AM 8 definition between volumetric flow rate and area, and if you
09:13AM 9 substitute that in to this previous frictional relationship then
09:13AM 10 you now have a calculation for pressure drop.

09:13AM 11 Or that's what I assume the H is here. This
09:13AM 12 actually emphasizes the point that the ratio here of perimeter
09:13AM 13 to area is quite important. And that comes directly from the
09:13AM 14 hydraulic diameter, and it is that ratio that is important.

09:13AM 15 Q All right. We can do some addition, subtraction,
09:13AM 16 multiplication over here and see if the hydraulic diameter is
09:13AM 17 really what the area you're flowing that flow rate through
09:13AM 18 there.

09:13AM 19 But we don't have to do that up here, because the
09:13AM 20 flow rate, area Q, is flowing through A; isn't it?

09:13AM 21 A So, I think, if you just go back to the previous equation,
09:13AM 22 we could walk you through how they get here. But this really
09:13AM 23 is, if my memory is right from the equation that you showed me
09:13AM 24 earlier, this is just a substitution of the hydraulic diameter
09:14AM 25 into that previous equation.

09:14AM 1 This in fact emphasizes that the ratio of wetted
09:14AM 2 perimeter and area are what is important, despite the fact that
09:14AM 3 it's counterintuitive.

09:14AM 4 Q What's important is to get the right frictional coefficient;
09:14AM 5 isn't it?

09:14AM 6 A In this case, it's what's important to get the right
09:14AM 7 pressure drop. That's the equation we're looking at.

09:14AM 8 Q So it's your testimony -- you got to get the right pressure
09:14AM 9 drop -- you got to use the hydraulic diameter to get the right
09:14AM 10 pressure drop; right?

09:14AM 11 A Yeah, that's correct. And specifically, I mean, when you
09:14AM 12 think about this pipeline, pressure drop is very important,
09:14AM 13 resistance to flow is very important. It determines how the
09:14AM 14 pressure and temperature change down the length of the pipe.

09:14AM 15 In multiphase flow, that changes the ratio of gas
09:14AM 16 to liquid, that changes the velocities as they move down the
09:14AM 17 pipes.

09:14AM 18 It's very important.

09:14AM 19 Q Okay. But it's your testimony that the hydraulic diameter
09:15AM 20 concept, everything with the same hydraulic diameter, no matter
09:15AM 21 how large the actual area is, even if the modeled area -- let me
09:15AM 22 start that question again.

09:15AM 23 It's your testimony that, no matter how large the
09:15AM 24 actual area is, if you have the same hydraulic diameter and the
09:15AM 25 same pressure drop, you're going to get the same flow rate;

09:15AM 1 right?

09:15AM 2 MR. FIELDS: Objection. Asked and answered, Your
09:15AM 3 Honor.

09:15AM 4 THE COURT: Overruled.

09:15AM 5 BY MR. CHAERES:

09:15AM 6 A Yes, that's correct. I mean, again, we put some bounds when
09:15AM 7 we were talking about it and you were talking about infinitely
09:15AM 8 large riser pipes. You start to get in a very specialized
09:15AM 9 situation where now the fluid doesn't interact with certain --
09:15AM 10 the other fluid in the pipe.

09:15AM 11 But, yes, in the examples you gave, despite the
09:15AM 12 fact there's a large difference in cross-sectional area, yes, it
09:15AM 13 will result in the same pressure drop and the same volumetric
09:15AM 14 flow rate.

09:15AM 15 Q If that's the definition of flow rate, how does that thing
09:16AM 16 change with your hydraulic diameter? That thing is your
09:16AM 17 velocity times your actual area; right?

09:16AM 18 A Again, so this v equals QA . This is a definition. So this
09:16AM 19 is just an interrelationship between variables calculated from
09:16AM 20 the same model. This is not something that could be then used
09:16AM 21 to calculate a new number.

09:16AM 22 So, for example, in my model you can't calculate a
09:16AM 23 velocity and then say, oh, I want to take the velocity out of
09:16AM 24 this model, and then use that relationship to calculate a new
09:16AM 25 volumetric flow rate using a bigger cross-sectional area.

09:16AM 1 What this tells you is that, given a solution to
09:16AM 2 the equations, that that's how those variables are related. So
09:16AM 3 a velocity using the hydraulic diameter is related to the
09:16AM 4 volumetric flow rate by the velocity equals Q over A .

09:17AM 5 And, in the construct of a model that is all using
09:17AM 6 the hydraulic diameter, that will be exactly true.

09:17AM 7 MR. CHAERES: Okay. If we could pull down the
09:17AM 8 call-out.

09:17AM 9 BY MR. CHAERES:

09:17AM 10 Q Now, let's go back to page -- actually, I'll hold this down
09:17AM 11 for a moment.

09:17AM 12 So it's not counterintuitive if you have the same --
09:17AM 13 if you maintain the velocities to pressure drop's relationship
09:17AM 14 across all shapes of the same hydraulic diameter; is it? That's
09:17AM 15 not a counterintuitive thing; is it?

09:17AM 16 A To me, it is, as an expert. I've read the literature. I'm
09:17AM 17 now a believer in hydraulic diameter. I've used it multiple
09:17AM 18 times throughout my career. It matches and is accepted in
09:17AM 19 industry.

09:17AM 20 Q And after your model is predicting velocities that are
09:17AM 21 one-half the actual velocities in this -- excuse me -- your
09:18AM 22 model would have to model velocities, or double the velocities
09:18AM 23 in the system; wouldn't it?

09:18AM 24 A They'll be faster.

09:18AM 25 Q They'll be double.

09:18AM 1 A Well, this is multiphase flow. So, again, we've tried to
09:18AM 2 simplify this, and probably for the sake of this conversation
09:18AM 3 that's probably best.

09:18AM 4 But multiphase flow is really incredibly
09:18AM 5 complicated. You have multiple velocities. You have a gas
09:18AM 6 velocity; you have a liquid velocity. They're moving at
09:18AM 7 different speeds at different portions of the pipe. You have an
09:18AM 8 average mixture velocity.

09:18AM 9 But, yes, probably -- or the average measured of
09:18AM 10 velocities should be faster in general than the measured
09:18AM 11 velocity in the true system.

09:18AM 12 Q And it would have to be double if your area is off by half;
09:18AM 13 wouldn't it?

09:18AM 14 A It's not exactly half, and there are different area drill
09:18AM 15 pipes. So, no, it's not an exact 2:1 ratio. Remember, you
09:19AM 16 know, the drill pipe example that you've used, which is a large
09:19AM 17 section of the riser. There's also a drill pipe upstream of
09:19AM 18 that which is much smaller which results in a different ratio.

09:19AM 19 Q And then there's another segment upstream of that which
09:19AM 20 results in a larger ratio; isn't there?

09:19AM 21 A A 22-foot section, yes, of a 45,000 foot riser.

09:19AM 22 Q So 75 percent of your riser has 2.03, as I think the ratio
09:19AM 23 of the area of the -- the area in the actual system to the area
09:19AM 24 in your model.

09:19AM 25 Does that sound about right?

09:19AM 1 A There were 264 over 130, yes.

09:19AM 2 Q Now, you also testified yesterday that the user manuals say
09:19AM 3 what you did with the hydraulic diameter is correct.

09:19AM 4 MR. CHAERES: I'd like to look at Exhibit 130544.

09:19AM 5 BY MR. CHAERES:

09:19AM 6 Q This is the most recent OLGA user manual I can get my hands
09:20AM 7 on. Do you recognize this document?

09:20AM 8 A Yeah, this is -- it's certainly not the most recent user
09:20AM 9 manual. There's version 7.2, which I used in this particular
09:20AM 10 investigation. And now, just recently, a few days ago, 7.3 was
09:20AM 11 released.

09:20AM 12 Q Okay. Now, let's go to page 444 of this document.

09:20AM 13 All right. If we could call out the table
09:20AM 14 beginning with pipes.

09:20AM 15 This is telling me how to input various inputs;
09:20AM 16 right? And it says here: For diameter for pipe.

09:20AM 17 Again, hydraulic diameter. That's what's used to
09:20AM 18 input for your pipe; right?

09:20AM 19 A Sorry, where are you specifically?

09:20AM 20 Q Diameter. It says input the hydraulic diameter of the pipe;
09:20AM 21 right?

09:20AM 22 A Yep, that's correct.

09:20AM 23 Q And then, above that -- and, again, this is consistent if
09:21AM 24 you want to maintain a relationship between pressure drops and
09:21AM 25 velocities; right?

09:21AM 1 A Yes. This is for the pipe keyword in OLGA. This is a
09:21AM 2 specific keyword when you're modeling the pipe. This particular
09:21AM 3 input in diameter is one of the inputs, and this manual is
09:21AM 4 confirming the use of hydraulic diameter.

09:21AM 5 Q And, again, you need the hydraulic diameter because you want
09:21AM 6 to maintain your relationship between the wetted perimeter and
09:21AM 7 the area; right?

09:21AM 8 A Yes, that's correct.

09:21AM 9 Q And that will get you the right pressure drops for a given
09:21AM 10 velocity; correct?

09:21AM 11 A No. That will give me the right pressure drops or the right
09:21AM 12 relationships between flow rate and pressure drop.

09:21AM 13 Q It's more intuitive if you say that it gives you the right
09:21AM 14 relationship between the pressure drop and the velocity; isn't
09:21AM 15 it?

09:21AM 16 A No, I don't believe that it is.

09:21AM 17 Q Okay. Now, let's look up above diameter to this area entry.
09:21AM 18 So this area 1. It gives you an opportunity to enter correct
09:22AM 19 total flow area; doesn't it?

09:22AM 20 A So this particular keyword is when you're using multiple
09:22AM 21 pipes. They call them equivalent pipes that are flowing in
09:22AM 22 parallel with one another.

09:22AM 23 This particular keyword is only used, again, in a
09:22AM 24 special case where you have multiple pipes flowing in parallel.
09:22AM 25 This keyword is not used for a single pipe situation.

09:22AM 1 Q What's the real number? Is it -- well, let me withdraw that
09:22AM 2 question.

09:22AM 3 So an integer is where you're counting 1, 2, 3, 4,
09:22AM 4 5; right?

09:22AM 5 A That's correct.

09:22AM 6 Q With a real number, you can have decimals. You can say 1.5,
09:22AM 7 1.75, that kind of thing; right?

09:22AM 8 A Yes.

09:22AM 9 Q 2.03.

09:22AM 10 Now, the number of equivalent pipes down here, you
09:22AM 11 can input a real number for that; can't you?

09:22AM 12 A Again, this is a section of the manual that's referring to
09:22AM 13 parallel pipes flowing next to each other. This would not be
09:23AM 14 the correct use of the software in this particular case. This
09:23AM 15 would take a real number input, or that's what it says in the
09:23AM 16 manual.

09:23AM 17 Q Like a half a pipe or, you know, sort of a like a Pacman
09:23AM 18 shape of a pipe, that's not something you'd actually be modeling
09:23AM 19 in reality; right?

09:23AM 20 You would only input a real number for the number
09:23AM 21 of equivalent pipes in a fraction form if you from were
09:23AM 22 transforming something that was different from what was going on
09:23AM 23 in your model; wouldn't you?

09:23AM 24 A Again, the situation that they're trying to address in this
09:23AM 25 particular section with these particular keywords -- so what you

09:23AM 1 shouldn't take from this is that all of these keywords are used
09:23AM 2 at any given time. It depends very specifically on the model
09:23AM 3 that you create.

09:23AM 4 And, when they say number of equivalent pipes, in
09:23AM 5 production fields you oftentimes have three or five pipes
09:23AM 6 running in parallel. This is -- the area and the number of
09:24AM 7 equivalent pipe is what they're referring to.

09:24AM 8 Q You ever have 2.5 pipes running in parallel in reality?

09:24AM 9 A No. And, in general, I've never seen it used that way. I
09:24AM 10 mean, it does say that it would accept a real number, but there
09:24AM 11 are numerous problems with this manual.

09:24AM 12 It could in fact accept a real number, but I have
09:24AM 13 never seen it used that way.

09:24AM 14 Q Okay. Let's look at page 429 of this document, and let's
09:24AM 15 call out the table beginning with leak.

09:24AM 16 So we were just talking about how to input pipes;
09:24AM 17 right?

09:24AM 18 Now we're talking about how to input leaks. Do
09:24AM 19 you see that?

09:24AM 20 A Yes. So this is the section of a model that looks like it's
09:24AM 21 focused on the leak key, yes.

09:24AM 22 Q Okay. Now, let's go down to see what they say about
09:24AM 23 diameter in the leak key.

09:25AM 24 Maximum equivalent diameter of leak area. There's
09:25AM 25 no mention of hydraulic diameter there; is there?

09:25AM 1 A No. So what they're asking you to input is the maximum
09:25AM 2 equivalent diameter.

09:25AM 3 Now, the equivalent diameter is, again, this
09:25AM 4 transformation. In this case, hydraulic diameter.

09:25AM 5 Q It said hydraulic diameter in the pipe thing; didn't it?

09:25AM 6 A Yeah. There was no definition per maximum equivalent
09:25AM 7 diameter. So what they are asking you to do is calculate an
09:25AM 8 equivalent diameter, hydraulic diameter.

09:25AM 9 Hydraulic diameter is one such diameter, and then
09:25AM 10 put that into the model.

09:25AM 11 Q So you think that they meant hydraulic diameter when they
09:25AM 12 wrote equivalent diameter here?

09:25AM 13 A No, I'm not saying that. I'm saying equivalent diameter is
09:25AM 14 a word that refers to these geometric transformations. They
09:25AM 15 were not specific about which transformation that they were
09:26AM 16 asking users to use.

09:26AM 17 There are of a number of empirically derived
09:26AM 18 transformations when you're looking at irregularly shaped holes.
09:26AM 19 So, an example as, sometimes they're much smaller than the
09:26AM 20 hydraulic diameter.

09:26AM 21 But, in this particular case, we used the
09:26AM 22 hydraulic diameter as the equivalent diameter in this section.

09:26AM 23 Q And they specified what geometric transformation they wanted
09:26AM 24 you to use in the pipe section when they said hydraulic
09:26AM 25 diameter; didn't they?

09:26AM 1 A Yes. Specifically, in that section, they confirmed the use
09:26AM 2 of hydraulic diameter.

09:26AM 3 Q And they didn't here; did they?

09:26AM 4 A No. Again, I think this has to do with a context. So a
09:26AM 5 leak hole can be very irregularly shaped. And there's a large
09:26AM 6 body of research around characterizing leak holes and the
09:26AM 7 specific diameter or transformation that would correctly
09:26AM 8 characterize that, some of which are smaller than the hydraulic
09:27AM 9 diameter.

09:27AM 10 This is just, we don't know which correlation
09:27AM 11 you're going to use. We don't know enough about the leak holes.
09:27AM 12 Certainly, pipes aren't star-shaped or anything like that, so
09:27AM 13 they can safely say hydraulic diameter. When you're looking at
09:27AM 14 a hole, it could be any irregular shape.

09:27AM 15 So, at this particular section, I think they
09:27AM 16 stayed safely more generic.

09:27AM 17 Q When Tim Lockett was modeling the leak, he did not use a
09:27AM 18 hydraulic diameter; did he?

09:27AM 19 A I didn't see Tim Lockett modeling anything. I just saw an
09:27AM 20 email where he was calculating an equivalent area diameter. I
09:27AM 21 don't know what he actually used in his calculations.

09:27AM 22 MR. FIELDS: Your Honor, I'm sorry. May I approach and
09:27AM 23 give the witness some water?

09:27AM 24 THE COURT: Sure.

09:27AM 25 BY MR. CHAKERES:

09:27AM 1 Q In the email that Tim Lockett -- from Tim Lockett that you
09:27AM 2 saw, he was discussing calculating leaks; right? Calculating
09:28AM 3 flow through leaks; wasn't he?

09:28AM 4 A Yes. That's what he was discussing.

09:28AM 5 Q And the area transform that he used for that was an area
09:28AM 6 transform that was going to give him the equivalent of the area
09:28AM 7 as was actually flowing through leaks; wasn't it?

09:28AM 8 A So, as I think in this email, he's again trying to
09:28AM 9 transform, and he uses a transform that would calculate the
09:28AM 10 diameter of the equivalent area of that leak, yes.

09:28AM 11 MR. CHAERES: Okay. We can pull this down.

09:28AM 12 So if we could just go real quickly back to
09:28AM 13 demonstrative D-22201.

09:28AM 14 BY MR. CHAERES:

09:28AM 15 Q Again, we were talking here about at the beginning, this is
09:28AM 16 approximation for multiphase flow, but it actually holds true
09:28AM 17 for each phase. Mass flow rate with a density times the
09:29AM 18 velocity times the area; right?

09:29AM 19 A Yeah, that's correct. If the velocity is an average mixture
09:29AM 20 velocity, that would hold true.

09:29AM 21 Q Okay. And the difference between your model and reality, at
09:29AM 22 least for the sake of the -- the large majority of the riser, is
09:29AM 23 that the area available flow through the riser with a 6'65"
09:29AM 24 drill pipe is about double what the area was in your model;
09:29AM 25 isn't that true?

09:29AM 1 A That's correct.

09:29AM 2 Q And the velocity, you state, drops by an equivalent amount
09:29AM 3 in order to keep the mass flow rate the same; isn't that true?

09:29AM 4 A It changes. I think the velocity in my model would be
09:29AM 5 faster than the velocity.

09:29AM 6 Q I stand corrected.

09:29AM 7 The area drops in your model so the velocity
09:29AM 8 increases in your model; correct?

09:29AM 9 A That's correct.

09:29AM 10 Q Now, if the velocity were to have stayed the same and your
09:29AM 11 model was within reality, then the mass flow rate in reality
09:29AM 12 would have been double what the mass flow rate was in your
09:30AM 13 model?

09:30AM 14 A No. Again, that's really incorrect. Again, you're now
09:30AM 15 taking definitions and you're trying to make them predictive.

09:30AM 16 What I've used is the best available technology.
09:30AM 17 I've made an approximation that's based on science and that's
09:30AM 18 backed by a large body of literature. You cannot then
09:30AM 19 cherry-pick one number that you like out of my model and then
09:30AM 20 plug it into a relationship. This is just the definition. And
09:30AM 21 then try to predict something else. It's just not correct to do
09:30AM 22 that.

09:30AM 23 Q So, to sum up, you claim that for any -- well, you claim
09:30AM 24 that this definition is being taken out of context. This
09:30AM 25 definition has to hold true; right?

09:30AM 1 A Yeah. The definition holds true given the construct of a
09:31AM 2 particular model. So, if you were to take my model and you were
09:31AM 3 to use my area, my velocity, and my density, of course then you
09:31AM 4 would get the same mass flow rate that my model's predicting.

09:31AM 5 What I am saying is that you can say, Oh, I like
09:31AM 6 this one result from your model, let me take that and let me
09:31AM 7 take an area that wasn't used in the model, and then expect to
09:31AM 8 get the correct mass flow rate. That's just not the way it's
09:31AM 9 done.

09:31AM 10 There's nothing in the literature that would say
09:31AM 11 that. There's nothing in the OLGA manual that says: Oh, by the
09:31AM 12 way, you need to scale your numbers by a factor of 2. It's just
09:31AM 13 not correct.

09:31AM 14 Q The OLGA manual allows you to input real numbers for
09:31AM 15 equivalent pipes in order get the total correct area for flow;
09:31AM 16 right?

09:31AM 17 A No. Again, equivalent pipes is a scenario where you have
09:31AM 18 multiple pipes flowing in parallel. This is quite common in the
09:32AM 19 oil and gas industry, and that's why that was introduced.

09:32AM 20 What the manual says, quite clearly, is use the
09:32AM 21 hydraulic diameter when you're modeling flow through a pipe.

09:32AM 22 Q And you use the hydraulic diameter to get the right pressure
09:32AM 23 drops and the right velocities; isn't that true?

09:32AM 24 A No. That's not what the manual says, and that's not the
09:32AM 25 purpose of the hydraulic diameter. The hydraulic diameter is

09:32AM 1 intended to correctly relate flow rates and pressure drops.

09:32AM 2 It's not intended to correctly relate velocities
09:32AM 3 and pressure drops.

09:32AM 4 MR. CHAERES: Dr. Zaldivar, I have no further
09:32AM 5 questions.

09:32AM 6 THE COURT: Redirect.

09:33AM 7 REDIRECT EXAMINATION

09:33AM 8 BY MR. FIELDS:

09:33AM 9 Q Good morning, Dr. Zaldivar. Barry Fields, and I have you on
09:33AM 10 redirect examination on behalf of BP and Anadarko.

09:33AM 11 Just us a few questions to follow-up.

09:33AM 12 MR. FIELDS: If we pull up TREX-130544.444.

09:33AM 13 BY MR. FIELDS:

09:33AM 14 Q We were just looking at this.

09:33AM 15 I want to specifically look at the example that
09:33AM 16 you were asked about equivalent pipes. And that's under Area.
09:33AM 17 Do you see that?

09:33AM 18 A Yes, I do.

09:33AM 19 MR. FIELDS: If Your Honor doesn't mind, just so that
09:33AM 20 we're clear, could Dr. Zaldivar go down to the chart and sort of
09:33AM 21 draw an example of equivalent pipes as compared to the situation
09:33AM 22 we're dealing with here?

09:33AM 23 THE COURT: Okay.

09:33AM 24 BY MR. FIELDS:

09:33AM 25 Q So would you draw what -- when you talk about what are

09:34AM 1 equivalent pipes, what is that and what we're dealing with in an
09:34AM 2 equivalent pipe situation?

09:34AM 3 THE COURT: He'll need a microphone because nobody will
09:34AM 4 be able to hear him where he is.

09:34AM 5 THE WITNESS: Can you hear me?

09:34AM 6 MR. FIELDS: Yes.

09:34AM 7 THE WITNESS: So just go ahead?

09:34AM 8 So, again, what we're describing here -- didn't
09:34AM 9 work very well.

09:34AM 10 What we're describing here is a single pipe. This
09:35AM 11 is the riser with a drill pipe flowing through it. What they're
09:35AM 12 referring to in the manual is multiple pipes flowing in
09:35AM 13 parallel.

09:35AM 14 This is quite common in the oil and gas industry.
09:35AM 15 As they find new oil, they might lay another pipe identical to
09:35AM 16 the one right next to it. So, oftentimes, you see this where
09:35AM 17 you have multiple pipes.

09:35AM 18 It wouldn't be convenient to model each pipe
09:35AM 19 independently. It would result in bigger models. So this is a
09:35AM 20 shortcut that allows you to combine these pipes together.

09:35AM 21 BY MR. FIELDS:

09:35AM 22 Q In the situation that you were modeling, were you modeling a
09:35AM 23 situation that involved equivalent pipes?

09:35AM 24 A No.

09:35AM 25 Q Now, on cross examination, you were asked a series of

09:35AM 1 questions regarding a water tower. And I guess my first
09:35AM 2 question was, was that hypothetical example, was that dealing
09:36AM 3 with a single phase fluid or a multiphase fluid?

09:36AM 4 A I understood it to be a single phase fluid.

09:36AM 5 Q And, when you're dealing with multiphase flow or multiphase
09:36AM 6 fluids, are there other factors beyond the hydraulic diameter
09:36AM 7 that matter?

09:36AM 8 A Yes.

09:36AM 9 Q What are other examples or factors that matter?

09:36AM 10 A So, again, the ratio of gas to oil, the gas moves a little
09:36AM 11 bit faster. It can create a choking affect on the liquid.

09:36AM 12 There's lots of complexity here. The extent that the liquid
09:36AM 13 touches the particular surface.

09:36AM 14 But, yeah, there's lots of complexity here.

09:36AM 15 Q Is one of the factors that matters something called a
09:37AM 16 discharge coefficient?

09:37AM 17 A Oh, yes.

09:37AM 18 Q And what is a discharge coefficient?

09:37AM 19 A Discharge coefficient is a characterization of the pressure
09:37AM 20 recovery through a particular diameter.

09:37AM 21 Q And did you use discharge coefficients in your work?

09:37AM 22 A I did.

09:37AM 23 MR. FIELDS: Pull up TREX-11683.57 and 58.

09:37AM 24 BY MR. FIELDS:

09:37AM 25 Q What discharge coefficient did you use, if you recall, in

09:37AM 1 dealing with the kink leaks?

09:37AM 2 A So I used 0.84 for the kink leaks.

09:37AM 3 Q Okay. We don't need that then. Good memory.

09:37AM 4 Is that for a circular hole, or was it for a
09:37AM 5 rectangular hole?

09:37AM 6 A No. It's a circular hole. If you were to use a rectangular
09:37AM 7 hole, you would have to use a much lower discharge coefficient,
09:38AM 8 something on the order between 0.61 and 0.5.

09:38AM 9 Q And, in your view, was it a conservative assumption, to use
09:38AM 10 a discharge coefficient in that manner?

09:38AM 11 A Yes. To assume discharge coefficient of 0.84, it was a
09:38AM 12 conservative assumption. Actually, it's a consistent assumption
09:38AM 13 with the use of hydraulic diameter.

09:38AM 14 Had I taken a different approach and used the
09:38AM 15 equivalent area, then I would have had to greatly reduce the
09:38AM 16 discharge coefficient by almost 40 percent actually.

09:38AM 17 Q Now, you indicated on cross examination that the velocities
09:38AM 18 in your model, or that were predicted by your models, are not
09:38AM 19 the correct velocities when you use the hydraulic diameter?

09:38AM 20 A That's correct.

09:38AM 21 Q Now, is that something that's unique to your model, or is
09:38AM 22 that something that occurs whenever you're using the hydraulic
09:38AM 23 diameter in a multiphase flow simulator?

09:39AM 24 A No, this isn't unique to my model. The use of hydraulic
09:39AM 25 diameter is standard transformation. It would be used in any

09:39AM 1 situation like this.

09:39AM 2 Q And why do these models generate velocities that are
09:39AM 3 different than the actual velocities in the pipe?

09:39AM 4 A The purpose, again, is to accurately capture the
09:39AM 5 relationship between pressure drop and flow rate. You have an
09:39AM 6 increased velocity to get the correct pressure drop or to get
09:39AM 7 that correct resistance to flow.

09:39AM 8 Q And why can't you take the velocities out of your model or
09:39AM 9 the velocities that are generated from a multiphase flow
09:39AM 10 simulator when you're using the hydraulic diameter, and use that
09:39AM 11 velocity in another equation or in another model?

09:39AM 12 A Well, at least in the context -- I mean, in general, your
09:39AM 13 models are self-consistent. You're solving many equations. And
09:39AM 14 all of those equations relate the variables inside that model.

09:40AM 15 It would be very incorrect to then take one
09:40AM 16 parameter and then try to use that in another situation. In
09:40AM 17 particular, with like definitional sort of things, which is just
09:40AM 18 the relations of variables.

09:40AM 19 MR. FIELDS: Can we pull up D-24688.

09:40AM 20 BY MR. FIELDS:

09:40AM 21 Q You indicated on cross examination that you're aware of
09:40AM 22 literature out there that talks about why it's appropriate to
09:40AM 23 use the hydraulic diameter, and this is a slide you helped us
09:40AM 24 prepare.

09:40AM 25 Can you just provide the Court briefly with what

09:40AM 1 this shows about the use of hydraulic diameter in multiphase
09:40AM 2 flow modeling?

09:40AM 3 A Yes. So, on the left, this is an excerpt of the OLGA manual
09:41AM 4 that specifically focuses on flow in an annulus exactly like the
09:41AM 5 situation we have in the *Deepwater Horizon*.

09:41AM 6 It says the correct thing to do is to use the
09:41AM 7 hydraulic diameter. In the center, we have the textbook that
09:41AM 8 the government placed before us, the Miller textbook, also
09:41AM 9 recommending the use of hydraulic diameter.

09:41AM 10 And then last we have an article by Koch which has
09:41AM 11 a very strong statement which says: Until a proven relationship
09:41AM 12 for equivalent diameter is forthcoming, there is no other choice
09:41AM 13 than to use the hydraulic diameter.

09:41AM 14 Q Thank you.

09:41AM 15 MR. FIELDS: No further questions, Your Honor.

09:41AM 16 THE COURT: Thank you, sir, you're done.

09:42AM 17 Who is your next witness?

09:42AM 18 MR. BROCK: Our next witness is Dr. Nestic.

09:42AM 19 THE COURT: Who is next, Mr. Brock?

09:42AM 20 MR. BROCK: Dr. Nestic.

09:42AM 21 THE COURT: Let's go ahead and take a 15 minute recess.

09:42AM 22 (Proceedings in recess.)

10:08AM 23 THE COURT: Please be seated.

10:08AM 24 Go ahead, Mr. Brock.

10:08AM 25 SRDJAN NESIC, Ph.D., being first duly sworn,

10:08AM 1 testified as follows:

10:08AM 2 THE CLERK: Will you take a seat. State and spell your
10:08AM 3 name for the record, please.

10:08AM 4 THE WITNESS: My name is Srdjan Nestic, S-R-D-J-A-N,
10:08AM 5 last name N-E-S-I-C.

10:08AM 6 MS. CROSS: Your Honor, Anna Cross on behalf of the
10:08AM 7 United States.

10:08AM 8 I just want to remind the Court that there is a
10:08AM 9 *Daubert* motion pending against Dr. Nestic. It's Docket No.
10:09AM 10 11508. And we're happy to argue it or leave it on the papers.

10:09AM 11 THE COURT: Yeah, I've looked at it. I'm going to deny
10:09AM 12 the -- I think the issues that you raise in your motion are more
10:09AM 13 properly subject of cross examination and will go to the weight
10:09AM 14 of this expert's testimony.

10:09AM 15 So I'll deny the motion.

10:09AM 16 MS. CROSS: Understood. Thank you.

10:09AM 17 MR. BROCK: Can I proceed now?

10:09AM 18 THE COURT: Yes.

10:09AM 19 DIRECT EXAMINATION

10:09AM 20 BY MR. BROCK:

10:09AM 21 Q Mike Brock on behalf of BP and Anadarko. And this will be
10:09AM 22 your direct examination, Dr. Nestic.

10:09AM 23 Would you begin by stating your full name for the
10:09AM 24 record and tell Judge Barbier where you live and work.

10:09AM 25 A My name is Srdjan Nestic, and I live and work in Athens,

10:09AM 1 Ohio.

10:09AM 2 Q What were you asked to do by BP, Dr. Nestic?

10:09AM 3 A I was asked by BP to offer my opinions as to what were the
10:09AM 4 effects of erosion on the change of flow rate through the BOP.

10:10AM 5 MR. BROCK: I'm going to call up now D-23626. And
10:10AM 6 could I have the first slide, please.

10:10AM 7 BY MR. BROCK:

10:10AM 8 Q Dr. Nestic, can you use this slide to describe for Judge
10:10AM 9 Barbier your educational background, please?

10:10AM 10 A I have a Bachelors and Masters in mechanical engineering
10:10AM 11 from the University of Belgrade. And I also have a Ph.D. in
10:10AM 12 chemical engineering from the University of Saskatchewan in
10:10AM 13 Canada.

10:10AM 14 Q Did you study the issue of erosion as part of your graduate
10:10AM 15 degrees?

10:10AM 16 A I have. And, actually, erosion was one of the key topics in
10:10AM 17 the course of my Ph.D. work.

10:10AM 18 Q Now, after you received your Ph.D. degree, where did you
10:10AM 19 work?

10:10AM 20 A Straight after my Ph.D., I went and worked for the Institute
10:10AM 21 For Energy Technology in Norway, in Oslo, Norway.

10:11AM 22 Q What is the Institute For Energy and Technology?

10:11AM 23 A It is the largest research institute in the country, and
10:11AM 24 used to be a nuclear institute. But, when I was there, it had
10:11AM 25 already switched and did all its work almost on problems related

10:11AM 1 to oil and gas production in the North Sea.

10:11AM 2 Q What was your position with the Institute For Energy
10:11AM 3 Technology?

10:11AM 4 A I was a principal research scientist over there.

10:11AM 5 Q What does that mean?

10:11AM 6 A That means I was a project leader on numerous projects which
10:11AM 7 mostly related to the issues of multiphase flow and metal loss
10:11AM 8 by erosion and corrosion in the facilities in the North Sea.
10:11AM 9 That is, the oil and gas facilities in the North Sea.

10:11AM 10 Q Can you describe the work that you were doing in the area of
10:11AM 11 erosion during the period of time that you were with the
10:11AM 12 Institute For Energy Technology?

10:11AM 13 A There were a number of different projects that dealt with
10:11AM 14 the various modes of metal loss, and all of them were
10:12AM 15 exclusively related to so-called internal metal loss. That
10:12AM 16 means from the inside of the pipe. And most of them were
10:12AM 17 related to offshore oil and gas production.

10:12AM 18 Q Why is this an issue that's of importance to the oil and gas
10:12AM 19 industry?

10:12AM 20 A Well, it is hugely important to the oil and gas industry
10:12AM 21 because, whether in the design stage or the operational stage of
10:12AM 22 any given field, there is an enormous pressure on all the
10:12AM 23 engineers to design things and operate things in a way that
10:12AM 24 there aren't any breaches of the pipe wall, whatever the
10:12AM 25 mechanism is, so there is no uncontrolled release. And they

10:12AM 1 have to make sure that doesn't happen for 30 to 50 years,
10:12AM 2 typically.

10:12AM 3 Q Now, you show here on this slide that you were with the
10:12AM 4 Institute For Energy Technology from 1991 to 1996, and then you
10:12AM 5 went to the University of Queensland. And we list here senior
10:13AM 6 lecturer of mechanical engineering.

10:13AM 7 Can you describe for Judge Barbier what you did
10:13AM 8 during this time and how that work is relevant to your opinions
10:13AM 9 here today.

10:13AM 10 A Sure.

10:13AM 11 Your Honor, I moved from a pure research position
10:13AM 12 in Norway to a combined teaching-research position in the
10:13AM 13 University of Queensland. There, I had shared duties. I taught
10:13AM 14 courses on fluid mechanics, corrosion, erosion, computation of
10:13AM 15 fluid dynamics.

10:13AM 16 I also guided Ph.D. students to do their research
10:13AM 17 projects on the Master's and Ph.D. level in those exact same
10:13AM 18 fields. So I had computation of fluid dynamics thesis; I had
10:13AM 19 erosion thesis, et cetera.

10:13AM 20 Q Will you be using your knowledge and experience with regard
10:13AM 21 to erosion and computational fluid dynamics to present to the
10:13AM 22 Court today your opinions about erosion within the BOP and the
10:13AM 23 kink riser?

10:13AM 24 A Yes, I will.

10:14AM 25 Q Now, at the end of your tenure at the University of

10:14AM 1 Queensland, we show here that you moved to Ohio University in
10:14AM 2 2002.

10:14AM 3 Would you describe for Judge Barbier what your
10:14AM 4 position is at Ohio University? And maybe just start with some
10:14AM 5 of the courses that you teach and the work that do you in the
10:14AM 6 field of erosion.

10:14AM 7 A I moved in 2002. January 2nd, I started at Ohio University
10:14AM 8 as a full professor there. So, I had my share of teaching
10:14AM 9 duties.

10:14AM 10 But I also took at the same time a directorship of
10:14AM 11 the Institute For Corrosion and Multiphase Technology. On the
10:14AM 12 teaching side, I continued with courses along the fluid
10:14AM 13 mechanics, computation of fluid mechanics, corrosion, erosion
10:14AM 14 type of classes that I taught at both undergraduate and graduate
10:14AM 15 level.

10:14AM 16 And, on the research side, I was directing work at
10:14AM 17 the Institute For Corrosion and Multiphase Technology.

10:15AM 18 Q Now, you mentioned this briefly in that answer, the
10:15AM 19 Institute For Corrosion and Multiphase Technology. Can you
10:15AM 20 describe for Judge Barbier what that institute is and what it
10:15AM 21 does.

10:15AM 22 A The institute is the largest, and I would say one of the
10:15AM 23 leading institutes, for studying problem of metal loss by
10:15AM 24 erosion and corrosion in the world. That's the main reason
10:15AM 25 actually I moved to Ohio University.

10:15AM 1 We have the biggest projects and lots of different
10:15AM 2 industrial sponsors. Whereas, all our activities are directed
10:15AM 3 towards problems seen in the oil and gas industry. We are
10:15AM 4 hundred percent sponsored by the industry, and all my graduate
10:15AM 5 students and other research staff are focused on problems of
10:15AM 6 metal loss in multiphase flow in that industry.

10:15AM 7 Q What type of research does the institute do for major oil
10:15AM 8 companies and engineering companies that support the oil
10:16AM 9 companies?

10:16AM 10 A We do research that is sounding very narrow, but it's a very
10:16AM 11 important area. We focus on various modes of metal loss within
10:16AM 12 the different pipes and other equipment they have.

10:16AM 13 So it's so-called internal corrosion in the oil
10:16AM 14 and gas industry, starting from corrosion down -- and erosion as
10:16AM 15 well -- down in the well. Then erosion and corrosion in the
10:16AM 16 so-called surface equipment. Then in the very long pipelines.
10:16AM 17 So we exclusively do that kind of work.

10:16AM 18 Our sponsors are, as I already alluded, oil and
10:16AM 19 gas companies, engineering companies, as well as chemical
10:16AM 20 companies that support the previous ones.

10:16AM 21 Q Does your role as the director of the institute give you
10:16AM 22 expertise to help answer the question of erosion in the Macondo
10:16AM 23 BOP end riser?

10:16AM 24 A Oh, indeed, yes.

10:16AM 25 Q And why is that so?

10:16AM 1 A Because, starting even with my Masters about 30 years ago, I
10:17AM 2 have worked with issues of computation fluid dynamics.

10:17AM 3 Actually, my Ph.D. thesis was the pioneering work in application
10:17AM 4 of computation of fluid dynamics in erosion. That was the first
10:17AM 5 time that was ever done.

10:17AM 6 And I've continued since to be active in that
10:17AM 7 area. I have conducted many research studies myself. I've
10:17AM 8 guided numerous students who looked at this combination of
10:17AM 9 affect -- how flow affects erosion.

10:17AM 10 So, therefore, I feel I'm directly applying all
10:17AM 11 that knowledge in my opinions when I offer them to the Court
10:17AM 12 here.

10:17AM 13 Q Thank you.

10:17AM 14 We've used this term here in the slide with regard
10:17AM 15 to your qualifications, computational fluid dynamics, and you've
10:17AM 16 just mentioned that to the Court.

10:17AM 17 What is computational fluid dynamics, and how does
10:17AM 18 it assist you in evaluating a case like the one we're looking at
10:17AM 19 here?

10:18AM 20 A Your Honor, I know you heard a lot about very sophisticated
10:18AM 21 computer-based techniques to resolve problems, and this is one
10:18AM 22 of them.

10:18AM 23 Computational fluid dynamics is a mathematical
10:18AM 24 technique that's then implemented in computers to solve
10:18AM 25 equations of fluid flow and any associated effect in a way that

10:18AM 1 we cannot do otherwise.

10:18AM 2 Using this technique, we can get very detailed
10:18AM 3 information of what flow does through complicated geometries.

10:18AM 4 And, in the case that we're looking at here in the Macondo well,
10:18AM 5 we are having very complex geometries. So the computational
10:18AM 6 fluid dynamics is the only way that can give us the insight of
10:18AM 7 what the fluid did, the hydrocarbons did, as well as any
10:18AM 8 particles that were carried with it.

10:18AM 9 Q Thank you.

10:18AM 10 Now, just last question on this topic. We've
10:18AM 11 listed here on this slide: Co-authored over 70 peer-reviewed
10:19AM 12 papers, 100 conference papers and book articles in the field.

10:19AM 13 In terms of your work with regard to corrosion,
10:19AM 14 erosion, and CFD, are you published in all of those areas?

10:19AM 15 A Yes. Those three topics you mentioned were the main topics
10:19AM 16 that I ever published about.

10:19AM 17 Q Right. Thank you.

10:19AM 18 MR. BROCK: Your Honor, at this point, we would tender
10:19AM 19 Dr. Nestic as an expert witness in the computational fluid
10:19AM 20 dynamics and metal erosion.

10:19AM 21 MS. CROSS: Under our *Daubert* motion and on cross
10:19AM 22 examination, no objection.

10:19AM 23 THE COURT: All right. He's accepted.

10:19AM 24 BY MR. BROCK:

10:19AM 25 Q Let's go now, Dr. Nestic, to an overview of just the basic

10:19AM 1 concept of erosion, what we're talking about. I've called up
10:19AM 2 D-24603, and I'll just ask you, first of all, what is metal
10:19AM 3 erosion? What are we talking about when we talk about the
10:19AM 4 concept of erosion?

10:19AM 5 A Metal erosion is a name for a phenomena where metallic
10:20AM 6 surface is mechanically removed by repeated impact of solid
10:20AM 7 particles. Very frequently, those solid particles are sand.

10:20AM 8 I have a little animation here that I would like
10:20AM 9 to start. It is a simplification of the situation, but I think
10:20AM 10 it illustrates the point. Here, it shows one individual
10:20AM 11 particle striking the surface and causing damage by these
10:20AM 12 repeated impacts. In reality, we have large numbers of
10:20AM 13 particles impacting any given area and causing the metal to be
10:20AM 14 lost.

10:20AM 15 So, again, to summarize, it's a mechanical mode of
10:20AM 16 metal loss that's often seen in the field.

10:20AM 17 Q What are the factors that must be present in order for
10:20AM 18 erosion to occur?

10:20AM 19 A They stem directly from this animation. As you can imagine
10:20AM 20 just by looking at this still picture, we have to have enough
10:20AM 21 particles there, enough sand in this case, to cause erosion.

10:21AM 22 The second important parameter is that those
10:21AM 23 particles, the sand, must impact the surface with sufficient
10:21AM 24 energy. Translated into simple terms, it has to move fast
10:21AM 25 enough so that it can dig into the surface.

10:21AM 1 And the third condition is the particles have to
10:21AM 2 come at a right angle. It's not enough that they're there and
10:21AM 3 they're moving fast. They have to come at a right angle so they
10:21AM 4 can chisel out a piece of metal surface.

10:21AM 5 So, therefore, it's not sufficient to say in a
10:21AM 6 straight line you could have a lot of particles moving fast, but
10:21AM 7 if they just barely scrape the surface and roll over they don't
10:21AM 8 cause erosion. Erosion is caused when particles hit at a
10:21AM 9 particular angle with a particular intensity.

10:21AM 10 Q You have described that to us before as angle of impact.

10:21AM 11 A Correct.

10:21AM 12 Q And that has significance in terms of evaluating how much
10:21AM 13 erosion will occur given other conditions?

10:21AM 14 A That is true.

10:21AM 15 Q Okay. Now, based on your knowledge, education, and
10:21AM 16 experience, does erosion occur as long as solid particles are
10:22AM 17 moving in the system?

10:22AM 18 A One can say that. Given that the conditions are conducive
10:22AM 19 to corrosion -- that is, the angle of impact is there and the
10:22AM 20 velocity is there -- one can then safely assume that as long as
10:22AM 21 the particles are there, corrosion -- sorry -- erosion is going
10:22AM 22 to continue. That is a very logical extension of the previous
10:22AM 23 arguments I just gave.

10:22AM 24 Q Now, you have prepared a report that has been submitted in
10:22AM 25 this case; correct?

10:22AM 1 A That's right.

10:22AM 2 Q And let me just ask you, first, what information or
10:22AM 3 background materials did you use to analyze the effect of metal
10:22AM 4 erosion on flow for the period you studied?

10:22AM 5 A Well, to summarize on a very high level, I needed the
10:22AM 6 geometries that I was interested in. I needed the description
10:22AM 7 of those geometries in a very precise way. I need information
10:22AM 8 about the fluids that were passing through those geometries.
10:23AM 9 And, finally, I needed information about the presence of sand in
10:23AM 10 that system.

10:23AM 11 Q I'm going to call up now D-23648, which I think in some ways
10:23AM 12 summarizes what you just shared with the Court.

10:23AM 13 But, in terms of your approach to the issue that
10:23AM 14 we're talking about today, Dr. Nestic, what was your overall
10:23AM 15 methodology or approach to looking at this issue?

10:23AM 16 A Your Honor, I know I'm going to talk about these four points
10:23AM 17 in great detail, but I think it's helpful if we summarize now
10:23AM 18 what I have done.

10:23AM 19 So one of the first things that I had to determine
10:23AM 20 is to find the period of erosion. In other words, to put
10:23AM 21 boundaries on the time that I looked at the erosion and what
10:23AM 22 effects it may have caused and did cause actually to flow.

