



County Court Reporters, Inc.
Stephenson, VA 22656
www.countycourtreporters.com

Maryland Court Reporting &
Video Services, LLC
Baltimore, MD 21218
www.marylandreporting.com

The Reporters Group
Stephenson, VA 22656
www.reportersgroup.com

Court Reporting, Video
& Litigation Technology
Pittsburgh, PA
www.advlegaltech.com

Court Reporting, Video
& Litigation Technology
Breckenridge, CO 80424
www.advlegaltech.com

Corporate: Historic Jordan Springs  1160 Jordan Springs Road  Stephenson, VA 22656

U.S. ENVIRONMENTAL PROTECTION AGENCY
10TH CONFERENCE OF AIR QUALITY MODELS
DAY THREE

U.S. ENVIRONMENTAL PROTECTION AGENCY
109 W. ALEXANDER DRIVE
RESEARCH TRIANGLE PARK, NORTH CAROLINA

MARCH 15, 2012

8:30 A.M.

1 GUEST SPEAKERS:

2 Mark Bennett, CH2M HILL

3 Andy Berger, Tri-State Generation and Transmission

4 George Bridgers, US EPA - OAQPS

5 Pietro Catizone, TRC Environmental Corp.

6 Tony Colombari, Trinity Consultants

7 Allen Dittenhoefer, Environplan Consulting

8 Nicole Downey

9 Tyler Fox, US EPA - OAQPS

10 Ryan Gesser, Georgia-Pacific, LLC

11 Steve Gossett, Eastman Chemical Co.

12 Sergio Guerra, Wenck Associates

13 Steven Hanna, Hanna Consultants

14 Qiguo Jing, Trinity Consultants

15 Ashley Jones, Trinity Consultants

16 Eladio Knipping, Electrical Power Research Institute

17 Cindy Langworthy, Hunton & Williams, LLP

18 Mike Lebeis, DTE Energy

19 David Long, American Electric Power

20 Stephen Mueller, Tennessee Valley Authority

21 Robert (Bob) Paine, AECOM

22 George Schewe, Trinity Consultants

23 Lloyd Schulman, Exponent

24 Joe Scire, Exponent

25 Justin Walters, Southern Company

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

GUEST SPEAKERS:

Richard (Chet) Wayland, US EPA - OAQPS

Dana Wood, BP America Production Co.

Anand Yegnan, ERM

1 **U.S. ENVIRONMENTAL PROTECTION AGENCY**

2 **10TH CONFERENCE OF AIR QUALITY MODELS**

3 **MARCH 15, 2012**

4 **MR. GEORGE BRIDGERS:** Well, welcome

5 back, everybody. Hopefully everybody got a little bit
6 of rest. I know I did last night. I think the amount
7 of rest that I got last night was -- let's see, the
8 magnitude of rest was the same level of decrease in
9 the, or the increase in stringency of the NO2
10 standards, so tenfold increase of sleep, so it was
11 great. Today is -- we're going to change gears a
12 little bit. Today is where we get to listen to
13 everyone that has requested to come and speak. This is
14 a public presentation session. The format is a little
15 bit different because we will not offer or entertain
16 questions and answers so, hopefully, we can make it
17 through the thirtyish presentations somewhat on time.
18 We will have, I don't want to call it open-mic but we
19 will have, after all of the presented presentation --
20 or the requested presentations, we will have time for
21 others in the audience that, if they have prepared
22 comments, they can come up to the microphone and offer
23 those. But I also interject that at any point that,
24 you know, comments can be submitted to the docket.
25 They don't actually have to be verbally read today.

1 Just to go through a little bit of
2 logistics. I did this yesterday morning without the
3 aid of the slide. I will do it this morning because we
4 have a few new people in here today. Just a reminder
5 that this is a public hearing, as I said. Everything
6 that's presented and said is part of the official
7 docket. Things are transcribed so be careful what you
8 say if you don't want it repeated years from now. We
9 also ask that as you come to the microphone, when
10 you're offering your public comment or during the
11 presentations, the presenters to announce themselves.
12 So, for the record, this is George Bridgers from the
13 U.S. EPA.

14 We're scheduled -- we're packed today.
15 We've had a couple of changes in the schedule that
16 we'll work with as we go along because of some --
17 someone could not attend today because of a family
18 emergency, but they will be submitting their comments
19 to the docket. Let's see, I've already said there's no
20 Q&A and the other thing, this was mentioned yesterday
21 during the afternoon sessions, that we will be
22 extending the public comment period for the Conference
23 through April 30th. We won't do that through a Federal
24 Register printing. What we'll do is we will have a
25 memo that's signed and then add it to the docket. So

1 that's how it becomes official, but I also encourage
2 everyone that after the Conference that just because
3 April 30th has come and passed doesn't mean that we
4 can't continue to engage. I mean, that's part of what
5 we're trying to do moving forward is to have this
6 collaborative effort as a community as we look for -
7 forward to the different developments and changes that
8 may need to happen between now and the 11th Conference
9 which, if everything goes beautifully, would be - what,
10 in October, 2014. And that's all I have to say there.
11 Let me back up a little bit because I think Chet wanted
12 to come say a few comments and then after that, we'll
13 launch right into the public presentations.

14 **MR. CHET WAYLAND:** Great. Thank you,
15 George. Unfortunately, this afternoon, I have to run
16 out for some other meetings and so I won't be here when
17 things wrap up at closing, so I wanted to take this
18 opportunity in the morning to thank everybody again for
19 coming. I've been able to sit in for most of the last
20 two days and I'm going to sit in for as much of today
21 as I can, and it's really been phenomenal to hear all
22 of the issues that have been raised, the comments that
23 have come in, suggestions, presentations. It's been
24 great, and I really appreciate everybody taking the
25 time to come. I heard a couple of things yesterday

1 that I just wanted to kind of, you know, elaborate on
2 and that's, you know, people are all coming up with
3 specific issues they'd like us to address. I think
4 Tyler was correct in saying we do have limited
5 resources and, you know, we have limited budgets and
6 different things like that, but if the community as a
7 whole through their comment process that comes in from
8 this conference can help us to prioritize which items
9 are the ones that are the most important to you, then I
10 promise you we will take that prioritization and work
11 on it in that order. So, if folks can kind of, you
12 know, somehow gather around and try to come look at it
13 like this is the most important issue and this is
14 second and this is third, then that will help us a lot
15 to say, okay, this is where we do need to put our
16 resources here at EPA and work on those specific
17 issues. And we're happy to do that and I promise you
18 we will do that, if we can get some kind of a semi-
19 consensus of, you know, what are the highest priority
20 issues to be looking at.

21 The other thing is the field study issue
22 that came up. I think that's a great idea.
23 Unfortunately, EPA does not have a lot of resources to
24 go ahead and do big field studies like we maybe had
25 ten, twenty years ago, but if there are others who want

1 to pull together and do field studies and work with us
2 or work together, I think that's great. The more data
3 you have, the better tools that we will always have.
4 So, I would encourage folks that are interested in that
5 to maybe collaborate with each other and, you know,
6 come up with some proposals and some ideas and some
7 protocols, and I think we'd be very supportive of
8 additional field studies for any of these tools.

9 So, and just to reiterate, I know some
10 folks made notice yesterday but for a little while in
11 the afternoon, Janet McCabe, our Deputy Assistant
12 Administrator for OAR, joined us. She was here for
13 several other meetings and an SAB Panel in the morning
14 here and she just wanted to slide in. She had seen the
15 agenda and was very interested, and she stayed for
16 about a half hour or so and heard a lot of the Q&A on
17 NO2 and SO2 and then had some several -- several
18 meetings with her afterwards. She's very interested in
19 this. She wanted me to let everybody know that she and
20 Gina McCarthy, our AA for OAR, are both very interested
21 and aware of the NO2 and the SO2 and the PM2.5 issues.
22 They were thrilled that we were having this and that
23 this many people were coming. She got a lot out of the
24 short amount of time she was here yesterday, and I just
25 wanted to let folks know that she is generally watching

1 this and making sure that we are addressing these
2 issues that you guys are raising. So, with that, I
3 hope you guys have a good day today. I'm looking
4 forward to the, you know, presentations and again,
5 thank you all very much for coming. If today is like
6 the last two days, it's going to be great, and I really
7 appreciate all of your attendance. So, thank you.

8 **MR. GEORGE BRIDGERS:** Thank you, Chet.
9 Well, we are going to actually transition right into
10 the public presentations so we can, hopefully, get a
11 little bit ahead of schedule. So, the first handful of
12 sessions are from the AWMA AB-3 Committee.

13 **MR. PIETRO CATIZONE:** Good morning.
14 Home stretch is here, I guess. I'm Pete Catizone. I'm
15 the Vice Chair of the Air Waste Management AB-3
16 Meteorology Committee and first of all, I'd like to
17 thank EPA for inviting AB-3 to be part of the 10th
18 Modeling Conference and also inviting us to be part of
19 the Attendee committee that has been conferenced in the
20 last couple of months, to put together and help out
21 with the agenda. We're happy to do that. As you might
22 have seen from the references to AB-3 in the last
23 couple of days, AB-3 has been involved all along. I
24 know that we've been in most of the EPA conferences,
25 but we've also had specialty conferences, which I'll

1 talk about a little bit, typically the year after the
2 Modeling Conference to further focus and iron out some
3 of the modeling issues that face the group in the
4 industry. The AB-3 Technical Coordinating Committee is
5 part of the Tech Council of AWMA and we are very
6 active. We have more than 200 members currently in our
7 committee. To be on the committee is not that
8 difficult. You just need to attend one of the meetings
9 or ask to be part of the meeting and/or be a member of
10 the AWMA. We have a wide, broad representation on our
11 committee. We have government folks that participate,
12 industry folks and, of course, consultants are always
13 there.

14 The basic objectives of AB-3 is actually
15 very simple. We want to promote the best science we
16 possibly can and apply it as best as we can to the
17 issues and concerns that face us all. So, to that
18 extent, we try to provide technical support in peer-
19 review of papers for our annual meetings. We
20 participate in and support specialty conferences and
21 workshops, contribute to technical programs whenever we
22 are asked to or can, and provide comments on regulatory
23 and relevant technical issues as we doing here today.

24 For this particular event, we assembled
25 a group of AB-3 members. They're all listed here.

1 Just for the record, the current Chair of AB-3 is Mark
2 Bennett. I'm the Vice Chair and David Long is the
3 Secretary. I believe every one of those folks listed
4 here are here today and have provided in some way
5 comments to this 10th Modeling Conference. I'd like to
6 thank them for their time and effort to put in the
7 comments that we have already presented and the ones
8 we're going to present here today. It's purely a
9 voluntary organization, so any time effort that's spent
10 is truly out of our own time.

11 We got involved talking about the 10th
12 Modeling Conference actually about a year ago and that
13 resulted in meetings internally with AB-3 and then,
14 subsequently, we had a meeting with EPA staff OAQPS --
15 a conference call on August 4, 2011. At that time we,
16 I think, discussed approximately fourteen or fifteen
17 different topics and issues that the membership was
18 interested in either addressing or participating in
19 discussions with at the Modeling Conference. At that
20 time, we all thought the Modeling Conference would be
21 in October. We actually were able to put more
22 information and provide better comments, I think, due
23 to the fact that it was delayed but, nonetheless, out
24 of those comments, about five different topics and I
25 believe seven or eight specific presentations came out.

1 A couple of those topics were asked by George to be
2 brought into the main agenda of the 10th Modeling
3 Conference, and those have been presented already. Ron
4 Peterson presented on Tuesday on the use of equivalent
5 building dimensions in AERMOD, and Gail talked a little
6 bit about the system availability -- the modeling --
7 the CALPUFF modeling system and the availability of
8 such also on Tuesday. Today nearly following my
9 introduc -- my introduction is going to have Joe Scire
10 and Lloyd Schulman. Joe's going to have actually two
11 presentations, first on new developments and
12 evaluations of the CALPUFF model, basically folks in
13 the Inversion 6.4 work that he's done, and then also an
14 assessment of EPA ETEX evaluation study. Lloyd is
15 going to further discuss the issues related to the
16 building downwash modeling with AERMOD. Later on
17 today, George Schewe is going to also have a
18 presentation on AERMET versus AERMINUTE issues that
19 he's been working on.

20 There are other topics of interest. As
21 I said, in August we had talked about fourteen
22 different areas we were interested in, and some of
23 those have -- are still on our radar screen. Some of
24 these are leftovers from the last conference, so you
25 might have seen some of these comments and

1 recommendations before, but to the extent that they're
2 still of interest to the membership, we thought we'd
3 repeat them here. There are three listed here and I'll
4 go through each one on subsequent slides. The last one
5 here relates to long-range transport database that we
6 know has been available but other than I believe Joe,
7 who got it through a FOIA request, we have not seen it.
8 I think the community would like to know whether that
9 information or database is available and, if so, how do
10 we go about getting it.