10:23AM 23 Then I went on to the geometries that were eroded.
10:24AM 24 So I focused on those geometries that did make a big difference,
10:24AM 25 that did restrict the flow, and then opened up as time went

10:24AM 1 because of erosion. And, fortunately, we had not only the
10:24AM 2 pre-eroded geometries, the pristine ones that were deployed, but
10:24AM 3 we also had recovered most important components of the eroded
10:24AM 4 geometries. So I used both of those.

10:24AM 5 And I then finally went to my computational fluid
10:24AM 6 dynamics. It's a complicated technique, as you'll get a glance
10:24AM 7 of in a minute. But we were able -- I was able to get answers
10:24AM 8 as to how restrictive were these geometries exactly one-by-one,
10:24AM 9 and then also able to determine what kind of effect they had on
10:24AM 10 flow before they eroded and after they eroded.

10:24AM 11 Those are the two important signposts in time I
10:24AM 12 will come back to.

10:24AM 13 And, finally, the last thing I did was, once I
10:24AM 14 determined those restrictions and how they changed, I answered
10:25AM 15 the question how would the flow then -- flow rate change based
10:25AM 16 on that procedure.

10:25AM 17 MR. BROCK: Okay. I'm going to call out No. D-23629,
10:25AM 18 which is TREX-11529R.

10:25AM 19 BY MR. BROCK:

10:25AM 20 Q I'll ask you if this is the cover page to your report?

10:25AM 21 A Yes, it is.

10:25AM 22 MR. BROCK: Your Honor, at this time, we would move
10:25AM 23 Dr. Nestic's report into evidence.

10:25AM 24 THE COURT: All right. That's admitted.

10:25AM 25 (Exhibit admitted.)

10:25AM 1 BY MR. BROCK:

10:25AM 2 Q Now, Dr. Nestic, have you formed opinions in this case, and
10:25AM 3 will D-23631 on the slide that I have just put up, help you to
10:25AM 4 explain at a high level to Judge Barbier what your opinions are
10:25AM 5 here?

10:25AM 6 A Yes. I did form opinions, and this slide is a fair summary
10:25AM 7 of that.

10:25AM 8 Q Just, at a high level, would you walk through your opinions
10:25AM 9 about erosion that took place in the blind shear ram and to the
10:26AM 10 kink riser -- to the BOP and the kink riser?

10:26AM 11 A Yes.

10:26AM 12 Your Honor, I've kind of went in very high level
10:26AM 13 at what I set to do, and we are now jumping right to the end.
10:26AM 14 We are going to elaborate. I'm showing you here the main
10:26AM 15 findings that I reached in my work. These are not all the
10:26AM 16 findings, but these are the things that made the biggest
10:26AM 17 difference.

10:26AM 18 The first bullet point here says that the blind
10:26AM 19 sheer rams and the casing sheer rams were significant
10:26AM 20 restrictions in flow when they were activated and before they
10:26AM 21 were actually eroded. Blind sheer rams more so than the casing
10:26AM 22 sheer rams, but they were both significant restriction to flow.

10:26AM 23 And I have calculated that, and I'll show you
10:26AM 24 actually some evidence later on.

10:26AM 25 I've also concluded that this erosion that

10:26AM 1 proceeded over about a five-week period of time significantly
10:26AM 2 changed the flow restrictions in the BOP, and that the
10:26AM 3 resistance they offered has gone down tremendously due to
10:27AM 4 erosion.

10:27AM 5 Then I've actually been in a position to put
10:27AM 6 numbers to these points that I just described. I was able to
10:27AM 7 calculate how much exactly that this resistance change, by what
10:27AM 8 factor. And, therefore, I was able to say that the flow
10:27AM 9 approximately doubled, with an assumption that the BOP was the
10:27AM 10 main restriction in flow. That was my focus. I did not have
10:27AM 11 focus on the rest of the flow path.

10:27AM 12 And, finally, what I've determined by my
10:27AM 13 simulations was that this increase from the beginning when
10:27AM 14 everything was in its pristine state to the end was a gradual
10:27AM 15 process. I'm not saying linear, like a straight line process,
10:27AM 16 but it was a gradual process that for the most part it just went
10:27AM 17 progressively from the initial state to the last state.

10:27AM 18 So that's a high level summary of what I found.

10:28AM 19 Q Thank you, Dr. Nestic.

10:28AM 20 I'm going to go now to D-23632. And ask you,
10:28AM 21 Dr. Nestic, to describe for Judge Barbier which geometries you
10:28AM 22 studied to determine the effects of metal erosion on flow rate
10:28AM 23 at the Macondo well.

10:28AM 24 A Sure.

10:28AM 25 Your Honor, you've seen probably these name and

10:28AM 1 these images many times. But, just to summarize, after a very
10:28AM 2 careful analysis of what should I look at, I've singled out
10:28AM 3 these four main geometries within the BOP and the kinked riser
10:28AM 4 to be, A, the most restrictive to flow; and, B, the ones that
10:28AM 5 change. Not equally, but the ones that change most over this
10:28AM 6 period of time.

10:28AM 7 And, there, if you go from bottom up, the casing
10:28AM 8 sheer rams, the blind sheer rams which I already mentioned, then
10:28AM 9 to some upper annular and the kinked riser.

10:28AM 10 So those were the four geometries that I
10:28AM 11 identified.

10:29AM 12 Q Why did you select those four geometries?

10:29AM 13 A Well, there were two main criteria, one which is very
10:29AM 14 obvious. I have gone to Michoud twice. I have seen the
10:29AM 15 pictures. I've seen the actual pieces. Indeed, I did focus on
10:29AM 16 those elements that have shown a high level of erosion. So they
10:29AM 17 became an immediate candidate.

10:29AM 18 But, on top of that, I had to make sure that I
10:29AM 19 understood and analyzed the flow path to see where was the fluid
10:29AM 20 going at any given point in time.

10:29AM 21 So, therefore, it wasn't always the case when
10:29AM 22 something eroded a lot that it affected the flow a lot. So I
10:29AM 23 kind of have to have both. That, A, there were restrictions
10:29AM 24 which are important; and, B, that they have eroded.

10:29AM 25 So, once I've kind of used those two criteria, I

10:29AM 1 came up with these four geometries that in this period I looked
10:29AM 2 at, April 22nd to May 27th, were more relevant.

10:29AM 3 Q Now, have you helped us with a demonstrative exhibit that
10:30AM 4 you believe illustrates the event that you believe to be most
10:30AM 5 significant to erosion?

10:30AM 6 A Yes.

10:30AM 7 Q I'm going to call out now D-23633-B.

10:30AM 8 And you see, here, we have a slide titled:
10:30AM 9 Timeline of Significant Erosion Events.

10:30AM 10 Do you see that?

10:30AM 11 A Yes.

10:30AM 12 Q Now, in terms of orienting Judge Barbier to your work, I
10:30AM 13 think you described this just a minute ago. When do you start
10:30AM 14 your analysis and when do you conclude your analysis?

10:30AM 15 A My analysis starts on April 22nd. And that's because that
10:30AM 16 is the date when the blind sheer rams activated. And they have
10:30AM 17 been designed to be a valve that essentially shuts off the flow
10:30AM 18 altogether, severs everything in its way and shuts off the well.

10:30AM 19 We all know that that didn't happen. But they did
10:30AM 20 close almost fully, and there was a case that they restricted
10:30AM 21 the flow. And then, as pictures showed and some models I'll
10:30AM 22 show in a second, they severely eroded and opened up in the
10:31AM 23 process.

10:31AM 24 So that's my starting date.

10:31AM 25 If we now look here forward, I'm going to kind of

10:31AM 1 draw your attention to April 29th. That's a week later when the
10:31AM 2 casing shear rams activated. So they're in an intact pristine
10:31AM 3 condition before they were activated, withdrawn in their
10:31AM 4 cavities, and then they were pushed into the flow. They were
10:31AM 5 designed to cut everything in between and severe everything
10:31AM 6 that's in their way, but not to seal the well.

10:31AM 7 That's what they did. They closed entirely, but
10:31AM 8 they did not seal the well. And they eroded, too.

10:31AM 9 So we know from that perspective, without any
10:31AM 10 modeling, without any real sophisticated analysis, that since
10:31AM 11 they were only activated April 29th and they eroded, that
10:31AM 12 erosion must have been going on.

10:31AM 13 Likewise, if we now fast-forward to May 19th, a
10:31AM 14 third hole in the kink riser appeared. I will show some of that
10:31AM 15 footage later on. Another hole appeared just beyond the bend.
10:32AM 16 We knew that was erosion hole. So that was an another signpost
10:32AM 17 for me to say sand production and erosion must have been
10:32AM 18 occurring until May 19th, and surely beyond. Because there was
10:32AM 19 no reason to assume that everything was eroded until May 19th,
10:32AM 20 the hole was made, and then stopped. So I knew it went beyond.
10:32AM 21 I didn't know exactly how far and how long.

10:32AM 22 And, finally, based on the expert opinions of Dr.
10:32AM 23 Vaziri, who is a sand expert, sand production expert, he
10:32AM 24 suggested that sand production lasted at least until the end of
10:32AM 25 May.

10:32AM 1 So I've used that and moved it a little forward to
10:32AM 2 be on the safe side, and I picked May 27th as a day when erosion
10:32AM 3 in any significant way has ceased. I don't say it has stopped
10:32AM 4 then, but that's conservative. It lasted at least until May
10:32AM 5 27th.

10:32AM 6 Q All right. Thank you very much.

10:32AM 7 I want to turn now to some of the components of
10:33AM 8 the BOP that you analyzed, and we're going to start with the
10:33AM 9 blind shear ram.

10:33AM 10 Okay, are you with me?

10:33AM 11 A Yes.

10:33AM 12 Q So you've just mentioned to Judge Barbier that they were
10:33AM 13 activated on April the 22nd.

10:33AM 14 And I've called out now D-23635-A. And I'll ask
10:33AM 15 you first, you mentioned that you traveled to Michoud. Did you
10:33AM 16 actually analyze or look at the rams from the BOP?

10:33AM 17 A Yes, I have.

10:33AM 18 Q Now, this is a couple of pictures of the blind shear ram;
10:33AM 19 correct?

10:33AM 20 A Yes.

10:33AM 21 Q And can you tell Judge Barbier what you're seeing in these
10:33AM 22 pictures and what is significant to you as an expert in erosion?

10:33AM 23 A Well, Your Honor, again, these pictures are quite drastic
10:33AM 24 examples of massive erosion. What you see there on the screen
10:34AM 25 are two blocks of the blind sheer rams.

10:34AM 1 May I pick up the prop at this stage? I think it
10:34AM 2 helps, rather than looking at the pictures, which I'm sure
10:34AM 3 you've seen a million times.

10:34AM 4 Q Which one are you going to pick up?

10:34AM 5 A Of the blind shear rams, I'll start with the ones before
10:34AM 6 they eroded.

10:34AM 7 Q So this would be D-24200, which is a pre-eroded blind shear
10:34AM 8 ram 3D model.

10:34AM 9 Just tell the judge how this was created; and
10:34AM 10 then, if you have something that will be a good teaching point,
10:34AM 11 please share that.

10:34AM 12 A Sure. This is a replica, a very realistic replica of the
10:34AM 13 real blocks that were present in the BOP before they have
10:34AM 14 eroded.

10:34AM 15 So we have obtained detailed design files from
10:34AM 16 Cameron, and then used them to make this model here that I'm
10:34AM 17 going to open up in a second.

10:34AM 18 The same information from Cameron was used to
10:34AM 19 create the geometries I simulated. So, if you can imagine, I've
10:34AM 20 been able to create these two geometries in their virtual form
10:35AM 21 and pull them into my study. So I operated with exactly the
10:35AM 22 same geometries like these within my computational environment.

10:35AM 23 Q Go ahead.

10:35AM 24 A And, in going back to the point, so what you see in front of
10:35AM 25 you, Your Honor, is pretty much these two pieces. But you see

10:35AM 1 them there on the screen after they eroded. This is what they
10:35AM 2 kind of would have looked before they eroded as they were just
10:35AM 3 activated.

10:35AM 4 So, when they close and tried to seal the well,
10:35AM 5 they didn't go all the way through, and that there was a gap
10:35AM 6 left, and that led to erosion that you can see on your screen.

10:35AM 7 So that's probably the easiest way to show how
10:35AM 8 massive, just by comparing before -- and if I may pick up the
10:35AM 9 other set, these two are identical as --

10:35AM 10 Q Just one second. So you're holding up now D-24202, which is
10:35AM 11 the eroded blind shear ram 3D model; correct?

10:36AM 12 A Correct. Thank you.

10:36AM 13 So these two are actually virtually identical or
10:36AM 14 totally identical to the ones you see on the picture there.

10:36AM 15 So you can see there -- actually, anyone can
10:36AM 16 recognize, there was massive erosion that took place here.
10:36AM 17 These were in their closed state, so one can observe immediately
10:36AM 18 without doing any calculations that it must have been much
10:36AM 19 easier for the fluid to push through these holes on the sides
10:36AM 20 even when they push like that than it was the case before they
10:36AM 21 eroded.

10:36AM 22 Q Now, as an erosion expert, do you have an opinion as to
10:36AM 23 whether this erosion demonstrates that the blind sheer rams were
10:36AM 24 acting as a restriction to flow?

10:36AM 25 A Yes, I do.

10:36AM 1 Q What is that opinion?

10:36AM 2 A Well, again, I will pick up the noneroded version of the
10:36AM 3 blind sheer rams. And they clearly show that, even if they
10:36AM 4 didn't close completely, they closed sufficiently so that the
10:36AM 5 flow could not pass through the middle.

10:37AM 6 The flow had to swing sideways; because, when you
10:37AM 7 look at the eroded version of them, the damage is pretty much
10:37AM 8 all on the sides. It's not so much in the middle of the blades.
10:37AM 9 So that means that these rams have obstructed the flow in the
10:37AM 10 middle.

10:37AM 11 And, by the way, that's what our simulations are
10:37AM 12 going to show that I'll stream in a second.

10:37AM 13 But, even without them, one can conclude that this
10:37AM 14 must have been the restriction in the flow, and therefore the
10:37AM 15 flow kind of pushed its way through the sides.

10:37AM 16 Q Let's turn our attention now to your analysis of the casing
10:37AM 17 sheer rams. And, very quickly -- I've called up D-23637A -- we
10:37AM 18 show here, consistent with your timeline, that they were
10:37AM 19 activated on April the 29th.

10:37AM 20 And if you would just speak to Judge Barbier about
10:37AM 21 your findings from your analysis of the casing shear ram.

10:37AM 22 A Sure, I can.

10:37AM 23 May I also ask for permission to pick up the
10:38AM 24 physical models?

10:38AM 25 Q Yes.

10:38AM 1 A So I'm picking up D-24201, which is --

10:38AM 2 Q Thank you, by the way.

10:38AM 3 A My pleasure. I thought this was faster.

10:38AM 4 And if I can pull them apart. They are not easy
10:38AM 5 to pull apart. Actually, that's realistic, because it takes
10:38AM 6 some force to push these things together, significant force, in
10:38AM 7 reality. So it's not that it's not been a well-made model.

10:38AM 8 But, going back to our story, this is the version
10:38AM 9 of the pristine uneroded casing sheer rams. Now, you saw how
10:38AM 10 hard it is. I can't push them together in front of you here,
10:38AM 11 but they were designed when they closed to sheer and to cut
10:38AM 12 everything in their way.

10:38AM 13 Yet, these blades were not so tight so that the
10:38AM 14 flow would not pass through them. There was some flow in
10:38AM 15 between those blades even in a closed arrangement.

10:38AM 16 Therefore, what you see there on the screen, Your
10:38AM 17 Honor, is what I have on this other prop. It is D-24203, which
10:39AM 18 is identical. If I open it up, these two pieces are identical
10:39AM 19 to the ones you see there on the screen in this arrangement.

10:39AM 20 Now, again, we see some erosion. Although it's
10:39AM 21 with a naked eye, it's clear that it's not massive like it was
10:39AM 22 in the BSR. And I'll come back to that. But we can clearly see
10:39AM 23 effects of erosion.

10:39AM 24 Q Now, can you just describe the evidence of erosion that you
10:39AM 25 see there on the casing sheer rams? What do you see?

10:39AM 1 A Indeed, the easier one to describe is the so-called top
10:39AM 2 blade. So, if I may orient you here, so that blade was in a
10:39AM 3 horizontal position when it closed on the other one and severed
10:39AM 4 the drill pipe. That was the only thing between the blades.

10:39AM 5 And so that severed drill pipe was still producing
10:39AM 6 sand, which is clear by this almost circular pattern that was
10:40AM 7 created by the impact of the particles that couldn't make that
10:40AM 8 very sudden and sharp bend. The fluid went like this and then
10:40AM 9 between the blades and out.

10:40AM 10 The particles didn't -- weren't so quick to turn,
10:40AM 11 so they made an imprint because of these numerous impacts that
10:40AM 12 you see there.

10:40AM 13 The interesting thing is that that level of damage
10:40AM 14 is much less than what we see on the blind sheer rams, and that
10:40AM 15 is because of that direct impact the particles had.

10:40AM 16 If you will recall, Your Honor, I described to
10:40AM 17 have the best, quote, unquote, erosion, one needs to come at an
10:40AM 18 angle to chisel out a piece of metal. So just pounding at it
10:40AM 19 more or less directly is not as effective. It does erode, but
10:40AM 20 it doesn't lead to dramatic effects.

10:40AM 21 Q Now, the casing sheer rams were activated on April the 29th.

10:40AM 22 Did they create an obstruction to flow?

10:40AM 23 A Yes, they did. If not sealed the well, they definitely
10:40AM 24 posed an obstruction to flow.

10:40AM 25 Q Now, let's turn to a discussion of the upper annular

10:41AM 1 preventer, D-23639A.

10:41AM 2 And, before I go to that, let me just ask one
10:41AM 3 question. From looking at these photographs and the models that
10:41AM 4 you've just shown to Judge Barbier, can you tell the Court
10:41AM 5 whether or not there was sand still being produced in the system
10:41AM 6 as of April the 29th?

10:41AM 7 A For sure, not on April 29th, because they were activated.
10:41AM 8 They were new, if you want, pristine, when they were activated.

10:41AM 9 This must have been produced beyond April 29th,
10:41AM 10 because it has happened well into May and I think all the way
10:41AM 11 out to the end of May, this sort of damage. This is sort of
10:41AM 12 unambiguous, I think, in this case.

10:41AM 13 Q Thank you. Now, let's look at the upper annular preventer,
10:41AM 14 D-23639A.

10:42AM 15 Did you personally inspect the recovered upper
10:42AM 16 annular preventer and drill pipe?

10:42AM 17 A Yes, I did.

10:42AM 18 Q Is this the drill pipe we've referred to in this case as the
10:42AM 19 1B1?

10:42AM 20 A I think that's correct.

10:42AM 21 Q Okay. Now, when we talk about 1B1, what are we referring
10:42AM 22 to?

10:42AM 23 A Well, Your Honor, we're talking about the first valve, to
10:42AM 24 call it a valve, that closes the upper annular. It squeeze onto
10:42AM 25 the drill pipe, as you've heard probably so many times. The

10:42AM 1 seal that they formed wasn't perfect. It was a leaky seal.

10:42AM 2 The fluid was squeezing by that tool joint, as
10:42AM 3 they call it, that's shown here on that bottom picture, and it
10:42AM 4 was going so intensely through there that it eroded this 1B1
10:42AM 5 section of pipe.

10:42AM 6 We can see two locations, the one where we have an
10:42AM 7 imprint, and then the completely severed section at the end
10:42AM 8 there.

10:42AM 9 Q Do these photographs that we're looking at here demonstrate
10:43AM 10 that the upper annular preventer was acting as a restriction to
10:43AM 11 flow?

10:43AM 12 A Yes. For the short period that this pipe was held in place,
10:43AM 13 it was a restriction to flow.

10:43AM 14 Q Thank you.

10:43AM 15 Let's now talk about the kinked riser for a few
10:43AM 16 minutes. Just for the record, when we use the term kinked
10:43AM 17 riser, what are we talking about?

10:43AM 18 A It's a term for a bent pipe. But a pipe that went, when it
10:43AM 19 bends, it's sort of neck-down in that section where it was
10:43AM 20 actually turning 90 degrees. So the cross-section was much
10:43AM 21 smaller than the normal full-bore section.

10:43AM 22 Q When the riser kinked on April 22nd, did it create flow
10:43AM 23 restriction?

10:43AM 24 A Yes, it did.

10:43AM 25 Q And why do you say that?

10:43AM 1 A Well, for the simple fact that I just mentioned: The
10:43AM 2 cross-sectional area right there in that kink, in that 90-degree
10:43AM 3 bend, was much smaller than the cross-sectional area of the
10:44AM 4 pipe, of the riser.

10:44AM 5 So, therefore, just that restricting of flow was
10:44AM 6 -- and then the fact that it bent. So that, every bend is a
10:44AM 7 restriction as well, even a full-bore bend.

10:44AM 8 But this was a double restriction from that point
10:44AM 9 of view.

10:44AM 10 Q Okay. Did your analysis of the photographs and materials
10:44AM 11 indicate whether or not that flow restriction changed over time,
10:44AM 12 that is referring to the kinked riser?

10:44AM 13 A The kinked riser changed over time somewhat because of the
10:44AM 14 holes that appeared at various points in time that were caused
10:44AM 15 by erosion, and that has changed the hydrodynamics there.

10:44AM 16 Q Let's look at that D-24452. Do you see, we have here
10:44AM 17 photographs of the kinked riser taken at three time points? Do
10:44AM 18 you see that?

10:44AM 19 A Yes.

10:44AM 20 Q Can you describe for Judge Barbier what these photographs
10:44AM 21 demonstrate and why they are important to you in your analysis
10:44AM 22 of this case.

10:44AM 23 A Yes.

10:44AM 24 Your Honor, if I may really draw your attention to
10:45AM 25 the big screen, because that's where I can only point with my

10:45AM 1 laser.

10:45AM 2 You see three very important points in time:

10:45AM 3 April 22nd; there's the kink seen from the back and the fluid is
10:45AM 4 going through and exiting on the other end of the riser, but
10:45AM 5 there's no holes.

10:45AM 6 Fast-forward to April 28th, so-called first two
10:45AM 7 holes appear. One there in the middle of the pipe just past the
10:45AM 8 bend, which is an erosion-caused hole.

10:45AM 9 And then another one here that at the very side
10:45AM 10 where there was some squishing and stretching of the pipe which
10:45AM 11 could have been implicated in the erosion hole that formed
10:45AM 12 there.

10:45AM 13 But the one that's most important is a signpost
10:45AM 14 for everything I did. That third hole, these two on May 19th
10:45AM 15 are the same, even if the color is different, as April 28th. So
10:45AM 16 these two here are the same holes, probably slightly larger.

10:45AM 17 But this third one right there, so-called third
10:45AM 18 hole, is the one that appeared on May 19th.

10:46AM 19 So it was critical for us to have that piece of
10:46AM 20 information, as it tells us that sand production and erosion was
10:46AM 21 happening on that date and well beyond that date.

10:46AM 22 Q Now, I want to talk a little more about this kinked riser
10:46AM 23 and the holes, and I'm going to go to our next call-out which is
10:46AM 24 D-23644B.

10:46AM 25 Dr. Nesic, the first thing I'd ask you to do is to

10:46AM 1 orient Judge Barbier to what he's looking at here. Probably the
10:46AM 2 best way to do it is if you can sort of describe for him, if he
10:46AM 3 was looking at this, where would it be here in relation to the
10:46AM 4 riser at the top of the BOP.

10:46AM 5 A So, Your Honor, this picture on the left, the large image,
10:46AM 6 would be obtained if you can imagine standing where it says
10:46AM 7 kinked riser and looking in the direction of the red arrow.

10:46AM 8 In other words, this photograph is at a 90-degree
10:47AM 9 rotation from what you see there on this sketch. So it is
10:47AM 10 really looking at the kink, where that kink is. Not from the
10:47AM 11 side like on this little animation, but actually looking at it
10:47AM 12 sort of front-on. And that's what you would see.

10:47AM 13 Q Let me see if I understand this. So the picture that we're
10:47AM 14 looking at here, if we rotated it and put it on the top of the
10:47AM 15 kinked riser there, that's what the orientation would be?

10:47AM 16 A That is correct.

10:47AM 17 Now, it looks like --

10:47AM 18 THE COURT: It would line up with the arrow?

10:47AM 19 THE WITNESS: Yes. You can imagine yourself standing
10:47AM 20 where it says kinked riser, looking in the direction of the
10:47AM 21 arrow, this is what you would see.

10:47AM 22 This looks odd because this was taken in Michoud
10:47AM 23 when it was on the ground. The picture is from the bottom-up so
10:47AM 24 it doesn't appear natural. But that's what we're looking at.

10:47AM 25 BY MR. BROCK:

10:47AM 1 Q Do you have an opinion as to whether or not these holes are
10:48AM 2 caused by erosion?

10:48AM 3 A Oh, I know for sure they were caused by erosion.

10:48AM 4 Q And how do you know that, Dr. Nestic?

10:48AM 5 A Well, even without looking from the inside of the -- this is
10:48AM 6 just an outside view. There's two important pieces of
10:48AM 7 information that without any doubt tell me that this is erosion.

10:48AM 8 And let me start first with the orientation of
10:48AM 9 these holes. These holes are aligned with the flow. If you
10:48AM 10 look -- the flow is coming from the bottom, going through, and
10:48AM 11 then continuing upwards in this photograph.

10:48AM 12 So these holes are exactly -- their shape is oval,
10:48AM 13 and it goes in the direction of the flow.

10:48AM 14 If these holes were created by anything else, say
10:48AM 15 by cracking, which I heard, the cracks wouldn't be going in that
10:48AM 16 direction. The cracks would be going in the perpendicular
10:48AM 17 direction, sort of across. Cracks would look like that.

10:48AM 18 This would be where most of the stretching is
10:48AM 19 going on. Which we all know, if we take something and bend,
10:49AM 20 it's going to break like this, not like that. So, to me, that
10:49AM 21 was the sort of the first clue that was very convincing.

10:49AM 22 There's another one that, if you look at the
10:49AM 23 locations of these two holes, is actually past the bend. The
10:49AM 24 bend, the axis of the bend is somewhere there.

10:49AM 25 So, again, if it was some sort of

10:49AM 1 cracking-induced, as I've heard, that's where the cracks would
10:49AM 2 appear. These are not cracks. You will see in a second when we
10:49AM 3 switch this piece around, they don't look like cracks. We know
10:49AM 4 from the place, they are past the middle. That, they've
10:49AM 5 definitely formed beyond where cracking could be occurring.

10:49AM 6 THE COURT: How many holes do you see in that photo?

10:49AM 7 THE WITNESS: I see three. I see these two that I
10:49AM 8 focused most of attention. First, this one was shown to appear
10:49AM 9 on May 19th, so that's kind of the most important one for me.

10:49AM 10 I see another one that appeared on April 28th.
10:49AM 11 And, its sibling here, this one appeared at the same time as the
10:49AM 12 other one.

10:49AM 13 So I see three holes.

10:49AM 14 Now, why I've been avoiding to talk about this
10:50AM 15 one, you can see that this hole is roughly in that sort of
10:50AM 16 position where we could have and did have a lot of stretching of
10:50AM 17 the pipe. I can't imagine that this third hole, which is
10:50AM 18 upstream of the other two, could have formed partially by
10:50AM 19 cracking and then aggravated by erosion, or the other way
10:50AM 20 around.

10:50AM 21 I can't be 100 percent sure.

10:50AM 22 THE COURT: That's not a fourth hole over on the right
10:50AM 23 corner; is it?

10:50AM 24 THE WITNESS: There is actually another hole on the --

10:50AM 25 THE COURT: I see a blue color in middle, it looks

10:50AM 1 like.

10:50AM 2 THE WITNESS: Yeah. That's where first they cut this.

10:50AM 3 When we took the picture, this was kind of sliced in half, so it
10:50AM 4 was hard to see that properly.

10:50AM 5 But also, there was additional damage on either
10:50AM 6 side of this picture where pieces were detached. But we don't
10:50AM 7 know exactly when was that done, when they were recovering the
10:50AM 8 piece or when they were cutting the piece. That is not obvious.

10:50AM 9 So I tend not to rely on that information of where there was a
10:50AM 10 lot of damage, mechanical damage to the sides. That's why I
10:51AM 11 focus all my attention on these two middle holes, which were
10:51AM 12 kind of away from all this other stuff that was going on.

10:51AM 13 BY MR. BROCK:

10:51AM 14 Q All right. Thank you.

10:51AM 15 Let's turn now to the issue of the duration of the
10:51AM 16 erosion period. We've talked about the geometries you've
10:51AM 17 selected.

10:51AM 18 What did you use to define the period of metal
10:51AM 19 erosion?

10:51AM 20 A I have based my opinions on two main sources. One is the
10:51AM 21 opinions of Dr. Hans Vaziri, who is an expert on sand
10:51AM 22 production. And I relied on his opinions that sand was produced
10:51AM 23 in sufficient quantities between April 20th and end of May. So
10:51AM 24 that was one guiding piece of information.

10:51AM 25 And indeed, I've also used, as I already

10:51AM 1 mentioned, the appearance of the third erosion-caused hole in
10:51AM 2 the kinked riser on May 19th.

10:52AM 3 I also relied on Dr. Vaziri for some other
10:52AM 4 opinions. The most important one of them is this issue of half
10:52AM 5 of the sand being produced in the first two weeks and the rest
10:52AM 6 in the other three, three and a half weeks.

10:52AM 7 Q By your visual observation of the pictures and your
10:52AM 8 understanding of the erosion, were you able to verify Dr.
10:52AM 9 Vaziri's finding that was sand present in the system into May?

10:52AM 10 A Yes. As I mentioned, that appearance of that third hole on
10:52AM 11 May 19th is the most convincing piece of evidence. I mean, I
10:52AM 12 already mentioned the casing shear rams that eroded past April
10:52AM 13 29th.

10:52AM 14 But this May 19th is the most convincing date when
10:52AM 15 we know that sand was produced and erosion was going on, because
10:52AM 16 it punched a hole in the kinked riser. As I said, it's very
10:53AM 17 reasonable to assume that that went past May 19th and past May
10:53AM 18 20th.

10:53AM 19 So I've kind of bounded it with those two key
10:53AM 20 dates that I had at my disposal.

10:53AM 21 Q Okay.

10:33AM 22 MR. FIELDS: Could I get D-24723, please.

10:53AM 23 Thank you.

10:33AM 24 BY MR. FIELDS:

10:53AM 25 Q You mentioned to Judge Barbier a minute ago that you had

10:53AM 1 also looked at the inside of the kinked riser; right?

10:53AM 2 A That's correct.

10:53AM 3 Q And can you describe for Judge Barbier what this photograph
10:53AM 4 shows, and if it helps you to understand that erosion was still
10:53AM 5 occurring on May the 19th and beyond.

10:53AM 6 A Sure.

10:53AM 7 Your Honor, I know this is kind of hard; these
10:53AM 8 pictures aren't perfect. This is the view of that same piece
10:53AM 9 you saw just a minute ago. A, it's flipped around so that you
10:53AM 10 can see the inside of the pipe.

10:53AM 11 But what we have is also now the flow is coming,
10:54AM 12 if you can imagine, from the top coming down. So it comes --
10:54AM 13 that's the way this piece was oriented. So the flow is going
10:54AM 14 apparently in a different direction, but it's really -- the BOP
10:54AM 15 would be now above and then going downwards. That's how this
10:54AM 16 picture is oriented.

10:54AM 17 And what you see here, again, if you can make out
10:54AM 18 this kind of light area there, that's sort of the most sheering
10:54AM 19 bearing area. So most of the stretching and the bending of the
10:54AM 20 pipe occurred roughly across that axis.

10:54AM 21 The holes that we saw from the other side, this
10:54AM 22 second and third hole, particularly the third hole, is down
10:54AM 23 here. So it's well past that section of maximum stress and
10:54AM 24 stretch of the pipe.

10:54AM 25 Now, you've asked me, Your Honor, what about those

10:54AM 1 holes on the sides. They're better visible from this angle.

10:54AM 2 You can see that there was a hole right there that's caused,

10:54AM 3 again, it looks like erosion by this sort of drawn out surface,

10:54AM 4 that erosion was part of that story.

10:54AM 5 But it is right in that axis where there was a lot

10:55AM 6 of bending, so I can't rule out some cracking happening before

10:55AM 7 or after erosion. So that's why I'm not basing my analysis on

10:55AM 8 that hole as much as the other holes.

10:55AM 9 The two holes in the middle are clearly away from

10:55AM 10 any point of maximum stress, so therefore I'm confident that

10:55AM 11 they're erosion-driven.

10:55AM 12 Again, if you look at the shape of these surfaces,

10:55AM 13 Your Honor, and then I pick any of these props I have and look

10:55AM 14 at the shape of the surfaces on this blind shear ram block, you

10:55AM 15 can see that sort of drawn-out shape.

10:55AM 16 For example, this one here -- whoops, I apologize

10:55AM 17 -- looks very similar to what you see close to those holes over

10:55AM 18 there.

10:55AM 19 So I knew, again, beyond any doubt, that this was

10:55AM 20 caused by erosion, those two middle holes were.

10:55AM 21 Q Thank you.

10:55AM 22 What date did you use as your end date for erosion

10:56AM 23 in the BOP and the kinked riser, and why did you select the

10:56AM 24 date?

10:56AM 25 A As I previously mentioned, I bounded it with May 19 when

10:56AM 1 this third hole we just saw appeared. I heard and read what
10:56AM 2 Vaziri, Dr. Vaziri, said, that it lasted at least until the end
10:56AM 3 of May, sand production did.

10:56AM 4 So therefore, I picked, I think still
10:56AM 5 conservatively, that erosion must have been going on until May
10:56AM 6 27th. So I have moved it forward a few days compared to
10:56AM 7 Dr. Vaziri's calculation just to be on the safe side.

10:56AM 8 I think I can say with great confidence that
10:56AM 9 erosion occurred at least until May 27th.

10:56AM 10 Q Let's turn now to one of your main opinions, and that is
10:56AM 11 that flow rate doubled over the first five weeks of the incident
10:56AM 12 due to erosion.

10:56AM 13 And I'll ask you first, Dr. Nesic, what metric did
10:57AM 14 you use to evaluate the impact that each of the restrictions
10:57AM 15 that we have talked about had on flow?

10:57AM 16 A I've used pressure drop, to put it very succinctly. And
10:57AM 17 that's what you've heard a lot here. Pressure drop is the best
10:57AM 18 method, best metric, that we engineers use to describe how hard
10:57AM 19 it is for flow to go through something.

10:57AM 20 It's not intuitive.

10:57AM 21 Q Let me stop you just for a second. That's fine.

10:57AM 22 So you may have been going to this, but why do you
10:57AM 23 use pressure drop to evaluate erosion?

10:57AM 24 A Because that is a universal metric that is used across all
10:57AM 25 of the engineering branches that deal with fluid flow to

10:57AM 1 describe how hard it is for flow or how easy it is for flow to
10:57AM 2 pass through a given geometry.

10:57AM 3 Q I'm going to pull up now D-23628A.

10:58AM 4 This is just a slide showing pressure drop versus
10:58AM 5 flow rate. Judge Barbier has seen the example of the hose.
10:58AM 6 But, in the context of your methodology, can you just use this
10:58AM 7 to describe what you're going to be doing and how you evaluate
10:58AM 8 and use the concept of the pressure drop.

10:58AM 9 A What one sees in this picture is a very simple analogy
10:58AM 10 that's actually quite, quite accurate of how restriction in the
10:58AM 11 flow results in a pressure drop change.

10:58AM 12 And what you see, Your Honor, on the left here is
10:58AM 13 a hose that's pinched on the end. So, therefore, the flow
10:59AM 14 cannot really pass with ease through that pinched end there, so
10:59AM 15 it builds up pressure ahead of it.

10:59AM 16 So, if we then calculate the pressure drop, which
10:59AM 17 is really the pressure in the hose minus the pressure in the
10:59AM 18 atmosphere, which is constant, it's large. It's a large number.

10:59AM 19 So corresponding to the high restriction is a high
10:59AM 20 pressure drop. That results in a low flow rate. We all know,
10:59AM 21 when we pinch the hose, the flow rate goes down if you really do
10:59AM 22 that effectively.

10:59AM 23 If I then turn your attention to the other
10:59AM 24 example, if we let go, indeed now the fluid comes out at higher
10:59AM 25 flow rate, but the pressure in the hose is now not as high

10:59AM 1 because the fluid just passes right through. It's almost the
10:59AM 2 same as the pressure outside. So low pressure drop means low
10:59AM 3 restriction and results in a high flow rate.

10:59AM 4 So that's that I think intuitive example that high
10:59AM 5 restriction means high pressure drop which means low flow rate,
11:00AM 6 and vice-versa.

11:00AM 7 Q When you talk about pressure drop, you're talking about on
11:00AM 8 either side of the restriction?

11:00AM 9 A Correct. And that's really how much pressure changes as it
11:00AM 10 pushes through, as the fluid pushes through a given geometry.

11:00AM 11 Q Now, one of the things you did in this case was to model the
11:00AM 12 restriction to flow that was provided by each component; is that
11:00AM 13 right?

11:00AM 14 A That's right.

11:00AM 15 Q All right. So how did you go about doing that?

11:00AM 16 A Once we obtained the various geometries of interest -- and,
11:00AM 17 just to remind you, the blind sheer rams, the casing sheer rams,
11:00AM 18 upper annular, and kink, we have imported those geometries into
11:00AM 19 our computational environment. That was the first step.

11:00AM 20 Q And did you use that input to create a model of particles
11:00AM 21 passing through the various components that you analyzed?

11:01AM 22 A That's right. That's exactly what we did, Your Honor. So
11:01AM 23 we took an electronic version of these geometries that I have
11:01AM 24 just shown you, we moved them into this computerized
11:01AM 25 environment. We put them right against each other the way I did

11:01AM 1 with my hands, and it happened in reality. And then we model
11:01AM 2 how flow goes.

11:01AM 3 And I will show you some animations to bring that
11:01AM 4 home, but we exactly calculated how flow moved through those
11:01AM 5 geometries before they eroded and after they eroded. We were
11:01AM 6 also able to show how particles move through that same geometry.

11:01AM 7 Q Now, I'm going to call up a simulation, which is D-24207A1.
11:01AM 8 I think you've just described how you developed this simulation.
11:01AM 9 I'm going to run it.

11:01AM 10 You want to talk about it a little more?

11:01AM 11 A If you don't mind.

11:01AM 12 Q Sure.

11:01AM 13 A So it's actually not as visible on that screen, but I
11:02AM 14 believe on our small screens it's easier to see.

11:02AM 15 What you can make out is an outline of the kink.
11:02AM 16 So the white lines are supposed to denote that the boundaries of
11:02AM 17 that riser, that kink there. You can see the kink somewhere
11:02AM 18 roughly in the middle of that screen.

11:02AM 19 What we did is we've gotten that geometry by laser
11:02AM 20 scan. We then moved it into our computational environment,
11:02AM 21 populated it with million little points inside so we could
11:02AM 22 calculate exactly how the fluid moved.

11:02AM 23 And, finally, what you will see in this animation,
11:02AM 24 we released a swirl of particles and watched how they moved
11:02AM 25 through this geometry.

11:02AM 1 So now you can start it now.

11:02AM 2 Q You ready to do that?

11:02AM 3 A Thank you.

11:02AM 4 Q All right. So now describe for Judge Barbier what he sees.

11:02AM 5 A So, if you imagine, Your Honor, these are solid particles,
11:02AM 6 sand. They're colored blue just to see them better. They're
11:02AM 7 approaching this kink where the cross section is neck-down.

11:02AM 8 There's actually a very tight spot in the middle.

11:02AM 9 The fluid with the particles then swings left and
11:02AM 10 right. As it has to pass through these narrow passages, of
11:03AM 11 course it accelerates in that process, because now it's a tight
11:03AM 12 spot it passes through.

11:03AM 13 What you see in red here in this graph are
11:03AM 14 locations where we have predicted very intense impacts of
11:03AM 15 particles coming and going through.

11:03AM 16 And, indeed, these would be the locations which
11:03AM 17 should result in the highest degree of erosion.

11:03AM 18 Q What conclusions did you draw from the simulation?

11:03AM 19 A Well, there were multitude different things. But the ones
11:03AM 20 that stand out, first, I've drawn the number out of this, the
11:03AM 21 exact pressure drop as the fluid went through this geometry.

11:03AM 22 We also looked at the locations of erosion where
11:03AM 23 they were predicted.

11:03AM 24 Q I'm going to now call out D-2426A. This may be what you
11:03AM 25 just referenced; but how does your simulation match up with the

11:04AM 1 actual kinked riser? And is that important to you in your
11:04AM 2 analysis here?

11:04AM 3 A It is very important, because the goal of every mathematical
11:04AM 4 computer-based simulation is to kind of root itself in reality.

11:04AM 5 And, yes, we were using the exact equations of
11:04AM 6 fluid flow and particle motion, the best possible description of
11:04AM 7 the geometry, but we really didn't have any direct evidence that
11:04AM 8 flow moved exactly like that through the kinked riser. We
11:04AM 9 didn't have any probe in there to measure that.

11:04AM 10 So the best evidence we had in determining whether
11:04AM 11 this particular flow pattern -- and I'm using this kinked riser
11:04AM 12 -- was right, we compared where we predicted the most intense
11:04AM 13 erosion. These are these red areas on the graph. Then the two
11:04AM 14 holes which are, you know, more or less in the same regions.

11:04AM 15 So there's good overlap fact. So that told us
11:04AM 16 that these five-alarm mathematical checks and physical checks
11:05AM 17 that these calculations are right, this was an anchor in
11:05AM 18 reality. We call it a reality check.

11:05AM 19 I was very happy. I think it is remarkable, for
11:05AM 20 such a complicated system, that we got this close.

11:05AM 21 THE COURT: Let me ask you something.

11:05AM 22 THE WITNESS: Sure.

11:05AM 23 THE COURT: Why is it that, when you modeled this or in
11:05AM 24 your opinion when the sand is moving through here and impacting,
11:05AM 25 why is it only making these two holes in these two specific

11:05AM 1 spots and not eroding more or less evenly across that plane, so
11:05AM 2 to speak?

11:05AM 3 THE WITNESS: That's right. That's a very good
11:05AM 4 question. Because that's what one would imagine, at least when
11:05AM 5 one sees the pictures.

11:05AM 6 What it is actually is that the cross-section of
11:05AM 7 that plane that you just referred to is actually dog-boned. It
11:05AM 8 looks like that.

11:05AM 9 So the particles tend to swing sideways because of
11:05AM 10 that tight spot in the middle. That's why you see the attack
11:06AM 11 kind of being focused on more on the sides, not right there in
11:06AM 12 the middle.

11:06AM 13 Another reason is that, what you don't see in this
11:06AM 14 simulation is there were actually two drill pipes caught inside,
11:06AM 15 which are not here, and they have sort of also channeled the
11:06AM 16 flow to go to a relatively narrow passage. That's where those
11:06AM 17 two holes have appeared.

11:06AM 18 BY MR. BROCK:

11:06AM 19 Q Thank you.

11:06AM 20 Let's go to now one of the other geometries that
11:06AM 21 you looked at, the blind sheer rams. And I'll just call up --
11:06AM 22 I'm not going to play it yet -- I'm going to call up D-24213A1.

11:06AM 23 Would you just describe for Judge Barbier what
11:06AM 24 we're looking at here and what you did with this information.

11:06AM 25 A Sure.

11:06AM 1 Your Honor, this is one of the thousands,
11:06AM 2 literally thousands, of simulations we did. This shows a flow
11:07AM 3 through a blind shear ram.

11:07AM 4 Now, I'm going to pick up the prop because I think
11:07AM 5 it's easier. That's why I didn't show this one first. It is
11:07AM 6 somewhat more complicated to appreciate.

11:07AM 7 So, if I may pick up these blind shear ram blocks
11:07AM 8 before they were eroded, what you're looking at there, Your
11:07AM 9 Honor, is kind of a view exactly from where you sit towards
11:07AM 10 these blocks.

11:07AM 11 If you would imagine the blocks were made from
11:07AM 12 Plexiglas or something transparent, you would see more or less a
11:07AM 13 picture like that.

11:07AM 14 So the flow is coming from the bottom, going
11:07AM 15 through these blades which are almost closed - you will see what
11:07AM 16 the animation shows -- and then the flow has to snake through
11:07AM 17 the openings that are left and get out.

11:07AM 18 Again, the blue on the screen are the particles.

11:07AM 19 Q So we've got it running now.

11:07AM 20 If you can describe for Judge Barbier what you see
11:07AM 21 here and what its significance is.

11:07AM 22 A This is obviously a very slowed down version of the real
11:07AM 23 event.

11:07AM 24 What you see is then this swirl of particles
11:08AM 25 approaching this partially closed section by the BSR blocks.

11:08AM 1 And they cannot pass through the middle, as you can imagine,
11:08AM 2 because there's overlapping blades there.

11:08AM 3 But there's opening on the sides, and the
11:08AM 4 particles make this sudden turn to the right and then sudden
11:08AM 5 turn to the left. On both sides actually there's two like bends
11:08AM 6 right next to each other. Indeed, there's a lot of particle
11:08AM 7 impacting going on there. Not so much head-on. That doesn't
11:08AM 8 cause as much erosion.

11:08AM 9 But these got an angular impact here on the side.
11:08AM 10 The red color indicates a lot of erosion going on right there.

11:08AM 11 Another important point I don't know if you can
11:08AM 12 make out, Your Honor, there's actually a drill pipe here that's
11:08AM 13 been caught. It's not easy to see in this complicated case
11:08AM 14 depiction.

11:08AM 15 So we have the full-blown geometry of the blind
11:08AM 16 shear rams with the drill pipe and particles moving through it.

11:08AM 17 Q For this simulation, what conclusion did you draw?

11:09AM 18 A We looked at the location of erosion, obviously, which we
11:09AM 19 can see where saw it on the recovered blocks. But most
11:09AM 20 important information for us was to calculate the pressure drop.
11:09AM 21 In other words, the obstacle that this particular geometry
11:09AM 22 presented to flow.

11:09AM 23 Q Now, I think you said this, but just to be clear for the
11:09AM 24 record, did you compare the erosion that your model predicted
11:09AM 25 with the recovered blind shear ram?

11:09AM 1 A Indeed, we did. Again, one of the reality checks was that
11:09AM 2 we predicted locations of erosion where we actually saw physical
11:09AM 3 evidence that erosion happened. That wasn't -- never expected
11:09AM 4 to be, you know, a perfect match, but we wanted to see that
11:09AM 5 areas that were predicted erosion have actually eroded. That
11:09AM 6 was important.

11:09AM 7 Q Now, did you analyze the other study restrictions with
11:10AM 8 regard to erosion in the same way?

11:10AM 9 A Yes. So we have repeated this same situation.

11:10AM 10 But then, if I may pick up the eroded blind sheer
11:10AM 11 rams, we then repeated exactly the same calculation with these
11:10AM 12 precise geometries that I'm holding in my hand. And, indeed,
11:10AM 13 one can imagine, I can put my finger through this now, so
11:10AM 14 there's a large opening there. And the flow now winds with much
11:10AM 15 more ease through these holes.

11:10AM 16 These are the eroded blind shear rams. I believe
11:10AM 17 we have another animation to show that. I'm not sure if it's
11:10AM 18 coming up.

11:10AM 19 Q This is D-24201A1, and it's a simulation of particles
11:10AM 20 passing through the eroded blind shear ram. So if you could
11:10AM 21 describe what this is.

11:10AM 22 A Yeah.

11:10AM 23 So, in many ways, it's a similar situation. Like
11:10AM 24 with the pre-eroded geometry, you're looking at the flow from
11:11AM 25 the side. The particles are coming from the bottom, and they,

11:11AM 1 again, seem to do the same thing. But not exactly.

11:11AM 2 They are swinging to the left and to the right,
11:11AM 3 but now you can see there's no sudden turns. They have already
11:11AM 4 pushed their way and eroded part of the blind shear rams and are
11:11AM 5 coming out with much more ease on the other side.

11:11AM 6 So the pressure drop we calculated on these blocks
11:11AM 7 was about 20 something times less. The resistance was 20
11:11AM 8 something times less after erosion than before.

11:11AM 9 Q Okay. I don't know how long this goes on; let me just stop
11:11AM 10 it.

11:11AM 11 So, in terms of what we've talked about so far,
11:11AM 12 you looked at the geometries of the BOP in their pristine
11:11AM 13 condition and analyzed, through your modeling efforts, how those
11:11AM 14 obstacles would affect flow in the BOP; correct?

11:12AM 15 A Yes.

11:12AM 16 Q And then, as you've described, you were able to look at the
11:12AM 17 components of the BOP at the end of the spill after the
11:12AM 18 components were recovered, and you were able to analyze those to
11:12AM 19 see what change had occurred to those components at the time of
11:12AM 20 recovery?

11:12AM 21 A Correct.

11:12AM 22 Q Now, why is it important to you as an expert in erosion,
11:12AM 23 that you're able to know the geometry of the components, both
11:12AM 24 before and after the event?

11:12AM 25 A That was of huge importance for me. Because, Your Honor,

11:12AM 1 normally, in the work I do, which is sometimes very similar to
11:12AM 2 this situation here, we know, say, how something looks before it
11:12AM 3 eroded.

11:12AM 4 The industrial partners ask us: Can you predict
11:13AM 5 what something's going look like in 20 years, so that they know
11:13AM 6 how to design for it. In other words, we only know one point in
11:13AM 7 time, and then we're trying to see and predict how something
11:13AM 8 will look at another point in time without ever being able to
11:13AM 9 know what that outcome is going to be. We have to predict it.

11:13AM 10 In this case, we had a unique privilege which --
11:13AM 11 to have both before- and after-situation known. We didn't need
11:13AM 12 to guess how much erosion will happen after 35 days; we actually
11:13AM 13 had the eroded components.

11:13AM 14 So that has anchored my analysis in two points in
11:13AM 15 time, which hugely increases the reliability of everything I
11:13AM 16 concluded from that.

11:13AM 17 Q Now, after you have that information and the things that
11:13AM 18 we've already talked about, in order to understand how the
11:13AM 19 restrictions affected the flow over time, what did you do next?

11:13AM 20 A So, if we start from that position, I knew what the
11:14AM 21 restriction was before erosion; I knew what the restriction was
11:14AM 22 after erosion. The last remaining question was, how did it
11:14AM 23 change from that point 1 to that point 2. We had no physical
11:14AM 24 evidence in that interim period before the first and the last
11:14AM 25 day of erosion.

11:14AM 1 We did not know in the same way what the erosion
11:14AM 2 was, so that's where our computational fluid dynamics models
11:14AM 3 came in to help. We have performed a so-called transient
11:14AM 4 analysis.

11:14AM 5 Q And describe for Judge Barbier the tool that you used; that
11:14AM 6 is, the transient analysis or simulation that you used, to
11:14AM 7 develop information that will help you describe to the Court how
11:14AM 8 changes occurred over time.

11:14AM 9 A Your Honor, we started with a virgin geometry, so noneroded
11:14AM 10 geometry. And then used our calculations to predict, if you
11:15AM 11 will, now how those geometries must have looked on the second
11:15AM 12 day and the third day and the fourth day and so on, due to the
11:15AM 13 enormous complexity of this geometry, which now the programs had
11:15AM 14 to modify over time. So they had to distort them as the
11:15AM 15 calculations went on. We had to simply use these geometries.
11:15AM 16 So, they didn't look exactly like this in our transient
11:15AM 17 simulations, but they retained all the key features.

11:15AM 18 But, for the purpose of this argument, if you can
11:15AM 19 imagine, we would have started with something very similar to
11:15AM 20 this, ran a simulation on the first day. Kind of what you saw,
11:15AM 21 calculated erosion rate, and then went in and modified this
11:15AM 22 geometry ever so slightly to account for other erosion.

11:15AM 23 Then we simulated the flow again through this
11:15AM 24 partially eroded geometry on day 2. Got the new erosion rate,
11:15AM 25 fed those back in the loop. Moved to day 3. So, essentially,

11:15AM 1 it was a series of calculations from day to day, or even within
11:16AM 2 hour by hour, very intense. Which took us through time to see
11:16AM 3 how the geometries changed.

11:16AM 4 Q Now, for how many days did you get good information data as
11:16AM 5 a result of that effort?

11:16AM 6 A That effort was a very intense calculation, something that's
11:16AM 7 rarely been attempted that I know of by anyone. We were able to
11:16AM 8 get 10 good days of data. And, that was very important for us,
11:16AM 9 that we had 10 solid days of data.

11:16AM 10 Because, remember, we knew the beginning and the
11:16AM 11 end point. We did not need to project into the future and
11:16AM 12 wonder whether it was right or wrong. We knew where this is
11:16AM 13 going to end, so all we needed is enough data points in time so
11:16AM 14 that we could connect that beginning with the end.

11:16AM 15 We wanted to go for 35 days. That was our goal
11:16AM 16 and hope. But that wasn't possible. But we had enough, 10 good
11:17AM 17 days of simulations.

11:17AM 18 Q What is your basis for saying that the data that you
11:17AM 19 obtained for those 10 days is reliable? That is, something we
11:17AM 20 can count on.

11:17AM 21 A Because I have done very similar simulations many, many,
11:17AM 22 many times before, and all of those who have tried something
11:17AM 23 like this know that these simulations are difficult, and there
11:17AM 24 is various reasons and various points in time they stop giving
11:17AM 25 good answers.

11:17AM 1 But we also know from mathematical and physical
11:17AM 2 criteria when data are good and when they're not. So we looked
11:17AM 3 at every day and every geometry that we got the next day and
11:17AM 4 checked mathematically and physically is it realistic.

11:17AM 5 When it was, we went to the next day. And then
11:17AM 6 went day 1, 2, 3 through 10. And then, on the 11th and 12th
11:17AM 7 day, things started happening. We saw mathematically, we saw
11:18AM 8 physically and visually that something was wrong. We had to
11:18AM 9 stop there and discard those data.

11:18AM 10 Q Now, I'm going to call out D-23892. And I'll just ask you,
11:18AM 11 Dr. Nestic, to describe for Judge Barbier what this graph
11:18AM 12 represents and why it is important to you in your evaluation of
11:18AM 13 this case.

11:18AM 14 A So, Your Honor, you have time on the horizontal axis, and
11:18AM 15 this is pressure drop, or you can think of it as resistance to
11:18AM 16 flow.

11:18AM 17 The numbers are pressure drop really in pascals,
11:18AM 18 which is an equivalent of the psi. But the actual numbers are
11:18AM 19 not what I needed. I knew what in a real case was my initial
11:18AM 20 and last point. All I needed from this simulation was to know
11:18AM 21 whether to connect my initial and last point with a straight
11:18AM 22 line or some other type of line.

11:19AM 23 And we did this over and over again. And, for
11:19AM 24 about ten days, we got -- no matter what geometry we looked at
11:19AM 25 -- that the change was linear. So I was very happy with that.

11:19AM 1 I had no expectation to it being linear or anything else. But,
11:19AM 2 every time we got data like this, you can see, even by the naked
11:19AM 3 eye, that this was a linear change.

11:19AM 4 So that is the only thing I moved -- I used from
11:19AM 5 this transient simulation and moved them back into my pressure
11:19AM 6 drop analysis. I knew the beginning, I knew the end, and now I
11:19AM 7 was able to draw a line between those two.

11:19AM 8 Q If you know the beginning and you know the end, are 10 days
11:19AM 9 of good data sufficient for you to reliably form opinions about
11:19AM 10 the way restrictions changed over time?

11:19AM 11 A Oh, indeed. I mean, we all know that you only need two
11:19AM 12 points to define a line. If three points looked like to be on
11:19AM 13 the line, that's already safer.

11:19AM 14 To have 10 points that in this case correlate 97
11:19AM 15 percent with the straight line, I mean, that to me was a case
11:20AM 16 beyond doubt.

11:20AM 17 Q What did you conclude about the way restrictions changed
11:20AM 18 over time based on your transient simulations?

11:20AM 19 A Again, I had the privilege of asking these transient
11:20AM 20 simulations a very simple question, asking them just to tell me
11:20AM 21 what was the trend of change of pressure drop.

11:20AM 22 In other words, was it a straight line or
11:20AM 23 something else? I got an answer that it was a straight line,
11:20AM 24 and that's the only thing I extracted and used it to reach my
11:20AM 25 final conclusions.

11:20AM 1 Q How did you decide that a linear trend was the best fit for
11:20AM 2 this data?

11:20AM 3 A As I just mentioned, these data looked straight -- they
11:20AM 4 looked like a straight line. Mathematically, they have a high
11:20AM 5 degree of correlation. They're 97. Something accurate, which is
11:21AM 6 way beyond -- normally, one expects 70 percent, and say
11:21AM 7 everything above 70 percent is a straight line. This was 97
11:21AM 8 percent.

11:21AM 9 So my visual intuitive observation was confirmed.
11:21AM 10 So I was very confident to take a straight line as the best
11:21AM 11 representation of this data.

11:21AM 12 By the way, it suffices to say that, whenever one
11:21AM 13 has multiple options to describe something, in this case a bunch
11:21AM 14 of points, what one chooses is that scientifically acceptable is
11:21AM 15 the simplest fit. And this was, A, a very good straight fit;
11:21AM 16 and, B, it is the simplest of all possible fits.

11:21AM 17 Q All right. Thank you, Dr. Nestic.

11:21AM 18 Now, up until this point, we've been talking about
11:21AM 19 your analysis of individual components; correct?

11:21AM 20 A That's right.

11:21AM 21 Q The ones you've identified of your subjects of
11:21AM 22 investigation?

11:21AM 23 A Correct.

11:21AM 24 Q So let's talk now a little bit about the combined effect of
11:22AM 25 restrictions and how you went about looking at pressure drop

11:22AM 1 across the BOP system; okay?

11:22AM 2 A Sure.

11:22AM 3 Q All right.

11:22AM 4 I'm going to call out now D-23945, and this is one
11:22AM 5 of the charts from your report.

11:22AM 6 Can you explain to the Court what is represented
11:22AM 7 by this graph and how it is helpful to understanding the
11:22AM 8 changing flow restrictions over time.

11:22AM 9 A Sure.

11:22AM 10 Your Honor, this is one of the two summarizing
11:22AM 11 graphs where everything I did, all those complicated simulations
11:22AM 12 through difficult geometries, which we did thousand times over,
11:22AM 13 everything comes together in these last two graphs that I'm
11:22AM 14 going to show.

11:22AM 15 So the graph in front of you shows how pressure
11:22AM 16 drops on the vertical axis -- that's really a resistance to
11:22AM 17 flow -- changes over this period of time that I analyze. And
11:23AM 18 these are all calculations. This is not based on my
11:23AM 19 assumptions.

11:23AM 20 We can see that, if nothing else is important,
11:23AM 21 when you take away method that -- it starts from 3 and a half
11:23AM 22 and goes to 1. That means that the resistance to flow over this
11:23AM 23 period of time changed 3 and a half times.

11:23AM 24 Q Let me stop you right there.

11:23AM 25 A Sure.

11:23AM 1 Q Just so that we can orient Judge Barbier to what we're
11:23AM 2 looking at.

11:23AM 3 Right here, we have April the 22nd, and we have a
11:23AM 4 solid blue line.

11:23AM 5 Do you see that?

11:23AM 6 A Yes.

11:23AM 7 Q All right.

11:23AM 8 And, over here, you've got the schedule which
11:23AM 9 shows that solid blue is blind shear ram; right?

11:23AM 10 A That's right.

11:23AM 11 Q So what are you demonstrating here by this solid blue line
11:23AM 12 here on April the 22nd in relation to what you see at the end
11:23AM 13 point that you're using for erosion May the 27th?

11:23AM 14 A What we see, Your Honor, is here we've stacked up a number
11:24AM 15 of different elements together. If you take, say, 29th of
11:24AM 16 April --

11:24AM 17 Q Dr. Nestic --

11:24AM 18 A Yes.

11:24AM 19 Q -- focus on this blue line right here. I want you to
11:24AM 20 describe what that is, please.

11:24AM 21 A Okay.

11:24AM 22 Q Thank you.

11:24AM 23 A This blue line is singling out the blind sheer rams. Even
11:24AM 24 if I looked at the whole thing together. So blind shear rams
11:24AM 25 initially offered a high degree of restriction. And then we

11:24AM 1 knew exactly what it was on the 22nd of April because I knew my
11:24AM 2 geometry. We knew exactly what it was, the other blue line, on
11:24AM 3 the 27th of May. We knew it was 20 I think 4 times less.

11:24AM 4 THE COURT: What's the scale on the left?

11:24AM 5 THE WITNESS: The scale is pressure drop, but it is --

11:24AM 6 THE COURT: It's 3.5 what?

11:24AM 7 THE WITNESS: Times bigger than the pressure drop at
11:24AM 8 the end.

11:24AM 9 THE COURT: So it's not like --

11:24AM 10 THE WITNESS: It's a factor.

11:24AM 11 THE COURT: It's not a 3500 --

11:24AM 12 THE WITNESS: No.

11:24AM 13 THE COURT: -- pressure reading.

11:24AM 14 THE WITNESS: No. That's correct.

11:24AM 15 And there's a reason for that, Your Honor.

11:24AM 16 If I used a psi, say, for pressure drop, then if I
11:24AM 17 had a higher flow rate, I would have had more pressure drop in
11:25AM 18 the same geometry. If I had a lower flow rate in the same
11:25AM 19 geometry, I had a lower pressure drop. So it would appear that
11:25AM 20 line would be all over the place if I used the actual psi, if I
11:25AM 21 used the actual pressure drop.

11:25AM 22 If look at the ratio pressure drop, if you just
11:25AM 23 ask yourself not what was the actual pressure drop but how much
11:25AM 24 does it change from day 1 to day 35, by what factor. It's
11:25AM 25 always by factor 3 and a half overall.

11:25AM 1 So, no matter whether the flow was low or high, I
11:25AM 2 always get 3 and a half time more pressure drop at the beginning
11:25AM 3 than at the end. And that was so universal within very narrow
11:25AM 4 margins, which is convincing to me that I've singled out only
11:25AM 5 the affected geometry.

11:25AM 6 Your Honor, with due respect, I didn't know what
11:25AM 7 the flow rate was when I started my analysis, and that wasn't
11:25AM 8 the subject of my work. I didn't try to tell you what was the
11:25AM 9 pressure drop. I just tried to tell you how much does it
11:26AM 10 change.

11:26AM 11 And that's what this graph shows. It changed by 3
11:26AM 12 and a half times overall.

11:26AM 13 Q This describes the restriction at the beginning period that
11:26AM 14 you analyzed in relation to the restriction to flow that is
11:26AM 15 present on May 27th; right?

11:26AM 16 A Correct.

11:26AM 17 Q And you know that because you have the components in the
11:26AM 18 pristine condition and you have a calculation and you have
11:26AM 19 pristine and you have the recovered components on May the 27th,
11:26AM 20 and so you know precisely what you have there?

11:26AM 21 A That's right.

11:26AM 22 Q And then you've characterized here some of the other events
11:26AM 23 that occur in between. Is one those events on April the 29th
11:26AM 24 the shut-in or the closing of the casing shear ram?

11:26AM 25 A That's right.

11:26AM 1 Q And does this column demonstrate restriction to flow based
11:27AM 2 on your analysis that existed as of April the 29th?

11:27AM 3 A That's right.

11:27AM 4 Q And, the restriction, the total restriction of the flow that
11:27AM 5 you've calculated at this point is actually a little higher than
11:27AM 6 it was on April the 22nd; correct?

11:27AM 7 A That is correct.

11:27AM 8 Q The light-colored boxes -- we see blue here and red here --
11:27AM 9 what do the light-colored boxes depict on your scale here?

11:27AM 10 A I was trying to be very transparent in this graph and remind
11:27AM 11 everyone looking at this graph that I had hard numbers for day
11:27AM 12 1, the beginning of erosion, and day 35, the end of erosion.

11:27AM 13 That's why they're darker colored. Lighter colors
11:27AM 14 means that these bars in between are obtained by essentially
11:27AM 15 drawing more a less a straight line from beginning to end. So
11:27AM 16 they're what I called less hard or softer numbers. They were
11:28AM 17 obtained by my transient simulations. That's why I've
11:28AM 18 highlighted that for the BSR; it was done that way for the CSR.

11:28AM 19 The casing shear rams are the same. Beginning and
11:28AM 20 end are hard numbers. In between, I used my transient analysis.
11:28AM 21 I realize that is not as firm a number as the first one, but
11:28AM 22 it's as good as we can get. It was based on calculations.

11:28AM 23 Q Based on your evaluation of the components that you
11:28AM 24 analyzed, as well as the simulations that you ran, do you have
11:28AM 25 an opinion as to whether or not erosion had concluded in the BOP

11:28AM 1 and kinked riser within nine hours or a day?

11:28AM 2 A I think that's impossible.

11:28AM 3 Q Why do you say that?

11:28AM 4 A Well, there's many different reasons I can defend that and
11:28AM 5 prove myself correct.

11:28AM 6 First is we have physical evidence. We know that
11:28AM 7 the kinked riser erosion persisted until May 19th. We know that
11:28AM 8 casing shear rams such as closed on April 29th continued to
11:29AM 9 erode.

11:29AM 10 So I just cannot understand how one can make that
11:29AM 11 leap of imagination that from one case of very fast erosion to
11:29AM 12 determine that everything eroded at the same rate.

11:29AM 13 If I may just take the simplest example, even one
11:29AM 14 individual element which was there all the time eroded
11:29AM 15 differently different locations. So one cannot just take this
11:29AM 16 erosion rate and then apply it to everything else that existed.
11:29AM 17 That's point number one.

11:29AM 18 And, Your Honor, the other point is not everything
11:29AM 19 that eroded made the same difference. The erosion of the casing
11:29AM 20 shear rams did not make a big difference on the flow rate. You
11:29AM 21 can see that my red bars are more or less all the same height.
11:29AM 22 That means the casing shear rams were not perturbed so much by
11:29AM 23 erosion.

11:29AM 24 So one cannot just take one example and transpose
11:29AM 25 it. That's why I've done this thousand simulations, to catch

11:29AM 1 all this intricate detail and I'm able to stack them up in the
11:30AM 2 right way.

11:30AM 3 Q Okay. Now, let's go to one final topic, and that is
11:30AM 4 converting the pressure drop conclusions to flow rate
11:30AM 5 conclusions. And I'll just ask you, once you analyzed how
11:30AM 6 restrictions changed over time, were you able to reach
11:30AM 7 conclusions about the effects of metal erosion on flow rate?

11:30AM 8 A Yes, I was.

11:30AM 9 Q And what was the technique that you used for that?

11:30AM 10 A I've used most accepted technique that I know some of the
11:30AM 11 other government experts also used. It's based on the so-called
11:30AM 12 Bernoulli equation.

11:30AM 13 Q Now, I'm going to -- well, just describe briefly how used
11:30AM 14 the equation here.

11:30AM 15 A If we take away all the details, it essentially says that
11:30AM 16 pressure drop is directly proportional to velocity squared. In
11:30AM 17 other words, to go from this change of pressure drop to
11:30AM 18 velocity, I have to square root it.

11:30AM 19 So, while this was a straight line, something that
11:31AM 20 was a straight line will become a curved line in the other
11:31AM 21 block. But it's a simple quadratic or square root relationship.

11:31AM 22 Q Now, one final graph to sum up your opinions here,
11:31AM 23 Dr. Nesic. I have called up D-23995B, and I'll just ask you if
11:31AM 24 you can use this graph here, or chart here, to explain to Judge
11:31AM 25 Barbier your opinion about how changes in restrictions affected

11:31AM 1 flow over time.

11:31AM 2 A Your Honor, this is the ultimate graph, and answers the main
11:31AM 3 charge I had. And that was not what was the flow rate, but how
11:31AM 4 much did the flow rate change over time because of erosion of
11:31AM 5 the BOP.

11:31AM 6 And what you see here on this chart is the same
11:31AM 7 timeline, April 22nd to May 27th, and kind of an inverse of the
11:32AM 8 previous pressure drop plot, because there is that direct
11:32AM 9 relationship there.

11:32AM 10 What you see is essentially that, assuming the BOP
11:32AM 11 was the main restriction in the flow, the flow would have
11:32AM 12 doubled over this period of time because of the erosion of the
11:32AM 13 various components.

11:32AM 14 I would just add very briefly that, again, I don't
11:32AM 15 have an actual flow rate on this axis for the same reason as I
11:32AM 16 had before. I didn't get into this argument what would be the
11:32AM 17 exact flow rate. I only wanted to answer the question by how
11:32AM 18 much would any given flow rate change; what would be the factor.

11:32AM 19 I came up with a factor of 2 in this case.

11:32AM 20 Q Does your analysis of the ability of oil and gas to flow
11:32AM 21 through the BOP change based on the initial flow rate?

11:32AM 22 A No.

11:32AM 23 Q Why is that?

11:32AM 24 A Because, the way I've done it, isolated this geometrical
11:33AM 25 affect and separated it out from all the other affects that

11:33AM 1 effect, say, pressure drop. So nothing else. Either the
11:33AM 2 density of the fluid, the viscosity of the fluid, the actual
11:33AM 3 flow rate do not play into this.

11:33AM 4 Actually, they do; but, once you divide the flow
11:33AM 5 rate at the beginning and the end, they all cancel out. So you
11:33AM 6 see unambiguously and universally the change of flow that would
11:33AM 7 have been obtained at any given flow rate from 5 to 65,000
11:33AM 8 barrels a day because these components were eroded.

11:33AM 9 Q And what is the significance of knowing the geometry at the
11:33AM 10 beginning? That is that, in the pristine condition, versus the
11:33AM 11 geometry after 35 days of flow that includes sand on your
11:34AM 12 analysis?

11:34AM 13 A Well, it gave me this huge degree of confidence. This is an
11:34AM 14 unusual situation that in a real life problems we know two
11:34AM 15 points in time and are only really asked to connect them in the
11:34AM 16 most intelligent and best possible way.

11:34AM 17 Usually, we only know one point in time, and then
11:34AM 18 we're asked to predict how something will happen into the
11:34AM 19 future. Or, in the case of failure analysis, we go backward and
11:34AM 20 say, Okay, this is what we know. This is what broke. Go back
11:34AM 21 now and analyze what happened in the past.

11:34AM 22 But rarely do we know both points in time. This
11:34AM 23 was a privilege to have those two pieces of information. Made
11:34AM 24 my job so much more reliable. I knew the outcome at the
11:34AM 25 beginning and the end. I had quantified it, and then I did the

11:34AM 1 best possible way to connect the two points in time.

11:34AM 2 Q Dr. Nestic, what is your ultimate conclusion as to the effect
11:34AM 3 of metal erosion on flow rate, assuming that the BOP and the
11:34AM 4 kinked riser were restrictions to flow?

11:35AM 5 A I've concluded that this erosion of the elements of the BOP
11:35AM 6 and the kinked riser were so significant, that if the BOP was
11:35AM 7 the sole and the biggest restriction to flow, the flow would
11:35AM 8 have doubled over this period of time that I've analyzed.

11:35AM 9 Q And the period of time that you have studied is April the
11:35AM 10 22nd to May the 27th?

11:35AM 11 A That is correct.

11:35AM 12 Q And, in terms of the ability of the flow to cause erosion,
11:35AM 13 have you independently verified that erosion would be occurring
11:35AM 14 during that period of time?

11:35AM 15 A Yes, I have. I have the sand production data and I have the
11:35AM 16 erosion events that happened sort of along this whole timeline.

11:35AM 17 MR. BROCK: Thank you, Dr. Nestic. That's all we have
11:35AM 18 at this time.

11:35AM 19 THE WITNESS: Thank you.

11:35AM 20 THE COURT: All right. Cross examination.

11:36AM 21 MS. CROSS: Good morning, Your Honor. Anna Cross on
11:36AM 22 behalf of the United States.

11:36AM 23 CROSS EXAMINATION

11:36AM 24 BY MS. CROSS:

11:36AM 25 Q Good morning, Dr. Nestic.

11:36AM 1 A Good morning, Ms. Cross.

11:36AM 2 Q Dr. Nesic, you attempted to build a model to determine the
11:36AM 3 rate of metal erosion; right?

11:36AM 4 A I didn't attempt, I built one.

11:36AM 5 Q You attempted -- prior to developing a model you showed us
11:37AM 6 here, you tried to develop a model that would predict the rate
11:37AM 7 of metal erosion over time; right?

11:37AM 8 A No. I did not try to. I actually built one. And I didn't
11:37AM 9 build it prior to this. This was part of the whole exercise.

11:37AM 10 Q You're not providing an opinion about what the erosion rate
11:37AM 11 was; right?

11:37AM 12 A That is true.

11:37AM 13 Q And your model doesn't tell us what the erosion rate was;
11:37AM 14 does it?

11:37AM 15 A My model didn't need to tell us what the erosion rate was.
11:37AM 16 My model was trying to tell us what the effect of erosion was of
11:37AM 17 flow rate. I was not in the business of predicting erosion
11:37AM 18 rates.

11:37AM 19 Q Your original intent when you started your work on this case
11:37AM 20 was to calculate the erosion rate, and you found you couldn't do
11:37AM 21 that; right?

11:37AM 22 A No. I wouldn't agree with that. I actually did calculate
11:37AM 23 the erosion rates.

11:38AM 24 Q Let's go ahead and take a look at what you said in your
11:38AM 25 deposition.

11:38AM 1 MS. CROSS: Could we please have page 159, lines 1
11:38AM 2 through -- and it's going to go through 162.

11:38AM 3 BY MS. CROSS:

11:38AM 4 Q I asked you: Before the break you said that the erosion
11:38AM 5 rate calculated by your model had no material consequences on
11:38AM 6 your findings. What did you mean by that?

11:38AM 7 Answer: If you will allow me to explain that, I
11:38AM 8 need to offer a little bit of a historical perspective,
11:38AM 9 historical as it refers to my work.

11:38AM 10 Okay.

11:38AM 11 Our original intent when we started this work and
11:38AM 12 were charged with the task was to try to take the geometries of
11:38AM 13 interest within the BOP and the kinked riser and calculate the
11:38AM 14 erosion as accurately as we can, use that information to
11:38AM 15 describe how that geometry eroded and changed, keep calculating
11:38AM 16 the erosion rate in a transient sense, and in the end arrive
11:38AM 17 with the geometry of those elements as they were found and
11:38AM 18 recovered. Okay.

11:39AM 19 So, in order to do that, one needed at least two
11:39AM 20 things to work really well: That the erosion model,
11:39AM 21 particularly the very high erosion rates part of it --
11:39AM 22 continuing on to the next page it -- the very high erosion
11:39AM 23 rates --

11:39AM 24 THE COURT: Wait, wait, wait. You're not going to read
11:39AM 25 this whole page, are you? What was your original question to

11:39AM 1 him? What are you trying to prove here?

11:39AM 2 BY MS. CROSS:

11:39AM 3 Q Your model does not calculate an erosion rate that you
11:39AM 4 presented in your report; right?

11:39AM 5 A Ms. Cross, I've never presented erosion rates in my report
11:39AM 6 as related to the real geometries, because I didn't need that
11:39AM 7 information. I knew the geometry at the beginning and the end.

11:39AM 8 I will agree that it was difficult to work with
11:39AM 9 the real geometries and their erosion process over time, but I
11:39AM 10 did calculate the erosion rates. I've actually even calibrated
11:39AM 11 them with a laboratory study. So I did do that.

11:40AM 12 It was difficult to apply those erosion rates and
11:40AM 13 modify a very complicated geometry, and that's the only pathway
11:40AM 14 that we didn't follow compared to what we intended from the
11:40AM 15 beginning.

11:40AM 16 That's what I say in my deposition as well.

11:40AM 17 Q Okay. And so my question was simply, your opinion is not
11:40AM 18 that there was a certain erosion rate based on your modeling?

11:40AM 19 A That is true. That wasn't my thrust, that's right.

11:40AM 20 Q All right. In your modeling, you looked at scans of various
11:40AM 21 parts of the BOP and the riser showing erosion that were
11:40AM 22 recovered after the response; right?

11:40AM 23 A That's right.

11:40AM 24 Q Now, you're not providing your own opinion about the
11:40AM 25 duration of erosion; are you?

11:40AM 1 A Oh, yes, I am.

11:40AM 2 Q In your report, you said you assumed the period of erosion;
11:40AM 3 right?

11:40AM 4 A What that word means is that I formed an opinion as to what
11:41AM 5 it was; and, based on that, I used the assumed period in my
11:41AM 6 other calculations.

11:41AM 7 That doesn't mean I guess it. In our scientific
11:41AM 8 world, the word assume doesn't mean that I'm just wildly
11:41AM 9 guessing what it was.

11:41AM 10 Q You assumed the flow rate based on Dr. Vaziri's estimate of
11:41AM 11 the duration of sand production; right?

11:41AM 12 A Would you please repeat that question?

11:41AM 13 Q You based your assumptions that the end of the erosion
11:41AM 14 period was May 27th on Dr. Vaziri's opinion about the duration
11:41AM 15 of sand production?

11:41AM 16 A That is only partially true, so you got one of the two
11:41AM 17 important pieces of information. I did base my opinion on what
11:41AM 18 Dr. Vaziri said about sand production, and I extended that
11:41AM 19 saying, Well, if there was sand until the end of May, I can
11:41AM 20 safely assume that there was some erosion until the end of May.

11:41AM 21 But, as I have just testified in the direct, the
11:41AM 22 other compelling piece of evidence which I had which is totally
11:42AM 23 independent from Dr. Vaziri and what he thought, is with a third
11:42AM 24 hole in the kinked riser that appeared on May 19th.

11:42AM 25 So, here, we are now really debating how long past

11:42AM 1 May 19th and before the end of May erosion stopped, and I
11:42AM 2 stopped it conservatively on May 27th.

11:42AM 3 Q You can't say for certain that erosion didn't stop on, say,
11:42AM 4 May 26th; can you?

11:42AM 5 A Well, I'm not ready to speculate about, you know, a day
11:42AM 6 forward or backward. I thought May 27 best reflects a
11:42AM 7 compromise where I knew that it went beyond May 19th, and I took
11:42AM 8 it that it stopped some time before the end of May.

11:42AM 9 I think May 27th was a good measure. I don't know
11:42AM 10 of any reasons why I would now speculate about a day forward, a
11:42AM 11 day backward. In the end, it wouldn't make any big difference
11:42AM 12 on my analysis.

11:42AM 13 THE COURT: Tell me again where the May 27 came from.
11:43AM 14 What's his name, the other --

11:43AM 15 THE WITNESS: Vaziri.

11:43AM 16 THE COURT: He said that's when the sand production
11:43AM 17 ended?

11:43AM 18 THE WITNESS: He actually said end of May, so it means
11:43AM 19 a few days beyond. He had based it on a model he ran for sand
11:43AM 20 production and obviously his expertise.

11:43AM 21 THE COURT: And the 27th, you --

11:43AM 22 THE WITNESS: I moved it forward.

11:43AM 23 THE COURT: Sort of an average or something.

11:43AM 24 THE WITNESS: Well, no. It wasn't really --

11:43AM 25 THE COURT: Not an average, but what was your thinking

11:43AM 1 there?

11:43AM 2 THE WITNESS: I was thinking to be a little more
11:43AM 3 conservative. He said at least the end of May. I said, Well, I
11:43AM 4 don't want to stretch it that long because I know there's
11:43AM 5 arguments. We don't have physical evidence it was end of May.
11:43AM 6 We have May 19th. So I thought May 27th is a sensible one.

11:43AM 7 I had no reason, Your Honor, to say May 20th,
11:43AM 8 because I knew it was --

11:43AM 9 THE COURT: It is also the case, if you know, that the
11:43AM 10 sand production would be sort of declining?

11:43AM 11 THE WITNESS: That's right.

11:43AM 12 THE COURT: So that could be another factor.

11:43AM 13 THE WITNESS: That could be. It's not my area of
11:43AM 14 expertise, but that could definitely be another factor.

11:44AM 15 THE COURT: Go ahead.

11:44AM 16 BY MS. CROSS:

11:44AM 17 Q You didn't check Dr. Vaziri's work; right?

11:44AM 18 A I did not.

11:44AM 19 Q You didn't independently do any analysis to confirm that
11:44AM 20 sand production lasted until May 27th?

11:44AM 21 A No. I had all reasons to rely on Dr. Vaziri's opinions were
11:44AM 22 correct. I'm not a sand production expert, and I was never
11:44AM 23 attempting to perform such an analysis.

11:44AM 24 Q And you understand that Dr. Vaziri is not being called by BP
11:44AM 25 in this case; right?

11:44AM 1 A That, I understand, yes.

11:44AM 2 Q Let's talk about the pre-erosion geometries that you looked
11:44AM 3 at. You assign those pre-erosion geometry pressure drops to
11:44AM 4 April 22nd; right?

11:44AM 5 A That is true for the case of the blind shear rams. And I do
11:44AM 6 the same for the casing shear ram a week later when they close,
11:44AM 7 which was April 29.

11:44AM 8 Q So, for the blind shear ram, the upper annular and the
11:44AM 9 kinked riser, you assume that the pristine geometry, the
11:44AM 10 pre-erosion geometry as you called it, was still, in fact, the
11:45AM 11 geometry on April 22nd; right?

11:45AM 12 A Well, I took each one separately, so I don't think it's fair
11:45AM 13 to lump them together. But what is true in a sort of big
11:45AM 14 picture is that, on April 22nd, the blind shear rams were
11:45AM 15 activated and started eroding.

11:45AM 16 They were by a long shot, which everybody agrees,
11:45AM 17 the biggest resistance in that stack. So, therefore, you can
11:45AM 18 call it the day of the erosion -- or the erosion started in the
11:45AM 19 BOP, from my perspective.

11:45AM 20 So I wouldn't fully agree with your statement, but
11:45AM 21 there's elements of truth in that.

11:45AM 22 Q When Mr. Brock asked you about the period of erosion, you
11:45AM 23 said it was from April 22nd to May 27th; right?

11:45AM 24 A That's the integral view of the whole process, the certain
11:45AM 25 thing activated with delayed. The CSR was activated a week

11:45AM 1 later. I have lumped the other three together. So, in that
11:46AM 2 sense, you were correct, that they all started on the same day.
11:46AM 3 In my analysis.

11:46AM 4 Q Right. So you assumed that there was no erosion of the
11:46AM 5 upper annular or the kinked riser between April 22nd, the
11:46AM 6 blowout, and April 22nd when your modeling started; right?

11:46AM 7 MR. BROCK: I'd just object. I think you used April
11:46AM 8 22nd twice. I don't know what you meant to say.

11:46AM 9 THE COURT: You said April 22nd and April 22nd.

11:46AM 10 MS. COOK: Sorry.

11:46AM 11 THE COURT: Thought were you referring to different
11:46AM 12 times of that day.

11:46AM 13 THE WITNESS: Erosion was fast, but not that fast.

11:46AM 14 THE COURT: Why don't you restate your question.

11:46AM 15 BY MS. CROSS:

11:46AM 16 Q You assumed, Dr. Nestic, that April 22nd was the beginning of
11:46AM 17 erosion for the blind shear ram, the upper annular, and the
11:46AM 18 kinked riser; right?

11:46AM 19 A That is how I've lumped them together, that is correct.

11:46AM 20 Q So any erosion that happened in the upper annular or the
11:46AM 21 kinked riser, erosion to the drill pipe, for example, you
11:46AM 22 assumed none of that happened until April 22nd?

11:46AM 23 A Not entirely. If I may just explain.

11:47AM 24 When I look at something, whether something eroded
11:47AM 25 or not, if you will recall, Your Honor, I had two criteria:

11:47AM 1 Whether something eroded or not and whether it had an effect,
11:47AM 2 that erosion had an effect on the change of flow rate.

11:47AM 3 So, therefore, the only qualifying -- the major
11:47AM 4 qualifying geometry on April 22nd that fits both those criteria
11:47AM 5 were the blind shear rams. The kinked riser, if you look at how
11:47AM 6 they stack up, was a negligible -- it was only 1 or 2 percent,
11:47AM 7 the same as upper annular.

11:47AM 8 So I was not concerned with whether they were
11:47AM 9 little eroded before the blind shear rams closed. I was looking
11:47AM 10 at the big events, not every detail in the sense that you asked.

11:47AM 11 Q You didn't have any data between April 22nd and May 27th for
11:47AM 12 the blind shear ram; right?

11:47AM 13 A That's correct. We had the geometry at the beginning, April
11:48AM 14 22nd, and at the end, which is May 27th.

11:48AM 15 Q And you present in figure 33 -- and Mr. Brock asked you
11:48AM 16 about this -- what you called the hard numbers for the blind
11:48AM 17 shear ram; right?

11:48AM 18 A Well, it's not only me calling it that. When one has that
11:48AM 19 degree of accuracy and scientific knowledge about what happened,
11:48AM 20 I think that's a fair characterization of calling it hard data.
11:48AM 21 I think it's not fair to call it anything else.

11:48AM 22 Q What was the final pressure drop in your post-erosion
11:48AM 23 modeling for the blind shear ram?

11:48AM 24 A Can you please repeat the question?

11:48AM 25 Q Sure. What was the final pressure drop in the blind shear

11:48AM 1 ram for your post-erosion geometry?

11:48AM 2 A It was 20 something times less than what it was in the
11:48AM 3 pre-erosion geometries.

11:48AM 4 Q What was it in terms of pascals?

11:48AM 5 A Well, that would depend on whether you took any given flow
11:48AM 6 rate that you would assume. Since I was not trying to guess the
11:49AM 7 flow rate and then guess the pressure drop, I only looked by how
11:49AM 8 much it changed. And this 20 something factor, I believe it was
11:49AM 9 22 or 24, that big factor was the same whether I started with
11:49AM 10 5,000 stock barrels per day or 65.

11:49AM 11 When you divide the beginning with the end, you
11:49AM 12 always got about the same factor. That's why I don't remember
11:49AM 13 the actual pressure drop for any given flow rate. And,
11:49AM 14 actually, it's not important for my analysis.

11:49AM 15 Q You didn't present the actual pressure drops for your
11:49AM 16 pre-erosion geometry or your post-erosion geometry in your
11:49AM 17 report; right?

11:49AM 18 A No. Because, as I just argued, the actual numbers were not
11:49AM 19 important for the main conclusion. However, it is fair to say
11:49AM 20 that, in the produced files that I handed over, the actual
11:49AM 21 simulations for high flow rate and low flow rate and every
11:50AM 22 geometry were in actual units, pascals or psi, whatever you
11:50AM 23 want, so that the hard data in terms of units were there.

11:50AM 24 That just didn't affect my overall conclusion when
11:50AM 25 all those things came together in the graphs I've shown.

11:50AM 1 Q The post-erosion geometry pressure drop for the blind shear
11:50AM 2 rams in the files as you produced them was about 6 psi for the
11:50AM 3 high flow rate case, and between 0 and 1 psi for the low flow
11:50AM 4 rate case; right?

11:50AM 5 A Honestly, I have done thousand of simulations. At least a
11:50AM 6 few hundred of those were related to the blind shear rams. I
11:50AM 7 have no recollection of any individual number and what are you
11:50AM 8 exactly referring to. You may well be right, but that doesn't
11:50AM 9 stick in my memory.

11:50AM 10 MS. CROSS: Could we please have D-22820.

11:50AM 11 BY MS. CROSS:

11:51AM 12 Q Now, Dr. Nesic, this is a version of your figure 33 that
11:51AM 13 takes out everything except what you call the hard numbers for
11:51AM 14 the blind shear ram.

11:51AM 15 Do you agree that this accurately depicts the
11:51AM 16 blind shear ram numbers that you had April 22nd and May 27th?

11:51AM 17 A Yes, it looks right. I have haven't seen this graph in any
11:51AM 18 great detail before. But, yeah, it looks right.

11:51AM 19 Q And you used your transient modeling to try to figure out
11:51AM 20 how to connect those two dark blue blocks; right?

11:51AM 21 A That's true.

11:51AM 22 Q Okay. And you decided based on your transient modeling that
11:51AM 23 there was a straight line between those two blocks; is that
11:51AM 24 right?

11:51AM 25 A There was a straight line that connects. But there is a

11:51AM 1 straight line which best characterizes the change of pressure
11:51AM 2 drop with time due to erosion, that is correct.

11:51AM 3 Q Nothing in between April 22nd and May 27th is, in fact, a
11:52AM 4 calculation for the blind shear ram as you present your results
11:52AM 5 in figure 33; right?

11:52AM 6 A I'm sorry, but I have to disagree. I didn't just wave my
11:52AM 7 hands or use some guess or even just experience to connect the
11:52AM 8 points on the 22th of April to the 27th of May.

11:52AM 9 I've actually made the best possible attempt to
11:52AM 10 calculate what the nature of that line should be.