11 Regarding the Model Clearinghouse, we
12 are very happy that George has been brought on to
13 address and manage the Clearinghouse, and we look
14 forward to that, but traditionally the concerns of the
15 AB-3 committee members has been that the Clearinghouse
16 process does not allow for technical input by the
17 affected parties, the applicants and the general.
18 Therefore, we believe that permitting authority just
19 states their opinion and ask for Clearinghouse approval
20 without much involvement from the applicants. AB-3
21 would recommend that the affected parties be able to
22 provide comment along with the permitting authority's
23 correspondence to the Clearinghouse. I think that
24 getting involved would result maybe in a quicker and
25 faster resolution of the issues and, hopefully, the

1 resolution would have a common consensus on what the
2 result is as opposed to just having handed down a
3 requirement or a mandatory resolution.

4 Regarding the status of the modeling
5 guidance, we know that issuance of modeling guidances
6 have been lengthy at times and a lack of final guidance
7 sometimes for the user committee can result in the
8 viability of projects and the projects' schedules can
9 be affected. Specifically, we're talking about SO₂,
10 the draft guidance that was out since September 22,
11 2011. However, the final guidance we haven't seen and
12 we heard yesterday I believe that we don't have a
13 specific date for that to be issued. Also, the
14 secondary PM_{2.5} guidance that has been promised several
15 times and expected to be out as of this conference, we
16 have not seen yet. We are very interested in seeing
17 that. AB-3 believes that a collaborative effort might
18 help in expediting the process of some of these issues,
19 and we just want to know how can we help? How can we
20 get involved to help EPA recognize the limited
21 resources you do have, to not only set the priorities
22 as Chet said, but also provide support and technical
23 input whenever we can.

24 Finally, I'd like to announce as Tyler
25 mentioned the other day that, in fact, AB-3 has been

1 asked and is considering and planning the 5th Modeling
2 Conference. We are -- we actually discussed this last
3 night at our meeting. We are planning to have it late
4 this year, early next year as Tyler suggested. It's
5 likely to be more the beginning of next year than late
6 this year due to the schedule that we already have. As
7 the last one, I think to accommodate and encourage the
8 participation of EPA staff, we'll likely have it here
9 in Raleigh. If there's a particular venue that seems
10 appropriate, let us know. Otherwise, we'll find one or
11 maybe the same as we had last time, and for information
12 on that and for a call for papers for that, you can
13 stay tuned to wma.org. Thank you.

14 **MR. LLOYD SCHULMAN:** Good morning. My
15 name is Lloyd Schulman with Exponent in Natick,
16 Massachusetts. Today I'm going to be sending some
17 comments on building downwash and AERMOD. I'd like to
18 acknowledge my co-author with these comments, Joseph
19 Scire. The outline of the comments is going to be
20 talking about the recent change. I guess a year ago
21 Version 11059 to AERMOD, which we found is leading to
22 significant but unverified increases in predicting
23 concentrations for, mostly for wide buildings, but also
24 we want to talk about, even without this code change,
25 this recent code change, there have been documented

1 over-predictions for very wide buildings and I'm going
2 to present some slides about that also.

3 I won't dwell on the GEP stack height.
4 I think we all know this quite well. The only point I
5 wanted to bring out was that people talk about the 40
6 percent increase for excessive concentrations but that
7 has to be paired with contribution or causing a
8 violation of the standards, so you have to avoid that.
9 That's the definition of excessive concentration. The
10 change that was put forth about a year ago with Model
11 Change Bulletin Number 4, basically what it does -- you
12 don't have to read all the italics -- basically what it
13 does is it says that you have to model downwash now for
14 all stack heights, whether they're below or above the
15 GEP formula height, and the previous policy was to only
16 model downwash effects for stacks that were less than
17 the GEP formula height. Now we heard on Tuesday that
18 the change was made to eliminate discontinuities for
19 stacks that were straddling the formula height and that
20 the change will be justified by a pending clarification
21 memorandum. But as far as I know, we haven't seen any
22 consequence analyses. There hasn't been any public
23 comment or review and we feel that this is a very
24 significant change to the model that should warrant
25 more than a clarification memorandum in our Model

1 Change Bulletin. Now, I guess I'll
2 start off by saying, yes, there is downwash at formula
3 height. I think that's well known. It's part of the
4 definition of excessive concentrations, but that's not
5 really the key question. The key question is does
6 PRIME model it correctly for stacks above formula
7 height, and we think that it doesn't for many cases,
8 and I'll be talking about that today. The PRIME
9 algorithm was developed mostly for buildings that width
10 to height ratios that were quite small. I'm going to
11 list on the next slide of what those were, but they
12 were all less than 4.4 and it was sub-GEP stacks. Now
13 we're applying the model to stacks and building shapes
14 that are outside of that range. There was already a
15 problem that everyone's been well aware of for very
16 wide buildings because of the unrealistically long
17 projective lengths for BPIPFRM. Roger talked about
18 that on Tuesday and proposed an effective length remedy
19 that looks like it's a step in the right direction.
20 We're very encouraged by that, but we know it needs
21 further testing and confirmation. But this change now
22 in the allowing downwash for all buildings, including
23 these wide buildings, is only going to exacerbate that
24 problem, and I'll demonstrate that with some case
25 studies.

1 This is the width to height ratio for
2 the evaluation databases. The one that we relied on
3 most in developing PRIME was Bowline Point. We had
4 half the data for independent - for developmental data
5 for evaluating the model and half the data was for
6 independent evaluation. We also relied quite heavily
7 on the Snyder's wind tunnel data and Alaska north
8 slopes. So, most of the data that we used to develop
9 the model are for buildings that were not very wide at
10 all, and we got quite good agreement at least for the
11 sub-G, the stack heights with the data sets.

12 So, what I'm going to do now is talk
13 about a case analysis that's based on an actual source.
14 The numbers are roughly about what they are for that
15 source. It's a buoyant source. It's a very low
16 building. It's twenty meters high, 220 meters wide.
17 So, the width to height ratio is about eleven. The
18 existing stack height is above the formula -- the
19 formula height, of course, would be two and a half
20 times the twenty which would be fifty meters would be
21 the formula height for this structure. It's a little
22 bit higher than that but because it's below the sixty-
23 five meters, they get credit for that stack height and
24 have to model it now with downwash, whereas before
25 there was no downwash model with that stack height.