11:52AM 11 Now, I've known of many examples when people have
11:52AM 12 two points and no physical evidence in between, they just
11:52AM 13 connect them with a straight line.

11:52AM 14 But that's not what I did. I've actually
11:52AM 15 performed transient simulations, which you just referred to, and
11:52AM 16 they have indicated that the best possible line and the simplest
11:52AM 17 possible way to connect these two known states would be a linear
11:52AM 18 line.

11:52AM 19 So it doesn't mean that I just did it without
11:53AM 20 calculations.

11:53AM 21 Q And it's fair to say that there's only one line that would
11:53AM 22 connect these two points; isn't that right?

11:53AM 23 A If we assumed that the rate of sand production was constant,
11:53AM 24 that would be the case. We would only use one line to connect
11:53AM 25 these points.

11:53AM 1 Q Now, let's turn to your transient modeling. Your transient
11:53AM 2 modeling crashed after 10 to 12 days; right?

11:53AM 3 THE COURT: Ms. Cross, if you're moving to another
11:53AM 4 topic, I think we're going to break for lunch now.

11:53AM 5 You're going to be a while?

11:53AM 6 MS. CROSS: I am.

11:53AM 7 THE COURT: All right, let's break for lunch. We'll
11:53AM 8 come back at 1:15.

11:53AM 9 (Proceedings in Recess.)

10

11

CERTIFICATE

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14 I, Susan A. Zielie, Official Court Reporter, do hereby
15 certify that the foregoing transcript is correct.

15

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/S/ SUSAN A. ZIELIE, FCRR

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Susan A. Zielie, FCRR

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/	130 [3] - 2792:15, 2798:25, 2828:1 1300 [1] - 2771:10 130544 [1] - 2828:4 130712 [2] - 2817:5, 2817:6 130713 [2] - 2817:6, 2817:21 130713.44 [1] - 2819:18 1331 [1] - 2771:4 13th [4] - 2779:3, 2779:18, 2779:20, 2788:14 14271 [1] - 2768:15 15 [1] - 2842:21 159 [1] - 2905:1 16 [1] - 2774:24 1615 [1] - 2771:10 162 [1] - 2905:2 1665 [1] - 2771:4 16th [1] - 2779:3 17 [2] - 2766:5, 2773:2 1700 [1] - 2770:23 188 [1] - 2767:18 1885 [1] - 2768:5 19 [1] - 2876:25 1991 [1] - 2846:4 1996 [1] - 2846:4 19th [16] - 2859:13, 2859:18, 2859:19, 2869:14, 2869:18, 2872:9, 2874:2, 2874:11, 2874:14, 2874:17, 2875:5, 2899:7, 2907:24, 2908:1, 2908:7, 2909:6 1:15 [1] - 2916:8 1B1 [3] - 2866:19, 2866:21, 2867:4	20005 [1] - 2769:20 20006 [1] - 2771:14 2002 [2] - 2847:2, 2847:7 20044 [2] - 2768:15, 2768:24 2010 [1] - 2766:5 2013 [2] - 2766:5, 2773:2 2020 [1] - 2771:14 20th [8] - 2779:6, 2779:11, 2779:14, 2779:18, 2779:21, 2873:23, 2874:18, 2909:7 21 [1] - 2774:25 22 [1] - 2913:9 22-foot [1] - 2827:21 2216 [1] - 2767:11 22nd [27] - 2858:2, 2858:15, 2860:13, 2867:22, 2869:3, 2895:3, 2895:12, 2896:1, 2898:6, 2901:7, 2903:10, 2910:4, 2910:11, 2910:14, 2910:23, 2911:5, 2911:6, 2911:8, 2911:9, 2911:16, 2911:22, 2912:4, 2912:11, 2912:14, 2914:16, 2915:3 22th [1] - 2915:8 23:11 [1] - 2775:1 24 [2] - 2795:24, 2913:9 264 [1] - 2828:1 26th [1] - 2908:4 27 [2] - 2908:6, 2908:13 2775 [1] - 2772:6 27th [23] - 2858:2, 2860:2, 2860:5, 2877:6, 2877:9, 2895:13, 2896:3, 2897:15, 2897:19, 2901:7, 2903:10, 2907:14, 2908:2, 2908:9, 2908:21, 2909:6, 2909:20, 2910:23, 2912:11, 2912:14, 2914:16, 2915:3, 2915:8 2843 [1] - 2772:9 2873 [1] - 2772:5 28:27 [1] - 2774:24 28th [3] - 2869:6, 2869:15, 2872:10 29 [1] - 2910:7	2903 [1] - 2772:10 29th [12] - 2859:1, 2859:11, 2863:19, 2865:21, 2866:6, 2866:7, 2866:9, 2874:13, 2895:15, 2897:23, 2898:2, 2899:8 2:1 [1] - 2827:15 2nd [1] - 2847:7	5
/S [1] - 2916:16				5 [2] - 2830:4, 2902:7 5,000 [1] - 2913:10 50 [1] - 2846:1 500 [3] - 2766:23, 2767:23, 2771:18 5000 [1] - 2769:6 501 [1] - 2767:15 504 [1] - 2771:19 556 [1] - 2766:23 58 [1] - 2839:23 589-7781 [1] - 2771:19
0				
0 [1] - 2914:3 0.5 [1] - 2840:8 0.61 [1] - 2840:8 0.84 [2] - 2840:2, 2840:11				
1			3	
1 [27] - 2804:3, 2804:7, 2804:11, 2804:23, 2804:25, 2805:1, 2806:18, 2806:22, 2807:15, 2809:13, 2810:6, 2810:21, 2810:22, 2814:20, 2814:22, 2815:1, 2829:18, 2830:3, 2888:23, 2891:6, 2894:22, 2896:24, 2898:12, 2905:1, 2912:6, 2914:3 1.5 [1] - 2830:6 1.75 [1] - 2830:7 10 [11] - 2791:4, 2791:5, 2791:10, 2890:8, 2890:9, 2890:16, 2890:19, 2891:6, 2892:8, 2892:14, 2916:2 10-CV-2771 [1] - 2766:7 10-CV-4536 [1] - 2766:10 100 [2] - 2850:12, 2872:21 10003 [1] - 2767:8 1001 [1] - 2770:10 1050 [1] - 2792:11 1053 [1] - 2798:25 10650 [1] - 2815:15 10650.1.1.US [1] - 2815:21 11 [1] - 2766:14 1100 [1] - 2770:7 11488 [1] - 2795:24 11508 [1] - 2843:10 11th [1] - 2891:6 12 [1] - 2916:2 12.875 [4] - 2783:19, 2784:5, 2792:1, 2792:7 1201 [2] - 2769:23, 2770:23 12th [1] - 2891:6			3 [11] - 2792:4, 2799:4, 2817:23, 2830:3, 2889:25, 2891:6, 2894:21, 2894:23, 2896:25, 2897:2, 2897:11 3.5 [1] - 2896:6 30 [2] - 2846:1, 2849:1 300 [1] - 2769:12 316 [1] - 2767:4 32502 [1] - 2767:5 33 [4] - 2774:24, 2912:15, 2914:12, 2915:5 333 [1] - 2769:15 335 [1] - 2770:16 35 [6] - 2817:21, 2888:12, 2890:15, 2896:24, 2898:12, 2902:11 3500 [1] - 2896:11 35TH [1] - 2770:16 36130 [1] - 2767:23 3668 [1] - 2766:24 3700 [2] - 2770:7, 2770:10 39201 [1] - 2767:19 3D [2] - 2861:8, 2862:11 3X [1] - 2795:5	
	2		4	6
	2 [13] - 2808:18, 2809:13, 2810:7, 2810:16, 2818:10, 2830:3, 2836:12, 2888:23, 2889:24, 2891:6, 2901:19, 2912:6 2.03 [2] - 2827:22, 2830:9 2.5 [1] - 2831:8 20 [10] - 2766:5, 2791:11, 2805:6, 2805:8, 2887:7, 2888:5, 2896:3, 2913:2, 2913:8 20004 [1] - 2769:24		4 [7] - 2804:5, 2804:9, 2805:11, 2808:15, 2819:8, 2830:3, 2896:3 40 [1] - 2840:16 429 [1] - 2831:14 44 [1] - 2819:18 444 [1] - 2828:12 45 [1] - 2821:13 45,000 [1] - 2827:21 46 [1] - 2821:12 49 [1] - 2774:25 4A [3] - 2783:3, 2783:6, 2809:17	6 [1] - 2914:2 6'65 [1] - 2834:23 6.4 [1] - 2784:5 6.625 [3] - 2782:10, 2783:19, 2791:21 600 [1] - 2767:4 60654 [1] - 2769:12 65 [1] - 2913:10 65,000 [1] - 2902:7 655 [1] - 2769:20
				8
				8 [6] - 2798:16, 2798:19, 2798:25, 2799:1, 2810:11, 2810:19 820 [1] - 2766:20 8:00 [1] - 2773:5

9	2865:21, 2866:7, 2866:8, 2910:15, 2910:25 active [1] - 2849:6 activities [1] - 2848:2 actual [36] - 2784:22, 2784:23, 2787:11, 2788:9, 2791:19, 2797:8, 2797:24, 2801:7, 2809:5, 2809:6, 2809:8, 2809:9, 2821:21, 2821:24, 2822:10, 2823:3, 2824:21, 2824:24, 2825:17, 2826:21, 2827:23, 2841:3, 2857:15, 2882:1, 2891:18, 2896:20, 2896:21, 2896:23, 2901:15, 2902:2, 2913:13, 2913:15, 2913:18, 2913:20, 2913:22 add [3] - 2807:8, 2807:9, 2901:14 addition [1] - 2823:15 additional [5] - 2807:10, 2807:13, 2811:3, 2811:4, 2873:5 address [1] - 2830:24 administrative [1] - 2773:13 admitted [6] - 2773:22, 2773:23, 2774:20, 2774:21, 2854:24, 2854:25 Adrian [1] - 2796:2 affect [5] - 2839:11, 2849:9, 2887:14, 2901:25, 2913:24 affected [4] - 2857:22, 2888:19, 2897:5, 2900:25 affects [2] - 2849:9, 2901:25 after-situation [1] - 2888:11 aggravated [1] - 2872:19 ago [6] - 2773:18, 2828:10, 2849:1, 2858:13, 2874:25, 2875:9 agree [7] - 2785:7, 2794:13, 2808:16, 2904:22, 2906:8, 2910:20, 2914:15 agrees [1] - 2910:16 ahead [10] - 2775:6,	2819:18, 2821:12, 2838:7, 2842:21, 2842:24, 2861:23, 2878:15, 2904:24, 2909:15 AL [3] - 2766:8, 2766:12, 2767:23 ALABAMA [1] - 2767:21 ALAN [1] - 2771:3 alarm [1] - 2882:16 aligned [1] - 2871:9 ALLAN [1] - 2768:9 ALLEN [1] - 2770:15 allow [5] - 2788:4, 2789:7, 2789:8, 2794:24, 2905:7 allowed [1] - 2797:6 allowing [1] - 2788:13 allows [2] - 2836:14, 2838:20 alluded [1] - 2848:18 almost [9] - 2801:11, 2801:13, 2802:14, 2840:16, 2844:25, 2858:20, 2865:6, 2879:1, 2884:15 altogether [1] - 2858:18 AMERICA [3] - 2766:10, 2768:13, 2769:4 amount [9] - 2782:13, 2793:7, 2793:10, 2794:2, 2794:12, 2794:21, 2794:22, 2835:2 ANADARKO [2] - 2771:7, 2771:8 Anadarko [2] - 2837:10, 2843:21 analogy [1] - 2878:9 analysis [27] - 2857:2, 2858:14, 2858:15, 2859:10, 2863:16, 2863:21, 2868:10, 2868:21, 2876:7, 2882:2, 2888:14, 2889:4, 2889:6, 2892:6, 2893:19, 2897:7, 2898:2, 2898:20, 2901:20, 2902:19, 2908:12, 2909:19, 2909:23, 2911:3, 2913:14 analyze [6] - 2853:3, 2860:16, 2886:7, 2887:18, 2894:17, 2902:21	analyzed [8] - 2857:19, 2860:8, 2879:21, 2887:13, 2897:14, 2898:24, 2900:5, 2903:8 anchor [1] - 2882:17 anchored [1] - 2888:14 AND [2] - 2766:7, 2770:4 ANDREW [1] - 2769:9 ANGELES [2] - 2769:16, 2770:16 angle [7] - 2852:2, 2852:3, 2852:9, 2852:10, 2852:19, 2865:18, 2876:1 angles [1] - 2797:15 angular [1] - 2885:9 animation [6] - 2851:8, 2851:19, 2870:11, 2880:23, 2884:16, 2886:17 animations [1] - 2880:3 Anna [2] - 2843:6, 2903:21 ANNA [1] - 2768:21 annular [19] - 2782:22, 2782:23, 2783:6, 2784:8, 2784:15, 2784:16, 2784:17, 2857:9, 2865:25, 2866:13, 2866:16, 2866:24, 2867:10, 2879:18, 2910:8, 2911:5, 2911:17, 2911:20, 2912:7 annulus [2] - 2783:5, 2842:4 answer [13] - 2787:17, 2787:23, 2790:18, 2791:2, 2795:19, 2805:24, 2811:21, 2811:22, 2847:18, 2848:22, 2892:23, 2901:17, 2905:7 answered [2] - 2825:2, 2854:14 answers [3] - 2854:7, 2890:25, 2901:2 ANTHONY [1] - 2767:11 apart [2] - 2864:4, 2864:5 apologize [1] - 2876:16 appear [5] - 2869:7, 2870:24, 2872:2, 2872:8, 2896:19	appearance [2] - 2874:1, 2874:10 APPEARANCES [6] - 2766:17, 2767:1, 2768:1, 2769:1, 2770:1, 2771:1 appeared [9] - 2859:14, 2859:15, 2868:14, 2869:18, 2872:10, 2872:11, 2877:1, 2883:17, 2907:24 application [1] - 2849:3 apply [7] - 2778:14, 2781:15, 2783:2, 2821:3, 2899:16, 2906:12 applying [1] - 2849:10 appreciate [5] - 2778:16, 2781:21, 2800:19, 2808:4, 2884:6 approach [5] - 2794:16, 2833:22, 2840:14, 2853:13, 2853:15 approaching [3] - 2794:15, 2881:7, 2884:25 appropriate [3] - 2787:16, 2812:11, 2841:22 approximation [2] - 2834:16, 2835:17 April [45] - 2858:2, 2858:15, 2859:1, 2859:11, 2860:13, 2863:19, 2865:21, 2866:6, 2866:7, 2866:9, 2867:22, 2869:3, 2869:6, 2869:15, 2872:10, 2873:23, 2874:12, 2895:3, 2895:12, 2895:16, 2896:1, 2897:23, 2898:2, 2898:6, 2899:8, 2901:7, 2903:9, 2910:4, 2910:7, 2910:11, 2910:14, 2910:23, 2911:5, 2911:6, 2911:7, 2911:9, 2911:16, 2911:22, 2912:4, 2912:11, 2912:13, 2914:16, 2915:3, 2915:8 APRIL [1] - 2766:5 area [107] - 2776:19,
----------	---	---	---	--

2777:19, 2778:2,
2778:6, 2778:7,
2782:16, 2784:23,
2784:24, 2785:3,
2785:11, 2786:12,
2792:11, 2792:15,
2793:17, 2794:9,
2802:18, 2802:24,
2802:25, 2803:1,
2804:3, 2804:5,
2804:7, 2805:5,
2805:6, 2806:5,
2806:8, 2808:3,
2808:15, 2808:18,
2808:25, 2809:6,
2809:8, 2809:12,
2809:13, 2809:15,
2809:17, 2809:18,
2810:5, 2810:12,
2810:13, 2810:16,
2812:4, 2812:20,
2812:22, 2812:23,
2812:25, 2814:25,
2816:7, 2816:9,
2816:13, 2816:16,
2816:17, 2816:18,
2816:19, 2819:8,
2821:21, 2822:6,
2822:9, 2822:10,
2822:17, 2823:3,
2823:8, 2823:13,
2823:17, 2823:20,
2824:2, 2824:21,
2824:24, 2825:12,
2825:17, 2825:25,
2827:12, 2827:14,
2827:23, 2829:7,
2829:17, 2829:18,
2829:19, 2831:6,
2831:24, 2833:20,
2834:5, 2834:6,
2834:10, 2834:18,
2834:23, 2834:24,
2835:7, 2836:3,
2836:7, 2836:15,
2840:15, 2845:10,
2848:11, 2849:7,
2851:13, 2868:2,
2868:3, 2875:18,
2875:19, 2909:13
Area [1] - 2837:16
areas [10] - 2802:21,
2808:6, 2812:12,
2812:13, 2812:18,
2813:10, 2814:14,
2850:14, 2882:13,
2886:5
argue [1] - 2843:10
argued [1] - 2913:18
arguing [1] - 2811:7

argument [2] -
2889:18, 2901:16
arguments [3] -
2774:3, 2852:23,
2909:5
arrangement [2] -
2864:15, 2864:19
arrive [1] - 2905:16
arriving [1] - 2778:22
arrow [3] - 2870:7,
2870:18, 2870:21
article [1] - 2842:10
articles [1] - 2850:12
ASBILL [1] - 2770:9
aside [1] - 2805:5
ASSET [1] - 2766:8
assign [1] - 2910:3
assist [1] - 2849:18
associated [4] -
2785:17, 2811:4,
2820:19, 2849:25
assume [10] - 2791:4,
2823:11, 2840:11,
2852:20, 2859:19,
2874:17, 2907:8,
2907:20, 2910:9,
2913:6
assumed [7] - 2907:2,
2907:5, 2907:10,
2911:4, 2911:16,
2911:22, 2915:23
assuming [3] -
2804:14, 2901:10,
2903:3
assumption [5] -
2807:24, 2840:9,
2840:12, 2856:9
assumptions [3] -
2822:13, 2894:19,
2907:13
Athens [1] - 2843:25
atmosphere [1] -
2878:18
attack [1] - 2883:10
attempt [2] - 2904:4,
2915:9
attempted [3] -
2890:7, 2904:2,
2904:5
attempting [2] -
2804:1, 2909:23
attention [6] - 2859:1,
2863:16, 2868:24,
2872:8, 2873:11,
2878:23
ATTORNEY [2] -
2767:21, 2768:5
authored [1] - 2850:11
available [4] - 2811:5,
2821:21, 2834:23,

2835:16
AVENUE [4] -
2766:20, 2767:23,
2769:23, 2770:16
average [11] - 2778:4,
2778:5, 2778:15,
2789:19, 2799:5,
2799:9, 2827:8,
2827:9, 2834:19,
2908:23, 2908:25
averaged [2] - 2778:5,
2778:7
avoiding [1] - 2872:14
await [1] - 2774:9
aware [1] - 2841:21
axes [1] - 2796:13
axis [9] - 2796:18,
2797:16, 2871:24,
2875:20, 2876:5,
2891:14, 2894:16,
2901:15

B

Bachelors [1] -
2844:10
backed [1] - 2835:18
background [2] -
2844:9, 2853:3
backward [3] -
2902:19, 2908:6,
2908:11
ballpark [1] - 2800:20
Barbier [24] - 2843:24,
2844:9, 2846:7,
2847:3, 2847:20,
2855:4, 2856:21,
2858:12, 2860:12,
2860:21, 2863:20,
2866:4, 2868:20,
2870:1, 2874:25,
2875:3, 2878:5,
2881:4, 2883:23,
2884:20, 2889:5,
2891:11, 2895:1,
2900:25
BARBIER [1] -
2766:15
barely [1] - 2852:7
BARR [1] - 2767:4
barrels [4] - 2775:20,
2775:24, 2902:8,
2913:10
Barry [3] - 2773:14,
2787:14, 2837:9
BARRY [1] - 2769:11
bars [2] - 2898:14,
2899:21
base [1] - 2907:17
based [30] - 2775:19,

2785:16, 2787:21,
2797:5, 2799:14,
2799:16, 2799:17,
2799:23, 2800:3,
2823:3, 2835:17,
2849:21, 2852:15,
2854:15, 2859:22,
2873:20, 2882:4,
2892:18, 2894:18,
2898:1, 2898:22,
2898:23, 2900:11,
2901:21, 2906:18,
2907:5, 2907:10,
2907:13, 2908:19,
2914:22
basic [1] - 2850:25
basing [1] - 2876:7
basis [2] - 2775:18,
2890:18
BATON [1] - 2768:6
BAYLEN [1] - 2767:4
bear [1] - 2807:23
bearing [1] - 2875:19
became [1] - 2857:17
become [1] - 2900:20
BEFORE [1] - 2766:15
begin [1] - 2843:23
beginning [22] -
2799:24, 2828:14,
2831:15, 2834:15,
2856:13, 2890:10,
2890:14, 2892:6,
2892:8, 2897:2,
2897:13, 2898:12,
2898:15, 2898:19,
2902:5, 2902:10,
2902:25, 2906:7,
2906:15, 2911:16,
2912:13, 2913:11
behalf [6] - 2773:14,
2775:9, 2837:10,
2843:6, 2843:21,
2903:22
behavior [3] - 2779:1,
2800:16, 2801:8
Belgrade [1] - 2844:11
believer [1] - 2826:17
below [1] - 2819:1
bend [10] - 2859:15,
2865:8, 2868:3,
2868:6, 2868:7,
2869:8, 2871:19,
2871:23, 2871:24
bending [2] - 2875:19,
2876:6
bends [2] - 2867:19,
2885:5
BENSON [1] - 2768:19
bent [2] - 2867:18,
2868:6

Bernoulli [1] -
2900:12
best [18] - 2779:22,
2811:5, 2827:3,
2835:16, 2865:17,
2870:2, 2877:17,
2877:18, 2882:6,
2882:10, 2893:1,
2893:10, 2902:16,
2903:1, 2908:6,
2915:1, 2915:9,
2915:16
BETHANY [1] -
2768:22
better [2] - 2876:1,
2881:6
between [49] -
2779:17, 2783:11,
2783:15, 2784:9,
2784:24, 2785:9,
2785:11, 2785:13,
2786:16, 2789:20,
2792:5, 2793:17,
2794:16, 2794:20,
2795:22, 2798:22,
2802:15, 2803:19,
2805:10, 2806:1,
2814:14, 2817:15,
2820:19, 2822:5,
2822:19, 2823:8,
2825:19, 2828:24,
2829:6, 2829:12,
2829:14, 2834:21,
2840:8, 2841:5,
2859:5, 2864:15,
2865:4, 2865:9,
2873:23, 2892:7,
2897:23, 2898:14,
2898:20, 2911:5,
2912:11, 2914:3,
2914:23, 2915:3,
2915:12
beyond [13] - 2839:6,
2859:15, 2859:18,
2859:20, 2866:9,
2869:21, 2872:5,
2875:5, 2876:19,
2892:16, 2893:6,
2908:7, 2908:19
big [15] - 2782:24,
2782:25, 2783:23,
2784:1, 2793:9,
2853:24, 2868:25,
2899:20, 2908:11,
2910:13, 2912:10,
2913:9
bigger [7] - 2795:6,
2806:5, 2825:25,
2838:19, 2896:7
biggest [4] - 2848:1,

2855:16, 2903:7,
2910:17
BINGHAM [1] -
2771:12
bit [9] - 2777:10,
2780:2, 2781:25,
2789:10, 2794:21,
2814:4, 2839:11,
2893:24, 2905:8
blade [2] - 2865:2
blades [7] - 2863:8,
2864:13, 2864:15,
2865:4, 2865:9,
2884:15, 2885:2
blind [43] - 2855:9,
2855:18, 2855:21,
2857:8, 2858:16,
2860:9, 2860:18,
2860:25, 2861:5,
2861:7, 2862:11,
2862:23, 2863:3,
2865:14, 2876:14,
2879:17, 2883:21,
2884:3, 2884:7,
2885:15, 2885:25,
2886:10, 2886:16,
2886:20, 2887:4,
2895:9, 2895:23,
2895:24, 2910:5,
2910:8, 2910:14,
2911:17, 2912:5,
2912:9, 2912:12,
2912:16, 2912:23,
2912:25, 2914:1,
2914:6, 2914:14,
2914:16, 2915:4
block [2] - 2876:14,
2900:21
blocks [10] - 2860:25,
2861:13, 2884:7,
2884:10, 2884:11,
2884:25, 2885:19,
2887:6, 2914:20,
2914:23
blow [1] - 2815:20
blown [1] - 2885:15
blowout [1] - 2911:6
blue [11] - 2872:25,
2881:6, 2884:18,
2895:4, 2895:9,
2895:11, 2895:19,
2895:23, 2896:2,
2898:8, 2914:20
body [3] - 2811:18,
2833:6, 2835:18
BOLES [1] - 2769:15
boned [1] - 2883:7
book [9] - 2817:8,
2817:13, 2817:16,
2817:19, 2819:19,

2820:8, 2821:6,
2821:10, 2850:12
BOP [27] - 2844:4,
2846:22, 2848:23,
2855:10, 2856:2,
2856:9, 2857:3,
2860:8, 2860:16,
2861:13, 2870:4,
2875:14, 2876:23,
2887:12, 2887:14,
2887:17, 2894:1,
2898:25, 2901:5,
2901:10, 2901:21,
2903:3, 2903:5,
2903:6, 2905:13,
2906:21, 2910:19
bore [2] - 2867:21,
2868:7
bottom [18] - 2790:1,
2795:9, 2796:14,
2804:2, 2806:2,
2807:5, 2807:6,
2813:9, 2814:18,
2814:19, 2815:2,
2819:22, 2857:7,
2867:3, 2870:23,
2871:10, 2884:14,
2886:25
bottom-up [1] -
2870:23
boundaries [2] -
2853:21, 2880:16
bounded [2] -
2874:19, 2876:25
bounds [1] - 2825:6
BOWMAN [1] -
2770:21
BOX [4] - 2766:24,
2768:6, 2768:15,
2768:24
boxes [2] - 2898:8,
2898:9
BP [13] - 2766:11,
2769:3, 2769:4,
2769:4, 2773:14,
2774:2, 2774:25,
2815:18, 2837:10,
2843:21, 2844:2,
2844:3, 2909:24
BRAD [1] - 2770:14
BRANCH [1] - 2768:14
branches [1] -
2877:25
breaches [1] -
2845:24
break [5] - 2801:4,
2871:20, 2905:4,
2916:4, 2916:7
breaks [1] - 2795:3
BRENNAN [1] -

2770:9
BRIAN [2] - 2767:4,
2770:14
BRIDGET [1] -
2769:19
briefly [4] - 2841:25,
2847:18, 2900:13,
2901:14
bring [3] - 2814:4,
2814:11, 2880:3
BROAD [1] - 2767:15
BROADWAY [1] -
2767:8
BROCK [18] -
2769:23, 2842:18,
2842:20, 2843:17,
2843:20, 2844:5,
2844:7, 2850:18,
2850:24, 2854:17,
2854:19, 2854:22,
2855:1, 2870:25,
2873:13, 2883:18,
2903:17, 2911:7
Brock [6] - 2772:9,
2842:19, 2842:24,
2843:21, 2910:22,
2912:15
broke [1] - 2902:20
BRUCE [1] - 2770:21
BSR [3] - 2864:22,
2884:25, 2898:18
build [3] - 2788:20,
2904:2, 2904:9
builds [1] - 2878:15
built [3] - 2797:14,
2904:4, 2904:8
bullet [1] - 2855:18
bunch [2] - 2821:13,
2893:13
buoyancy [1] -
2788:18
buoyant [3] - 2800:20,
2800:25, 2801:4
BURLING [1] -
2769:22
burp [1] - 2800:5
business [1] -
2904:17
BY [67] - 2766:4,
2766:19, 2766:23,
2767:4, 2767:7,
2767:14, 2767:18,
2767:22, 2768:4,
2768:9, 2768:14,
2768:19, 2769:5,
2769:9, 2769:15,
2769:18, 2769:23,
2770:6, 2770:10,
2770:13, 2770:20,
2771:3, 2771:9,

2771:13, 2771:23,
2771:23, 2775:8,
2777:2, 2781:24,
2788:2, 2790:5,
2791:18, 2795:25,
2796:1, 2806:17,
2815:6, 2815:16,
2817:7, 2817:22,
2819:23, 2820:22,
2825:5, 2826:9,
2828:5, 2833:25,
2834:14, 2837:8,
2837:13, 2837:24,
2838:21, 2839:24,
2841:20, 2843:20,
2844:7, 2850:24,
2854:19, 2855:1,
2870:25, 2873:13,
2874:24, 2883:18,
2903:24, 2905:3,
2906:2, 2909:16,
2911:15, 2914:11

C

CA [2] - 2769:16,
2770:16
calculate [24] -
2785:21, 2802:19,
2804:15, 2804:19,
2807:17, 2809:22,
2810:2, 2815:2,
2817:25, 2825:21,
2825:22, 2825:24,
2832:7, 2834:9,
2856:7, 2878:16,
2880:22, 2885:20,
2904:20, 2904:22,
2905:13, 2906:3,
2906:10, 2915:10
calculated [9] -
2810:13, 2822:17,
2825:19, 2855:23,
2880:4, 2887:6,
2889:21, 2898:5,
2905:5
calculates [1] -
2785:16
calculating [10] -
2808:20, 2815:25,
2816:3, 2816:15,
2820:3, 2822:25,
2833:20, 2834:2,
2905:15
calculation [8] -
2804:16, 2817:23,
2823:10, 2877:7,
2886:11, 2890:6,
2897:18, 2915:4
calculations [12] -
2805:9, 2815:18,

2833:21, 2862:18,
2882:17, 2889:10,
2889:15, 2890:1,
2894:18, 2898:22,
2907:6, 2915:20
CALDWELL [1] -
2768:4
calibrated [1] -
2906:10
call-out [3] - 2815:20,
2826:8, 2869:23
call-outs [1] - 2774:14
CALLED [1] - 2773:4
Cameron [2] -
2861:16, 2861:18
CAMP [1] - 2768:10
Canada [1] - 2844:13
cancel [1] - 2902:5
candidate [1] -
2857:17
cannot [8] - 2795:6,
2835:18, 2850:1,
2878:14, 2885:1,
2899:10, 2899:15,
2899:24
CAPITOL [1] -
2767:18
capture [5] - 2785:12,
2785:24, 2786:8,
2786:15, 2841:4
captures [1] - 2787:2
career [1] - 2826:18
careful [2] - 2799:20,
2857:2
CARL [1] - 2766:15
carried [1] - 2850:8
case [48] - 2794:25,
2798:14, 2799:12,
2800:6, 2801:11,
2805:15, 2809:4,
2809:17, 2813:2,
2813:16, 2813:20,
2813:21, 2813:22,
2822:24, 2824:6,
2829:24, 2830:14,
2832:4, 2832:21,
2849:18, 2850:4,
2851:21, 2852:25,
2855:2, 2857:21,
2858:20, 2862:20,
2866:12, 2866:18,
2868:22, 2879:11,
2885:13, 2888:10,
2891:13, 2891:19,
2892:14, 2892:15,
2893:13, 2899:11,
2901:19, 2902:19,
2904:19, 2909:9,
2909:25, 2910:5,
2914:3, 2914:4,

<p>2915:24 cases [1] - 2792:19 casing [17] - 2855:19, 2855:21, 2857:7, 2859:2, 2863:16, 2863:21, 2864:9, 2864:25, 2865:21, 2874:12, 2879:17, 2897:24, 2898:19, 2899:8, 2899:19, 2899:22, 2910:6 catch [2] - 2812:15, 2899:25 caught [2] - 2883:14, 2885:13 caused [9] - 2852:8, 2853:22, 2868:14, 2869:8, 2871:2, 2871:3, 2874:1, 2876:2, 2876:20 causing [2] - 2851:11, 2851:13 cavities [1] - 2859:4 CCR [1] - 2771:17 ceased [1] - 2860:3 center [3] - 2786:18, 2793:10, 2842:7 centered [2] - 2783:10, 2783:14 CENTRE [1] - 2770:6 CERNICH [1] - 2768:20 certain [6] - 2788:4, 2805:9, 2825:9, 2906:18, 2908:3, 2910:24 certainly [8] - 2781:3, 2781:8, 2784:12, 2799:9, 2800:16, 2817:4, 2828:8, 2833:12 CERTIFICATE [1] - 2916:11 CERTIFIED [1] - 2771:17 certify [1] - 2916:14 cetera [1] - 2846:19 CFD [1] - 2850:14 CHAKERES [20] - 2798:11, 2798:13, 2806:13, 2806:17, 2815:15, 2815:16, 2817:5, 2817:7, 2817:21, 2817:22, 2819:21, 2819:23, 2825:5, 2826:7, 2826:9, 2828:4, 2828:5, 2834:11, 2834:14, 2837:4 chain [1] - 2814:19</p>	<p>CHAKERES [9] - 2768:21, 2775:5, 2775:8, 2788:1, 2788:2, 2790:5, 2815:6, 2820:22, 2833:25 Chakeres [2] - 2772:6, 2775:9 CHAKERES [8] - 2776:25, 2777:2, 2781:22, 2781:24, 2791:17, 2791:18, 2795:25, 2796:1 change [25] - 2781:10, 2791:12, 2806:9, 2824:14, 2825:16, 2844:4, 2854:15, 2856:7, 2857:5, 2878:11, 2887:19, 2888:23, 2891:25, 2892:3, 2892:21, 2896:24, 2897:10, 2900:17, 2901:4, 2901:18, 2901:21, 2902:6, 2912:2, 2915:1 changed [13] - 2854:14, 2856:2, 2868:11, 2868:13, 2868:15, 2890:3, 2892:10, 2892:17, 2894:23, 2897:11, 2900:6, 2905:15, 2913:8 changes [8] - 2781:14, 2824:15, 2824:16, 2835:4, 2879:9, 2889:8, 2894:17, 2900:25 changing [5] - 2779:17, 2781:5, 2781:6, 2806:9, 2894:8 channeled [1] - 2883:15 chapter [2] - 2817:23, 2817:24 characterization [2] - 2839:19, 2912:20 characterize [2] - 2809:3, 2833:8 characterized [1] - 2897:22 characterizes [1] - 2915:1 characterizing [1] - 2833:6 charge [1] - 2901:3 charged [1] - 2905:12 CHARLES [1] -</p>	<p>2767:15 chart [4] - 2798:5, 2837:20, 2900:24, 2901:6 charts [1] - 2894:5 check [2] - 2882:18, 2909:17 checked [1] - 2891:4 checks [3] - 2882:16, 2886:1 chemical [2] - 2844:12, 2848:19 cherry [1] - 2835:19 cherry-pick [1] - 2835:19 CHICAGO [1] - 2769:12 chisel [2] - 2852:4, 2865:18 choice [1] - 2842:12 choking [1] - 2839:11 chooses [1] - 2893:14 circle [8] - 2804:22, 2804:24, 2805:3, 2805:6, 2805:13, 2816:9, 2816:18, 2816:19 circles [1] - 2805:5 circular [10] - 2809:2, 2809:21, 2812:8, 2816:3, 2816:4, 2816:7, 2816:12, 2840:4, 2840:6, 2865:6 circulated [2] - 2773:17, 2774:17 cited [2] - 2817:17, 2821:6 CITY [1] - 2767:8 CIVIL [1] - 2768:14 claim [2] - 2835:23 clarification [1] - 2779:15 classes [1] - 2847:14 clean [1] - 2814:2 clear [8] - 2781:17, 2801:14, 2802:11, 2808:1, 2837:20, 2864:21, 2865:6, 2885:23 clearly [4] - 2836:20, 2863:3, 2864:22, 2876:9 CLERK [1] - 2843:2 close [12] - 2802:16, 2812:10, 2812:17, 2812:24, 2813:6, 2813:7, 2858:20, 2862:4, 2863:4, 2876:17, 2882:20,</p>	<p>2910:6 closed [10] - 2859:7, 2862:17, 2863:4, 2864:11, 2864:15, 2865:3, 2884:15, 2884:25, 2899:8, 2912:9 closer [1] - 2820:21 closes [1] - 2866:24 closing [1] - 2897:24 clue [1] - 2871:21 co [1] - 2850:11 co-authored [1] - 2850:11 coefficient [12] - 2818:20, 2818:25, 2819:3, 2824:4, 2839:16, 2839:18, 2839:19, 2839:25, 2840:7, 2840:10, 2840:11, 2840:16 Coefficient [1] - 2818:22 coefficients [1] - 2839:21 colleagues [1] - 2795:23 COLLIER [1] - 2769:10 color [3] - 2869:15, 2872:25, 2885:10 colored [4] - 2881:6, 2898:8, 2898:9, 2898:13 colors [1] - 2898:13 column [1] - 2898:1 combination [1] - 2849:8 combine [7] - 2809:10, 2812:2, 2812:12, 2813:15, 2813:23, 2838:20 combined [31] - 2802:7, 2808:6, 2808:7, 2808:21, 2808:25, 2809:9, 2809:13, 2809:15, 2809:16, 2809:18, 2809:19, 2810:5, 2810:10, 2810:12, 2810:13, 2810:14, 2810:16, 2811:25, 2812:4, 2812:18, 2812:20, 2812:23, 2813:10, 2846:12, 2893:24 coming [11] - 2799:1, 2805:22, 2807:13, 2871:10, 2875:11, 2875:12, 2881:15,</p>	<p>2884:14, 2886:18, 2886:25, 2887:5 common [2] - 2836:18, 2838:14 commonly [1] - 2776:13 companies [6] - 2848:8, 2848:9, 2848:19, 2848:20 COMPANY [2] - 2769:4, 2771:8 compare [1] - 2885:24 compared [4] - 2837:21, 2877:6, 2882:12, 2906:14 comparing [2] - 2797:17, 2862:8 compelling [1] - 2907:22 COMPLAINT [1] - 2766:7 completely [2] - 2863:4, 2867:7 complex [3] - 2814:8, 2814:10, 2850:5 complexity [4] - 2790:23, 2839:12, 2839:14, 2889:13 complicated [8] - 2827:5, 2850:3, 2854:6, 2882:20, 2884:6, 2885:13, 2894:11, 2906:13 component [1] - 2879:12 components [14] - 2854:3, 2860:7, 2879:21, 2887:17, 2887:18, 2887:19, 2887:23, 2888:13, 2893:19, 2897:17, 2897:19, 2898:23, 2901:13, 2902:8 compressible [3] - 2781:18, 2781:19 compromise [1] - 2908:7 computation [5] - 2846:14, 2846:18, 2847:13, 2849:2, 2849:4 computational [11] - 2846:21, 2849:15, 2849:17, 2849:23, 2850:5, 2850:19, 2854:5, 2861:22, 2879:19, 2880:20, 2889:2 compute [1] - 2814:25 computer [2] -</p>
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<p>2849:21, 2882:4 COMPUTER [1] - 2771:23 computer-based [2] - 2849:21, 2882:4 computerized [1] - 2879:24 computers [1] - 2849:24 concept [8] - 2781:15, 2795:3, 2819:24, 2821:2, 2824:20, 2851:1, 2851:4, 2878:8 concerned [1] - 2912:8 conclude [4] - 2811:10, 2858:14, 2863:13, 2892:17 concluded [4] - 2855:25, 2888:16, 2898:25, 2903:5 conclusion [4] - 2885:17, 2903:2, 2913:19, 2913:24 conclusions [6] - 2791:16, 2881:18, 2892:25, 2900:4, 2900:5, 2900:7 condition [5] - 2852:1, 2859:3, 2887:13, 2897:18, 2902:10 conditions [9] - 2787:11, 2788:10, 2788:21, 2789:2, 2789:4, 2789:9, 2791:16, 2852:13, 2852:18 conducive [1] - 2852:18 conducted [1] - 2849:7 conference [1] - 2850:12 confidence [2] - 2877:8, 2902:13 confident [2] - 2876:10, 2893:10 confirm [3] - 2812:17, 2819:5, 2909:19 confirmed [2] - 2833:1, 2893:9 confirming [1] - 2829:4 conjunction [1] - 2785:21 connect [10] - 2890:14, 2891:21, 2902:15, 2903:1, 2914:20, 2915:7,</p>	<p>2915:13, 2915:17, 2915:22, 2915:24 connects [1] - 2914:25 consequences [1] - 2905:5 conservative [5] - 2807:24, 2840:9, 2840:12, 2860:4, 2909:3 conservatively [3] - 2808:1, 2877:5, 2908:2 consideration [1] - 2815:23 considered [3] - 2781:19, 2795:15, 2815:17 consistent [6] - 2798:3, 2798:10, 2828:23, 2840:12, 2841:13, 2863:18 consists [1] - 2778:19 constant [3] - 2781:1, 2878:18, 2915:23 construct [2] - 2826:5, 2836:1 consulted [1] - 2802:18 Cont [1] - 2772:4 context [8] - 2818:18, 2819:14, 2821:1, 2822:13, 2833:4, 2835:24, 2841:12, 2878:6 continue [2] - 2813:15, 2852:22 CONTINUED [5] - 2767:1, 2768:1, 2769:1, 2770:1, 2771:1 continued [3] - 2847:12, 2849:6, 2899:8 continuing [2] - 2871:11, 2905:22 contrary [1] - 2787:23 convenient [1] - 2838:18 conversation [1] - 2827:2 convert [2] - 2775:23, 2809:20 converted [2] - 2809:1, 2812:8 converting [3] - 2816:4, 2816:16, 2900:4 convincing [4] - 2871:21, 2874:11,</p>	<p>2874:14, 2897:4 COOK [1] - 2911:10 COREY [1] - 2767:22 corner [1] - 2872:23 CORPORATION [1] - 2771:7 correct [173] - 2775:12, 2775:13, 2775:24, 2775:25, 2776:10, 2776:14, 2777:6, 2777:8, 2777:9, 2777:13, 2777:18, 2777:21, 2778:10, 2778:20, 2778:21, 2779:2, 2779:4, 2779:5, 2779:8, 2779:9, 2779:10, 2779:21, 2780:5, 2780:6, 2780:8, 2780:13, 2780:15, 2780:16, 2780:18, 2780:20, 2780:21, 2780:22, 2780:23, 2780:24, 2780:25, 2781:2, 2782:8, 2782:18, 2782:19, 2782:20, 2783:1, 2783:8, 2783:16, 2783:20, 2783:25, 2784:25, 2785:1, 2785:2, 2785:18, 2785:19, 2785:22, 2785:23, 2786:1, 2786:2, 2786:3, 2786:4, 2786:5, 2786:6, 2786:8, 2787:2, 2787:19, 2788:5, 2788:6, 2788:11, 2788:25, 2789:3, 2791:9, 2792:2, 2794:5, 2794:18, 2795:15, 2795:19, 2795:21, 2798:3, 2799:14, 2799:15, 2799:18, 2800:21, 2800:22, 2800:25, 2801:1, 2801:5, 2801:6, 2801:10, 2801:24, 2801:25, 2802:3, 2802:5, 2802:9, 2803:24, 2804:5, 2804:6, 2804:8, 2804:10, 2804:13, 2805:4, 2809:15, 2810:8, 2810:9, 2810:15, 2810:18, 2810:20, 2810:23, 2811:5, 2811:10, 2811:12,</p>	<p>2811:14, 2811:21, 2812:20, 2814:16, 2815:5, 2816:21, 2817:1, 2817:18, 2818:11, 2818:13, 2819:4, 2819:10, 2819:13, 2820:11, 2820:25, 2821:5, 2821:24, 2822:1, 2822:11, 2824:11, 2825:6, 2828:3, 2828:22, 2829:8, 2829:10, 2829:18, 2830:5, 2830:14, 2834:19, 2835:1, 2835:8, 2835:9, 2835:21, 2836:8, 2836:13, 2836:15, 2840:19, 2840:20, 2841:6, 2841:7, 2842:6, 2852:11, 2852:25, 2860:19, 2862:11, 2862:12, 2866:20, 2870:16, 2875:2, 2879:9, 2887:14, 2887:21, 2893:19, 2893:23, 2896:14, 2897:16, 2898:6, 2898:7, 2899:5, 2903:11, 2909:22, 2911:2, 2911:19, 2912:13, 2915:2, 2916:14 corrected [1] - 2835:6 correction [1] - 2820:23 correctly [7] - 2785:12, 2786:15, 2787:2, 2813:1, 2833:7, 2837:1, 2837:2 correlate [1] - 2892:14 correlation [2] - 2833:10, 2893:5 corresponding [7] - 2809:6, 2812:13, 2812:19, 2816:8, 2816:19, 2822:9, 2878:19 corresponds [1] - 2789:16 Corrosion [3] - 2847:11, 2847:17, 2847:19 corrosion [10] - 2845:8, 2846:14, 2847:13, 2847:24, 2848:13, 2848:14, 2848:15, 2850:13, 2852:19, 2852:21</p>	<p>count [1] - 2890:20 counterintuitive [15] - 2792:23, 2793:13, 2793:21, 2793:22, 2794:18, 2794:23, 2795:18, 2806:5, 2806:7, 2806:10, 2806:11, 2815:12, 2824:3, 2826:12, 2826:15 counting [1] - 2830:3 country [1] - 2844:23 couple [2] - 2773:18, 2860:18 course [5] - 2790:18, 2795:11, 2836:3, 2844:17, 2881:11 courses [3] - 2846:14, 2847:5, 2847:12 Court [17] - 2774:5, 2774:10, 2775:5, 2775:15, 2775:17, 2778:19, 2799:13, 2841:25, 2843:8, 2846:22, 2849:11, 2849:16, 2853:12, 2866:4, 2889:7, 2894:6, 2916:13 COURT [53] - 2766:1, 2771:17, 2773:4, 2773:7, 2773:21, 2774:7, 2774:11, 2774:19, 2774:23, 2775:6, 2787:19, 2790:3, 2814:22, 2820:21, 2825:4, 2833:24, 2837:6, 2837:23, 2838:3, 2842:16, 2842:19, 2842:21, 2842:23, 2843:11, 2843:18, 2850:23, 2854:24, 2870:18, 2872:6, 2872:22, 2872:25, 2882:21, 2882:23, 2896:4, 2896:6, 2896:9, 2896:11, 2896:13, 2903:20, 2905:24, 2908:13, 2908:16, 2908:21, 2908:23, 2908:25, 2909:9, 2909:12, 2909:15, 2911:9, 2911:11, 2911:14, 2916:3, 2916:7 Court's [1] - 2806:16 cover [1] - 2854:20 COVINGTON [1] - 2769:22 cracking [5] -</p>
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<p>2871:15, 2872:1, 2872:5, 2872:19, 2876:6</p> <p>cracking-induced [1] - 2872:1</p> <p>cracks [6] - 2871:15, 2871:16, 2871:17, 2872:1, 2872:2, 2872:3</p> <p>crashed [1] - 2916:2</p> <p>create [9] - 2801:5, 2813:23, 2831:3, 2839:11, 2861:19, 2861:20, 2865:22, 2867:22, 2879:20</p> <p>created [5] - 2809:5, 2861:9, 2865:7, 2871:14</p> <p>crisis [1] - 2773:11</p> <p>criteria [5] - 2857:13, 2857:25, 2891:2, 2911:25, 2912:4</p> <p>critical [1] - 2869:19</p> <p>CROSS [16] - 2768:21, 2775:7, 2843:6, 2843:16, 2850:21, 2903:21, 2903:23, 2903:24, 2905:1, 2905:3, 2906:2, 2909:16, 2911:15, 2914:10, 2914:11, 2916:6</p> <p>cross [27] - 2775:10, 2784:24, 2785:3, 2816:16, 2819:8, 2819:20, 2820:2, 2821:21, 2821:25, 2822:10, 2823:3, 2825:12, 2825:25, 2838:25, 2840:17, 2841:21, 2843:13, 2850:21, 2867:20, 2868:2, 2868:3, 2881:7, 2883:6, 2903:20, 2904:1, 2906:5, 2916:3</p> <p>Cross [5] - 2772:6, 2772:10, 2843:6, 2903:21</p> <p>cross-section [4] - 2821:21, 2821:25, 2867:20, 2883:6</p> <p>cross-sectional [10] - 2784:24, 2785:3, 2816:16, 2819:8, 2822:10, 2823:3, 2825:12, 2825:25, 2868:2, 2868:3</p> <p>cross-sections [2] - 2819:20, 2820:2</p>	<p>crux [1] - 2799:12</p> <p>CSR [2] - 2898:18, 2910:25</p> <p>curved [1] - 2900:20</p> <p>cut [4] - 2809:24, 2859:5, 2864:11, 2873:2</p> <p>cutting [1] - 2873:8</p> <hr/> <p style="text-align: center;">D</p> <hr/> <p>D-0221 [1] - 2777:1</p> <p>D-2205 [2] - 2791:17, 2798:12</p> <p>D-22201 [1] - 2834:13</p> <p>D-22210 [1] - 2781:23</p> <p>D-22485 [1] - 2806:14</p> <p>D-22486 [1] - 2813:25</p> <p>D-22487 [1] - 2815:14</p> <p>D-22820 [1] - 2914:10</p> <p>D-23626 [1] - 2844:5</p> <p>D-23628A [1] - 2878:3</p> <p>D-23629 [1] - 2854:17</p> <p>D-23631 [1] - 2855:3</p> <p>D-23632 [1] - 2856:20</p> <p>D-23633-B [1] - 2858:7</p> <p>D-23635-A [1] - 2860:14</p> <p>D-23637A [1] - 2863:17</p> <p>D-23639A [2] - 2866:1, 2866:14</p> <p>D-23644B [1] - 2869:24</p> <p>D-23648 [1] - 2853:11</p> <p>D-23892 [1] - 2891:10</p> <p>D-23945 [1] - 2894:4</p> <p>D-23995B [1] - 2900:23</p> <p>D-24200 [1] - 2861:7</p> <p>D-24201 [1] - 2864:1</p> <p>D-24201A1 [1] - 2886:19</p> <p>D-24202 [1] - 2862:10</p> <p>D-24203 [1] - 2864:17</p> <p>D-24207A1 [1] - 2880:7</p> <p>D-24213A1 [1] - 2883:22</p> <p>D-2426A [1] - 2881:24</p> <p>D-24452 [1] - 2868:16</p> <p>D-24603 [1] - 2851:2</p> <p>D-24688 [1] - 2841:19</p> <p>D-24723 [1] - 2874:22</p> <p>D/E [1] - 2813:1</p> <p>daisy [1] - 2814:19</p> <p>daisy-chain [1] - 2814:19</p> <p>DALLAS [1] - 2770:23</p> <p>damage [7] - 2851:11,</p>	<p>2863:7, 2865:13, 2866:11, 2873:5, 2873:10</p> <p>dark [1] - 2914:20</p> <p>darker [1] - 2898:13</p> <p>data [16] - 2890:4, 2890:8, 2890:9, 2890:13, 2890:18, 2891:2, 2891:9, 2892:2, 2892:9, 2893:2, 2893:3, 2893:11, 2903:15, 2912:11, 2912:20, 2913:23</p> <p>date [8] - 2858:16, 2858:24, 2869:21, 2874:14, 2876:22, 2876:24</p> <p>dates [1] - 2874:20</p> <p>Daubert [2] - 2843:9, 2850:21</p> <p>DAVIS [1] - 2770:15</p> <p>DAVIS-DENNY [1] - 2770:15</p> <p>DAY [1] - 2766:14</p> <p>days [16] - 2773:18, 2779:20, 2828:10, 2877:6, 2888:12, 2890:4, 2890:8, 2890:9, 2890:15, 2890:17, 2890:19, 2891:24, 2892:8, 2902:11, 2908:19, 2916:2</p> <p>DC [5] - 2768:15, 2768:24, 2769:20, 2769:24, 2771:14</p> <p>deal [1] - 2877:25</p> <p>dealing [5] - 2837:22, 2838:1, 2839:2, 2839:5, 2840:1</p> <p>dealt [1] - 2845:13</p> <p>debating [1] - 2907:25</p> <p>DEBORAH [1] - 2771:9</p> <p>decades [1] - 2811:8</p> <p>decide [1] - 2893:1</p> <p>decided [2] - 2822:2, 2914:22</p> <p>decimals [1] - 2830:6</p> <p>declining [1] - 2909:10</p> <p>Deepwater [1] - 2842:5</p> <p>DEEPWATER [3] - 2766:4, 2770:4, 2770:5</p> <p>Deepwater/Macondo /Horizon [1] - 2813:20</p>	<p>defend [1] - 2899:4</p> <p>define [3] - 2796:22, 2873:18, 2892:12</p> <p>defined [2] - 2775:20</p> <p>definitely [3] - 2865:23, 2872:5, 2909:14</p> <p>definition [12] - 2776:20, 2778:8, 2822:5, 2822:12, 2823:8, 2825:15, 2825:18, 2832:6, 2835:20, 2835:24, 2835:25, 2836:1</p> <p>definitional [1] - 2841:17</p> <p>definitions [2] - 2776:2, 2835:15</p> <p>degree [6] - 2844:18, 2881:17, 2893:5, 2895:25, 2902:13, 2912:19</p> <p>degrees [2] - 2844:15, 2867:20</p> <p>delayed [1] - 2910:25</p> <p>delta [4] - 2818:5, 2818:7, 2818:9, 2822:25</p> <p>demonstrate [3] - 2867:9, 2868:21, 2898:1</p> <p>demonstrates [1] - 2862:23</p> <p>demonstrating [1] - 2895:11</p> <p>demonstration [1] - 2795:17</p> <p>demonstrative [13] - 2776:4, 2776:23, 2776:25, 2778:17, 2781:22, 2784:19, 2786:17, 2791:17, 2798:11, 2806:14, 2817:14, 2834:13, 2858:3</p> <p>demonstratives [1] - 2774:14</p> <p>DENNY [1] - 2770:15</p> <p>denote [1] - 2880:16</p> <p>denotes [1] - 2818:12</p> <p>densities [3] - 2777:15, 2797:6, 2797:9</p> <p>density [13] - 2776:18, 2781:1, 2781:5, 2781:9, 2781:14, 2787:7, 2788:8, 2796:24, 2818:12, 2818:13, 2834:17, 2836:3, 2902:2</p>	<p>deny [2] - 2843:11, 2843:15</p> <p>DEPARTMENT [2] - 2768:13, 2768:17</p> <p>depict [1] - 2898:9</p> <p>depiction [1] - 2885:14</p> <p>depicts [1] - 2914:15</p> <p>deployed [1] - 2854:2</p> <p>deposition [10] - 2777:23, 2784:21, 2785:15, 2787:4, 2787:16, 2787:21, 2787:24, 2787:25, 2904:25, 2906:16</p> <p>depths [1] - 2809:7</p> <p>derivation [2] - 2783:22, 2821:20</p> <p>derived [2] - 2782:22, 2832:17</p> <p>deriving [1] - 2784:11</p> <p>describe [27] - 2782:20, 2783:2, 2844:8, 2845:10, 2846:7, 2847:3, 2847:20, 2856:21, 2864:24, 2865:1, 2868:20, 2870:2, 2875:3, 2877:18, 2878:1, 2878:7, 2881:4, 2883:23, 2884:20, 2886:21, 2889:5, 2889:7, 2891:11, 2893:13, 2895:20, 2900:13, 2905:15</p> <p>described [12] - 2776:5, 2778:22, 2788:16, 2796:7, 2799:24, 2799:25, 2852:10, 2856:6, 2858:13, 2865:16, 2880:8, 2887:16</p> <p>describes [1] - 2897:13</p> <p>describing [2] - 2838:8, 2838:10</p> <p>description [2] - 2853:6, 2882:6</p> <p>design [4] - 2845:21, 2845:23, 2861:15, 2888:6</p> <p>designed [3] - 2858:17, 2859:5, 2864:11</p> <p>despite [6] - 2794:17, 2806:4, 2811:20, 2815:4, 2824:2, 2825:11</p> <p>detached [1] - 2873:6</p>
--	--	---	---	--