1 And what I'm going to do is vary the -- both the stack
2 heights for that structure between something sub-GEP
3 and up to a number that's sixty-five meters, which
4 would be three and a quarter times the stack height,
5 and vary the width as well from a very narrow building,
6 which is half the height to one that's twenty times the
7 height. And we did a one-year simulation, calculated
8 the maximum concentrations without the buildings and
9 with the buildings and those are the results I'm going
10 to present in the next couple of slides.

11 This slide's a little busy but I'll try
12 and explain it. The -- on the vertical axis is the
13 concentration. The ratio -- concentration that the
14 building -- with the building and to without the
15 building and on the horizontal axis is the ratio of
16 stack height to the building height. So, the excessive
17 concentration threshold which is 40 percent is right
18 here going across because this is the concentration
19 ratio is the 40 percent, and the vertical dashed line
20 is the formula height for this structure, which is two
21 and a half times the building height. So, everything
22 to the right of this vertical line with -- previous to
23 the change would not have been modeled with downwash,
24 and everything to the left of the line would have been
25 modeled with downwash. So in the first slide, I'm

1 showing just the narrow structures which are kind of in
2 the range of what we tested PRIME for and you can see,
3 for example, that I'll look at the width to height
4 ratio of three and at two and a half times the building
5 height, you're looking at about a 25 percent increase
6 with the building as opposed to without the building.
7 And for the other stacks, the other buildings like the
8 cube and the one that's half, which are narrower, as
9 you expect, you get even lesser effects and they are
10 all below the 40 percent.

11 I also wanted to mention this line.
12 This line comes from the EPA's guideline on GEP --
13 GEP's guidance for the termination of GEP stack height.
14 It was put out in 1985 by Bill Snyder. Alan Huber was
15 probably involved in it as well, and this is based on
16 work done by Rex Britter, Hunt and Puttock on a
17 symposium paper they presented in 1976. It shows what
18 they call the theoretical estimate of the maximum
19 increase that you'd expect for any -- any building
20 width to height ratio, and it's developed for a very
21 long building. In fact, I believe it was a two-
22 dimensional obstacle that they used to develop their
23 mathematical estimates of what that would be, and you
24 can see that all the numbers are below that line. Now
25 when we jump to the wider structures that go from four

1 to six to eight up to the twenty and look at the
2 variation with building width and with stack height,
3 you can see that except for the width to height ratio
4 of four, almost all of them are -- again, I want to
5 point out this dashed line is the Britter line which is
6 supposed to be the theoretic less than the maximum
7 increase. Almost all of the points are well above that
8 and we're getting values for the very widest structures
9 that are eleven and twelve times higher than what would
10 have been gotten without a building. And again, all
11 these points over here on the right side of this
12 vertical dashed line are points that previous to the
13 change in the model would not have been modeled. They
14 would have been down here at one because you wouldn't
15 have modeled downwash. So, with this change in the
16 policy to avoid the discontinuity, you've introduced or
17 exacerbated a problem that we knew about and made it a
18 lot worse for a lot of sources.

19 So, just to go over this quickly, the
20 EPA has done research on building width to height
21 ratios. In the guideline for the determination of GEP
22 stack height, it does say that the maximum ground level
23 concentrations should not be increased by more than 40
24 to 8 percent for a stack that's at formula height. You
25 see that that's not met with the previous work and the

1 theoretical estimate of Britter, if you looked at the
2 lines and tried to figure out what it was, it's about
3 85 percent increase at two and a half building heights
4 which is formula height and about a 50 percent increase
5 at three times the building height per stack, about
6 three times the building height.

7 The research by Alan Huber's paper from
8 1989 was also discussed on Tuesday and it was used to
9 evaluate this effective length parameter and it does
10 offer a good dataset, but the summary of that paper at
11 the end said that as the width to height ratio
12 increased from above the two from four to eight, the
13 maximum ground level concentration was downwind
14 decreased at all distances, and that when you started
15 to get width to height ratios greater than eight, it
16 had little effect. And this -- this kind of makes
17 sense because if you look at a building that's say a
18 cube and you put it at a forty-five degree angle to the
19 wind, you're going to get like a wedge shape that's
20 going to create a Delta wind effect and you're going to
21 get these strong vortices coming off the leading edge
22 and around the ends that are going to be a very strong
23 downdraft that streamlines, and you're going to bring
24 strong downwash to that problem. When you start to get
25 a very wide building and put it at an angle, you're

1 going to lose that Delta wind effect and I think this
2 is what this study is showing, and the air around the
3 sides of the wide building never make it into the
4 middle anyway if your stack is in the middle. If your
5 stack is in the corner, it's a little bit of a
6 different issue, but that's why we need more research.

7 This is a -- now I want to try and
8 explain why we're getting these problems like -- Roger
9 touched on it a little bit. It's the affected - it's
10 the projected length issue, but this kind of
11 illustrates the problem. This is the actual structure,
12 and it's a long building. It's ten times wider than it
13 is high. Stack is two and a half times the building
14 height, but when you have a wind at a forty-five degree
15 angle to that structure, this becomes the projected
16 length from BPIPPRM, and now your stack, which is on
17 the upwind edge of the real building, is in the middle
18 of the new projected building that goes into PRIME and
19 the cavity which would have started somewhere over here
20 is now starting way down here. So, everything is
21 skewed away from what it really is and it creates
22 problems with predictions from PRIME. What I did was
23 take the worst hour for the width to height ratio
24 building of ten. I looked at 1-hour, just to see what
25 was going on and what I did is I varied the length of

1 the -- of the building. I started to bring it in from
2 the downwind edge forward, and if you look at the --
3 this high number, this is the number that you would
4 have gotten with the projected length as presented by
5 BPIPPRIME, and you get a very high increase
6 concentration with the building over no building. So,
7 you're getting a very large increase with that
8 building. The reason is, is that as the plume has more
9 time to travel before it reaches the near wake, it's
10 spreading more in the vertical and more of that plume
11 is being captured in the cavity and giving a very high
12 concentration. As you start to shrink that length, it
13 drops very rapidly and it seems to be a switch point,
14 in this case where the length to height ratio is about
15 five and a half. There's a switch point and now the
16 maximum jumps to the far wake, and it's pretty flat
17 because most of the mass is in the elevated plume and
18 the far wake is further away. It's much further out
19 where the maximum is. It's a pretty flat curve. It
20 does drop off and now this length that I used here is
21 the length that would be comparable to what the long
22 wind fetch would be for that angle for that building,
23 and you're getting a much lower number with an increase
24 of about two. This is consistent with the kinds of
25 things that Roger was talking about with the effective

1 length, and it's an important thing to get the length
2 right in this model.