<p>detail [4] - 2853:17, 2900:1, 2912:10, 2914:18</p> <p>detailed [2] - 2850:2, 2861:15</p> <p>details [1] - 2900:15</p> <p>determine [8] - 2797:9, 2822:20, 2822:22, 2853:19, 2854:9, 2856:22, 2899:12, 2904:2</p> <p>determined [4] - 2799:23, 2800:2, 2854:14, 2856:12</p> <p>determines [1] - 2824:13</p> <p>determining [4] - 2799:16, 2801:3, 2801:8, 2882:10</p> <p>develop [2] - 2889:7, 2904:6</p> <p>developed [1] - 2880:8</p> <p>developing [1] - 2904:5</p> <p>DEXTER [1] - 2767:23</p> <p>diameter [167] - 2780:1, 2780:3, 2780:4, 2780:8, 2780:9, 2780:10, 2780:11, 2781:15, 2782:9, 2782:13, 2782:16, 2782:24, 2782:25, 2783:10, 2783:17, 2783:23, 2783:24, 2784:4, 2784:10, 2784:17, 2784:22, 2784:23, 2785:16, 2785:21, 2786:2, 2786:11, 2786:21, 2789:7, 2791:20, 2791:21, 2791:25, 2792:5, 2792:6, 2792:18, 2793:3, 2794:8, 2795:3, 2795:15, 2798:18, 2798:23, 2801:15, 2801:16, 2802:20, 2803:9, 2803:11, 2803:17, 2803:23, 2804:4, 2804:12, 2804:23, 2804:24, 2804:25, 2805:2, 2805:16, 2805:19, 2805:20, 2806:21, 2807:16, 2807:18, 2808:5, 2808:8, 2808:14, 2808:20, 2809:5, 2809:6, 2809:11,</p>	<p>2809:20, 2809:22, 2810:13, 2810:22, 2811:18, 2811:25, 2812:13, 2812:19, 2813:1, 2813:11, 2813:16, 2813:19, 2813:24, 2814:13, 2816:8, 2816:19, 2816:24, 2817:15, 2819:2, 2819:8, 2819:11, 2819:25, 2820:4, 2820:5, 2820:9, 2821:2, 2821:7, 2821:11, 2821:20, 2821:22, 2822:9, 2822:16, 2822:17, 2823:14, 2823:16, 2823:24, 2824:9, 2824:19, 2824:20, 2824:24, 2825:16, 2826:3, 2826:6, 2826:14, 2826:17, 2828:3, 2828:16, 2828:17, 2828:20, 2829:3, 2829:4, 2829:5, 2829:17, 2831:23, 2831:24, 2831:25, 2832:2, 2832:3, 2832:4, 2832:5, 2832:7, 2832:8, 2832:9, 2832:11, 2832:12, 2832:13, 2832:20, 2832:22, 2832:25, 2833:2, 2833:7, 2833:9, 2833:13, 2833:18, 2833:20, 2834:10, 2836:21, 2836:22, 2836:25, 2839:6, 2839:20, 2840:13, 2840:19, 2840:23, 2840:25, 2841:10, 2841:23, 2842:1, 2842:7, 2842:9, 2842:12, 2842:13</p> <p>diameters [4] - 2782:6, 2801:23, 2808:17, 2811:1</p> <p>difference [9] - 2792:5, 2820:18, 2825:12, 2834:21, 2853:24, 2855:17, 2899:19, 2899:20, 2908:11</p> <p>different [26] - 2776:5, 2782:6, 2796:7, 2798:1, 2798:15, 2799:7, 2806:1, 2827:7, 2827:14, 2827:18, 2830:22,</p>	<p>2840:14, 2841:3, 2845:13, 2848:1, 2848:12, 2869:15, 2875:14, 2881:19, 2895:15, 2899:4, 2899:15, 2911:11</p> <p>differently [1] - 2899:15</p> <p>difficult [4] - 2890:23, 2894:12, 2906:8, 2906:12</p> <p>dig [1] - 2851:25</p> <p>dimension [1] - 2777:5</p> <p>dimensional [1] - 2775:11</p> <p>dimensionless [2] - 2820:13, 2820:15</p> <p>Direct [1] - 2772:9</p> <p>DIRECT [1] - 2843:19</p> <p>direct [5] - 2843:22, 2865:15, 2882:7, 2901:8, 2907:21</p> <p>directed [1] - 2848:2</p> <p>directing [1] - 2847:16</p> <p>direction [7] - 2774:5, 2870:7, 2870:20, 2871:13, 2871:16, 2871:17, 2875:14</p> <p>directly [6] - 2785:8, 2823:13, 2849:10, 2851:19, 2865:19, 2900:16</p> <p>director [1] - 2848:21</p> <p>directorship [1] - 2847:10</p> <p>disagree [1] - 2915:6</p> <p>discard [1] - 2891:9</p> <p>discharge [9] - 2839:16, 2839:18, 2839:19, 2839:21, 2839:25, 2840:7, 2840:10, 2840:11, 2840:16</p> <p>discussing [3] - 2820:20, 2834:2, 2834:4</p> <p>discussion [1] - 2865:25</p> <p>disposal [1] - 2874:20</p> <p>distance [1] - 2793:15</p> <p>distort [1] - 2889:14</p> <p>DISTRICT [3] - 2766:1, 2766:15</p> <p>divide [4] - 2822:8, 2822:9, 2902:4, 2913:11</p> <p>divided [2] - 2782:17, 2819:8</p> <p>DIVISION [2] -</p>	<p>2768:14, 2768:18</p> <p>Docket [1] - 2843:9</p> <p>DOCKET [3] - 2766:4, 2766:7, 2766:10</p> <p>document [3] - 2828:7, 2828:12, 2831:14</p> <p>dog [1] - 2883:7</p> <p>dog-boned [1] - 2883:7</p> <p>DOMENGEAUX [1] - 2766:22</p> <p>dominant [1] - 2800:13</p> <p>DON [1] - 2769:5</p> <p>DONALD [1] - 2770:20</p> <p>done [11] - 2809:25, 2836:9, 2842:16, 2849:5, 2853:18, 2873:7, 2890:21, 2898:18, 2899:25, 2901:24, 2914:5</p> <p>double [12] - 2783:10, 2783:17, 2790:10, 2791:10, 2801:5, 2810:25, 2826:22, 2826:25, 2827:12, 2834:24, 2835:12, 2868:8</p> <p>doubled [5] - 2810:24, 2856:9, 2877:11, 2901:12, 2903:8</p> <p>doubt [3] - 2871:7, 2876:19, 2892:16</p> <p>DOUGLAS [1] - 2768:9</p> <p>down [26] - 2773:10, 2778:16, 2782:9, 2795:3, 2797:22, 2816:22, 2819:1, 2819:21, 2821:15, 2824:14, 2824:16, 2826:7, 2826:10, 2830:10, 2831:22, 2834:11, 2837:20, 2848:14, 2848:15, 2856:3, 2867:19, 2875:12, 2875:22, 2878:21, 2881:7, 2884:22</p> <p>downwards [1] - 2875:15</p> <p>DOYEN [1] - 2770:13</p> <p>Dr [49] - 2773:16, 2775:2, 2775:9, 2775:11, 2796:21, 2812:4, 2812:23, 2837:4, 2837:9, 2837:20, 2842:18, 2842:20, 2843:9,</p>	<p>2843:22, 2844:2, 2844:8, 2850:19, 2850:25, 2853:14, 2854:23, 2855:2, 2856:19, 2856:21, 2859:22, 2869:25, 2871:4, 2873:21, 2874:3, 2874:8, 2877:2, 2877:7, 2877:13, 2891:11, 2893:17, 2895:17, 2900:23, 2903:2, 2903:17, 2903:25, 2904:2, 2907:10, 2907:14, 2907:18, 2907:23, 2909:17, 2909:21, 2909:24, 2911:16, 2914:12</p> <p>drag [1] - 2794:21</p> <p>dramatic [1] - 2865:20</p> <p>drastic [1] - 2860:23</p> <p>draw [13] - 2791:16, 2804:1, 2806:15, 2807:7, 2811:15, 2813:15, 2837:21, 2837:25, 2859:1, 2868:24, 2881:18, 2885:17, 2892:7</p> <p>drawing [7] - 2802:13, 2811:15, 2813:7, 2813:18, 2813:22, 2814:3, 2898:15</p> <p>drawn [3] - 2876:3, 2876:15, 2881:20</p> <p>drawn-out [1] - 2876:15</p> <p>drill [25] - 2782:2, 2782:7, 2782:8, 2782:11, 2782:13, 2783:9, 2783:14, 2783:15, 2784:9, 2786:18, 2786:19, 2827:14, 2827:16, 2827:17, 2834:24, 2838:11, 2865:4, 2865:5, 2866:16, 2866:18, 2866:25, 2883:14, 2885:12, 2885:16, 2911:21</p> <p>DRILLING [1] - 2770:4</p> <p>driven [1] - 2876:11</p> <p>driving [1] - 2785:4</p> <p>drop [73] - 2785:4, 2785:13, 2785:16, 2793:19, 2793:24, 2793:25, 2794:2, 2794:10, 2794:21, 2795:22, 2798:15, 2798:17, 2798:21, 2803:11, 2803:16,</p>
---	--	--	---	---

2803:19, 2803:22,
2805:17, 2805:23,
2816:25, 2821:8,
2823:1, 2823:10,
2824:7, 2824:9,
2824:10, 2824:12,
2824:25, 2825:13,
2829:12, 2829:14,
2841:5, 2841:6,
2877:16, 2877:17,
2877:23, 2878:4,
2878:8, 2878:11,
2878:16, 2878:20,
2879:2, 2879:5,
2879:7, 2881:21,
2885:20, 2887:6,
2891:15, 2891:17,
2892:6, 2892:21,
2893:25, 2896:5,
2896:7, 2896:16,
2896:17, 2896:19,
2896:21, 2896:22,
2896:23, 2897:2,
2897:9, 2900:4,
2900:16, 2900:17,
2901:8, 2902:1,
2912:22, 2912:25,
2913:7, 2913:13,
2914:1, 2915:2
drop's [1] - 2826:13
dropping [1] -
2786:16
drops [16] - 2785:22,
2785:24, 2787:3,
2817:16, 2819:15,
2828:24, 2829:9,
2829:11, 2835:2,
2835:7, 2836:23,
2837:1, 2837:3,
2894:16, 2910:3,
2913:15
Drs [1] - 2774:15
due [6] - 2811:22,
2856:3, 2877:12,
2889:12, 2897:6,
2915:2
duly [1] - 2842:25
duration [4] - 2873:15,
2906:25, 2907:11,
2907:14
during [5] - 2773:16,
2815:19, 2845:11,
2846:8, 2903:14
duties [2] - 2846:13,
2847:9
dynamics [13] -
2819:12, 2846:15,
2846:18, 2846:21,
2849:2, 2849:4,
2849:15, 2849:17,

2849:23, 2850:6,
2850:20, 2854:6,
2889:2

E

E&P [1] - 2771:8
earth [1] - 2795:11
ease [3] - 2878:14,
2886:15, 2887:5
easier [4] - 2862:19,
2865:1, 2880:14,
2884:5
easiest [1] - 2862:7
easily [1] - 2790:22
EAST [1] - 2767:18
EASTERN [1] - 2766:1
easy [3] - 2864:4,
2878:1, 2885:13
education [1] -
2852:15
educational [1] -
2844:9
EDWARDS [1] -
2766:22
effect [9] - 2849:25,
2853:3, 2854:9,
2893:24, 2902:1,
2903:2, 2904:16,
2912:1, 2912:2
effective [1] - 2865:19
effectively [1] -
2878:22
effects [6] - 2844:4,
2853:22, 2856:22,
2864:23, 2865:20,
2900:7
effort [4] - 2793:5,
2793:7, 2890:5,
2890:6
efforts [1] - 2887:13
EISERT [1] - 2769:19
either [3] - 2873:5,
2879:8, 2902:1
elaborate [1] -
2855:14
electronic [1] -
2879:23
element [1] - 2899:14
elements [5] -
2857:16, 2895:15,
2903:5, 2905:17,
2910:21
ELLIS [3] - 2769:9,
2769:14, 2769:18
ELM [1] - 2770:23
ELMO [1] - 2803:6
email [3] - 2833:20,
2834:1, 2834:8
emphasizes [2] -

2823:12, 2824:1
empirically [1] -
2832:17
end [43] - 2778:19,
2779:17, 2779:21,
2846:25, 2848:23,
2855:13, 2856:14,
2859:24, 2866:11,
2867:7, 2869:4,
2873:23, 2876:22,
2877:2, 2878:13,
2878:14, 2887:17,
2890:11, 2890:13,
2890:14, 2892:6,
2892:8, 2895:12,
2896:8, 2897:3,
2898:12, 2898:15,
2898:20, 2902:5,
2902:25, 2905:16,
2906:7, 2907:13,
2907:19, 2907:20,
2908:1, 2908:8,
2908:11, 2908:18,
2909:3, 2909:5,
2912:14, 2913:11
ended [1] - 2908:17
ENERGY [2] - 2770:6,
2770:19
Energy [5] - 2844:21,
2844:22, 2845:2,
2845:12, 2846:4
energy [1] - 2851:24
ENFORCEMENT [1] -
2768:19
ENGEL [1] - 2768:22
engineering [6] -
2844:10, 2844:12,
2846:6, 2848:8,
2848:19, 2877:25
engineers [2] -
2845:23, 2877:18
enormous [2] -
2845:22, 2889:13
ensure [1] - 2779:13
enter [1] - 2829:18
entire [3] - 2778:5,
2801:11, 2801:13
entirely [2] - 2859:7,
2911:23
entry [1] - 2829:17
ENVIRONMENT [1] -
2768:18
environment [5] -
2778:10, 2861:22,
2879:19, 2879:25,
2880:20
ENVIRONMENTAL [1]
- 2768:19
equal [6] - 2776:18,
2782:24, 2783:10,

2818:9, 2818:22,
2819:7
equally [1] - 2857:5
equals [3] - 2810:21,
2825:18, 2826:4
equating [1] - 2814:23
equation [18] - 2777:4,
2778:8, 2778:14,
2782:15, 2818:17,
2819:1, 2819:14,
2820:10, 2820:12,
2821:23, 2822:8,
2823:21, 2823:23,
2823:25, 2824:7,
2841:11, 2900:12,
2900:14
Equations [1] - 2818:2
equations [8] -
2818:4, 2820:5,
2821:18, 2826:2,
2841:13, 2841:14,
2849:25, 2882:5
equipment [2] -
2848:12, 2848:16
equivalent [30] -
2795:10, 2816:17,
2816:18, 2829:21,
2830:10, 2830:21,
2831:4, 2831:7,
2831:24, 2832:2,
2832:3, 2832:6,
2832:8, 2832:12,
2832:13, 2832:22,
2833:20, 2834:6,
2834:10, 2835:2,
2836:15, 2836:17,
2837:16, 2837:21,
2838:1, 2838:2,
2838:23, 2840:15,
2842:12, 2891:18
Erica [1] - 2774:12
erode [2] - 2865:19,
2899:9
eroded [42] - 2853:23,
2854:2, 2854:3,
2854:10, 2855:21,
2857:22, 2857:24,
2858:22, 2859:8,
2859:11, 2859:19,
2861:6, 2861:7,
2861:14, 2862:1,
2862:2, 2862:11,
2862:21, 2863:7,
2867:4, 2874:12,
2880:5, 2884:8,
2886:5, 2886:10,
2886:16, 2886:20,
2886:24, 2887:4,
2888:3, 2888:13,
2889:24, 2899:12,

2899:14, 2899:19,
2902:8, 2905:15,
2911:24, 2912:1,
2912:9
eroding [2] - 2883:1,
2910:15
Erosion [1] - 2858:9
erosion [163] - 2844:4,
2844:14, 2844:16,
2845:8, 2845:11,
2846:14, 2846:19,
2846:21, 2846:22,
2847:6, 2847:13,
2847:24, 2848:14,
2848:15, 2848:22,
2849:4, 2849:9,
2850:14, 2850:20,
2851:1, 2851:3,
2851:4, 2851:5,
2851:18, 2851:21,
2852:8, 2852:13,
2852:16, 2852:21,
2853:4, 2853:20,
2853:21, 2854:1,
2855:9, 2855:25,
2856:4, 2856:22,
2857:16, 2858:5,
2859:12, 2859:16,
2859:17, 2860:2,
2860:22, 2860:24,
2862:6, 2862:16,
2862:22, 2862:23,
2864:20, 2864:23,
2864:24, 2865:17,
2868:15, 2869:8,
2869:11, 2869:20,
2871:2, 2871:3,
2871:7, 2872:19,
2873:16, 2873:19,
2874:1, 2874:8,
2874:15, 2875:4,
2876:3, 2876:4,
2876:7, 2876:11,
2876:20, 2876:22,
2877:5, 2877:9,
2877:12, 2877:23,
2881:17, 2881:22,
2882:13, 2885:8,
2885:10, 2885:18,
2885:24, 2886:2,
2886:3, 2886:5,
2886:8, 2887:8,
2887:22, 2888:12,
2888:21, 2888:22,
2888:25, 2889:1,
2889:21, 2889:22,
2889:24, 2895:13,
2898:12, 2898:25,
2899:7, 2899:11,
2899:16, 2899:19,
2899:23, 2900:7,

2901:4, 2901:12, 2903:3, 2903:5, 2903:12, 2903:13, 2903:16, 2904:3, 2904:7, 2904:10, 2904:13, 2904:15, 2904:16, 2904:17, 2904:20, 2904:23, 2905:4, 2905:14, 2905:16, 2905:20, 2905:21, 2905:22, 2906:3, 2906:5, 2906:9, 2906:10, 2906:12, 2906:18, 2906:21, 2906:25, 2907:2, 2907:13, 2907:20, 2908:1, 2908:3, 2910:2, 2910:3, 2910:10, 2910:18, 2910:22, 2911:4, 2911:13, 2911:17, 2911:20, 2911:21, 2912:2, 2912:22, 2913:1, 2913:3, 2913:16, 2914:1, 2915:2

erosion-caused [2] - 2869:8, 2874:1

erosion-driven [1] - 2876:11

ESQ [49] - 2766:19, 2766:23, 2767:4, 2767:7, 2767:11, 2767:14, 2767:18, 2767:22, 2767:22, 2768:9, 2768:9, 2768:14, 2768:19, 2768:20, 2768:20, 2768:21, 2768:21, 2768:22, 2768:22, 2768:23, 2768:23, 2769:5, 2769:9, 2769:10, 2769:10, 2769:11, 2769:11, 2769:15, 2769:18, 2769:19, 2769:19, 2769:23, 2770:6, 2770:10, 2770:13, 2770:14, 2770:14, 2770:15, 2770:15, 2770:20, 2770:20, 2770:21, 2770:21, 2770:22, 2771:3, 2771:4, 2771:9, 2771:13, 2771:13

essentially [8] - 2786:12, 2786:17, 2814:12, 2858:17, 2889:25, 2898:14, 2900:15, 2901:10

established [1] - 2806:21

estimate [7] - 2778:18, 2778:19, 2778:20, 2778:24, 2779:20, 2799:13, 2907:10

estimated [1] - 2779:22

estimates [1] - 2778:23

et [1] - 2846:19

ET [2] - 2766:8, 2766:12

evaluate [3] - 2877:14, 2877:23, 2878:7

evaluating [2] - 2849:18, 2852:12

evaluation [2] - 2891:12, 2898:23

evenly [1] - 2883:1

event [3] - 2858:4, 2884:23, 2887:24

events [4] - 2897:22, 2897:23, 2903:16, 2912:10

Events [1] - 2858:9

eventually [1] - 2795:7

evidence [13] - 2773:19, 2854:23, 2855:24, 2864:24, 2874:11, 2882:7, 2882:10, 2886:3, 2888:24, 2899:6, 2907:22, 2909:5, 2915:12

exact [10] - 2783:6, 2789:17, 2793:7, 2793:11, 2811:1, 2827:15, 2846:17, 2881:21, 2882:5, 2901:17

exactly [22] - 2793:2, 2797:12, 2826:6, 2827:14, 2842:4, 2854:8, 2856:7, 2859:21, 2861:21, 2871:12, 2873:7, 2879:22, 2880:4, 2880:22, 2882:8, 2884:9, 2886:11, 2887:1, 2889:16, 2896:1, 2896:2, 2914:8

EXAMINATION [4] - 2775:7, 2837:7, 2843:19, 2903:23

examination [11] - 2773:16, 2774:15, 2775:10, 2837:10, 2838:25, 2840:17,

2841:21, 2843:13, 2843:22, 2850:22, 2903:20

example [24] - 2783:18, 2790:24, 2791:1, 2793:2, 2794:15, 2798:6, 2799:3, 2801:21, 2803:25, 2810:22, 2813:13, 2825:22, 2827:16, 2832:19, 2837:15, 2837:21, 2839:2, 2876:16, 2878:5, 2878:24, 2879:4, 2899:13, 2899:24, 2911:21

examples [5] - 2793:25, 2825:11, 2839:9, 2860:24, 2915:11

except [1] - 2914:13

exceptionally [1] - 2807:23

excerpt [1] - 2842:3

exclusively [2] - 2845:15, 2848:17

excuse [1] - 2826:21

exercise [1] - 2904:9

exert [2] - 2793:5, 2793:6

exerts [1] - 2786:19

Exhibit [5] - 2795:24, 2815:15, 2817:5, 2828:4, 2854:25

exhibit [1] - 2858:3

exhibits [4] - 2773:15, 2773:17, 2773:19, 2774:15

Exhibits [2] - 2773:23, 2774:21

existed [2] - 2898:2, 2899:16

exiting [1] - 2869:4

expand [1] - 2804:22

expanding [1] - 2794:6

expect [4] - 2781:4, 2781:14, 2781:17, 2836:7

expectation [1] - 2892:1

expected [2] - 2774:5, 2886:3

expects [1] - 2893:6

experience [3] - 2846:20, 2852:16, 2915:7

expert [12] - 2795:23, 2796:2, 2826:16, 2850:19, 2859:22,

2859:23, 2860:22, 2862:22, 2873:21, 2887:22, 2909:22

expert's [1] - 2843:14

expertise [3] - 2848:22, 2908:20, 2909:14

experts [1] - 2900:11

explain [5] - 2855:4, 2894:6, 2900:24, 2905:7, 2911:23

EXPLORATION [2] - 2766:11, 2769:3

extend [4] - 2794:13, 2794:19, 2795:6, 2795:13

extended [1] - 2907:18

extension [1] - 2852:22

extent [1] - 2839:12

extra [1] - 2786:19

extracted [1] - 2892:24

eye [2] - 2864:21, 2892:3

F

facilities [2] - 2845:8, 2845:9

fact [16] - 2794:17, 2797:11, 2806:4, 2811:8, 2811:20, 2812:11, 2815:4, 2824:1, 2824:2, 2825:12, 2831:12, 2868:1, 2868:6, 2882:15, 2910:10, 2915:3

factor [14] - 2797:7, 2798:16, 2836:12, 2856:8, 2896:10, 2896:24, 2896:25, 2901:18, 2901:19, 2909:12, 2909:14, 2913:8, 2913:9, 2913:12

factors [4] - 2839:6, 2839:9, 2839:15, 2851:17

failure [1] - 2902:19

fair [7] - 2777:25, 2855:6, 2910:12, 2912:20, 2912:21, 2913:19, 2915:21

familiar [3] - 2781:8, 2797:12, 2818:16

FANNIN [1] - 2770:10

far [4] - 2776:1,

2777:22, 2859:21, 2887:11

fast [9] - 2789:22, 2851:24, 2852:3, 2852:6, 2859:13, 2869:6, 2899:11, 2911:13

fast-forward [2] - 2859:13, 2869:6

faster [9] - 2786:23, 2789:23, 2791:8, 2799:10, 2826:24, 2827:10, 2835:5, 2839:11, 2864:3

FCRR [2] - 2916:16, 2916:17

features [1] - 2889:17

fed [1] - 2889:25

few [6] - 2828:10, 2837:11, 2867:15, 2877:6, 2908:19, 2914:6

field [4] - 2845:22, 2847:6, 2850:12, 2851:16

Fields [4] - 2772:5, 2773:14, 2787:14, 2837:9

fields [2] - 2831:5, 2846:18

FIELDS [20] - 2769:11, 2773:13, 2773:24, 2787:14, 2825:2, 2833:22, 2837:8, 2837:12, 2837:13, 2837:19, 2837:24, 2838:6, 2838:21, 2839:23, 2839:24, 2841:19, 2841:20, 2842:15, 2874:22, 2874:24

FIFTEENTH [1] - 2769:20

figure [6] - 2795:25, 2808:14, 2912:15, 2914:12, 2914:19, 2915:5

filed [1] - 2774:2

files [3] - 2861:15, 2913:20, 2914:2

filing [1] - 2774:10

final [5] - 2892:25, 2900:3, 2900:22, 2912:22, 2912:25

finally [6] - 2853:9, 2854:5, 2854:13, 2856:12, 2859:22, 2880:23

findings [4] - 2855:15, 2855:16, 2863:21,

<p>2905:6 fine [1] - 2877:21 finger [1] - 2886:13 finish [1] - 2792:21 firm [1] - 2898:21 FIRM [1] - 2767:10 first [26] - 2839:1, 2842:25, 2844:6, 2849:4, 2851:2, 2853:2, 2853:19, 2855:18, 2860:15, 2866:23, 2869:6, 2869:25, 2871:8, 2871:21, 2872:8, 2873:2, 2874:5, 2877:11, 2877:13, 2879:19, 2881:20, 2884:5, 2888:24, 2889:20, 2898:21, 2899:6 fit [3] - 2893:1, 2893:15 FITCH [1] - 2771:13 fits [2] - 2893:16, 2912:4 five [4] - 2831:5, 2856:1, 2877:11, 2882:16 five-alarm [1] - 2882:16 five-week [1] - 2856:1 FL [2] - 2767:5, 2818:22 flash [1] - 2775:23 flat [1] - 2779:7 FLEMING [1] - 2770:22 flip [1] - 2803:6 flipped [1] - 2875:9 floor [1] - 2779:7 FLOOR [1] - 2770:16 flow [334] - 2775:15, 2775:17, 2775:22, 2775:24, 2776:5, 2776:8, 2776:9, 2776:11, 2776:13, 2776:16, 2776:18, 2776:20, 2777:3, 2777:5, 2777:7, 2777:11, 2777:12, 2777:19, 2778:5, 2778:8, 2778:9, 2778:11, 2778:12, 2778:14, 2778:18, 2778:19, 2778:20, 2778:24, 2778:25, 2779:7, 2779:13, 2779:17, 2779:22, 2779:23, 2780:3, 2780:8, 2780:13,</p>	<p>2780:18, 2780:20, 2780:22, 2780:24, 2781:3, 2781:4, 2781:19, 2781:20, 2782:22, 2783:4, 2783:6, 2784:8, 2784:15, 2784:16, 2784:17, 2784:23, 2784:25, 2785:3, 2785:6, 2785:13, 2786:16, 2786:20, 2786:22, 2787:3, 2789:10, 2789:15, 2789:16, 2789:18, 2790:24, 2791:8, 2791:13, 2792:11, 2792:15, 2793:11, 2793:17, 2794:2, 2794:5, 2794:9, 2794:10, 2794:12, 2794:16, 2794:21, 2794:22, 2794:24, 2795:22, 2796:4, 2796:7, 2796:8, 2797:4, 2797:5, 2797:9, 2797:19, 2798:1, 2799:6, 2799:13, 2799:14, 2799:16, 2799:20, 2799:21, 2799:23, 2799:24, 2800:1, 2800:8, 2800:9, 2800:13, 2800:16, 2800:17, 2800:18, 2800:20, 2800:24, 2801:9, 2801:10, 2801:12, 2801:13, 2801:16, 2801:17, 2803:11, 2803:12, 2803:16, 2803:17, 2803:19, 2804:15, 2804:19, 2805:12, 2805:13, 2805:16, 2805:22, 2806:1, 2806:4, 2806:9, 2807:2, 2807:13, 2807:17, 2807:25, 2809:3, 2809:6, 2809:23, 2810:2, 2810:3, 2810:24, 2810:25, 2814:17, 2814:18, 2815:2, 2815:9, 2815:18, 2815:25, 2816:3, 2816:4, 2816:7, 2816:12, 2816:25, 2817:13, 2817:15, 2817:23, 2817:25, 2820:15, 2820:16, 2820:20, 2820:24, 2821:1, 2821:3,</p>	<p>2821:4, 2821:5, 2821:8, 2821:17, 2821:18, 2821:19, 2821:21, 2822:6, 2822:7, 2822:18, 2823:1, 2823:2, 2823:8, 2823:17, 2823:20, 2824:13, 2824:15, 2824:25, 2825:14, 2825:15, 2825:25, 2826:4, 2827:1, 2827:4, 2829:12, 2829:19, 2834:3, 2834:16, 2834:17, 2834:23, 2835:3, 2835:11, 2835:12, 2836:4, 2836:8, 2836:15, 2836:21, 2837:1, 2839:5, 2840:23, 2841:5, 2841:7, 2841:9, 2842:2, 2842:4, 2844:4, 2845:7, 2848:6, 2849:9, 2849:25, 2850:3, 2853:4, 2853:22, 2853:25, 2854:10, 2854:15, 2855:20, 2855:22, 2856:2, 2856:8, 2856:10, 2856:11, 2856:22, 2857:4, 2857:19, 2857:22, 2858:17, 2858:21, 2859:4, 2862:24, 2863:5, 2863:6, 2863:9, 2863:14, 2863:15, 2864:14, 2865:22, 2865:24, 2867:11, 2867:13, 2867:22, 2868:5, 2868:11, 2871:9, 2871:10, 2871:13, 2875:11, 2875:13, 2877:11, 2877:15, 2877:19, 2877:25, 2878:1, 2878:5, 2878:11, 2878:13, 2878:20, 2878:21, 2878:25, 2879:3, 2879:5, 2879:12, 2880:2, 2880:4, 2882:6, 2882:8, 2882:11, 2883:16, 2884:2, 2884:14, 2884:16, 2885:22, 2886:14, 2886:24, 2887:14, 2888:19, 2889:23, 2891:16, 2894:8, 2894:17, 2894:22, 2896:17,</p>	<p>2896:18, 2897:1, 2897:7, 2897:14, 2898:1, 2898:4, 2899:20, 2900:4, 2900:7, 2901:1, 2901:3, 2901:4, 2901:11, 2901:15, 2901:17, 2901:18, 2901:20, 2901:21, 2902:3, 2902:4, 2902:6, 2902:7, 2902:11, 2903:3, 2903:4, 2903:7, 2903:12, 2904:17, 2907:10, 2912:2, 2913:5, 2913:7, 2913:13, 2913:21, 2914:3 flowing [15] - 2776:20, 2778:7, 2782:17, 2786:18, 2788:15, 2800:14, 2823:17, 2823:20, 2829:21, 2829:24, 2830:13, 2834:7, 2836:18, 2838:11, 2838:12 flows [5] - 2776:8, 2782:23, 2786:23, 2791:13, 2796:6 fluid [61] - 2776:17, 2776:18, 2780:16, 2781:13, 2781:18, 2782:17, 2785:20, 2786:15, 2786:23, 2790:19, 2790:21, 2791:16, 2793:4, 2793:7, 2793:11, 2794:1, 2795:7, 2795:9, 2795:12, 2797:9, 2804:18, 2807:10, 2819:12, 2825:9, 2825:10, 2839:3, 2839:4, 2846:14, 2846:15, 2846:18, 2846:21, 2847:12, 2847:13, 2849:2, 2849:4, 2849:15, 2849:17, 2849:23, 2849:25, 2850:6, 2850:7, 2850:19, 2854:5, 2857:19, 2862:19, 2865:8, 2867:2, 2869:3, 2877:25, 2878:24, 2879:1, 2879:10, 2880:22, 2881:9, 2881:21, 2882:6, 2889:2, 2902:2 fluids [5] - 2790:22, 2790:25, 2791:4,</p>	<p>2839:6, 2853:8 FLYNN [1] - 2768:14 focus [7] - 2799:21, 2848:11, 2856:10, 2856:11, 2857:15, 2873:11, 2895:19 focused [7] - 2807:25, 2820:25, 2831:21, 2848:5, 2853:24, 2872:8, 2883:11 focuses [2] - 2820:18, 2842:4 follow [3] - 2820:19, 2837:11, 2906:14 follow-up [1] - 2837:11 follows [1] - 2843:1 foot [1] - 2827:21 footage [1] - 2859:15 FOR [8] - 2766:19, 2767:21, 2768:3, 2768:13, 2769:3, 2770:3, 2770:18, 2771:7 force [7] - 2785:4, 2785:5, 2793:10, 2793:12, 2811:3, 2864:6 foregoing [1] - 2916:14 form [5] - 2782:15, 2830:21, 2855:6, 2861:20, 2892:9 formed [6] - 2855:2, 2867:1, 2869:11, 2872:5, 2872:18, 2907:4 formula [8] - 2783:3, 2784:14, 2784:15, 2808:17, 2822:20, 2822:22, 2822:24 forthcoming [1] - 2842:12 fortunately [1] - 2854:1 forward [8] - 2858:25, 2859:13, 2860:1, 2869:6, 2877:6, 2908:6, 2908:10, 2908:22 four [7] - 2782:16, 2802:11, 2853:16, 2857:3, 2857:10, 2857:12, 2858:1 fourth [2] - 2872:22, 2889:12 fraction [1] - 2830:21 FRANK [1] - 2767:18 frequently [1] - 2851:7 friction [2] - 2790:20,</p>
--	---	---	--	---