3 Also, I just wanted to go quickly
4 through some work that was done earlier for a Alcoa,
5 Tennessee smelter where they had measured data for two
6 years. Most of the emissions were from point sources,
7 and the simulations were made with BLP AERMOD and
8 CALPUFF and measured at -- comparing it to monitor
9 concentrations. This is an overview of the plant and
10 you can see its line sources. It's quite long. Most
11 aluminum reduction facilities have width to height
12 ratios of about twenty, and the results that we found
13 for the 1-hour, this is a quantile quantile plot, and
14 the dashed line is the observations at that monitor.
15 BLP and CALPUFF did quite well. They over-predict by,
16 I don't know, about 50 percent maybe at the top end of
17 the distribution. AERMOD was over-predicting by about
18 a factor of two at the top end, but maybe by a factor
19 of ten somewhere here at about the ninety to ninety-
20 fifth percentile.

21 When you look at the annual numbers you
22 see the same kind of behavior. AERMOD is about a
23 factor of ten over what was observed for the annual
24 numbers for the two years of the study. CALPUFF and
25 BLP, which are using a different downwash model for

1 this, it's the BLP downwash, do quite well because they
2 don't have this effective length problem. So, the
3 findings from that study for very wide buildings were
4 that when you look at very wide buildings, you're
5 getting numbers that really are comparable to what
6 we've seen with our case analyses. The fact is, we got
7 overpredictions of about ten to twelve, and in this
8 study that we're getting overpredictions of about the
9 same amount. So, it's kind of a comparable result with
10 measured data that supports what we're seeing with our
11 case study, and BLP and CALPUFF, the BLP algorithms did
12 quite well. So, our recommendation from this is that
13 EPA should allow the use of the alternative models and
14 Section 3.2 petitions.

15 So, this brings up a couple of
16 questions. For example, if you -- if you did a fluid
17 modeling study and found the stack height that gave you
18 that 40 percent increase, then you put it into AERMOD,
19 you had a fairly wide building, you could wind up with
20 an order of magnitude increase for that stack height.
21 Now what do you do? Do you model -- do you keep that
22 stack height that you got from the wind tunnel and get
23 an order of magnitude increase or do you get a higher
24 credit and say, well, AERMOD says that the value is ten
25 times higher, so I'm going to be able to raise my stack

1 even more. And in the end, aren't we really trading
2 one discontinuity for another for these buildings?

3 So, the conclusions I have is that the -
4 - the change to the downwash procedures in AERMOD are
5 significant. We showed with the case study that there
6 was about a sevenfold increase for width to height
7 ratios of eight, and a twelvefold increase for even
8 higher, with the height ratios for stacks of formula
9 height. And these results are inconsistent and, in
10 fact, they are contrary to what we've seen from the
11 wind tunnel studies and theoretical estimates by
12 Britter for basically two-dimensional structures which
13 have a cap of about 85 percent at formula height.
14 There hasn't been any peer review or comment on this
15 change to the model and we think the clarification memo
16 really isn't sufficient and it should be studied
17 further before it's released. Our recommendation is
18 that we should remove this from the regulatory version
19 until it can be further studied because of the fact
20 that it's causing even greater problems with some of
21 these wider structures and also because we really
22 haven't even evaluated it for narrow structures the
23 stacks above formula height. And I think a suggestion
24 I would make would be that we should bundle with the
25 work that Roger's doing now with the effective building

1 length, since they're really intertwined. I mean, the
2 wide building problem is intertwined with the effective
3 length parameter that Roger's talking about versus the
4 projected length that's in the model now, and we feel
5 that the best course would be to correct the wide
6 building problem looking at something like the
7 effective length parameter and then with that
8 improvement, then go in and evaluate it for different
9 stack heights and show that it works and release this
10 all as one package. We're not -- we're not against
11 modeling stacks above formula height with downwash
12 effects because they exist, but we want to get it
13 right.

14 **MR. GEORGE BRIDGERS:** Thanks, Lloyd.
15 Now we have a couple of presentations, again under the
16 auspice of the AB-3 Committee, from Joe Scire.

17 **MR. JOE SCIRE:** Okay, good morning. I
18 have two talks. The first talk is about the -- it's an
19 assessment of the EPA evaluation study that was
20 recently -- recently released and, in particular, I'll
21 be focusing on the ETEX portion of that study. ETEX is
22 the European tracer study and it covers the area shown
23 in this figure. It actually covers a very large domain
24 and it involved -- it was designed actually for
25 evaluating emergency response type models. So,

1 accidental releases are emergency responses. In
2 particular, the concern was nuclear material released
3 from accidents from nuclear power plants. In this
4 particular experiment, ETEX-1, the tracer was released
5 for twelve hours, starting at about four p.m. local
6 time, and there were samples taken at 168 samplers all
7 over western and central Europe and -- most of these
8 samplers were well beyond 300 kilometers. In fact,
9 some of the samples were taken as far as 2,000
10 kilometers away. So, to put this in perspective, most
11 of the applications with CALPUFF are done for Class 1
12 type studies, and this -- within about 300 kilometers,
13 and this is a 300 kilometer box, just to give you a
14 sense of what that -- that looks like. This
15 application on the CALPUFF side is something that is
16 well-beyond the kind of applications for which is
17 normally used. Five different models were evaluated
18 focusing on ETEX-1. There have been a number of papers
19 and presentations over several years on the results of
20 these evaluations presented by EPA or, more recently,
21 by Environ as well. The information that I received
22 and I'd analyzed was obtained through a Freedom of
23 Information Act request, which was made in October of
24 2010 and the data were received in August of 2011. The
25 study used the new EPA processor MMIF to drive CALPUFF

1 that used 36 kilometer MM5 data. These statistics we
2 heard about a little bit yesterday. There were two
3 that I'm focusing on, the figure in merit -- the figure
4 of merit in space and the rank statistic. I just
5 wanted to mention about the figure of merit in space,
6 it basically determines what's the overlap between a
7 predicted and an observation.

8 The results that were presented in the
9 EPA report or the Environ report, I wasn't sure what to
10 call it so I called it EPA Environ, they -- they were -
11 - they looked pretty bad for CALPUFF. They had the
12 lowest figure of merit score and CAMx had the best.
13 The other models were somewhere in between. In terms
14 of the rank, it looked pretty bad for CALPUFF again.
15 The rank was pretty low, less than -- one about .7 and,
16 again, CAMx came out in the top and the other models
17 were somewhere in between. So, I, once we had the
18 data, we could then look at this and -- and really
19 figure out what was going on.

20 As people have mentioned a number of
21 times over the last few days, the details are
22 important, so we finally had something we could work
23 with. We had data and it is probably a year old now,
24 so I don't know if it's exactly what was used in the
25 final report or not, but all I can talk to is what we

1 received under the Freedom of Information Act request.
2 There were a veritable number of configurations for
3 each model. CAMx was run 20 different ways, and the
4 rank used was the highest of those 20 different runs.
5 The HYSPLIT was run nine different ways. Its rank was
6 assigned a value of 1.8. Although it had higher
7 performance in some other cases, that's not the one
8 that was presented in the summary slides. SCIPUFF, we
9 could only find one run and FLEXPART, and then CALPUFF
10 had about six runs. On CAMx, there were runs with the
11 Plume-in-grid and without it -- without it produced the
12 highest score and that's the one that was presented.
13 With the pick the scores were, in some cases,
14 substantially lower. HYSPLIT arranged from some pretty
15 low scores, one up to the highest score of any of the
16 models in those runs, which was 2.1.

17 Okay, so what did we do? Well, the
18 first thing we did is we ran CALPUFF the way EPA ran
19 it, tried to determine could we reproduce the results.
20 We couldn't exactly, but we felt it was close enough.
21 So, we think we understood what the model parameters
22 used were. So then what we did is we did some
23 sensitivity runs. Clearly, the problems I'll show you
24 is that CALPUFF had the model plume going off on the
25 left side of a diversion flow. And if you want a left

1 side of the branch, it went off to where the observed
2 plume didn't go. If you were in the center or the
3 right side, then the material went a different
4 direction. This was very important because by making
5 certain changes to the way PUFF's splitting was done
6 and also correcting some -- some areas in the input
7 files, we were able to get numbers that were
8 substantially better on this figure of merit score, and
9 it's really almost a binary thing. Either you get it
10 going the right way or you miss it entirely. So, it
11 doesn't mean that you have to change a lot to change
12 the results substantially.

13 On the -- the rank, which is a weighting
14 of four different parameters, we did some tests. We
15 think this is the one that would most closely
16 correspond to the way we would run it in this
17 particular application, and we're -- in this case, the
18 results again changed dramatically. Small change of
19 where the plumes go is at the beginning, other release
20 matters a lot.

21 We also ran the model in a CAMx type of
22 way with an initial dilution associated like in a layer
23 in model, there would be a dilution over the 36
24 kilometer grid cell, and we find that if we add initial
25 dilution, we'd get numbers that were really quite high.

1 I'm not saying that's the way we'd run the model, but
2 it does help to explain to a certain extent why CAMx
3 does fairly well because it's a highly diffusive model
4 when you run it in a Eulerian model mode without the
5 plumbing grid.

6 Okay, so how did we go about this? What
7 happened? Well, in analyzing the winds, it's very
8 clear that ETEX-1 is very sensitive to exactly where
9 the puff goes at the very beginning. Small changes in
10 the trajectory will result in either a complete miss,
11 which is what happened in the EPA runs or not. So,
12 what you do and how you initiate the splitting is very
13 important. You really want to do a lot of horizontal
14 splitting at the beginning and get lots of puffs. Some
15 of the models do that effectively immediately like your
16 layering grid will immediately dilute the plumes over
17 thirty-six kilometers by thirty-six kilometers. So,
18 it's less sensitive to the exact, maybe deficiencies in
19 the wind because you have a wider plume to start with.

20 Also, the performance measures are very
21 highly dependent on time and pure space statistics.
22 So, the amount of overlap that you get matters a lot.
23 We also looked at MMIF versus CALMET. We found that we
24 had some better runs with CALMET, and I'll go into why
25 a little bit later in the talk, and then we looked at

1 the resolution. In fact, the meteorology at thirty-six
2 kilometers didn't pass the performance tests that were
3 done to evaluate its performance relative to the
4 guidelines. So, and I think that it is quite coarse,
5 especially when you're talking about the near-field,
6 and then we -- as I said, we'll go through some things
7 that I found that needed to be changed about the setup.
8 So, I have four runs the way it was run by EPA and
9 Environ. Well, the way it was run by EPA and then
10 analyzed by Environ. Then different runs looking at
11 thirty six kilometer MM5 data with enhanced splitting,
12 and then we also rated with twelve kilometer MM5 data
13 because we believed the -- the Met data is a
14 significant factor in the performance, at least for
15 CALPUFF, and then again with the enhanced splitting.
16 This is the result from the EPA runs. These are the
17 observations. You can kind of see the colored area
18 with this plume going all over this part of Europe.
19 CALPUFF went off into left field because it took the
20 branch and got caught in that, and the puffs did not
21 split properly. The puffs basically went as a group
22 unsplit the wrong way. SCIPUFF had -- was fairly
23 diffusive and covered a large area, FLEXPART, HYSPLIT
24 and CAMx. If you -- you're up here and all your
25 observations are down here, your scores are basically

1 close to zero.

2 So, the first run we did was to fix
3 certain errors in the configuration, but random with
4 MM5 data, EPA's MM5 data, although running CALMET
5 rather than MIFF. And you can see what you -- what you
6 started to see is rather than this blob going up here,
7 this is the -- the original run at T plus thirty-six
8 hours and T plus sixty hours. This is the modified run
9 at the same two times. You start to see this plume
10 extending in a proper direction over central Europe.
11 Second run, we optimized the splitting in the near-
12 field and we got even better results here. So, the
13 original run and a revised run. In all of these
14 slides, the left-hand column is the original EPA run in
15 every slide and on the right-hand slide is the revised
16 run. Run number three we use here better MM5 data
17 twelve kilometers resolution. Then we start to get a
18 really good pattern. It looks quite decent. Together
19 with splitting, we're getting something that performs
20 fairly well and then, finally, the last one is we,
21 again, optimized the splitting in the near-field. The
22 first twelve hours of release are actually critical in
23 this, and you see that the -- the paths are quite
24 different.