<p>2820:4 frictional [13] - 2785:5, 2785:17, 2786:19, 2793:19, 2806:1, 2811:3, 2814:9, 2819:16, 2820:9, 2823:1, 2823:6, 2823:9, 2824:4 FRILOT [1] - 2770:5 front [4] - 2861:24, 2864:10, 2870:12, 2894:15 front-on [1] - 2870:12 full [7] - 2779:23, 2812:15, 2843:23, 2847:8, 2867:21, 2868:7, 2885:15 full-blown [1] - 2885:15 full-bore [2] - 2867:21, 2868:7 fully [2] - 2858:20, 2910:20 fundamental [1] - 2806:4 future [2] - 2890:11, 2902:19</p>	<p>GENERAL [1] - 2768:5 GENERAL'S [1] - 2767:21 generally [5] - 2784:11, 2785:7, 2789:20, 2791:2, 2797:14 generate [1] - 2841:2 generated [1] - 2841:9 generic [1] - 2833:16 geometric [12] - 2780:12, 2780:14, 2786:10, 2786:11, 2789:6, 2795:15, 2811:5, 2811:9, 2811:11, 2811:12, 2832:14, 2832:23 geometrical [1] - 2901:24 geometries [37] - 2816:24, 2821:14, 2850:3, 2850:5, 2853:6, 2853:7, 2853:8, 2853:23, 2853:24, 2854:2, 2854:4, 2854:8, 2856:21, 2857:3, 2857:10, 2857:12, 2858:1, 2861:19, 2861:20, 2861:22, 2873:16, 2879:16, 2879:18, 2879:23, 2880:5, 2883:20, 2886:12, 2887:12, 2889:11, 2889:15, 2890:3, 2894:12, 2905:12, 2906:6, 2906:9, 2910:2, 2913:3 geometry [47] - 2809:21, 2812:9, 2814:8, 2814:10, 2816:4, 2816:15, 2816:20, 2821:7, 2878:2, 2879:10, 2880:6, 2880:19, 2880:25, 2881:21, 2882:7, 2885:15, 2885:21, 2886:24, 2887:23, 2889:9, 2889:10, 2889:13, 2889:22, 2889:24, 2891:3, 2891:24, 2896:2, 2896:18, 2896:19, 2897:5, 2902:9, 2902:11, 2905:15, 2905:17, 2906:7, 2906:13, 2910:3, 2910:9, 2910:10, 2910:11,</p>	<p>2912:4, 2912:13, 2913:1, 2913:16, 2913:22, 2914:1 giant [1] - 2794:11 given [29] - 2793:24, 2798:14, 2798:17, 2798:21, 2803:10, 2803:16, 2803:22, 2805:16, 2805:23, 2809:13, 2809:15, 2809:17, 2809:18, 2821:8, 2826:1, 2829:9, 2831:2, 2836:1, 2845:22, 2851:13, 2852:13, 2852:18, 2857:20, 2878:2, 2879:10, 2901:18, 2902:7, 2913:5, 2913:13 GLADSTEIN [1] - 2768:22 glance [1] - 2854:6 GMBH [1] - 2766:8 goal [2] - 2882:3, 2890:15 GODWIN [3] - 2770:19, 2770:20, 2771:3 government [3] - 2773:8, 2842:8, 2900:11 gradient [2] - 2788:17, 2788:18 gradual [2] - 2856:14, 2856:16 graduate [3] - 2844:14, 2847:14, 2848:4 GRAND [1] - 2770:16 GRANT [1] - 2770:15 graph [12] - 2881:13, 2882:13, 2889:11, 2894:7, 2894:15, 2897:11, 2898:10, 2898:11, 2900:22, 2900:24, 2901:2, 2914:17 graphs [3] - 2894:11, 2894:13, 2913:25 great [3] - 2853:17, 2877:8, 2914:18 greater [2] - 2797:25, 2805:6 greatly [1] - 2840:15 GREENWALD [1] - 2767:7 grinder [1] - 2804:21 Gringarten [1] - 2774:16 ground [1] - 2870:23</p>	<p>guess [8] - 2790:17, 2807:7, 2839:1, 2888:12, 2907:7, 2913:6, 2913:7, 2915:7 guessing [1] - 2907:9 guided [2] - 2846:16, 2849:8 guiding [1] - 2873:24 GULF [1] - 2766:5 GWENDOLYN [1] - 2771:4</p>	<p>heat [1] - 2788:19 height [3] - 2804:14, 2804:18, 2899:21 held [1] - 2867:12 help [5] - 2820:15, 2848:22, 2855:3, 2889:3, 2889:7 helped [2] - 2841:23, 2858:3 helpful [2] - 2853:17, 2894:7 helps [2] - 2861:2, 2875:4</p>
H				
<p>gap [6] - 2783:11, 2783:15, 2783:17, 2784:8, 2806:18, 2862:5 gas [34] - 2777:11, 2777:14, 2781:18, 2789:16, 2789:20, 2789:22, 2790:1, 2790:10, 2790:12, 2790:15, 2791:5, 2791:10, 2796:18, 2796:25, 2797:18, 2797:25, 2799:7, 2800:14, 2801:3, 2824:15, 2827:5, 2836:19, 2838:14, 2839:10, 2845:1, 2845:9, 2845:17, 2845:18, 2845:20, 2848:3, 2848:14, 2848:19, 2901:20 gas/v [1] - 2796:18 GASAWAY [1] - 2769:18 general [9] - 2782:15, 2791:16, 2794:17, 2797:17, 2799:19, 2812:21, 2827:10, 2831:9, 2841:12</p>	<p>half [18] - 2783:20, 2784:1, 2784:3, 2784:4, 2784:5, 2815:20, 2826:21, 2827:12, 2827:14, 2830:17, 2873:3, 2874:4, 2874:6, 2894:21, 2894:23, 2896:25, 2897:2, 2897:12 HALLIBURTON [1] - 2770:18 hand [1] - 2886:12 handed [1] - 2913:20 hands [3] - 2828:6, 2880:1, 2915:7 Hans [1] - 2873:21 happy [5] - 2773:9, 2773:10, 2843:10, 2882:19, 2891:25 hard [13] - 2796:11, 2864:10, 2873:4, 2875:7, 2877:18, 2878:1, 2898:11, 2898:16, 2898:20, 2912:16, 2912:20, 2913:23, 2914:13 HARIKLIA [1] - 2769:10 HARVEY [1] - 2768:23 HAYCRAFT [1] - 2769:5 HB406 [1] - 2771:18 head [5] - 2776:24, 2818:5, 2820:3, 2821:17, 2885:7 head-on [1] - 2885:7 hear [2] - 2838:4, 2838:5 heard [7] - 2787:14, 2849:20, 2866:25, 2871:15, 2872:1, 2877:1, 2877:17 HEARD [1] - 2766:15 hearing [1] - 2774:20</p>	<p>HERMAN [3] - 2766:19, 2766:19 Hewitt [1] - 2797:13 Hewitt-Roberts [1] - 2797:13 high [20] - 2798:8, 2853:5, 2855:4, 2855:8, 2855:12, 2856:18, 2857:16, 2878:19, 2878:25, 2879:3, 2879:4, 2879:5, 2893:4, 2895:25, 2897:1, 2905:21, 2905:22, 2913:21, 2914:3 higher [4] - 2799:4, 2878:24, 2896:17, 2898:5 highest [1] - 2881:17 highlighted [1] - 2898:18 Himmelhoch [1] - 2773:25 HIMMELHOCH [4] - 2768:23, 2773:20, 2773:25, 2774:9 historical [2] - 2905:8, 2905:9 hit [1] - 2852:8 hold [4] - 2788:19, 2826:10, 2834:20, 2835:25 holding [2] - 2862:10, 2886:12 HOLDINGS [1] - 2770:3 holds [2] - 2834:16, 2836:1 hole [56] - 2803:1, 2803:4, 2805:25, 2806:24, 2807:4, 2807:5, 2807:8, 2807:9, 2807:12, 2807:15, 2808:1, 2809:1, 2809:2, 2809:6, 2809:12,</p>		

2809:13, 2811:2,
2813:2, 2813:12,
2814:5, 2814:8,
2814:12, 2814:20,
2814:22, 2815:1,
2815:10, 2833:5,
2833:14, 2840:4,
2840:5, 2840:6,
2840:7, 2859:14,
2859:15, 2859:16,
2859:20, 2869:8,
2869:11, 2869:14,
2869:18, 2872:15,
2872:17, 2872:22,
2872:24, 2874:1,
2874:10, 2874:16,
2875:22, 2876:2,
2876:8, 2877:1,
2907:24
hole's [1] - 2806:25
holes [74] - 2802:12,
2802:13, 2802:15,
2802:19, 2802:20,
2802:24, 2807:6,
2808:2, 2808:3,
2808:6, 2808:8,
2808:15, 2808:21,
2809:9, 2809:10,
2809:16, 2809:19,
2809:21, 2809:23,
2810:3, 2810:5,
2810:6, 2810:10,
2811:13, 2812:2,
2812:5, 2812:8,
2812:10, 2812:17,
2812:24, 2813:3,
2813:6, 2813:7,
2813:9, 2813:15,
2813:18, 2813:22,
2814:3, 2814:11,
2814:19, 2814:25,
2815:8, 2816:15,
2832:18, 2833:6,
2833:11, 2862:19,
2868:14, 2869:5,
2869:7, 2869:16,
2869:23, 2871:1,
2871:9, 2871:12,
2871:14, 2871:23,
2872:6, 2872:13,
2873:11, 2875:21,
2876:1, 2876:8,
2876:9, 2876:17,
2876:20, 2882:14,
2882:25, 2883:17,
2886:15
home [1] - 2880:4
honestly [1] - 2914:5
Honor [48] - 2773:13,
2773:24, 2773:25,

2774:12, 2774:22,
2775:5, 2787:14,
2788:1, 2825:3,
2833:22, 2837:19,
2842:15, 2843:6,
2846:11, 2849:20,
2850:18, 2853:16,
2854:22, 2855:12,
2856:25, 2860:23,
2861:25, 2864:17,
2865:16, 2866:23,
2868:24, 2870:5,
2875:7, 2875:25,
2876:13, 2878:12,
2879:22, 2881:5,
2884:1, 2884:9,
2885:12, 2887:25,
2889:9, 2891:14,
2894:10, 2895:14,
2896:15, 2897:6,
2899:18, 2901:2,
2903:21, 2909:7,
2911:25
HONORABLE [1] -
2766:15
hope [1] - 2890:16
HOPE [1] - 2769:15
Horizon [1] - 2842:5
HORIZON [1] - 2766:4
horizontal [2] -
2865:3, 2891:14
hose [5] - 2878:5,
2878:13, 2878:17,
2878:21, 2878:25
hour [3] - 2787:5,
2890:2
hours [4] - 2774:24,
2774:25, 2787:5,
2899:1
housekeeping [1] -
2774:1
HOUSTON [2] -
2770:11, 2771:5
huge [2] - 2887:25,
2902:13
hugely [2] - 2845:20,
2888:15
hum [1] - 2777:24
hundred [2] - 2848:4,
2914:6
hydraulic [130] -
2780:1, 2780:4,
2780:8, 2780:11,
2781:15, 2782:16,
2782:24, 2783:10,
2783:17, 2783:23,
2784:4, 2784:9,
2784:17, 2784:22,
2785:16, 2785:21,
2786:2, 2786:11,

2786:21, 2789:7,
2791:25, 2792:6,
2792:18, 2793:3,
2794:8, 2795:3,
2795:15, 2798:17,
2798:23, 2801:15,
2801:16, 2801:23,
2802:20, 2803:9,
2803:11, 2803:17,
2803:22, 2804:4,
2804:11, 2804:24,
2805:2, 2805:15,
2805:18, 2805:20,
2806:21, 2807:16,
2807:18, 2808:5,
2808:7, 2808:14,
2808:17, 2808:20,
2809:10, 2809:20,
2809:21, 2810:13,
2810:22, 2811:1,
2811:17, 2811:25,
2812:13, 2812:19,
2812:25, 2813:11,
2813:16, 2813:19,
2813:23, 2814:13,
2816:8, 2816:24,
2817:15, 2819:2,
2819:7, 2819:11,
2819:24, 2820:5,
2820:8, 2821:2,
2821:7, 2821:11,
2821:20, 2821:22,
2822:9, 2822:15,
2822:17, 2823:14,
2823:16, 2823:24,
2824:9, 2824:19,
2824:20, 2824:24,
2825:16, 2826:3,
2826:6, 2826:14,
2826:17, 2828:3,
2828:17, 2828:20,
2829:4, 2829:5,
2831:25, 2832:4,
2832:5, 2832:8,
2832:9, 2832:11,
2832:20, 2832:22,
2832:24, 2833:2,
2833:8, 2833:13,
2833:18, 2836:21,
2836:22, 2836:25,
2839:6, 2840:13,
2840:19, 2840:22,
2840:24, 2841:10,
2841:23, 2842:1,
2842:7, 2842:9,
2842:13
hydrocarbons [1] -
2850:7
hydrodynamic [2] -
2799:22, 2800:17
hydrodynamics [1] -

2868:15
hypothetical [4] -
2792:3, 2803:7,
2813:14, 2839:2
I
idea [3] - 2774:7,
2795:12, 2803:21
ideally [1] - 2786:8
identical [6] -
2838:15, 2862:9,
2862:13, 2862:14,
2864:18
identified [2] -
2857:11, 2893:21
IL [1] - 2769:12
illustrates [2] -
2851:10, 2858:4
image [1] - 2870:5
images [1] - 2857:1
imagination [1] -
2899:11
imagine [13] -
2784:12, 2851:19,
2861:19, 2870:6,
2870:19, 2872:17,
2875:12, 2881:5,
2883:4, 2884:11,
2885:1, 2886:13,
2889:19
imaging [1] - 2795:10
immediate [1] -
2857:17
immediately [1] -
2862:17
impact [8] - 2851:6,
2851:23, 2852:10,
2852:19, 2865:7,
2865:15, 2877:14,
2885:9
impacting [3] -
2851:13, 2882:24,
2885:7
impacts [3] - 2851:12,
2865:11, 2881:14
implemented [1] -
2849:24
implicated [1] -
2869:11
importance [2] -
2845:18, 2887:25
important [34] -
2801:2, 2801:8,
2823:13, 2823:14,
2824:2, 2824:4,
2824:6, 2824:12,
2824:13, 2824:18,
2845:20, 2848:11,
2851:22, 2854:3,

2854:11, 2857:24,
2868:21, 2869:2,
2869:13, 2871:6,
2872:9, 2874:4,
2882:1, 2882:3,
2885:11, 2885:20,
2886:6, 2887:22,
2890:8, 2891:12,
2894:20, 2907:17,
2913:14, 2913:19
imported [1] - 2879:18
imposed [1] - 2787:7
impossible [1] -
2899:2
imprint [2] - 2865:11,
2867:7
IN [3] - 2766:4,
2766:5, 2766:7
INC [5] - 2766:12,
2769:3, 2770:4,
2770:5, 2770:19
inch [14] - 2782:10,
2804:3, 2804:7,
2804:11, 2806:18,
2806:22, 2807:15,
2810:6, 2810:21,
2810:22, 2814:20,
2814:22, 2815:1
inches [12] - 2791:20,
2791:21, 2791:22,
2792:1, 2792:8,
2792:12, 2792:15,
2804:9, 2808:19,
2810:7, 2810:16,
2810:19
incident [1] - 2877:11
included [1] - 2776:8
includes [1] - 2902:11
incompressible [1] -
2781:13
incorrect [7] -
2793:23, 2801:18,
2806:6, 2806:12,
2810:5, 2835:14,
2841:15
increase [5] - 2786:14,
2794:9, 2810:25,
2813:19, 2856:13
increased [1] - 2841:6
increases [2] - 2835:8,
2888:15
incredibly [1] - 2827:4
indeed [10] - 2848:24,
2857:15, 2865:1,
2873:25, 2878:24,
2881:16, 2885:6,
2886:1, 2886:12,
2892:11
independent [2] -
2812:5, 2907:23

<p>independently [5] - 2812:9, 2813:4, 2838:19, 2903:13, 2909:19</p> <p>indicate [1] - 2868:11</p> <p>indicated [3] - 2840:17, 2841:21, 2915:16</p> <p>indicates [1] - 2885:10</p> <p>individual [4] - 2851:10, 2893:19, 2899:14, 2914:7</p> <p>induced [3] - 2800:2, 2800:7, 2872:1</p> <p>indulge [1] - 2813:14</p> <p>indulgence [1] - 2806:16</p> <p>industrial [2] - 2848:2, 2888:4</p> <p>industry [10] - 2821:11, 2826:19, 2836:19, 2838:14, 2845:19, 2845:20, 2848:3, 2848:4, 2848:6, 2848:14</p> <p>infinitely [1] - 2825:7</p> <p>infinity [1] - 2794:14</p> <p>information [20] - 2780:7, 2802:22, 2850:3, 2853:2, 2853:7, 2853:9, 2861:18, 2869:20, 2871:7, 2873:9, 2873:24, 2883:24, 2885:20, 2888:17, 2889:7, 2890:4, 2902:23, 2905:14, 2906:7, 2907:17</p> <p>initial [4] - 2856:17, 2891:19, 2891:21, 2901:21</p> <p>inner [7] - 2782:25, 2783:11, 2791:21, 2792:5, 2793:16, 2794:8, 2795:14</p> <p>input [14] - 2780:9, 2828:15, 2828:18, 2828:20, 2829:3, 2830:11, 2830:15, 2830:20, 2831:16, 2831:18, 2832:1, 2836:14, 2879:20</p> <p>inputs [2] - 2828:15, 2829:3</p> <p>inside [11] - 2782:2, 2782:7, 2782:11, 2822:13, 2841:14, 2845:16, 2871:5, 2875:1, 2875:10,</p>	<p>2880:21, 2883:14</p> <p>insight [1] - 2850:6</p> <p>inspect [1] - 2866:15</p> <p>instance [1] - 2795:8</p> <p>instead [3] - 2801:14, 2814:3, 2822:7</p> <p>Institute [8] - 2844:20, 2844:22, 2845:2, 2845:12, 2846:4, 2847:11, 2847:17, 2847:19</p> <p>institute [6] - 2844:23, 2844:24, 2847:20, 2847:22, 2848:7, 2848:21</p> <p>institutes [1] - 2847:23</p> <p>intact [1] - 2859:2</p> <p>integer [1] - 2830:3</p> <p>integral [1] - 2910:24</p> <p>intelligent [1] - 2902:16</p> <p>intended [3] - 2837:1, 2837:2, 2906:14</p> <p>intense [4] - 2881:14, 2882:12, 2890:2, 2890:6</p> <p>intensely [1] - 2867:4</p> <p>intensity [1] - 2852:9</p> <p>intent [2] - 2904:19, 2905:11</p> <p>interact [1] - 2825:9</p> <p>interaction [1] - 2795:8</p> <p>interactions [1] - 2814:9</p> <p>interest [2] - 2879:16, 2905:13</p> <p>interested [1] - 2853:6</p> <p>interesting [1] - 2865:13</p> <p>INTERESTS [1] - 2767:21</p> <p>interfacial [1] - 2790:20</p> <p>interim [1] - 2888:24</p> <p>internal [2] - 2845:15, 2848:13</p> <p>interrelationship [1] - 2825:19</p> <p>intricate [1] - 2900:1</p> <p>introduce [1] - 2819:24</p> <p>introduced [2] - 2806:1, 2836:19</p> <p>intuitive [6] - 2792:24, 2792:25, 2829:13, 2877:20, 2879:4, 2893:9</p> <p>intuitively [1] -</p>	<p>2815:12</p> <p>inverse [1] - 2901:7</p> <p>investigation [2] - 2828:10, 2893:22</p> <p>involved [2] - 2777:10, 2838:23</p> <p>IRPINO [2] - 2767:10, 2767:11</p> <p>irregular [3] - 2809:1, 2816:15, 2833:14</p> <p>irregular-shaped [1] - 2809:1</p> <p>irregularly [2] - 2832:18, 2833:5</p> <p>isolated [1] - 2901:24</p> <p>issue [8] - 2776:17, 2787:15, 2844:14, 2845:18, 2853:13, 2853:15, 2873:15, 2874:4</p> <p>issues [3] - 2843:12, 2845:7, 2849:2</p> <p>itself [6] - 2775:18, 2778:15, 2781:10, 2786:13, 2798:5, 2882:4</p>	<p>JUDY [1] - 2768:23</p> <p>jump [1] - 2788:14</p> <p>jumping [1] - 2855:13</p> <p>JUSTICE [2] - 2768:13, 2768:17</p>	<p>2874:16, 2875:1, 2876:23, 2882:1, 2882:8, 2882:11, 2899:1, 2899:7, 2903:4, 2903:6, 2905:13, 2907:24, 2910:9, 2911:5, 2911:18, 2911:21, 2912:5</p> <p>KIRBY [1] - 2771:13</p> <p>KIRKLAND [3] - 2769:9, 2769:14, 2769:18</p> <p>keep [1] - 2902:9</p> <p>knowledge [4] - 2846:20, 2849:11, 2852:15, 2912:19</p> <p>known [3] - 2888:11, 2915:11, 2915:17</p> <p>Koch [1] - 2842:10</p> <p>KRAUS [1] - 2768:9</p> <p>KUHLER [2] - 2771:8, 2771:9</p> <p>KY [1] - 2771:13</p>		
		J	K			
		<p>JACKSON [1] - 2767:19</p> <p>JAMES [2] - 2766:23, 2768:4</p> <p>January [2] - 2773:10, 2847:7</p> <p>JEFFERSON [1] - 2766:23</p> <p>JENNY [1] - 2770:20</p> <p>job [1] - 2902:24</p> <p>Johnson [2] - 2796:2, 2796:21</p> <p>joint [1] - 2867:2</p> <p>jokes [1] - 2805:5</p> <p>JOSEPH [1] - 2769:19</p> <p>JR [1] - 2770:21</p> <p>JUDGE [1] - 2766:15</p> <p>judge [1] - 2861:9</p> <p>Judge [24] - 2843:24, 2844:8, 2846:7, 2847:3, 2847:20, 2855:4, 2856:21, 2858:12, 2860:12, 2860:21, 2863:20, 2866:4, 2868:20, 2870:1, 2874:25, 2875:3, 2878:5, 2881:4, 2883:23, 2884:20, 2889:5, 2891:11, 2895:1, 2900:24</p>	<p>key [5] - 2831:21, 2831:23, 2844:16, 2874:19, 2889:17</p> <p>keyword [5] - 2829:1, 2829:2, 2829:20, 2829:23, 2829:25</p> <p>keywords [2] - 2830:25, 2831:1</p> <p>kicking [1] - 2790:16</p> <p>kind [23] - 2796:21, 2797:11, 2821:18, 2830:7, 2848:17, 2854:9, 2855:12, 2857:23, 2857:25, 2858:25, 2862:2, 2863:15, 2872:9, 2873:3, 2873:12, 2874:19, 2875:7, 2875:18, 2882:4, 2883:11, 2884:9, 2889:20, 2901:7</p> <p>kink [25] - 2778:20, 2801:22, 2801:23, 2807:20, 2807:25, 2812:3, 2815:18, 2816:1, 2816:9, 2816:13, 2840:1, 2840:2, 2846:23, 2855:10, 2859:14, 2868:2, 2869:3, 2870:10, 2879:18, 2880:15, 2880:17, 2881:7</p> <p>kinked [30] - 2857:3, 2857:9, 2867:15, 2867:16, 2867:22, 2868:12, 2868:13, 2868:17, 2869:22, 2870:7, 2870:15, 2870:20, 2874:2,</p>	L		
				<p>LA [11] - 2766:5, 2766:20, 2766:24, 2767:12, 2767:15, 2768:6, 2768:10, 2769:7, 2770:7, 2771:10, 2771:19</p> <p>label [2] - 2806:13, 2815:14</p> <p>labeled [1] - 2813:1</p> <p>laboratory [1] - 2906:11</p> <p>LAFAYETTE [1] - 2766:24</p> <p>LAKE [1] - 2767:15</p> <p>LAMAR [1] - 2771:4</p> <p>laminar [1] - 2820:19</p> <p>LANGAN [1] - 2769:9</p> <p>language [2] - 2776:3, 2796:12</p> <p>large [22] - 2781:4, 2781:9, 2782:5, 2782:10, 2782:12, 2792:11, 2795:14, 2824:21, 2824:23, 2825:8, 2825:12, 2827:16, 2833:5, 2834:22, 2835:18, 2851:12, 2870:5, 2878:18, 2886:14</p> <p>large-scale [2] - 2781:4, 2781:9</p> <p>larger [3] - 2798:18, 2827:20, 2869:16</p>		

<p>largest [2] - 2844:23, 2847:22</p> <p>LASALLE [1] - 2769:12</p> <p>laser [2] - 2869:1, 2880:19</p> <p>last [11] - 2774:2, 2842:10, 2843:5, 2850:10, 2854:13, 2856:17, 2888:22, 2888:24, 2891:20, 2891:21, 2894:13</p> <p>lasted [4] - 2859:24, 2860:4, 2877:2, 2909:20</p> <p>LAW [1] - 2767:10</p> <p>lay [1] - 2838:15</p> <p>layer [2] - 2795:11, 2800:14</p> <p>lead [1] - 2865:20</p> <p>leader [1] - 2845:6</p> <p>leading [1] - 2847:23</p> <p>leak [20] - 2802:2, 2802:5, 2804:2, 2804:15, 2804:19, 2804:22, 2806:18, 2806:21, 2811:23, 2831:15, 2831:21, 2831:23, 2831:24, 2833:5, 2833:6, 2833:11, 2833:17, 2834:10</p> <p>leaking [1] - 2807:10</p> <p>leaks [21] - 2778:20, 2801:22, 2801:24, 2802:2, 2802:7, 2802:10, 2802:11, 2807:19, 2807:25, 2811:24, 2811:25, 2815:18, 2816:1, 2816:9, 2816:13, 2831:18, 2834:2, 2834:3, 2834:7, 2840:1, 2840:2</p> <p>leaky [1] - 2867:1</p> <p>leap [1] - 2899:11</p> <p>LEASING [1] - 2766:8</p> <p>least [11] - 2773:10, 2834:22, 2841:12, 2859:24, 2860:4, 2877:2, 2877:9, 2883:4, 2905:19, 2909:3, 2914:5</p> <p>leave [1] - 2843:10</p> <p>lecturer [1] - 2846:6</p> <p>led [1] - 2862:6</p> <p>LedaFlow [3] - 2778:25, 2780:7, 2785:15</p> <p>left [11] - 2782:1,</p>	<p>2791:19, 2842:3, 2862:6, 2870:5, 2878:12, 2881:9, 2884:17, 2885:5, 2887:2, 2896:4</p> <p>length [2] - 2782:9, 2824:14</p> <p>less [13] - 2798:19, 2865:14, 2865:19, 2882:14, 2883:1, 2884:12, 2887:7, 2887:8, 2896:3, 2898:15, 2898:16, 2899:21, 2913:2</p> <p>level [9] - 2846:17, 2847:15, 2853:5, 2855:4, 2855:8, 2855:12, 2856:18, 2857:16, 2865:13</p> <p>LEVIN [1] - 2767:3</p> <p>LEWIS [3] - 2769:4, 2770:19, 2771:3</p> <p>LI [1] - 2770:14</p> <p>life [1] - 2902:14</p> <p>light [3] - 2875:18, 2898:8, 2898:9</p> <p>light-colored [2] - 2898:8, 2898:9</p> <p>lighter [1] - 2898:13</p> <p>likely [4] - 2790:17, 2798:7, 2798:9, 2800:9</p> <p>likewise [2] - 2803:3, 2859:13</p> <p>line [33] - 2852:6, 2856:15, 2870:18, 2891:22, 2892:7, 2892:12, 2892:13, 2892:15, 2892:22, 2892:23, 2893:4, 2893:7, 2893:10, 2895:4, 2895:11, 2895:19, 2895:23, 2896:2, 2896:20, 2898:15, 2900:19, 2900:20, 2914:23, 2914:25, 2915:1, 2915:10, 2915:13, 2915:16, 2915:18, 2915:21, 2915:24</p> <p>linear [6] - 2856:15, 2891:25, 2892:1, 2892:3, 2893:1, 2915:17</p> <p>lines [2] - 2880:16, 2905:1</p> <p>liquid [22] - 2777:12, 2777:14, 2789:16, 2789:21, 2789:23, 2789:24, 2790:1,</p>	<p>2790:12, 2790:13, 2791:5, 2796:15, 2796:24, 2796:25, 2797:18, 2800:3, 2800:5, 2824:16, 2827:6, 2839:11, 2839:12</p> <p>liquid/v [1] - 2796:15</p> <p>LISKOW [1] - 2769:4</p> <p>list [4] - 2773:15, 2773:17, 2774:14, 2846:5</p> <p>listed [1] - 2850:11</p> <p>lists [1] - 2774:17</p> <p>literally [1] - 2884:2</p> <p>literature [4] - 2826:16, 2835:18, 2836:10, 2841:22</p> <p>live [2] - 2843:24, 2843:25</p> <p>LLC [1] - 2770:3</p> <p>location [1] - 2885:18</p> <p>locations [7] - 2867:6, 2871:23, 2881:14, 2881:16, 2881:22, 2886:2, 2899:15</p> <p>Lockett [6] - 2815:25, 2816:12, 2833:17, 2833:19, 2834:1</p> <p>logical [1] - 2852:22</p> <p>look [32] - 2779:12, 2781:13, 2784:14, 2791:15, 2791:17, 2796:13, 2801:12, 2801:21, 2828:4, 2829:17, 2831:14, 2837:15, 2857:2, 2858:25, 2860:16, 2863:7, 2866:13, 2868:16, 2871:10, 2871:17, 2871:22, 2872:3, 2876:12, 2876:13, 2887:16, 2888:5, 2888:8, 2889:16, 2896:22, 2904:24, 2911:24, 2912:5</p> <p>looked [25] - 2779:3, 2779:6, 2801:10, 2805:24, 2807:24, 2843:11, 2849:8, 2853:21, 2858:1, 2862:2, 2875:1, 2881:22, 2883:21, 2885:18, 2887:12, 2889:11, 2891:2, 2891:24, 2892:12, 2893:3, 2893:4, 2895:24, 2906:20, 2910:2, 2913:7</p>	<p>looking [31] - 2779:12, 2781:4, 2781:8, 2811:9, 2824:7, 2832:18, 2833:13, 2837:14, 2849:18, 2850:4, 2851:20, 2853:15, 2861:2, 2866:3, 2867:9, 2870:1, 2870:3, 2870:7, 2870:10, 2870:11, 2870:14, 2870:20, 2870:24, 2871:5, 2883:24, 2884:8, 2886:24, 2893:25, 2895:2, 2898:11, 2912:9</p> <p>looks [13] - 2773:8, 2800:12, 2822:24, 2831:20, 2870:17, 2870:22, 2872:25, 2876:3, 2876:17, 2883:8, 2888:2, 2914:17, 2914:18</p> <p>loop [1] - 2889:25</p> <p>LOS [2] - 2769:16, 2770:16</p> <p>loss [10] - 2818:20, 2818:25, 2819:3, 2845:7, 2845:14, 2845:15, 2847:23, 2848:6, 2848:11, 2851:16</p> <p>Loss [1] - 2818:22</p> <p>losses [4] - 2785:17, 2818:4, 2820:3, 2820:9</p> <p>Losses [1] - 2818:3</p> <p>lost [1] - 2851:14</p> <p>LOUISIANA [3] - 2766:1, 2768:3, 2768:4</p> <p>low [9] - 2798:7, 2800:4, 2878:20, 2879:2, 2879:5, 2897:1, 2913:21, 2914:3</p> <p>lower [3] - 2840:7, 2896:18, 2896:19</p> <p>LP [1] - 2771:8</p> <p>LUIS [1] - 2770:14</p> <p>lump [1] - 2910:13</p> <p>lumped [2] - 2911:1, 2911:19</p> <p>lunch [2] - 2916:4, 2916:7</p> <p>LUNDY [3] - 2767:14, 2767:14</p> <p>LUXENBERG [1] - 2767:7</p>	<p style="text-align: center;">M</p> <p>Macondo [7] - 2787:1, 2788:14, 2789:5, 2789:9, 2848:22, 2850:4, 2856:23</p> <p>MAGAZINE [1] - 2767:11</p> <p>main [12] - 2796:23, 2847:24, 2850:15, 2855:14, 2856:10, 2857:3, 2857:13, 2873:20, 2877:10, 2901:2, 2901:11, 2913:19</p> <p>maintain [6] - 2784:24, 2785:10, 2794:23, 2826:13, 2828:24, 2829:6</p> <p>maintained [1] - 2792:4</p> <p>maintaining [3] - 2793:14, 2793:17, 2794:20</p> <p>maintains [2] - 2801:16, 2817:15</p> <p>major [2] - 2848:7, 2912:3</p> <p>majority [3] - 2782:10, 2782:12, 2834:22</p> <p>manner [1] - 2840:10</p> <p>manual [12] - 2828:6, 2828:9, 2829:3, 2830:12, 2830:16, 2831:11, 2836:11, 2836:14, 2836:20, 2836:24, 2838:12, 2842:3</p> <p>manuals [1] - 2828:2</p> <p>map [6] - 2796:4, 2797:4, 2797:12, 2800:8, 2801:12</p> <p>maps [5] - 2797:14, 2799:20, 2799:21, 2800:17, 2800:18</p> <p>margins [1] - 2897:4</p> <p>MARTIN [1] - 2769:15</p> <p>MARTINEZ [1] - 2770:20</p> <p>mass [23] - 2775:15, 2775:19, 2775:20, 2775:24, 2776:16, 2776:18, 2776:20, 2777:5, 2777:11, 2777:14, 2778:8, 2778:9, 2778:11, 2778:12, 2794:24, 2801:16, 2834:17, 2835:3, 2835:11, 2835:12, 2836:4,</p>
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<p>2836:8 massive [4] - 2860:24, 2862:8, 2862:16, 2864:21 Master's [1] - 2846:17 Masters [2] - 2844:10, 2849:1 match [2] - 2881:25, 2886:4 matches [2] - 2801:9, 2826:18 material [2] - 2815:24, 2905:5 materials [5] - 2788:19, 2815:17, 2815:23, 2853:3, 2868:10 math [1] - 2798:24 mathematical [4] - 2849:23, 2882:3, 2882:16, 2891:1 mathematically [3] - 2891:4, 2891:7, 2893:4 matter [11] - 2773:14, 2774:1, 2774:13, 2790:3, 2790:4, 2824:20, 2824:23, 2839:7, 2839:9, 2891:24, 2897:1 matters [1] - 2839:15 MATTHEW [2] - 2767:14, 2769:11 maximum [6] - 2807:25, 2831:24, 2832:1, 2832:6, 2875:23, 2876:10 MAZE [1] - 2767:22 MCCUTCHEN [1] - 2771:12 MDL-2179 [1] - 2766:4 mean [18] - 2776:19, 2792:23, 2807:3, 2807:7, 2809:24, 2820:25, 2824:11, 2825:6, 2831:10, 2841:12, 2845:5, 2874:11, 2892:11, 2892:15, 2905:6, 2907:7, 2907:8, 2915:19 means [15] - 2783:6, 2788:15, 2789:4, 2789:6, 2845:6, 2845:16, 2863:9, 2879:2, 2879:5, 2894:22, 2898:14, 2899:22, 2907:4, 2908:18 meant [2] - 2832:11,</p>	<p>2911:8 measure [2] - 2882:9, 2908:9 measured [2] - 2827:9, 2827:10 mechanical [4] - 2844:10, 2846:6, 2851:15, 2873:10 MECHANICAL [1] - 2771:23 mechanically [1] - 2851:6 mechanics [4] - 2780:16, 2846:14, 2847:13 mechanism [2] - 2800:16, 2845:25 mechanisms [1] - 2800:1 memory [3] - 2823:23, 2840:3, 2914:9 mention [1] - 2831:25 mentioned [15] - 2792:22, 2820:13, 2847:18, 2849:16, 2850:15, 2857:8, 2860:12, 2860:15, 2868:1, 2874:1, 2874:10, 2874:12, 2874:25, 2876:25, 2893:3 MERIT [1] - 2771:18 Merrill [1] - 2774:15 metal [20] - 2845:7, 2845:14, 2845:15, 2847:23, 2848:6, 2848:11, 2850:20, 2851:2, 2851:5, 2851:13, 2851:16, 2852:4, 2853:3, 2856:22, 2865:18, 2873:18, 2900:7, 2903:3, 2904:3, 2904:7 metallic [1] - 2851:5 meter [3] - 2790:6, 2790:13, 2797:21 meters [6] - 2790:10, 2790:15, 2791:4, 2791:5, 2791:10, 2791:11 method [2] - 2877:18, 2894:21 methodology [2] - 2853:15, 2878:6 metric [3] - 2877:13, 2877:18, 2877:24 MEXICO [1] - 2766:5 MICHAEL [2] - 2770:13, 2772:4</p>	<p>Michoud [3] - 2857:14, 2860:15, 2870:22 microphone [2] - 2820:21, 2838:3 middle [14] - 2863:5, 2863:8, 2863:10, 2869:7, 2872:4, 2872:25, 2873:11, 2876:9, 2876:20, 2880:18, 2881:8, 2883:10, 2883:12, 2885:1 might [6] - 2776:11, 2784:13, 2794:14, 2798:1, 2817:6, 2838:15 mike [1] - 2843:21 MILLER [1] - 2770:6 Miller [1] - 2842:8 million [2] - 2861:3, 2880:21 mind [3] - 2807:23, 2837:19, 2880:11 mine [1] - 2807:24 minus [5] - 2782:25, 2783:19, 2783:23, 2784:1, 2878:17 minute [7] - 2784:20, 2787:19, 2842:21, 2854:7, 2858:13, 2874:25, 2875:9 minutes [3] - 2774:24, 2774:25, 2867:16 MITCHELL [1] - 2767:3 mixture [4] - 2778:15, 2799:6, 2827:8, 2834:19 mode [1] - 2851:15 model [87] - 2775:11, 2775:12, 2775:18, 2775:24, 2777:8, 2779:11, 2780:3, 2780:7, 2780:10, 2781:10, 2782:5, 2786:4, 2786:7, 2786:24, 2787:2, 2787:5, 2788:3, 2788:13, 2788:18, 2788:20, 2788:23, 2789:7, 2790:19, 2791:25, 2792:15, 2794:11, 2794:14, 2795:18, 2798:16, 2798:19, 2798:22, 2800:21, 2801:17, 2802:10, 2802:16, 2808:8, 2822:15, 2822:16, 2825:20,</p>	<p>2825:22, 2825:24, 2826:5, 2826:20, 2826:22, 2827:24, 2830:23, 2831:2, 2831:20, 2832:10, 2834:21, 2834:24, 2835:4, 2835:7, 2835:8, 2835:11, 2835:13, 2835:19, 2836:2, 2836:6, 2836:7, 2838:18, 2840:18, 2840:21, 2840:24, 2841:8, 2841:11, 2841:14, 2861:8, 2861:16, 2862:11, 2864:7, 2879:11, 2879:20, 2880:1, 2885:24, 2904:2, 2904:5, 2904:6, 2904:13, 2904:15, 2904:16, 2905:5, 2905:20, 2906:3, 2908:19 model's [1] - 2836:4 modeled [11] - 2784:16, 2799:3, 2799:10, 2802:2, 2812:2, 2812:5, 2812:9, 2813:3, 2816:13, 2824:21, 2882:23 modeling [21] - 2775:14, 2781:3, 2811:6, 2829:2, 2830:18, 2833:17, 2833:19, 2836:21, 2838:22, 2842:2, 2859:10, 2887:13, 2906:18, 2906:20, 2911:6, 2912:23, 2914:19, 2914:22, 2916:1, 2916:2 models [10] - 2788:12, 2809:2, 2838:19, 2840:18, 2841:2, 2841:13, 2858:21, 2863:24, 2866:3, 2889:2 modes [2] - 2845:14, 2848:11 modification [1] - 2800:7 modified [1] - 2889:21 modify [2] - 2889:14, 2906:13 moment [1] - 2826:11 MONTGOMERY [1] - 2767:23 MORGAN [2] - 2767:17</p>	<p>MORNING [1] - 2766:14 morning [7] - 2773:7, 2774:12, 2775:2, 2837:9, 2903:21, 2903:25, 2904:1 most [24] - 2781:3, 2781:8, 2792:25, 2828:6, 2828:8, 2845:16, 2854:3, 2856:16, 2857:4, 2857:5, 2858:4, 2869:13, 2871:18, 2872:8, 2872:9, 2874:4, 2874:11, 2874:14, 2875:18, 2875:19, 2882:12, 2885:19, 2900:10, 2902:16 mostly [1] - 2845:7 motion [6] - 2774:3, 2843:9, 2843:12, 2843:15, 2850:21, 2882:6 mouth [2] - 2793:4, 2793:8 move [8] - 2787:12, 2788:10, 2800:3, 2807:12, 2824:16, 2851:24, 2854:22, 2880:6 moved [16] - 2846:11, 2847:1, 2847:7, 2847:25, 2860:1, 2877:6, 2879:24, 2880:4, 2880:20, 2880:22, 2880:24, 2882:8, 2889:25, 2892:4, 2892:5, 2908:22 moves [1] - 2839:10 moving [18] - 2789:22, 2789:23, 2789:25, 2790:6, 2790:9, 2790:13, 2790:15, 2790:25, 2791:4, 2791:5, 2799:7, 2827:6, 2852:3, 2852:6, 2852:17, 2882:24, 2885:16, 2916:3 MR [72] - 2773:13, 2773:24, 2775:5, 2775:8, 2776:25, 2777:2, 2781:22, 2781:24, 2787:14, 2788:1, 2788:2, 2790:5, 2791:17, 2791:18, 2795:25, 2796:1, 2798:11,</p>
---	--	---	--	---

2798:13, 2806:13, 2806:17, 2815:6, 2815:15, 2815:16, 2817:5, 2817:7, 2817:21, 2817:22, 2819:21, 2819:23, 2820:22, 2825:2, 2825:5, 2826:7, 2826:9, 2828:4, 2828:5, 2833:22, 2833:25, 2834:11, 2834:14, 2837:4, 2837:8, 2837:12, 2837:13, 2837:19, 2837:24, 2838:6, 2838:21, 2839:23, 2839:24, 2841:19, 2841:20, 2842:15, 2842:18, 2842:20, 2843:17, 2843:20, 2844:5, 2844:7, 2850:18, 2850:24, 2854:17, 2854:19, 2854:22, 2855:1, 2870:25, 2873:13, 2874:22, 2874:24, 2883:18, 2903:17, 2911:7

MS [20] - 2767:19, 2773:20, 2773:25, 2774:9, 2774:12, 2774:22, 2843:6, 2843:16, 2850:21, 2903:21, 2903:24, 2905:1, 2905:3, 2906:2, 2909:16, 2911:10, 2911:15, 2914:10, 2914:11, 2916:6

Multiphase [3] - 2847:11, 2847:17, 2847:19

multiphase [23] - 2777:7, 2778:9, 2778:14, 2780:24, 2781:19, 2790:24, 2799:6, 2810:3, 2820:16, 2821:4, 2824:15, 2827:1, 2827:4, 2834:16, 2839:3, 2839:5, 2840:23, 2841:9, 2842:1, 2845:7, 2848:6

multiple [9] - 2799:7, 2826:17, 2827:5, 2829:20, 2829:24, 2836:18, 2838:12, 2838:17, 2893:13

multiplication [1] -

2823:16

multiplied [1] - 2792:4

multiply [1] - 2808:18

multitude [1] - 2881:19

MUNGER [1] - 2770:13

must [9] - 2851:17, 2851:23, 2859:12, 2859:17, 2862:18, 2863:14, 2866:9, 2877:5, 2889:11