25 Okay, MM5, what are the problems with

1 it? Well, okay, thirty-six kilometers is a pretty
2 coarse resolution. The dispersion models are not all
3 equally sensitive to it. If you have a Eulerian model
4 and you spread things out, it's less sensitive maybe to
5 certain areas in the -- in the model winds. It doesn't
6 mean you'll get a better result for regulatory purposes
7 but you're less likely to get a miss. The twelve
8 kilometer MM5 simulations had better resolution and
9 they performed better. And when I say they performed
10 better, there were some data at the release site. A
11 sonic anemometer at eighteen meters, which is the blue
12 trace, a sonar with four level -- three levels up to
13 one hundred meters, and then the green line is the MM5
14 data. So, what this is showing is the wind direction
15 and this red line here is the twelve-hour release
16 period. So, this is a critical time period. This is
17 where the tracer was released and it was allowed to get
18 transported downwind. You can see that the MM5 winds
19 were off by about thirty degrees, and it can make a big
20 difference between missing and hitting that -- that
21 branch point. And then -- then the wind speeds also
22 were off quite a bit. You're seeing the MM5 winds
23 being quite light relative to the sonic anemometer in
24 the sonar data. When we used the twelve kilometer MM5
25 data, the MM5 did better. It had a better match to the

1 winds measured at the release site.

2 Okay, Environ's report indicates that
3 they conclude in, I believe incorrectly, that the
4 meteorological errors that were noted in the evaluation
5 were not the primary cause of poor performance. It
6 certainly was a big factor in the performance of
7 CALPUFF. In -- we also showed that with tests with the
8 better winds especially, but even with the old winds,
9 when you correct certain errors and had proper puff
10 splitting, the results improve quite a bit.

11 I also will not have time to talk about
12 this today, but I think the performance measures that
13 are being used are not really as -- are not as relevant
14 as they should be for regulatory modeling. I think
15 they overemphasize the peering in time and space and
16 they don't account for other factors which it can be
17 sometimes even more important than that. But that will
18 be another talk at another time.

19 Okay. So, I mentioned errors. What
20 were the errors? Well, we looked at the files. There
21 were some datums that were incorrect. In some places,
22 the data was specified as NWS-84. In other places,
23 WGS-84. The tracer released in the CALPUFF run was
24 over the wrong time period. It was over thirteen hours
25 rather than the correct twelve hours. So, and also the

1 averaging periods when you had an absurd three-hour
2 average concentration and the predicted three average
3 concentration, they weren't the same three hours. They
4 were misaligned by one hour. So, there was an overlap
5 that they weren't strictly speaking correct.

6 The stack diameter in the CALPUFF one
7 was set at one meter but it actually is not. It's a
8 very small stack and that's a picture of the release.
9 It's more like one inch. That isn't actually that big
10 of a deal in the results in that particular issue, but
11 one that is is the puff release rate. There's been
12 some discussion yesterday about slugs and why does it
13 help and why does it perform well. If you use the
14 integrated puff model in CALPUFF and you only emit one
15 puff per hour, which is the way this was run, you take
16 a full time step worth of emissions, 3,600 seconds of
17 emissions and packed into a single unit, a single puff,
18 and send it on its way. And in a case where you're
19 measuring overlap with observed plumes, that's not a
20 very good way to do it because by definition, you're
21 too much mass for a ride. Too early and you won't have
22 the trailing mass coming out at the end. So, that's
23 responsible for some of the problems is that the
24 configuration it had, one puff released -- releasing
25 the mass rather than many puffs. And then there were

1 some other issues with documentation not being quite
2 correct about whether trained adjustments were made or
3 were not. They actually were made.

4 So, these things were all corrected plus
5 the other things and then we modeled the -- the results
6 with these new configurations. So, I wanted to mention
7 one other thing. There are some statements in the
8 Environ report about MMIF and CALMET and, basically,
9 one of the presentations says that -- that, these are
10 taken directly from that. Concerns have been raised
11 regarding CALMET. There are many options so you can
12 get multiple answers. That's true. You can draw many
13 options. CALMET has been shown to degrade
14 meteorological model performance. I'm not quite sure
15 what that means. We don't see that happening, and we
16 find that maybe there was some errors made in the
17 attempt to achieve a pass-through MM5 data into CALPUFF
18 through CALMET in the EPA runs. They -- EPA developed
19 this tool which, by the way, I think is a very good
20 development, especially for the fact that it is
21 interfaced to the graphical display tools. So, I have
22 no real problems with MMIF, but I guess what I'm trying
23 to address is some of the comments related to CALMET.
24 They go on to say MMIF will bypass CALMET and its
25 problems. Well, I don't know. We got better results

1 with CALMET, and these problems if you feel don't exist
2 if you run CALMET properly. So, CALMET, if it's
3 properly configured in its pass-through mode, does not
4 change the MM5 winds at all. It passed through exactly
5 at the same point in space to the same point in space
6 in CALPUFF. I mentioned about the other day about
7 MMIF, MMIF always does spacial interpolation of the MM5
8 winds. MMIF by its design does not place the CALPUFF
9 and CALMET grid points at the same location as MM5.
10 It's displaced by half a cell. So, if you have NX Plan
11 Y MM5 grid points, MMIF will produce NX minus one by NX
12 -- NY minus one grid points for CALPUFF. As a result
13 of that, you always do interpolation, whereas if you do
14 a true passing with CALMET, putting the CALMET grid
15 points at the location of the MM5 cross - dark points
16 where the winds are defined, that doesn't occur.
17 CALMET will pass through MM5 data on MM5 grid points.
18 MMIF does not exactly. It does this interpolation.
19 Both programs will do vertical interpolation because
20 they -- the two models have different grids and that's
21 unavoidable. To make it clear, this is the
22 configuration to do a CALMET pass-through. These are
23 the settings that you have to place on CALMET to have
24 CALMET go through and just provide the MM5 data
25 unchanged. We did a couple tests. We took the ETEX

1 experiment, took a bunch of grid points. We ran it
2 through MMIF. We ran it through CALMET and we took
3 those grid points and compared the original MM5 wind
4 direction with the output coming from MMIF, and what
5 you see is pretty highly correlated but there are some
6 differences and some scatter, and it's because of the
7 horizontal interpolation that's being done. That is
8 not necessary to do that, but it is being done. In
9 terms of CALMET, in true pass-through mode, they match
10 exactly. The same with wind direction. This is -- I'm
11 sorry, this is wind direction. This is wind speed.
12 Same thing. The interpolation causes some change in
13 terms of what CALPUFF sees coming out of MM5.