N

N-E-S-I-C [1] - 2843:5

N.W [1] - 2769:20

naked [2] - 2864:21, 2892:2

name [8] - 2843:3, 2843:4, 2843:5, 2843:23, 2843:25, 2851:5, 2856:25, 2908:14

narrow [4] - 2848:10, 2881:10, 2883:16, 2897:3

narrowing [1] - 2786:12

Nat [1] - 2775:9

NATHANIEL [1] - 2768:21

natural [1] - 2870:24

NATURAL [1] - 2768:18

nature [1] - 2915:10

near [6] - 2782:13, 2787:11, 2788:9, 2789:21, 2798:25, 2808:6

neck [2] - 2867:19, 2881:7

neck-down [2] - 2867:19, 2881:7

need [18] - 2785:10, 2790:19, 2790:20, 2796:12, 2798:24, 2800:19, 2829:5, 2836:12, 2838:3, 2840:3, 2853:7, 2888:11, 2890:11, 2892:11, 2904:15, 2905:8, 2906:6

needed [7] - 2853:5, 2853:6, 2853:9, 2890:13, 2891:19, 2891:20, 2905:19

needs [1] - 2865:17

negligible [1] - 2912:6

Nesic [31] - 2802:18,

2802:22, 2812:4, 2812:23, 2842:18, 2842:20, 2843:4, 2843:9, 2843:22, 2843:25, 2844:2, 2844:8, 2850:19, 2850:25, 2853:14, 2855:2, 2856:19, 2856:21, 2869:25, 2871:4, 2877:13, 2891:11, 2893:17, 2895:17, 2900:23, 2903:2, 2903:17, 2903:25, 2904:2, 2911:16, 2914:12

NESIC [2] - 2772:8, 2842:25

Nesic's [1] - 2854:23

never [5] - 2831:9, 2831:13, 2886:3, 2906:5, 2909:22

NEW [9] - 2766:5, 2766:20, 2767:8, 2767:12, 2768:10, 2769:7, 2770:7, 2771:10, 2771:19

new [5] - 2825:21, 2825:24, 2838:15, 2866:8, 2889:24

next [16] - 2773:11, 2807:12, 2807:17, 2811:23, 2819:5, 2830:13, 2838:16, 2842:17, 2842:18, 2842:19, 2869:23, 2885:6, 2888:19, 2891:3, 2891:5, 2905:22

night [1] - 2774:2

nine [1] - 2899:1

NO [3] - 2766:4, 2766:7, 2766:10

nobody [1] - 2838:3

noncircular [4] - 2780:13, 2819:20, 2820:2, 2821:13

nondimensional [1] - 2797:16

none [2] - 2774:20, 2911:22

noneroded [2] - 2863:2, 2889:9

NONJURY [1] - 2766:14

normal [1] - 2867:21

normally [2] - 2888:1, 2893:6

NORTH [1] - 2768:5

North [3] - 2845:1, 2845:8, 2845:9

Norway [3] - 2844:21, 2846:12

nothing [5] - 2836:10, 2836:11, 2894:20, 2902:1, 2915:3

nuclear [1] - 2844:24

number [27] - 2809:14, 2820:4, 2820:10, 2820:12, 2820:18, 2820:23, 2825:21, 2830:1, 2830:6, 2830:10, 2830:11, 2830:15, 2830:20, 2831:4, 2831:6, 2831:10, 2831:12, 2832:17, 2835:19, 2845:13, 2878:18, 2881:20, 2895:14, 2898:21, 2899:17, 2914:7

numbers [13] - 2836:12, 2836:14, 2851:12, 2856:6, 2891:17, 2891:18, 2898:11, 2898:16, 2898:20, 2912:16, 2913:18, 2914:13, 2914:16

numerous [5] - 2811:7, 2831:11, 2845:6, 2849:8, 2865:11

NW [2] - 2769:23, 2771:14

NY [1] - 2767:8

O

O'CONNOR [1] - 2769:19

O'KEEFE [1] - 2766:20

O'ROURKE [1] - 2768:20

oath [1] - 2775:3

object [1] - 2911:7

objection [4] - 2773:18, 2773:21, 2825:2, 2850:22

objections [3] - 2773:20, 2774:18, 2774:19

observation [2] - 2874:7, 2893:9

observe [1] - 2862:17

observed [4] - 2778:25, 2799:14, 2800:21, 2801:8

obstacle [1] - 2885:21

obstacles [1] -

2887:14

obstructed [1] - 2863:9

obstruction [3] - 2793:4, 2865:22, 2865:24

obtained [7] - 2861:15, 2870:6, 2879:16, 2890:19, 2898:14, 2898:17, 2902:7

obvious [2] - 2857:14, 2873:8

obviously [4] - 2787:20, 2884:22, 2885:18, 2908:20

occasionally [1] - 2800:5

occur [5] - 2813:24, 2851:18, 2852:13, 2852:16, 2897:23

occurred [4] - 2875:20, 2877:9, 2887:19, 2889:8

occurring [4] - 2859:18, 2872:5, 2875:5, 2903:13

occurs [1] - 2840:22

ocean [1] - 2779:8

OCTOBER [2] - 2766:5, 2773:2

odd [1] - 2870:22

OF [10] - 2766:1, 2766:5, 2766:8, 2766:10, 2766:14, 2768:3, 2768:4, 2768:13, 2768:17

offer [5] - 2773:19, 2774:2, 2844:3, 2849:11, 2905:8

offered [2] - 2856:3, 2895:25

OFFICE [4] - 2766:24, 2767:21, 2768:6, 2768:15

Official [1] - 2916:13

OFFICIAL [1] - 2771:17

OFFSHORE [1] - 2770:4

offshore [1] - 2845:17

often [2] - 2797:15, 2851:16

oftentimes [2] - 2831:5, 2838:16

Ohio [5] - 2844:1, 2847:1, 2847:4, 2847:7, 2847:25

oil [17] - 2800:13, 2801:3, 2836:19,

2838:14, 2838:15,
2839:10, 2845:1,
2845:9, 2845:17,
2845:18, 2845:20,
2848:3, 2848:7,
2848:8, 2848:13,
2848:18, 2901:20
OIL [2] - 2766:4,
2766:4
OLGA [5] - 2828:6,
2829:1, 2836:11,
2836:14, 2842:3
OLSON [1] - 2770:13
ON [1] - 2766:5
once [5] - 2854:13,
2857:25, 2879:16,
2900:5, 2902:4
one [121] - 2773:13,
2774:13, 2775:11,
2777:5, 2784:6,
2787:15, 2788:12,
2790:6, 2790:13,
2792:25, 2795:23,
2797:21, 2797:22,
2800:1, 2800:12,
2803:1, 2803:3,
2806:15, 2808:7,
2811:1, 2811:16,
2811:17, 2811:18,
2812:6, 2812:24,
2813:2, 2813:12,
2813:16, 2813:23,
2814:1, 2814:4,
2814:8, 2814:12,
2814:13, 2815:10,
2816:11, 2817:16,
2820:12, 2822:12,
2826:21, 2829:3,
2829:22, 2832:9,
2835:19, 2836:6,
2838:16, 2839:15,
2841:15, 2844:16,
2847:22, 2849:18,
2849:21, 2851:10,
2852:18, 2852:20,
2853:19, 2854:8,
2857:13, 2861:4,
2862:10, 2862:17,
2863:13, 2865:1,
2865:3, 2865:17,
2866:2, 2867:6,
2869:7, 2869:9,
2869:13, 2869:17,
2869:18, 2871:22,
2872:8, 2872:9,
2872:10, 2872:11,
2872:12, 2872:15,
2873:20, 2873:24,
2874:4, 2876:16,
2877:10, 2878:9,

2879:11, 2883:4,
2883:5, 2883:20,
2884:1, 2884:5,
2886:1, 2886:13,
2888:6, 2893:6,
2893:12, 2893:14,
2894:4, 2894:10,
2897:23, 2898:21,
2899:10, 2899:11,
2899:13, 2899:15,
2899:17, 2899:24,
2900:3, 2900:22,
2902:17, 2904:4,
2904:8, 2905:19,
2907:16, 2909:6,
2910:12, 2912:18,
2915:21, 2915:24
ONE [1] - 2769:5
one-by-one [1] -
2854:8
one-dimensional [1] -
2775:11
one-half [1] - 2826:21
one-third [1] - 2784:6
ones [9] - 2848:20,
2854:2, 2857:4,
2857:5, 2861:5,
2862:14, 2864:19,
2881:19, 2893:21
open [2] - 2861:17,
2864:18
opened [2] - 2853:25,
2858:22
opening [2] - 2885:3,
2886:14
openings [1] -
2884:17
operate [1] - 2845:23
operated [1] - 2861:21
operational [1] -
2845:21
opine [1] - 2779:16
opinion [12] -
2862:22, 2863:1,
2871:1, 2882:24,
2898:25, 2900:25,
2904:10, 2906:17,
2906:24, 2907:4,
2907:14, 2907:17
opinions [17] -
2844:3, 2846:8,
2846:22, 2849:11,
2855:2, 2855:4,
2855:6, 2855:8,
2859:22, 2873:20,
2873:21, 2873:22,
2874:4, 2877:10,
2892:9, 2900:22,
2909:21
opportunity [1] -

2829:18
opposed [1] - 2784:22
opposite [3] -
2806:24, 2806:25,
2807:3
options [1] - 2893:13
order [13] - 2774:9,
2785:12, 2786:15,
2788:4, 2791:16,
2800:21, 2809:3,
2835:3, 2836:15,
2840:8, 2851:17,
2888:18, 2905:19
ORDER [1] - 2773:4
orient [3] - 2865:2,
2870:1, 2895:1
orientation [2] -
2870:15, 2871:8
oriented [2] - 2875:13,
2875:16
orienting [1] - 2858:12
orifice [1] - 2816:3
orifices [2] - 2805:22,
2807:17
original [4] - 2816:4,
2904:19, 2905:11,
2905:25
ORLEANS [8] -
2766:5, 2766:20,
2767:12, 2768:10,
2769:7, 2770:7,
2771:10, 2771:19
oscillating [1] -
2788:5
oscillation [1] -
2787:7
Oslo [1] - 2844:21
otherwise [1] - 2850:1
outcome [2] - 2888:9,
2902:24
outer [6] - 2782:25,
2783:11, 2791:20,
2791:21, 2792:5,
2793:16
outline [1] - 2880:15
outs [1] - 2774:14
outside [3] - 2812:3,
2871:6, 2879:2
oval [1] - 2871:12
overall [4] - 2853:14,
2896:25, 2897:12,
2913:24
overlap [1] - 2882:15
overlapping [2] -
2815:8, 2885:2
overruled [1] - 2825:4
overview [1] - 2850:25
own [3] - 2777:15,
2777:17, 2906:24

P

P.O [1] - 2768:24
Pacman [1] - 2830:17
page [16] - 2795:24,
2796:21, 2796:23,
2817:21, 2818:2,
2819:5, 2819:18,
2821:12, 2823:5,
2826:10, 2828:12,
2831:14, 2854:20,
2905:1, 2905:22,
2905:25
paid [1] - 2773:8
PAPANTONIO [1] -
2767:3
paper [1] - 2811:17
papers [3] - 2843:10,
2850:12
parallel [8] - 2794:16,
2829:22, 2829:24,
2830:13, 2831:6,
2831:8, 2836:18,
2838:13
parameter [2] -
2841:16, 2851:22
parameters [2] -
2820:13, 2820:15
part [7] - 2815:22,
2844:14, 2856:16,
2876:4, 2887:4,
2904:9, 2905:21
partially [4] - 2872:18,
2884:25, 2889:24,
2907:16
particle [3] - 2851:11,
2882:6, 2885:6
particles [27] - 2850:8,
2851:7, 2851:13,
2851:21, 2851:23,
2852:1, 2852:6,
2852:8, 2852:16,
2852:21, 2865:7,
2865:10, 2865:15,
2879:20, 2880:6,
2880:24, 2881:5,
2881:9, 2881:15,
2883:9, 2884:18,
2884:24, 2885:4,
2885:16, 2886:19,
2886:25
particular [33] -
2781:18, 2790:21,
2790:24, 2793:2,
2794:15, 2797:15,
2800:6, 2801:11,
2805:15, 2813:13,
2813:20, 2813:21,
2813:22, 2815:11,
2821:25, 2822:24,

2828:9, 2829:2,
2829:20, 2829:23,
2830:14, 2830:25,
2832:21, 2833:15,
2836:2, 2839:13,
2839:20, 2841:17,
2852:9, 2882:11,
2885:21
particularly [2] -
2875:22, 2905:21
parties [2] - 2773:18,
2774:17
partners [1] - 2888:4
parts [1] - 2906:21
pascals [3] - 2891:17,
2913:4, 2913:22
pass [6] - 2863:5,
2864:14, 2878:2,
2878:14, 2881:10,
2885:1
passage [1] - 2883:16
passages [1] -
2881:10
passes [2] - 2879:1,
2881:12
passing [3] - 2853:8,
2879:21, 2886:20
past [10] - 2779:11,
2869:7, 2871:23,
2872:4, 2874:12,
2874:17, 2875:23,
2902:21, 2907:25
path [14] - 2780:3,
2780:8, 2780:13,
2783:7, 2784:8,
2784:15, 2784:16,
2784:17, 2810:24,
2816:4, 2816:7,
2816:12, 2856:11,
2857:19
paths [2] - 2803:11,
2803:16
pathway [1] - 2906:13
pattern [4] - 2800:24,
2820:16, 2865:6,
2882:11
patterns [9] - 2776:5,
2776:9, 2776:13,
2789:11, 2791:13,
2796:8, 2799:14,
2799:16, 2820:20
PAUL [1] - 2769:10
peak [1] - 2801:5
peer [1] - 2850:11
peer-reviewed [1] -
2850:11
PENCAK [2] -
2774:12, 2774:22
Pencak [1] - 2774:12
pending [1] - 2843:9

<p>PENNSYLVANIA [1] - 2769:23</p> <p>PENSACOLA [1] - 2767:5</p> <p>people [2] - 2773:10, 2915:11</p> <p>per [11] - 2790:6, 2790:10, 2790:13, 2790:15, 2791:4, 2791:5, 2791:10, 2791:11, 2797:21, 2832:6, 2913:10</p> <p>percent [11] - 2805:6, 2805:8, 2827:22, 2840:16, 2848:4, 2872:21, 2892:15, 2893:6, 2893:7, 2893:8, 2912:6</p> <p>perfect [3] - 2867:1, 2875:8, 2886:4</p> <p>perfectly [2] - 2783:9, 2783:14</p> <p>perform [2] - 2781:12, 2909:23</p> <p>performed [3] - 2815:18, 2889:3, 2915:15</p> <p>perimeter [34] - 2782:17, 2784:25, 2785:5, 2785:11, 2793:18, 2802:19, 2802:24, 2803:3, 2803:4, 2804:5, 2804:9, 2808:3, 2808:15, 2809:1, 2809:9, 2809:16, 2809:18, 2809:19, 2810:10, 2810:12, 2810:14, 2810:19, 2812:4, 2812:20, 2812:22, 2812:23, 2814:14, 2815:1, 2819:9, 2823:12, 2824:2, 2829:6</p> <p>perimeters [6] - 2802:21, 2808:7, 2812:12, 2812:13, 2812:19, 2813:10</p> <p>period [27] - 2779:6, 2779:11, 2779:12, 2779:23, 2785:14, 2788:4, 2845:11, 2853:4, 2853:20, 2856:1, 2857:6, 2858:1, 2867:12, 2873:16, 2873:18, 2888:24, 2894:17, 2894:23, 2897:13, 2901:12, 2903:8, 2903:9, 2903:14,</p>	<p>2907:2, 2907:5, 2907:14, 2910:22</p> <p>permission [1] - 2863:23</p> <p>perpendicular [1] - 2871:16</p> <p>persisted [1] - 2899:7</p> <p>personally [1] - 2866:15</p> <p>perspective [3] - 2859:9, 2905:8, 2910:19</p> <p>perturbed [1] - 2899:22</p> <p>PETITION [1] - 2766:8</p> <p>PETOSA [1] - 2767:18</p> <p>PETROLEUM [1] - 2771:7</p> <p>Ph.D [8] - 2842:25, 2844:11, 2844:17, 2844:18, 2844:20, 2846:16, 2846:17, 2849:3</p> <p>phase [21] - 2776:17, 2777:3, 2777:11, 2777:12, 2777:14, 2778:1, 2778:3, 2778:4, 2778:5, 2778:12, 2780:22, 2789:19, 2799:18, 2820:25, 2821:3, 2821:5, 2822:5, 2834:17, 2839:3, 2839:4</p> <p>phases [4] - 2778:9, 2800:23, 2801:2, 2801:7</p> <p>phenomena [1] - 2851:5</p> <p>phenomenon [2] - 2781:4, 2792:23</p> <p>photo [1] - 2872:6</p> <p>photograph [3] - 2870:8, 2871:11, 2875:3</p> <p>photographs [5] - 2866:3, 2867:9, 2868:10, 2868:17, 2868:20</p> <p>phrase [2] - 2787:20, 2787:21</p> <p>physical [8] - 2863:24, 2882:16, 2886:2, 2888:23, 2891:1, 2899:6, 2909:5, 2915:12</p> <p>physically [2] - 2891:4, 2891:8</p> <p>Pi [1] - 2805:10</p> <p>pick [10] - 2835:19,</p>	<p>2861:1, 2861:4, 2862:8, 2863:2, 2863:23, 2876:13, 2884:4, 2884:7, 2886:10</p> <p>picked [2] - 2860:2, 2877:4</p> <p>picking [1] - 2864:1</p> <p>picture [12] - 2851:20, 2862:14, 2867:3, 2870:5, 2870:13, 2870:23, 2873:3, 2873:6, 2875:16, 2878:9, 2884:13, 2910:14</p> <p>pictures [10] - 2821:13, 2857:15, 2858:21, 2860:18, 2860:22, 2860:23, 2861:2, 2874:7, 2875:8, 2883:5</p> <p>piece [11] - 2852:4, 2865:18, 2869:9, 2872:3, 2873:8, 2873:24, 2874:11, 2875:8, 2875:13, 2907:22</p> <p>pieces [7] - 2857:15, 2861:25, 2864:18, 2871:6, 2873:6, 2902:23, 2907:17</p> <p>pinch [1] - 2878:21</p> <p>pinched [2] - 2878:13, 2878:14</p> <p>pioneering [1] - 2849:3</p> <p>pipe [84] - 2782:2, 2782:7, 2782:8, 2782:11, 2782:13, 2782:24, 2782:25, 2783:1, 2783:9, 2783:11, 2783:14, 2783:15, 2783:23, 2783:24, 2784:1, 2784:2, 2784:9, 2784:12, 2785:4, 2786:13, 2786:15, 2786:18, 2786:19, 2786:22, 2789:4, 2790:1, 2790:2, 2791:21, 2792:5, 2792:6, 2792:11, 2794:8, 2795:8, 2795:9, 2795:10, 2820:4, 2824:14, 2825:10, 2827:7, 2827:16, 2827:17, 2828:16, 2828:18, 2828:20, 2829:1, 2829:2, 2829:25,</p>	<p>2830:17, 2830:18, 2831:7, 2832:5, 2832:24, 2834:24, 2836:21, 2838:2, 2838:10, 2838:11, 2838:15, 2838:18, 2841:3, 2845:16, 2845:24, 2865:4, 2865:5, 2866:16, 2866:18, 2866:25, 2867:5, 2867:12, 2867:18, 2868:4, 2869:7, 2869:10, 2872:17, 2875:10, 2875:20, 2875:24, 2885:12, 2885:16, 2911:21</p> <p>pipeline [1] - 2824:12</p> <p>pipelines [1] - 2848:16</p> <p>pipes [28] - 2795:14, 2824:17, 2825:8, 2827:15, 2828:14, 2829:21, 2829:24, 2830:10, 2830:13, 2830:21, 2831:4, 2831:5, 2831:8, 2831:16, 2833:12, 2836:15, 2836:17, 2836:18, 2837:16, 2837:21, 2838:1, 2838:12, 2838:17, 2838:20, 2838:23, 2848:12, 2883:14</p> <p>place [6] - 2779:1, 2855:9, 2862:16, 2867:12, 2872:4, 2896:20</p> <p>placed [1] - 2842:8</p> <p>PLAINTIFFS [1] - 2766:19</p> <p>plane [2] - 2883:1, 2883:7</p> <p>plates [1] - 2794:16</p> <p>play [2] - 2883:22, 2902:3</p> <p>PLC [1] - 2769:4</p> <p>pleasure [1] - 2864:3</p> <p>Plexiglas [1] - 2884:12</p> <p>plot [1] - 2901:8</p> <p>plug [1] - 2835:20</p> <p>plunk [1] - 2806:24</p> <p>plus [2] - 2803:1, 2803:4</p> <p>point [29] - 2776:11, 2792:20, 2792:21, 2794:14, 2794:15, 2823:12, 2850:18, 2851:10, 2855:18,</p>	<p>2857:20, 2861:10, 2861:24, 2868:8, 2868:25, 2876:10, 2885:11, 2888:6, 2888:8, 2888:23, 2890:11, 2891:20, 2891:21, 2893:18, 2895:13, 2898:5, 2899:17, 2899:18, 2902:17</p> <p>points [21] - 2779:3, 2853:16, 2856:6, 2868:14, 2868:17, 2869:2, 2880:21, 2888:14, 2890:13, 2890:24, 2892:12, 2892:14, 2893:14, 2902:15, 2902:22, 2903:1, 2915:8, 2915:12, 2915:22, 2915:25</p> <p>POLK [1] - 2771:8</p> <p>populated [1] - 2880:21</p> <p>portion [1] - 2818:2</p> <p>portions [2] - 2790:12, 2827:7</p> <p>posed [1] - 2865:24</p> <p>posited [1] - 2817:14</p> <p>position [9] - 2800:3, 2845:2, 2846:11, 2846:12, 2847:4, 2856:5, 2865:3, 2872:16, 2888:20</p> <p>possession [1] - 2773:15</p> <p>possible [10] - 2787:11, 2788:10, 2882:6, 2890:16, 2893:16, 2902:16, 2903:1, 2915:9, 2915:16, 2915:17</p> <p>POST [3] - 2766:24, 2768:6, 2768:15</p> <p>post [4] - 2912:22, 2913:1, 2913:16, 2914:1</p> <p>post-erosion [4] - 2912:22, 2913:1, 2913:16, 2914:1</p> <p>potential [1] - 2802:11</p> <p>pounding [1] - 2865:18</p> <p>POYDRAS [4] - 2769:6, 2770:7, 2771:10, 2771:18</p> <p>PR [1] - 2818:7</p> <p>pre [8] - 2854:2, 2861:7, 2886:24, 2910:2, 2910:3,</p>
--	--	--	--	--

<p>2910:10, 2913:3, 2913:16</p> <p>pre-eroded [3] - 2854:2, 2861:7, 2886:24</p> <p>pre-erosion [5] - 2910:2, 2910:3, 2910:10, 2913:3, 2913:16</p> <p>precise [2] - 2853:7, 2886:12</p> <p>precisely [4] - 2779:9, 2792:20, 2792:21, 2897:20</p> <p>predict [9] - 2778:25, 2801:17, 2835:21, 2888:4, 2888:7, 2888:9, 2889:10, 2902:18, 2904:6</p> <p>predicted [7] - 2840:18, 2881:14, 2881:23, 2882:12, 2885:24, 2886:2, 2886:5</p> <p>predicting [3] - 2826:20, 2836:4, 2904:17</p> <p>predictive [1] - 2835:15</p> <p>preliminary [1] - 2774:13</p> <p>premise [2] - 2794:13, 2804:17</p> <p>prepare [1] - 2841:24</p> <p>prepared [1] - 2852:24</p> <p>PRESCOTT [1] - 2770:21</p> <p>presence [1] - 2853:9</p> <p>present [14] - 2775:15, 2779:13, 2786:25, 2789:20, 2802:12, 2808:2, 2846:21, 2851:17, 2861:13, 2874:9, 2897:15, 2912:15, 2913:15, 2915:4</p> <p>presented [5] - 2775:16, 2778:18, 2885:22, 2906:4, 2906:5</p> <p>pressure [106] - 2781:5, 2785:4, 2785:13, 2785:16, 2785:21, 2785:24, 2786:16, 2787:3, 2787:6, 2788:8, 2788:22, 2793:19, 2793:24, 2793:25, 2794:1, 2794:10, 2794:20, 2795:22,</p>	<p>2798:14, 2798:17, 2798:21, 2803:10, 2803:16, 2803:19, 2803:22, 2805:17, 2805:23, 2816:25, 2817:16, 2817:23, 2818:7, 2819:15, 2820:9, 2821:8, 2823:1, 2823:10, 2824:7, 2824:8, 2824:10, 2824:12, 2824:14, 2824:25, 2825:13, 2826:13, 2828:24, 2829:9, 2829:11, 2829:12, 2829:14, 2836:22, 2837:1, 2837:3, 2839:19, 2841:5, 2841:6, 2845:22, 2877:16, 2877:17, 2877:23, 2878:4, 2878:8, 2878:11, 2878:15, 2878:16, 2878:17, 2878:20, 2878:25, 2879:2, 2879:5, 2879:7, 2879:9, 2881:21, 2885:20, 2887:6, 2891:15, 2891:17, 2892:5, 2892:21, 2893:25, 2894:15, 2896:5, 2896:7, 2896:13, 2896:16, 2896:17, 2896:19, 2896:21, 2896:22, 2896:23, 2897:2, 2897:9, 2900:4, 2900:16, 2900:17, 2901:8, 2902:1, 2910:3, 2912:22, 2912:25, 2913:7, 2913:13, 2913:15, 2914:1, 2915:1</p> <p>presume [2] - 2781:9, 2803:5</p> <p>presumed [1] - 2803:2</p> <p>presuming [2] - 2783:14, 2798:24</p> <p>pretend [2] - 2783:9, 2811:24</p> <p>pretty [2] - 2861:25, 2863:7</p> <p>preventer [4] - 2866:1, 2866:13, 2866:16, 2867:10</p> <p>previous [6] - 2823:9, 2823:21, 2823:25, 2848:20, 2852:22, 2901:8</p> <p>previously [1] -</p>	<p>2876:25</p> <p>principal [1] - 2845:4</p> <p>principle [1] - 2819:12</p> <p>pristine [10] - 2854:2, 2856:14, 2859:2, 2864:9, 2866:8, 2887:12, 2897:18, 2897:19, 2902:10, 2910:9</p> <p>privilege [3] - 2888:10, 2892:19, 2902:23</p> <p>probe [1] - 2882:9</p> <p>problem [6] - 2781:13, 2781:18, 2781:20, 2805:25, 2815:11, 2847:23</p> <p>problems [17] - 2780:16, 2780:18, 2780:20, 2780:22, 2780:24, 2781:1, 2781:8, 2781:9, 2781:16, 2791:3, 2811:6, 2831:11, 2844:25, 2848:3, 2848:5, 2849:21, 2902:14</p> <p>procedure [2] - 2820:3, 2854:16</p> <p>proceed [1] - 2843:17</p> <p>proceeded [1] - 2856:1</p> <p>PROCEEDINGS [3] - 2766:14, 2771:23, 2773:1</p> <p>Proceedings [2] - 2842:22, 2916:9</p> <p>process [8] - 2775:23, 2856:15, 2856:16, 2858:23, 2881:11, 2906:9, 2910:24</p> <p>PROCTOR [1] - 2767:3</p> <p>produced [7] - 2866:5, 2866:9, 2873:22, 2874:5, 2874:15, 2913:20, 2914:2</p> <p>PRODUCED [1] - 2771:23</p> <p>producing [1] - 2865:5</p> <p>PRODUCTION [3] - 2766:11, 2769:3, 2769:4</p> <p>production [19] - 2831:5, 2845:1, 2845:17, 2859:17, 2859:23, 2859:24, 2869:20, 2873:22, 2877:3, 2903:15,</p>	<p>2907:11, 2907:15, 2907:18, 2908:16, 2908:20, 2909:10, 2909:20, 2909:22, 2915:23</p> <p>professor [1] - 2847:8</p> <p>profile [4] - 2788:24, 2789:2, 2801:15</p> <p>profiles [12] - 2787:6, 2787:7, 2787:11, 2788:8, 2788:9, 2788:16, 2788:22, 2788:23</p> <p>programs [1] - 2889:13</p> <p>progressively [1] - 2856:17</p> <p>project [2] - 2845:6, 2890:11</p> <p>projects [4] - 2845:6, 2845:13, 2846:17, 2848:1</p> <p>proof [1] - 2774:2</p> <p>prop [3] - 2861:1, 2864:17, 2884:4</p> <p>proper [1] - 2787:18</p> <p>properly [2] - 2843:13, 2873:4</p> <p>proportional [4] - 2785:3, 2785:5, 2785:8, 2900:16</p> <p>proposition [2] - 2817:17, 2821:7</p> <p>props [1] - 2876:13</p> <p>prove [2] - 2899:5, 2906:1</p> <p>proven [1] - 2842:11</p> <p>provide [7] - 2779:20, 2779:22, 2779:23, 2799:13, 2803:23, 2808:24, 2841:25</p> <p>provided [10] - 2802:18, 2802:22, 2808:23, 2808:25, 2809:8, 2812:3, 2812:22, 2815:17, 2815:22, 2879:12</p> <p>providing [2] - 2904:10, 2906:24</p> <p>psi [6] - 2891:18, 2896:16, 2896:20, 2913:22, 2914:2, 2914:3</p> <p>published [2] - 2850:14, 2850:16</p> <p>pull [19] - 2776:25, 2784:19, 2789:13, 2796:11, 2796:21, 2815:15, 2816:22, 2818:2, 2818:25,</p>	<p>2820:21, 2826:7, 2834:11, 2837:12, 2839:23, 2841:19, 2861:21, 2864:4, 2864:5, 2878:3</p> <p>punched [3] - 2815:8, 2815:10, 2874:16</p> <p>pure [1] - 2846:11</p> <p>purpose [4] - 2795:17, 2836:25, 2841:4, 2889:18</p> <p>push [6] - 2794:6, 2801:3, 2862:19, 2862:20, 2864:6, 2864:10</p> <p>pushed [3] - 2859:4, 2863:15, 2887:4</p> <p>pushes [2] - 2879:10</p> <p>pushing [2] - 2794:8, 2794:10</p> <p>put [15] - 2800:11, 2804:2, 2811:23, 2813:9, 2813:25, 2814:17, 2825:6, 2832:10, 2853:20, 2855:3, 2856:5, 2870:14, 2877:16, 2879:25, 2886:13</p> <p>putting [1] - 2805:5</p>
Q				
			<p>QA [1] - 2825:18</p> <p>quadratic [1] - 2900:21</p> <p>qualifications [1] - 2849:15</p> <p>qualifying [2] - 2912:3, 2912:4</p> <p>quantified [1] - 2902:25</p> <p>quantities [1] - 2873:23</p> <p>quarters [1] - 2782:12</p> <p>Queensland [3] - 2846:5, 2846:13, 2847:1</p> <p>questions [4] - 2837:5, 2837:11, 2839:1, 2842:15</p> <p>quick [1] - 2865:10</p> <p>quickly [2] - 2834:12, 2863:17</p> <p>quite [11] - 2781:18, 2783:21, 2789:22, 2800:12, 2823:13, 2836:18, 2836:20, 2838:14, 2860:23, 2878:10</p> <p>quote [1] - 2865:17</p>	

R

radius [2] - 2784:1, 2784:2

RAFFERTY [1] - 2767:3

raise [1] - 2843:12

ram [23] - 2855:9, 2860:9, 2860:18, 2861:8, 2862:11, 2863:21, 2876:14, 2884:3, 2884:7, 2885:25, 2886:20, 2895:9, 2897:24, 2910:6, 2910:8, 2911:17, 2912:12, 2912:17, 2912:23, 2913:1, 2914:14, 2914:16, 2915:4

rams [39] - 2855:19, 2855:21, 2855:22, 2857:8, 2858:16, 2859:2, 2860:16, 2860:25, 2861:5, 2862:23, 2863:3, 2863:9, 2863:17, 2864:9, 2864:25, 2865:14, 2865:21, 2874:12, 2879:17, 2883:21, 2885:16, 2886:11, 2886:16, 2887:4, 2895:23, 2895:24, 2898:19, 2899:8, 2899:20, 2899:22, 2910:5, 2910:14, 2912:5, 2912:9, 2914:2, 2914:6

ran [6] - 2787:4, 2788:3, 2889:20, 2898:24, 2908:19

range [1] - 2779:23

rarely [2] - 2890:7, 2902:22

rate [112] - 2775:22, 2775:24, 2776:16, 2776:18, 2776:20, 2777:5, 2777:11, 2777:12, 2778:8, 2778:11, 2778:12, 2778:18, 2779:22, 2785:13, 2786:16, 2787:3, 2793:11, 2794:5, 2795:22, 2803:12, 2803:17, 2803:20, 2804:15, 2805:12, 2805:13, 2805:16, 2805:22, 2806:4, 2807:2, 2809:23, 2810:2,

2814:18, 2815:2, 2815:9, 2816:25, 2821:8, 2821:17, 2821:18, 2821:19, 2822:7, 2822:18, 2823:1, 2823:2, 2823:3, 2823:8, 2823:17, 2823:20, 2824:25, 2825:14, 2825:15, 2825:25, 2826:4, 2829:12, 2834:17, 2835:3, 2835:11, 2835:12, 2836:4, 2836:8, 2841:5, 2844:4, 2854:15, 2856:22, 2877:11, 2878:5, 2878:20, 2878:21, 2878:25, 2879:3, 2879:5, 2889:21, 2889:24, 2896:17, 2896:18, 2897:7, 2899:12, 2899:16, 2899:20, 2900:4, 2900:7, 2901:3, 2901:4, 2901:15, 2901:17, 2901:18, 2901:21, 2902:3, 2902:5, 2902:7, 2903:3, 2904:3, 2904:6, 2904:10, 2904:13, 2904:15, 2904:17, 2904:20, 2905:5, 2905:16, 2906:3, 2906:18, 2907:10, 2912:2, 2913:6, 2913:7, 2913:13, 2913:21, 2914:3, 2914:4, 2915:23

rates [23] - 2775:15, 2775:17, 2778:9, 2778:25, 2779:7, 2779:23, 2794:24, 2799:14, 2801:9, 2801:17, 2806:9, 2807:25, 2817:15, 2837:1, 2904:18, 2904:23, 2905:21, 2905:23, 2906:5, 2906:10, 2906:12

rather [1] - 2861:2

ratio [23] - 2784:24, 2785:10, 2789:20, 2797:6, 2797:11, 2798:1, 2798:4, 2798:7, 2798:8, 2798:25, 2799:23, 2805:10, 2814:14, 2823:12, 2823:14, 2824:1, 2824:15,

2827:15, 2827:18, 2827:20, 2827:22, 2839:10, 2896:22

ratios [2] - 2795:13, 2797:20

RE [2] - 2766:4, 2766:7

reach [2] - 2892:24, 2900:6

reached [1] - 2855:15

read [5] - 2796:2, 2796:11, 2826:16, 2877:1, 2905:24

reading [2] - 2821:25, 2896:13

ready [2] - 2881:2, 2908:5

real [16] - 2830:1, 2830:6, 2830:11, 2830:15, 2830:20, 2831:10, 2831:12, 2834:12, 2836:14, 2859:10, 2861:13, 2884:22, 2891:19, 2902:14, 2906:6, 2906:9

realistic [3] - 2861:12, 2864:5, 2891:4

reality [13] - 2805:22, 2830:19, 2831:8, 2834:21, 2835:11, 2851:12, 2864:7, 2880:1, 2882:4, 2882:18, 2886:1

realize [1] - 2898:21

really [24] - 2787:15, 2793:13, 2794:23, 2799:5, 2800:15, 2811:19, 2823:17, 2823:22, 2827:4, 2835:14, 2868:24, 2870:10, 2875:14, 2878:14, 2878:17, 2878:21, 2879:9, 2882:7, 2891:17, 2894:16, 2902:15, 2905:20, 2907:25, 2908:24

REALTIME [1] - 2771:17

reason [9] - 2784:22, 2785:2, 2788:7, 2847:24, 2859:19, 2883:13, 2896:15, 2901:15, 2909:7

reasonable [1] - 2874:17

reasons [4] - 2890:24, 2899:4, 2908:10, 2909:21

reasserting [1] - 2774:2

receive [1] - 2773:18

received [2] - 2774:18, 2844:18

recent [2] - 2828:6, 2828:8

recently [1] - 2828:10

recess [2] - 2842:21, 2842:22

Recess [1] - 2916:9

recognize [5] - 2796:4, 2815:24, 2818:5, 2828:7, 2862:16

recollection [1] - 2914:7

recommending [1] - 2842:9

record [4] - 2843:3, 2843:24, 2867:16, 2885:24

RECORDED [1] - 2771:23

recovered [8] - 2854:3, 2866:15, 2885:19, 2885:25, 2887:18, 2897:19, 2905:18, 2906:22

recovering [1] - 2873:7

recovery [2] - 2839:20, 2887:20

rectangular [2] - 2840:5, 2840:6

red [6] - 2870:7, 2881:13, 2882:13, 2885:10, 2898:8, 2899:21

Redirect [1] - 2772:5

redirect [2] - 2837:6, 2837:10

REDIRECT [1] - 2837:7

reduce [1] - 2840:15

referenced [1] - 2881:25

referred [5] - 2821:10, 2822:11, 2866:18, 2883:7, 2915:15

referring [8] - 2780:4, 2830:12, 2831:7, 2838:12, 2866:21, 2868:12, 2911:11, 2914:8

refers [2] - 2832:14, 2905:9

reflects [1] - 2908:6

REGAN [1] - 2769:11

regard [4] - 2846:20,

2849:14, 2850:13, 2886:8

regarding [1] - 2839:1

regards [1] - 2821:10

regime [16] - 2796:4, 2797:4, 2797:5, 2797:9, 2797:19, 2798:1, 2799:20, 2799:21, 2800:8, 2800:10, 2800:17, 2800:18, 2800:20, 2800:24, 2801:12, 2820:16

regimes [4] - 2776:11, 2776:13, 2796:7, 2801:11

regions [1] - 2882:14

REGISTERED [1] - 2771:18

regular [1] - 2816:20

rejecting [1] - 2803:21

relate [3] - 2837:1, 2837:2, 2841:14

related [9] - 2805:10, 2826:2, 2826:3, 2844:25, 2845:7, 2845:15, 2845:17, 2906:6, 2914:6

relates [1] - 2822:12

relating [2] - 2784:23, 2819:14

relation [3] - 2870:3, 2895:12, 2897:14

relations [1] - 2841:18

relationship [27] - 2783:4, 2785:9, 2785:10, 2785:12, 2786:16, 2793:17, 2793:20, 2794:20, 2795:21, 2803:19, 2806:1, 2817:15, 2819:16, 2822:19, 2823:6, 2823:7, 2823:9, 2825:24, 2826:13, 2828:24, 2829:6, 2829:14, 2835:20, 2841:5, 2842:11, 2900:21, 2901:9

relationships [1] - 2829:12

relative [7] - 2797:18, 2797:20, 2799:17, 2800:23, 2801:2, 2801:7

relatively [1] - 2883:16

release [1] - 2845:25

released [2] - 2828:11, 2880:24

relevant [3] - 2800:23,

<p>2846:8, 2858:2 reliability [1] - 2888:15 reliable [2] - 2890:19, 2902:24 reliably [1] - 2892:9 relied [2] - 2873:22, 2874:3 rely [2] - 2873:9, 2909:21 remaining [4] - 2774:19, 2774:25, 2775:1, 2888:22 remarkable [1] - 2882:19 remember [7] - 2776:6, 2787:8, 2799:6, 2802:13, 2827:15, 2890:10, 2913:12 remind [3] - 2843:8, 2879:17, 2898:10 removed [1] - 2851:6 RENAISSANCE [1] - 2770:22 repeat [7] - 2776:21, 2783:12, 2803:13, 2812:16, 2816:11, 2907:12, 2912:24 repeated [4] - 2851:6, 2851:12, 2886:9, 2886:11 rephrase [1] - 2803:9 replace [1] - 2820:4 replica [2] - 2861:12 report [12] - 2779:16, 2782:20, 2795:23, 2796:2, 2852:24, 2854:20, 2854:23, 2894:5, 2906:4, 2906:5, 2907:2, 2913:17 REPORTER [3] - 2771:17, 2771:17, 2771:18 Reporter [1] - 2916:13 represent [3] - 2789:9, 2796:22, 2798:5 representation [3] - 2777:4, 2786:9, 2893:11 representative [4] - 2788:8, 2788:22, 2788:25, 2789:1 represented [1] - 2894:6 represents [4] - 2796:6, 2818:5, 2818:7, 2891:12 required [1] - 2809:2</p>	<p>requires [1] - 2793:5 research [11] - 2833:6, 2844:23, 2845:4, 2846:11, 2846:12, 2846:16, 2847:16, 2848:5, 2848:7, 2848:10, 2849:7 resistance [11] - 2786:19, 2786:22, 2824:13, 2841:7, 2856:3, 2856:7, 2887:7, 2891:15, 2894:16, 2894:22, 2910:17 resolve [1] - 2849:21 RESOURCES [1] - 2768:18 respect [3] - 2779:12, 2811:22, 2897:6 respond [1] - 2774:4 response [4] - 2774:6, 2774:10, 2815:19, 2906:22 rest [2] - 2856:11, 2874:5 restate [1] - 2911:14 restrict [1] - 2853:25 restricted [1] - 2858:20 restricting [1] - 2868:5 restriction [26] - 2855:22, 2856:10, 2862:24, 2863:14, 2867:10, 2867:13, 2867:23, 2868:7, 2868:8, 2868:11, 2878:10, 2878:19, 2879:3, 2879:5, 2879:8, 2879:12, 2888:21, 2895:25, 2897:13, 2897:14, 2898:1, 2898:4, 2901:11, 2903:7 restrictions [14] - 2854:14, 2855:20, 2856:2, 2857:23, 2877:14, 2886:7, 2888:19, 2892:10, 2892:17, 2893:25, 2894:8, 2900:6, 2900:25, 2903:4 restrictive [2] - 2854:8, 2857:4 result [10] - 2779:7, 2798:9, 2799:3, 2805:16, 2806:4, 2825:13, 2836:6, 2838:19, 2881:17, 2890:5 results [8] - 2775:14,</p>	<p>2775:16, 2827:18, 2827:20, 2878:11, 2878:20, 2879:3, 2915:4 retained [1] - 2889:17 reviewed [1] - 2850:11 Reynolds [5] - 2820:4, 2820:10, 2820:12, 2820:18, 2820:23 rho [6] - 2796:15, 2796:18, 2796:22, 2796:24, 2818:9, 2818:12 RICHARD [2] - 2768:22, 2779:14 RICHESON [1] - 2771:9 RIG [1] - 2766:4 ring [1] - 2814:17 ripple [1] - 2790:22 ripples [2] - 2789:23, 2790:7 rippling [1] - 2790:2 riser [87] - 2778:20, 2778:24, 2779:7, 2782:5, 2782:9, 2782:10, 2782:12, 2783:10, 2783:15, 2784:9, 2787:1, 2787:8, 2787:12, 2788:5, 2788:10, 2788:17, 2788:25, 2789:5, 2791:8, 2791:20, 2792:4, 2794:6, 2794:7, 2794:11, 2795:6, 2799:3, 2799:4, 2799:10, 2800:3, 2800:4, 2800:21, 2800:25, 2801:4, 2801:11, 2801:13, 2802:15, 2809:4, 2812:3, 2825:8, 2827:17, 2827:21, 2827:22, 2834:22, 2834:23, 2838:11, 2846:23, 2848:23, 2855:10, 2857:3, 2857:9, 2859:14, 2867:15, 2867:17, 2867:22, 2868:4, 2868:12, 2868:13, 2868:17, 2869:4, 2869:22, 2870:4, 2870:7, 2870:15, 2870:20, 2874:2, 2874:16, 2875:1, 2876:23, 2880:17, 2882:1, 2882:8,</p>	<p>2882:11, 2899:1, 2899:7, 2903:4, 2903:6, 2905:13, 2906:21, 2907:24, 2910:9, 2911:5, 2911:18, 2911:21, 2912:5 RMR [1] - 2771:17 Robert [1] - 2773:16 ROBERT [2] - 2769:18, 2769:23 ROBERTS [1] - 2770:10 Roberts [1] - 2797:13 ROBIN [1] - 2767:7 role [1] - 2848:21 roll [1] - 2852:7 ROOM [1] - 2771:18 root [3] - 2882:4, 2900:18, 2900:21 rotated [1] - 2870:14 rotation [1] - 2870:9 ROUGE [1] - 2768:6 roughly [5] - 2805:10, 2815:2, 2872:15, 2875:20, 2880:18 round [2] - 2814:22, 2815:1 ROV [1] - 2779:13 ROY [2] - 2766:22, 2766:23 rule [1] - 2876:6 run [3] - 2788:20, 2788:21, 2880:9 running [3] - 2831:6, 2831:8, 2884:19</p>	<p>2908:19, 2909:10, 2909:20, 2909:22, 2915:23 SARAH [1] - 2768:23 Sarah [1] - 2773:25 Saskatchewan [1] - 2844:12 satisfactory [1] - 2820:3 saw [14] - 2821:20, 2821:22, 2822:8, 2833:19, 2834:2, 2864:9, 2875:9, 2875:21, 2877:1, 2885:19, 2886:2, 2889:20, 2891:7 scale [7] - 2781:4, 2781:9, 2797:7, 2836:12, 2896:4, 2896:5, 2898:9 scaled [1] - 2798:8 scan [1] - 2880:20 scans [1] - 2906:20 scenario [3] - 2795:5, 2808:2, 2836:17 schedule [1] - 2895:8 SHELL [1] - 2771:8 school [1] - 2811:19 science [10] - 2792:24, 2795:1, 2801:19, 2806:3, 2808:11, 2811:18, 2811:20, 2815:12, 2822:12, 2835:17 scientific [2] - 2907:7, 2912:19 scientifically [1] - 2893:14 scientist [1] - 2845:4 scientists [1] - 2811:9 SCOTT [1] - 2768:20 scrape [1] - 2852:7 screen [9] - 2860:24, 2862:1, 2862:6, 2864:16, 2864:19, 2868:25, 2880:13, 2880:18, 2884:18 screens [1] - 2880:14 Sea [3] - 2845:1, 2845:8, 2845:9 seal [5] - 2859:6, 2859:8, 2862:4, 2867:1 sealed [1] - 2865:23 SEAN [1] - 2770:22 seat [1] - 2843:2 seated [1] - 2842:23 second [13] - 2791:5, 2791:6, 2791:11, 2851:22, 2858:22,</p>
S				
<p>safe [2] - 2860:2, 2877:7 safely [4] - 2833:13, 2833:16, 2852:20, 2907:20 safer [1] - 2892:13 sake [2] - 2827:2, 2834:22 sand [31] - 2851:7, 2851:21, 2851:23, 2853:9, 2859:17, 2859:23, 2859:24, 2865:6, 2866:5, 2869:20, 2873:21, 2873:22, 2874:5, 2874:9, 2874:15, 2877:3, 2881:6, 2882:24, 2902:11, 2903:15, 2907:11, 2907:15, 2907:18, 2907:19, 2908:16,</p>				

2861:17, 2862:10,
2863:12, 2872:2,
2875:22, 2877:21,
2889:11
SECTION [4] - 2766:4,
2766:8, 2766:11,
2768:19
section [23] - 2812:3,
2821:15, 2821:21,
2821:25, 2827:17,
2827:21, 2830:12,
2830:25, 2831:20,
2832:22, 2832:24,
2833:1, 2833:15,
2867:5, 2867:7,
2867:19, 2867:20,
2867:21, 2875:23,
2881:7, 2883:6,
2884:25
sectional [10] -
2784:24, 2785:3,
2816:16, 2819:8,
2822:10, 2823:3,
2825:12, 2825:25,
2868:2, 2868:3
sections [2] -
2819:20, 2820:2
see [101] - 2779:6,
2782:3, 2789:23,
2790:1, 2790:2,
2790:7, 2791:23,
2792:9, 2792:13,
2792:16, 2796:9,
2796:16, 2796:23,
2797:2, 2797:15,
2800:7, 2800:9,
2801:11, 2804:2,
2806:19, 2814:6,
2817:19, 2817:24,
2818:1, 2818:4,
2819:19, 2820:6,
2823:16, 2831:19,
2831:22, 2833:19,
2837:17, 2838:16,
2857:19, 2858:8,
2858:10, 2860:24,
2861:24, 2861:25,
2862:6, 2862:14,
2862:15, 2864:16,
2864:19, 2864:20,
2864:22, 2864:25,
2865:12, 2865:14,
2867:6, 2868:16,
2868:18, 2869:2,
2870:9, 2870:12,
2870:13, 2870:21,
2872:2, 2872:6,
2872:7, 2872:10,
2872:13, 2872:15,
2872:25, 2873:4,

2875:10, 2875:17,
2876:2, 2876:15,
2876:17, 2878:12,
2880:14, 2880:17,
2880:23, 2881:6,
2881:13, 2883:10,
2883:13, 2884:12,
2884:15, 2884:20,
2884:24, 2885:13,
2885:19, 2886:4,
2887:3, 2887:19,
2888:7, 2890:2,
2892:2, 2894:20,
2895:5, 2895:12,
2895:14, 2898:8,
2899:21, 2901:6,
2901:10, 2902:6
seeing [2] - 2790:16,
2860:21
seem [1] - 2887:1
sees [3] - 2878:9,
2881:4, 2883:5
segment [1] - 2827:19
segments [1] - 2782:6
select [2] - 2857:12,
2876:23
selected [1] - 2873:17
self [1] - 2841:13
self-consistent [1] -
2841:13
senior [1] - 2846:5
sense [3] - 2905:16,
2911:2, 2912:10
sensible [1] - 2909:6
separate [1] - 2814:3
separated [1] -
2901:25
separately [1] -
2910:12
series [3] - 2797:16,
2838:25, 2890:1
SERVICES [1] -
2770:19
SESSION [1] -
2766:14
set [2] - 2855:13,
2862:9
several [2] - 2782:6,
2802:1
severe [1] - 2859:5
severed [3] - 2865:3,
2865:5, 2867:7
severely [1] - 2858:22
severs [1] - 2858:18
shape [8] - 2798:18,
2798:23, 2830:18,
2833:14, 2871:12,
2876:12, 2876:14,
2876:15
shaped [4] - 2809:1,

2832:18, 2833:5,
2833:12
shapes [3] - 2803:22,
2805:2, 2826:14
share [2] - 2847:8,
2861:11
shared [2] - 2846:13,
2853:12
sharp [1] - 2865:8
shear [35] - 2855:9,
2859:2, 2860:9,
2860:18, 2861:5,
2861:7, 2862:11,
2863:21, 2876:14,
2884:3, 2884:7,
2885:16, 2885:25,
2886:16, 2886:20,
2887:4, 2895:9,
2895:24, 2897:24,
2898:19, 2910:6,
2910:8, 2910:14,
2911:17, 2912:5,
2912:9, 2912:12,
2912:17, 2912:23,
2912:25, 2914:1,
2914:6, 2914:14,
2914:16, 2915:4
sheer [26] - 2855:19,
2855:21, 2855:22,
2857:8, 2858:16,
2860:25, 2862:23,
2863:3, 2863:17,
2864:9, 2864:11,
2864:25, 2865:14,
2865:21, 2874:12,
2879:17, 2883:21,
2886:10, 2895:23,
2899:8, 2899:20,
2899:22, 2910:5
sheering [1] - 2875:18
SHELL [1] - 2769:5
short [2] - 2774:1,
2867:12
shortcut [3] - 2782:23,
2783:2, 2838:20
shot [1] - 2910:16
show [15] - 2811:17,
2846:3, 2847:1,
2855:23, 2858:22,
2859:14, 2862:7,
2863:3, 2863:12,
2863:18, 2880:3,
2880:6, 2884:5,
2886:17, 2894:14
showed [3] - 2823:23,
2858:21, 2904:5
showing [3] -
2855:14, 2878:4,
2906:21
shown [6] - 2857:16,

2866:4, 2867:3,
2872:8, 2879:24,
2913:25
shows [8] - 2842:1,
2851:10, 2875:4,
2884:2, 2884:16,
2894:15, 2895:9,
2897:11
shut [1] - 2897:24
shut-in [1] - 2897:24
shuts [2] - 2858:17,
2858:18
sibling [1] - 2872:11
side [19] - 2773:9,
2804:3, 2806:24,
2806:25, 2807:3,
2807:4, 2807:9,
2847:12, 2847:16,
2860:2, 2869:9,
2870:11, 2873:6,
2875:21, 2877:7,
2879:8, 2885:9,
2886:25, 2887:5
sides [9] - 2783:20,
2862:19, 2863:8,
2863:15, 2873:10,
2876:1, 2883:11,
2885:3, 2885:5
sideways [2] - 2863:6,
2883:9
significance [3] -
2852:12, 2884:21,
2902:9
significant [7] -
2855:19, 2855:22,
2858:5, 2860:3,
2860:22, 2864:6,
2903:6
Significant [1] -
2858:9
significantly [2] -
2799:10, 2856:1
signpost [2] -
2859:16, 2869:13
signposts [1] -
2854:11
similar [8] - 2794:21,
2794:22, 2796:8,
2876:17, 2886:23,
2888:1, 2889:19,
2890:21
simple [5] - 2851:24,
2868:1, 2878:9,
2892:20, 2900:21
simplest [4] -
2893:15, 2893:16,
2899:13, 2915:16
simplification [1] -
2851:9
simplify [3] - 2783:3,

2783:4, 2827:2
simply [2] - 2889:15,
2906:17
simulated [2] -
2861:19, 2889:23
simulation [12] -
2880:7, 2880:8,
2881:18, 2881:25,
2882:4, 2883:14,
2885:17, 2886:19,
2889:6, 2889:20,
2891:20, 2892:5
simulations [16] -
2856:13, 2863:11,
2884:2, 2889:17,
2890:17, 2890:21,
2890:23, 2892:18,
2892:20, 2894:11,
2898:17, 2898:24,
2899:25, 2913:21,
2914:5, 2915:15
simulator [3] - 2810:3,
2840:23, 2841:10
SINCLAIR [1] -
2767:22
single [12] - 2775:23,
2776:17, 2777:3,
2780:22, 2820:25,
2821:3, 2821:5,
2822:5, 2829:25,
2838:10, 2839:3,
2839:4
singled [2] - 2857:2,
2897:4
singling [1] - 2895:23
sit [1] - 2884:9
sits [2] - 2801:12,
2801:13
situation [18] - 2793:1,
2795:7, 2825:9,
2829:25, 2830:24,
2837:21, 2838:2,
2838:22, 2838:23,
2841:1, 2841:16,
2842:5, 2851:9,
2886:9, 2886:23,
2888:2, 2888:11,
2902:14
situations [1] -
2792:25
size [10] - 2780:8,
2795:11, 2804:18,
2804:22, 2806:25,
2807:4, 2810:6,
2810:24, 2811:24,
2817:24
sketch [1] - 2870:9
skip [1] - 2821:12
sliced [1] - 2873:3
slide [10] - 2841:23,

2844:6, 2844:8,
2846:3, 2849:14,
2850:11, 2855:3,
2855:6, 2858:8,
2878:4
slightly [3] - 2815:8,
2869:16, 2889:22
sliver [1] - 2802:14
slow [5] - 2789:16,
2790:11, 2790:16,
2790:25
slow-moving [1] -
2790:25
slowly [1] - 2884:22
slowly [1] - 2790:7
slug [9] - 2776:8,
2778:25, 2779:13,
2799:23, 2799:24,
2800:1, 2800:8,
2800:16, 2801:8
slugging [5] -
2799:22, 2800:2,
2800:7, 2800:17
slugs [3] - 2800:12,
2800:21, 2801:3
small [5] - 2783:23,
2784:2, 2784:12,
2802:14, 2880:14
smaller [9] - 2786:22,
2789:4, 2791:14,
2793:6, 2827:18,
2832:19, 2833:8,
2867:21, 2868:3
SMITH [1] - 2770:21
smooth [1] - 2798:7
snake [1] - 2884:16
so-called [8] -
2845:15, 2848:13,
2848:16, 2865:1,
2869:6, 2869:17,
2889:3, 2900:11
softer [1] - 2898:16
software [1] - 2830:14
SOILEAU [1] -
2767:14
sole [1] - 2903:7
solid [8] - 2851:6,
2851:7, 2852:16,
2881:5, 2890:9,
2895:4, 2895:9,
2895:11
solution [1] - 2826:1
solve [2] - 2822:7,
2849:24
solving [2] - 2821:16,
2841:13
something's [1] -
2888:5
sometimes [2] -
2832:19, 2888:1

somewhat [2] -
2868:13, 2884:6
somewhere [4] -
2797:22, 2798:25,
2871:24, 2880:17
sophisticated [2] -
2849:20, 2859:10
sophistication [1] -
2790:23
sorry [9] - 2792:21,
2804:17, 2808:20,
2809:24, 2828:19,
2833:22, 2852:21,
2911:10, 2915:6
sort [25] - 2776:12,
2782:22, 2800:6,
2811:18, 2822:25,
2830:17, 2837:20,
2841:17, 2866:11,
2867:19, 2870:2,
2870:12, 2871:17,
2871:21, 2871:25,
2872:15, 2875:18,
2876:3, 2876:15,
2883:15, 2903:16,
2908:23, 2909:10,
2910:13
sorts [1] - 2814:9
sound [1] - 2827:25
sounding [1] -
2848:10
sounds [1] - 2815:12
sources [2] - 2817:16,
2873:20
SOUTH [4] - 2767:4,
2767:14, 2769:15,
2770:16
space [2] - 2794:22,
2814:14
speaking [2] - 2776:2,
2797:14
special [1] - 2829:24
specialized [1] -
2825:8
specific [11] -
2782:13, 2783:4,
2783:18, 2791:1,
2795:13, 2797:15,
2798:6, 2829:2,
2832:15, 2833:7,
2882:25
specifically [16] -
2782:22, 2784:3,
2791:15, 2799:22,
2801:10, 2805:24,
2811:9, 2812:22,
2819:16, 2820:18,
2824:11, 2828:19,
2831:2, 2833:1,
2837:15, 2842:4

specifics [1] - 2790:19
specified [1] -
2832:23
speculate [2] -
2908:5, 2908:10
speed [8] - 2786:14,
2789:25, 2790:3,
2790:4, 2790:9,
2798:7, 2798:9,
2799:8
speeds [1] - 2827:7
spell [1] - 2843:2
spend [1] - 2788:13
SPILL [1] - 2766:4
spill [1] - 2887:17
sponsored [1] -
2848:4
sponsors [2] - 2848:2,
2848:18
spot [3] - 2881:8,
2881:12, 2883:10
spots [2] - 2800:4,
2883:1
square [15] - 2792:11,
2792:15, 2804:3,
2804:4, 2805:3,
2805:7, 2805:14,
2805:25, 2806:18,
2808:18, 2810:16,
2814:13, 2814:20,
2900:18, 2900:21
SQUARE [1] - 2769:5
squared [4] - 2796:18,
2810:8, 2818:10,
2900:16
squares [2] - 2796:15,
2805:5
squeeze [1] - 2866:24
squeezing [1] -
2867:2
squishing [1] -
2869:10
Srdjan [2] - 2843:4,
2843:25
SRDJAN [3] - 2772:8,
2842:25, 2843:4
stabilize [5] - 2787:5,
2788:4, 2788:13,
2788:21, 2789:8
stable [2] - 2788:22,
2789:2
stack [3] - 2900:1,
2910:17, 2912:6
stacked [1] - 2895:14
staff [1] - 2848:5
stage [4] - 2775:23,
2845:21, 2861:1
stand [2] - 2835:6,
2881:20
standard [3] -

2780:12, 2780:14,
2840:25
standardly [1] -
2780:16
standing [2] - 2870:6,
2870:19
star [1] - 2833:12
star-shaped [1] -
2833:12
start [13] - 2788:12,
2789:8, 2797:24,
2824:22, 2825:8,
2847:4, 2851:9,
2858:13, 2860:8,
2861:5, 2871:8,
2881:1, 2888:20
started [13] - 2788:10,
2847:7, 2889:9,
2889:19, 2891:7,
2897:7, 2904:19,
2905:11, 2910:15,
2910:18, 2911:2,
2911:6, 2913:9
starting [4] - 2787:12,
2848:14, 2849:1,
2858:24
starts [2] - 2858:15,
2894:21
STATE [2] - 2768:3,
2768:4
state [9] - 2780:18,
2788:3, 2788:21,
2835:2, 2843:2,
2856:14, 2856:17,
2862:17
statement [3] -
2799:19, 2842:11,
2910:20
statements [1] -
2812:21
States [7] - 2774:1,
2774:13, 2774:14,
2774:24, 2775:9,
2843:7, 2903:22
states [1] - 2915:17
STATES [4] - 2766:1,
2766:10, 2766:15,
2768:13
States' [1] - 2774:15
STATES' [1] - 2767:21
stating [1] - 2843:23
stay [3] - 2807:2,
2817:2, 2817:4
stayed [2] - 2833:16,
2835:10
stays [2] - 2793:20,
2814:15
steady [3] - 2780:18,
2788:3, 2788:21
stem [1] - 2851:19

STENOGRAPHY [1] -
2771:23
step [1] - 2879:19
STEPHEN [2] -
2766:19, 2768:14
STEVEN [2] - 2768:20,
2770:10
stick [5] - 2776:17,
2777:3, 2823:2,
2914:9
still [15] - 2775:2,
2781:15, 2790:11,
2790:13, 2795:4,
2800:13, 2800:19,
2800:23, 2814:12,
2851:20, 2865:5,
2866:5, 2875:4,
2877:4, 2910:10
stock [3] - 2775:20,
2775:24, 2913:10
stop [6] - 2877:21,
2887:9, 2890:24,
2891:9, 2894:24,
2908:3
stopped [5] - 2859:20,
2860:3, 2908:1,
2908:2, 2908:8
story [2] - 2864:8,
2876:4
straight [19] -
2844:20, 2852:6,
2856:15, 2891:21,
2892:15, 2892:22,
2892:23, 2893:3,
2893:4, 2893:7,
2893:10, 2893:15,
2898:15, 2900:19,
2900:20, 2914:23,
2914:25, 2915:1,
2915:13
straightforward [1] -
2804:16
stratified [11] -
2776:8, 2789:15,
2789:18, 2798:7,
2798:9, 2800:9,
2800:13, 2800:20,
2800:24, 2801:13
straw [5] - 2793:3,
2793:5, 2793:6,
2793:9
stream [1] - 2863:12
STREET [16] -
2766:23, 2767:4,
2767:11, 2767:15,
2767:18, 2768:5,
2768:10, 2769:6,
2769:15, 2769:20,
2770:7, 2770:10,
2770:23, 2771:10,

<p>2771:14, 2771:18 stress [2] - 2875:23, 2876:10 stretch [2] - 2875:24, 2909:4 stretching [4] - 2869:10, 2871:18, 2872:16, 2875:19 striking [1] - 2851:11 string [1] - 2814:25 strong [1] - 2842:11 students [3] - 2846:16, 2848:5, 2849:8 studied [4] - 2815:11, 2853:4, 2856:22, 2903:9 studies [1] - 2849:7 study [4] - 2844:14, 2861:21, 2886:7, 2906:11 studying [2] - 2811:19, 2847:23 stuff [2] - 2776:24, 2873:12 subject [2] - 2843:13, 2897:8 subjects [1] - 2893:21 submitted [1] - 2852:24 substantially [1] - 2799:3 substitute [2] - 2821:17, 2823:9 Substituting [1] - 2821:16 substituting [1] - 2822:2 substitution [1] - 2823:24 subtract [1] - 2792:7 subtraction [1] - 2823:15 succinctly [1] - 2877:16 suck [1] - 2793:4 sudden [4] - 2865:8, 2885:4, 2887:3 suffices [1] - 2893:12 sufficient [4] - 2851:23, 2852:5, 2873:23, 2892:9 sufficiently [1] - 2863:4 suggested [1] - 2859:24 SUITE [9] - 2766:23, 2767:4, 2767:18, 2769:6, 2770:7, 2770:10, 2770:23,</p>	<p>2771:4, 2771:10 sum [5] - 2778:12, 2802:21, 2835:23, 2900:22 summarize [4] - 2851:15, 2853:5, 2853:17, 2857:1 summarizes [1] - 2853:12 summarizing [1] - 2894:10 summary [2] - 2855:6, 2856:18 superficial [5] - 2777:23, 2777:25, 2789:19, 2796:25 support [3] - 2821:6, 2848:8, 2848:20 supports [1] - 2808:11 supposed [2] - 2774:4, 2880:16 surely [2] - 2799:2, 2859:18 surface [11] - 2789:24, 2790:2, 2839:13, 2848:16, 2851:6, 2851:11, 2851:23, 2851:25, 2852:4, 2852:7, 2876:3 surfaces [2] - 2876:12, 2876:14 surprised [1] - 2822:25 surrebuttal [1] - 2774:3 Susan [2] - 2916:13, 2916:17 SUSAN [2] - 2771:17, 2916:16 susan_zielie@laed.uscourts.gov [1] - 2771:20 suspect [1] - 2818:18 SUTHERLAND [1] - 2770:9 swing [2] - 2863:6, 2883:9 swinging [1] - 2887:2 swings [1] - 2881:9 swirl [2] - 2880:24, 2884:24 switch [1] - 2872:3 switched [1] - 2844:25 sworn [1] - 2842:25 system [14] - 2785:20, 2785:25, 2795:14, 2800:5, 2817:23, 2826:23, 2827:11, 2827:23, 2852:17, 2853:10, 2866:5,</p>	<p>2874:9, 2882:20, 2894:1</p> <p style="text-align: center;">T</p> <p>table [3] - 2773:9, 2828:13, 2831:15 talks [1] - 2841:22 tank [20] - 2775:20, 2775:24, 2804:1, 2804:3, 2804:17, 2806:2, 2806:15, 2806:25, 2807:1, 2807:3, 2807:4, 2807:11, 2807:13, 2813:9, 2814:1, 2814:18, 2814:19, 2815:3, 2815:8, 2815:10 tanks [1] - 2807:6 task [1] - 2905:12 taught [2] - 2846:13, 2847:14 teach [1] - 2847:5 teaching [4] - 2846:12, 2847:8, 2847:12, 2861:10 teaching-research [1] - 2846:12 technique [5] - 2849:24, 2850:2, 2854:6, 2900:9, 2900:10 techniques [1] - 2849:21 technology [1] - 2835:16 Technology [8] - 2844:21, 2844:22, 2845:3, 2845:12, 2846:4, 2847:11, 2847:17, 2847:19 temperature [9] - 2781:6, 2787:6, 2788:8, 2788:15, 2788:17, 2788:18, 2788:23, 2794:1, 2824:14 ten [2] - 2797:23, 2891:24 tend [3] - 2790:22, 2873:9, 2883:9 tender [1] - 2850:18 tends [1] - 2800:3 tenure [1] - 2846:25 term [5] - 2798:4, 2818:14, 2849:14, 2867:16, 2867:18 termed [1] - 2799:11 terms [14] - 2776:2,</p>	<p>2792:22, 2793:10, 2797:16, 2798:1, 2850:13, 2851:24, 2852:12, 2853:13, 2858:12, 2887:11, 2903:12, 2913:4, 2913:23 terrain [2] - 2800:2, 2800:7 terrain-induced [2] - 2800:2, 2800:7 testified [12] - 2779:25, 2780:11, 2784:21, 2785:15, 2787:4, 2787:10, 2787:16, 2789:10, 2821:2, 2828:2, 2843:1, 2907:21 Testimony [1] - 2772:3 testimony [15] - 2786:24, 2788:24, 2793:24, 2801:14, 2803:10, 2803:18, 2803:21, 2805:12, 2814:17, 2816:23, 2817:2, 2824:8, 2824:19, 2824:23, 2843:14 text [1] - 2811:18 textbook [3] - 2817:13, 2842:7, 2842:8 texts [1] - 2811:7 THE [85] - 2766:4, 2766:5, 2766:7, 2766:15, 2766:19, 2767:21, 2768:3, 2768:13, 2773:7, 2773:21, 2774:7, 2774:11, 2774:19, 2774:23, 2775:4, 2775:6, 2787:19, 2790:3, 2790:4, 2814:22, 2814:24, 2820:21, 2825:4, 2833:24, 2837:6, 2837:23, 2838:3, 2838:5, 2838:7, 2842:16, 2842:19, 2842:21, 2842:23, 2843:2, 2843:4, 2843:11, 2843:18, 2850:23, 2854:24, 2870:18, 2870:19, 2872:6, 2872:7, 2872:22, 2872:24, 2872:25, 2873:2, 2882:21, 2882:22, 2882:23, 2883:3,</p>	<p>2896:4, 2896:5, 2896:6, 2896:7, 2896:9, 2896:10, 2896:11, 2896:12, 2896:13, 2896:14, 2903:19, 2903:20, 2905:24, 2908:13, 2908:15, 2908:16, 2908:18, 2908:21, 2908:22, 2908:23, 2908:24, 2908:25, 2909:2, 2909:9, 2909:11, 2909:12, 2909:13, 2909:15, 2911:9, 2911:11, 2911:13, 2911:14, 2916:3, 2916:7 therefore [12] - 2849:10, 2852:5, 2856:8, 2857:21, 2863:14, 2864:16, 2868:5, 2876:10, 2877:4, 2878:13, 2910:17, 2912:3 thesis [3] - 2846:18, 2846:19, 2849:3 they've [2] - 2823:6, 2872:4 thicker [1] - 2790:21 thinking [2] - 2908:25, 2909:2 THIRD [1] - 2768:5 third [14] - 2784:6, 2852:1, 2859:14, 2869:14, 2869:17, 2872:17, 2874:1, 2874:10, 2875:22, 2877:1, 2889:12, 2907:23 thirds [1] - 2783:19 THOMAS [2] - 2767:3, 2768:19 thousand [6] - 2794:7, 2794:9, 2794:19, 2894:12, 2899:25, 2914:5 thousands [3] - 2791:13, 2884:1, 2884:2 three [14] - 2782:12, 2793:25, 2802:11, 2811:25, 2831:5, 2850:15, 2868:17, 2869:2, 2872:7, 2872:13, 2874:6, 2892:12, 2911:1 three-quarters [1] - 2782:12 throughout [2] - 2788:23, 2826:18</p>
---	---	--	--	---

throw [1] - 2792:3
thrust [1] - 2906:19
tight [4] - 2864:13, 2881:8, 2881:11, 2883:10
Tim [6] - 2815:25, 2816:12, 2833:17, 2833:19, 2834:1
timekeepers [1] - 2774:23
timeline [4] - 2858:9, 2863:18, 2901:7, 2903:16
tiny [1] - 2795:11
titled [1] - 2858:8
TO [1] - 2773:4
today [3] - 2846:9, 2846:22, 2853:14
together [12] - 2814:4, 2814:11, 2838:20, 2864:6, 2864:10, 2894:13, 2895:15, 2895:24, 2910:13, 2911:1, 2911:19, 2911:25
TOLLES [1] - 2770:13
took [15] - 2779:1, 2798:8, 2809:1, 2810:12, 2812:25, 2815:7, 2847:10, 2855:9, 2862:16, 2873:3, 2879:23, 2890:2, 2908:7, 2910:12, 2913:5
tool [2] - 2867:2, 2889:5
top [10] - 2790:1, 2795:8, 2800:14, 2815:20, 2819:7, 2857:18, 2865:1, 2870:4, 2870:14, 2875:12
topic [4] - 2817:20, 2850:10, 2900:3, 2916:4
topics [3] - 2844:16, 2850:15
TORTS [1] - 2768:14
total [7] - 2775:23, 2778:11, 2802:24, 2802:25, 2829:19, 2836:15, 2898:4
totally [2] - 2862:14, 2907:22
touches [1] - 2839:13
touching [1] - 2802:14
towards [2] - 2848:3, 2884:9
TOWER [1] - 2770:22
tower [1] - 2839:1

traditional [1] - 2801:12
TRANSCRIPT [2] - 2766:14, 2771:23
transcript [1] - 2916:14
transform [5] - 2780:12, 2834:5, 2834:6, 2834:9
transformation [17] - 2780:14, 2786:10, 2786:11, 2789:6, 2795:16, 2809:22, 2811:6, 2811:10, 2811:11, 2811:12, 2816:17, 2816:18, 2832:4, 2832:15, 2832:23, 2833:7, 2840:25
transformations [2] - 2832:14, 2832:18
transforming [1] - 2830:22
transient [15] - 2780:20, 2889:3, 2889:6, 2889:16, 2892:5, 2892:18, 2892:19, 2898:17, 2898:20, 2905:16, 2914:19, 2914:22, 2915:15, 2916:1
translated [1] - 2851:24
TRANSOCEAN [3] - 2770:3, 2770:3, 2770:5
transparent [2] - 2884:12, 2898:10
transpose [1] - 2899:24
traveled [1] - 2860:15
treated [1] - 2813:1
tremendously [1] - 2856:3
trend [2] - 2892:21, 2893:1
TREX-11529R [1] - 2854:18
TREX-11683.57 [1] - 2839:23
TREX-130544.444 [1] - 2837:12
TRIAL [1] - 2766:14
tried [5] - 2827:1, 2862:4, 2890:22, 2897:9, 2904:6
TRITON [1] - 2766:8
true [30] - 2781:17, 2782:23, 2784:11, 2784:13, 2784:15,

2784:16, 2784:18, 2789:1, 2795:2, 2795:20, 2797:10, 2799:19, 2816:10, 2816:12, 2826:6, 2827:11, 2834:16, 2834:20, 2834:25, 2835:3, 2835:25, 2836:1, 2836:23, 2852:14, 2904:12, 2906:19, 2907:16, 2910:5, 2910:13, 2914:21
truth [1] - 2910:21
try [7] - 2813:15, 2835:21, 2841:16, 2897:8, 2904:8, 2905:12, 2914:19
trying [13] - 2784:6, 2793:4, 2799:12, 2799:13, 2813:23, 2830:24, 2834:8, 2835:15, 2888:7, 2898:10, 2904:16, 2906:1, 2913:6
turbulent [2] - 2820:19, 2820:24
turn [10] - 2860:7, 2863:16, 2865:10, 2865:25, 2873:15, 2877:10, 2878:23, 2885:4, 2885:5, 2916:1
turning [1] - 2867:20
turns [1] - 2887:3
twice [2] - 2857:14, 2911:8
two [73] - 2776:13, 2779:3, 2783:19, 2784:9, 2786:8, 2787:5, 2790:10, 2790:15, 2794:16, 2802:7, 2802:10, 2802:15, 2802:16, 2803:11, 2803:16, 2803:22, 2805:2, 2805:22, 2807:19, 2808:5, 2808:15, 2809:8, 2809:9, 2809:10, 2809:16, 2809:19, 2810:5, 2816:23, 2854:11, 2857:13, 2857:25, 2860:25, 2861:20, 2861:25, 2862:9, 2862:13, 2864:18, 2867:6, 2869:6, 2869:14, 2869:16, 2871:6, 2871:23, 2872:7, 2872:18,

2873:11, 2873:20, 2874:5, 2874:19, 2876:9, 2876:20, 2882:13, 2882:25, 2883:14, 2883:17, 2885:5, 2888:14, 2892:7, 2892:11, 2894:10, 2894:13, 2902:14, 2902:23, 2903:1, 2905:19, 2907:16, 2911:25, 2914:20, 2914:23, 2915:12, 2915:17, 2915:22
two-thirds [1] - 2783:19
TX [3] - 2770:11, 2770:23, 2771:5
type [3] - 2847:14, 2848:7, 2891:22
types [2] - 2776:9, 2781:15
typically [4] - 2818:12, 2818:13, 2821:18, 2846:2

U

U.S [2] - 2768:13, 2768:17
UG [1] - 2796:25
ultimate [2] - 2901:2, 2903:2
um-hum [1] - 2777:24
unambiguous [1] - 2866:12
unambiguously [1] - 2902:6
uncontrolled [1] - 2845:25
under [5] - 2775:2, 2818:2, 2818:22, 2837:16, 2850:21
undergraduate [1] - 2847:14
understood [5] - 2802:23, 2813:5, 2839:4, 2843:16, 2857:19
uneroded [1] - 2864:9
unfortunately [3] - 2792:24, 2795:1, 2795:20
unintuitive [3] - 2811:4, 2811:20, 2815:4
unique [4] - 2800:15, 2840:21, 2840:24, 2888:10
unit [3] - 2775:20,

2775:21, 2775:22
United [8] - 2774:1, 2774:13, 2774:14, 2774:15, 2774:24, 2775:9, 2843:7, 2903:22
UNITED [4] - 2766:1, 2766:10, 2766:15, 2768:13
units [3] - 2775:18, 2913:22, 2913:23
universal [2] - 2877:24, 2897:3
universally [1] - 2902:6
University [9] - 2844:11, 2844:12, 2846:5, 2846:13, 2846:25, 2847:1, 2847:4, 2847:7, 2847:25
unlikely [1] - 2790:25
unquote [1] - 2865:17
unusual [1] - 2902:14
up [61] - 2776:25, 2778:2, 2789:13, 2790:16, 2794:9, 2797:22, 2798:8, 2798:15, 2799:1, 2800:11, 2800:19, 2801:4, 2812:19, 2815:15, 2815:20, 2819:7, 2821:15, 2823:19, 2829:17, 2835:23, 2837:11, 2837:12, 2839:23, 2841:19, 2844:5, 2851:1, 2853:11, 2853:25, 2855:3, 2857:7, 2858:1, 2858:22, 2861:1, 2861:4, 2861:17, 2862:8, 2862:10, 2863:2, 2863:17, 2863:23, 2864:1, 2864:18, 2870:18, 2870:23, 2878:3, 2878:15, 2880:7, 2881:25, 2883:21, 2883:22, 2884:4, 2884:7, 2886:10, 2886:18, 2893:18, 2895:14, 2900:1, 2900:22, 2900:23, 2901:19, 2912:6
upper [12] - 2857:9, 2865:25, 2866:13, 2866:15, 2866:24, 2867:10, 2879:18, 2910:8, 2911:5,

<p>2911:17, 2911:20, 2912:7 upstream [5] - 2800:20, 2800:25, 2827:17, 2827:19, 2872:18 upwards [1] - 2871:11 user [3] - 2828:2, 2828:6, 2828:8 users [1] - 2832:16 uses [2] - 2785:15, 2834:9</p>	<p>2841:9 velocity [68] - 2776:19, 2777:17, 2777:23, 2778:1, 2778:4, 2778:5, 2778:15, 2787:5, 2787:10, 2788:9, 2788:24, 2789:1, 2791:10, 2793:20, 2794:4, 2794:20, 2794:23, 2796:25, 2797:1, 2797:18, 2797:25, 2798:15, 2798:18, 2798:19, 2798:20, 2799:1, 2799:2, 2799:4, 2799:6, 2799:9, 2801:15, 2803:23, 2818:14, 2818:18, 2822:2, 2822:6, 2822:8, 2822:16, 2823:3, 2825:17, 2825:23, 2826:3, 2826:4, 2827:6, 2827:8, 2827:11, 2829:10, 2829:14, 2834:18, 2834:19, 2834:20, 2835:2, 2835:4, 2835:5, 2835:7, 2835:10, 2836:3, 2841:6, 2841:11, 2852:20, 2900:16, 2900:18 verified [1] - 2903:13 verify [1] - 2874:8 versa [1] - 2879:6 version [7] - 2828:9, 2863:2, 2863:7, 2864:8, 2879:23, 2884:22, 2914:12 versus [3] - 2793:20, 2878:4, 2902:10 vertical [1] - 2894:16 vice [1] - 2879:6 vice-versa [1] - 2879:6 video [1] - 2800:11 videos [1] - 2779:13 view [6] - 2840:9, 2868:9, 2871:6, 2875:8, 2884:9, 2910:24 virgin [1] - 2889:9 virtual [1] - 2861:20 virtually [1] - 2862:13 viscosity [2] - 2790:21, 2902:2 visible [2] - 2876:1, 2880:13 visual [2] - 2874:7, 2893:9</p>	<p>visually [1] - 2891:8 volume [4] - 2775:21, 2775:22, 2807:10, 2809:3 volumetric [15] - 2775:17, 2775:22, 2785:13, 2787:3, 2793:11, 2794:4, 2794:24, 2801:17, 2821:19, 2822:6, 2822:18, 2823:8, 2825:13, 2825:25, 2826:4</p>	<p>2809:19, 2815:1, 2824:1, 2829:6 whereas [1] - 2848:2 white [1] - 2880:16 WHITELEY [1] - 2768:8 whole [8] - 2784:7, 2807:5, 2814:18, 2895:24, 2903:16, 2904:9, 2905:25, 2910:24 whoops [1] - 2876:16 wildly [1] - 2907:8 wind [2] - 2797:22, 2800:19 winds [1] - 2886:14 WINFIELD [1] - 2767:22 withdraw [1] - 2830:1 withdrawn [1] - 2859:3 WITNESS [26] - 2775:4, 2790:4, 2814:24, 2838:5, 2838:7, 2843:4, 2870:19, 2872:7, 2872:24, 2873:2, 2882:22, 2883:3, 2896:5, 2896:7, 2896:10, 2896:12, 2896:14, 2903:19, 2908:15, 2908:18, 2908:22, 2908:24, 2909:2, 2909:11, 2909:13, 2911:13 witness [5] - 2787:20, 2833:23, 2842:17, 2842:18, 2850:19 wonder [1] - 2890:12 word [5] - 2777:25, 2805:8, 2832:14, 2907:4, 2907:8 words [8] - 2776:13, 2789:17, 2853:20, 2870:8, 2885:21, 2888:6, 2892:22, 2900:17 workers [1] - 2773:8 works [1] - 2775:18 world [2] - 2847:24, 2907:8 worry [2] - 2778:2, 2781:14 WRIGHT [1] - 2766:22 wrote [1] - 2832:12</p>	<p>Y</p>
<p>V</p>		<p>W</p>	<p>y-axis [2] - 2796:18, 2797:16 year [5] - 2790:6, 2790:10, 2790:13, 2790:15, 2797:21 years [3] - 2846:1, 2849:1, 2888:5 yesterday [10] - 2775:17, 2776:4, 2778:22, 2779:25, 2780:11, 2781:25, 2789:10, 2800:12, 2817:14, 2828:2 YORK [2] - 2767:8, 2771:3 yourself [2] - 2870:19, 2896:23</p>	
<p>valve [3] - 2858:17, 2866:23, 2866:24 variables [6] - 2822:12, 2822:19, 2825:19, 2826:2, 2841:14, 2841:18 various [10] - 2828:15, 2845:14, 2848:11, 2868:14, 2879:16, 2879:21, 2890:24, 2901:13, 2906:20 vary [1] - 2794:24 Vaziri [9] - 2859:23, 2873:21, 2874:3, 2877:2, 2907:18, 2907:23, 2908:15, 2909:24 Vaziri's [6] - 2874:9, 2877:7, 2907:10, 2907:14, 2909:17, 2909:21 velocities [49] - 2785:17, 2785:18, 2785:20, 2786:4, 2786:7, 2786:9, 2786:24, 2786:25, 2789:18, 2789:19, 2789:20, 2789:21, 2793:14, 2795:21, 2797:5, 2797:8, 2797:20, 2797:21, 2798:22, 2799:7, 2799:17, 2799:18, 2800:23, 2801:2, 2801:7, 2801:18, 2806:8, 2811:13, 2817:2, 2817:4, 2819:15, 2824:16, 2826:13, 2826:20, 2826:21, 2826:22, 2827:5, 2827:10, 2828:25, 2836:23, 2837:2, 2840:17, 2840:19, 2841:2, 2841:3, 2841:8,</p>		<p>wait [4] - 2787:19, 2905:24 walk [4] - 2809:12, 2810:4, 2823:22, 2855:8 wall [3] - 2793:16, 2845:24 walls [2] - 2788:16, 2811:4 WARREN [1] - 2771:13 WASHINGTON [5] - 2768:15, 2768:24, 2769:20, 2769:24, 2771:14 watched [1] - 2880:24 water [11] - 2804:1, 2804:3, 2804:14, 2804:15, 2806:15, 2807:6, 2813:9, 2814:1, 2815:7, 2833:23, 2839:1 wave [1] - 2915:6 waves [3] - 2789:23, 2790:8, 2790:16 wavy [2] - 2776:8, 2798:9 ways [2] - 2853:11, 2886:23 week [4] - 2856:1, 2859:1, 2910:6, 2910:25 weeks [3] - 2874:5, 2874:6, 2877:11 weight [1] - 2843:13 WEINER [1] - 2771:9 WEITZ [1] - 2767:7 well-made [1] - 2864:7 wetted [15] - 2782:17, 2784:25, 2785:5, 2785:11, 2793:18, 2802:18, 2802:24, 2808:3, 2808:25, 2809:16, 2809:18,</p>	<p>Z</p>	
<p>valve [3] - 2858:17, 2866:23, 2866:24 variables [6] - 2822:12, 2822:19, 2825:19, 2826:2, 2841:14, 2841:18 various [10] - 2828:15, 2845:14, 2848:11, 2868:14, 2879:16, 2879:21, 2890:24, 2901:13, 2906:20 vary [1] - 2794:24 Vaziri [9] - 2859:23, 2873:21, 2874:3, 2877:2, 2907:18, 2907:23, 2908:15, 2909:24 Vaziri's [6] - 2874:9, 2877:7, 2907:10, 2907:14, 2909:17, 2909:21 velocities [49] - 2785:17, 2785:18, 2785:20, 2786:4, 2786:7, 2786:9, 2786:24, 2786:25, 2789:18, 2789:19, 2789:20, 2789:21, 2793:14, 2795:21, 2797:5, 2797:8, 2797:20, 2797:21, 2798:22, 2799:7, 2799:17, 2799:18, 2800:23, 2801:2, 2801:7, 2801:18, 2806:8, 2811:13, 2817:2, 2817:4, 2819:15, 2824:16, 2826:13, 2826:20, 2826:21, 2826:22, 2827:5, 2827:10, 2828:25, 2836:23, 2837:2, 2840:17, 2840:19, 2841:2, 2841:3, 2841:8,</p>			<p>ZALDIVAR [1] - 2772:4 Zaldivar [6] - 2775:2, 2775:9, 2775:11, 2837:4, 2837:9, 2837:20 Zielie [2] - 2916:13, 2916:17 ZIELIE [2] - 2771:17, 2916:16 Zimmerman [2] - 2773:16, 2774:16</p>	
<p>V</p>			<p>Z</p>	
<p>valve [3] - 2858:17, 2866:23, 2866:24 variables [6] - 2822:12, 2822:19, 2825:19, 2826:2, 2841:14, 2841:18 various [10] - 2828:15, 2845:14, 2848:11, 2868:14, 2879:16, 2879:21, 2890:24, 2901:13, 2906:20 vary [1] - 2794:24 Vaziri [9] - 2859:23, 2873:21, 2874:3, 2877:2, 2907:18, 2907:23, 2908:15, 2909:24 Vaziri's [6] - 2874:9, 2877:7, 2907:10, 2907:14, 2909:17, 2909:21 velocities [49] - 2785:17, 2785:18, 2785:20, 2786:4, 2786:7, 2786:9, 2786:24, 2786:25, 2789:18, 2789:19, 2789:20, 2789:21, 2793:14, 2795:21, 2797:5, 2797:8, 2797:20, 2797:21, 2798:22, 2799:7, 2799:17, 2799:18, 2800:23, 2801:2, 2801:7, 2801:18, 2806:8, 2811:13, 2817:2, 2817:4, 2819:15, 2824:16, 2826:13, 2826:20, 2826:21, 2826:22, 2827:5, 2827:10, 2828:25, 2836:23, 2837:2, 2840:17, 2840:19, 2841:2, 2841:3, 2841:8,</p>			<p>“MIKE” [1] - 2769:23</p>	
<p>V</p>			<p>X</p>	
<p>valve [3] - 2858:17, 2866:23, 2866:24 variables [6] - 2822:12, 2822:19, 2825:19, 2826:2, 2841:14, 2841:18 various [10] - 2828:15, 2845:14, 2848:11, 2868:14, 2879:16, 2879:21, 2890:24, 2901:13, 2906:20 vary [1] - 2794:24 Vaziri [9] - 2859:23, 2873:21, 2874:3, 2877:2, 2907:18, 2907:23, 2908:15, 2909:24 Vaziri's [6] - 2874:9, 2877:7, 2907:10, 2907:14, 2909:17, 2909:21 velocities [49] - 2785:17, 2785:18, 2785:20, 2786:4, 2786:7, 2786:9, 2786:24, 2786:25, 2789:18, 2789:19, 2789:20, 2789:21, 2793:14, 2795:21, 2797:5, 2797:8, 2797:20, 2797:21, 2798:22, 2799:7, 2799:17, 2799:18, 2800:23, 2801:2, 2801:7, 2801:18, 2806:8, 2811:13, 2817:2, 2817:4, 2819:15, 2824:16, 2826:13, 2826:20, 2826:21, 2826:22, 2827:5, 2827:10, 2828:25, 2836:23, 2837:2, 2840:17, 2840:19, 2841:2, 2841:3, 2841:8,</p>			<p>x-axis [1] - 2797:16</p>	