14 Okay. So, to conclude, EPA and Environ
15 did this study. They focused on ETEX-1 and we focused
16 on ETEX-1 for our analysis. What we found was that the
17 relatively simple unqualified conclusions, CALPUFF is
18 the worst, CAMx is the best, isn't supported by the
19 data. I think it's more -- a broader range and, of
20 course, you always have to run the models to try to
21 model the physics properly. There were some errors,
22 there were some inappropriate model configuration
23 settings, and the data driving the model was really not
24 adequate by the EPA's own definition of the model stats
25 program. When we changed the configuration, it did

1 much better and then with the MM5 at twelve kilometers,
2 it also did even better.

3 What I would say is for a recommendation
4 is that this process and these comments are coming very
5 late in the process. A lot of this work was done over
6 three or four years, and it was due to the lack of
7 access to the data sets that we couldn't really comment
8 on it. We saw the plots and the figures, but you have
9 to go into the details to actually understand how the
10 models were run and offer it suggestions or
11 corrections. So, consistent with AB-3, what we're
12 recommending, or what I'm recommending here, is full
13 and timely access to all model evaluation data for the
14 entire modeling community. Now I have this data set
15 but others don't. I think everybody would benefit
16 having the ability really poke around to see how these
17 models were run and make suggestions. I also think
18 that the evaluation process would benefit by the
19 involvement of the model developers, at least to have a
20 level of fairness. I mean, one model's run twenty
21 times by a group that it does the evaluation, another
22 model is only run once. I think to be fair in the
23 evaluation process, our input can only help you do a
24 better study.

25 For future work, we're planning to look

1 at the other data sets. There's a lot of information
2 in that report. It's a work over three or four years
3 and it will take some time to analyze, but we'll report
4 on those findings in future papers and conferences and
5 also, I just want to mention about the evaluation
6 measures. I think this question was whether these are
7 the correct measures to use for this kind of problem.
8 That's the end. Thank you very much.

9 **MR. JOE SCIRE:** Okay, I'm back. This
10 talk is concerning new developments and evaluation
11 studies that have been done with the CALPUFF model, and
12 I'm talking about Version 6.42b. This is the version
13 that has been funded by a number of groups, actually,
14 going back to API funding, AER to do some initial work
15 with a version of this work that I did when I was at
16 TRC, Phase I, and now work continuing at my current
17 company which is Exponent Phase II. West Associates
18 funded the implementation. The electric part, Research
19 Instituting has funded some of the evaluation work. As
20 an overview, 6.42b, for we have to be careful, people
21 refer to Version 6 as 6.4. The current version is
22 6.42b that reflects all of this work. It includes the
23 current version of the ISORROPIA aerosol scheme 2.1
24 similar to what's in the Eulerian models CAMx and CMAQ.
25 It includes EQUIS phase chemical conversion of SO2 in

1 rain droplets and then rain to sulfate, and this scheme
2 was adapted by AER, extracted from RAD and then put
3 into a version of CALPUFF. One of the new changes with
4 this new Version 6.42b is that it couples the output of
5 MM5 WRF with liquid water content data to feed directly
6 into the EQUIS face chemistry. Previous versions just
7 used a constant assumed liquid water content. And then
8 there's some other enhancements as well. New RIVAD
9 scheme, tracking ozone depletion of the plume, and then
10 as a secondary organic aerosol module that is based on
11 a CALTECH as OA routines that's in CMAQ. We evaluated
12 the new version of the model relative to an existing
13 dataset that's been used quite a bit and also a new
14 dataset, the Cumberland 1999 dataset, and then we did
15 some sensitivity into comparison tests between the
16 chemistry and CALPUFF with that in CMAQ 5.0. For the
17 SWWYTAF first dataset, this is a full simulation. 17
18 out of -- 700 -- 17 -- 17 out of 76 sources in
19 southwest Wyoming and surrounding areas with two
20 monitors in the area for air quality and a number of
21 monitors for acid deposition, sulfur and nitrogen
22 deposition. I can't talk about everything in 15
23 minutes, so I'm going to focus on the air quality data
24 and I'm also going to focus on nitrate in particular.

25 This is the modeling domain, the

1 monitor's here in this area, complex train all over the
2 place, and a lot of the sources in this region but also
3 in Utah, Idaho and northern Colorado. We ran the model
4 different ways. Well, we ran the current chemistry,
5 the modified new chemistry with and without the ammonia
6 limiting method. We tried the new aerosol chemistry
7 and the old aerosol chemistry, background ammonia,
8 constant as maybe the land managers would request and
9 then seasonally varying, and then EQUIS faced chemistry
10 looking at the effect on concentrations of both the --
11 the -- the wet removal brought by scavenger coefficient
12 (Inaudible) phase removal through the EQUIS faced
13 chemistry module. Liquid water content before, it was
14 just a constant for precipitating and non-precipitating
15 clouds. Now we're using full data from MM5 in this
16 case. She modeled both of those. We had seasonal
17 ammonia. Now these were based on new measurements for
18 a different year than the simulation year but these
19 were considered better data for ammonia because they're
20 actual measurements in that area. Doug Bloom gave a
21 paper on this. I think it was a year ago at an AWMA
22 Conference. Okay, to get to the bottom line here. We
23 have the results from CALPUFF - old chemistry, old
24 scavenging and any observation at this site of nitrate,
25 this is particulate nitrate, .1 observed and about .53.

1 So, you'll probably hear or have heard about lots of
2 complaints about overprediction and, depending on how
3 you run CALPUFF, you certainly can get that, you know,
4 with the old chemistry. If you run the model, this
5 line, as most class-run analyses would have to be run,
6 you wouldn't use varying ammonia. You would use
7 constant ammonia, and the results are slightly worse by
8 doing that. Incrementally, we implemented each of the
9 changes and evaluated its effect separate from others.
10 When you put in, in this case ALM, which has been
11 around for ten years or so, the -- the concentrations
12 are better relative to the observations but still more
13 than effect at three over-predicting. When you use the
14 new ISORROPIA chemistry for nitrate formation, even
15 without ALM, you do much better. When you use the
16 ISORROPIA and use the EQUIS faced chemistry, you do a
17 little bit better. When you combine these effects and
18 use the MM5 liquid water content, then you're doing
19 fairly well here and then if you use ammonia limiting
20 with that, you're over here. Even with constant
21 ammonia, if you just focus on the chemistry with none
22 of the other improvements, you still -- you do much
23 better. So just the new chemistry alone without better
24 ammonia or any other improvement goes from -- from this
25 to this, much closer to the observations. Still

1 conservative but closer to the observations.

2 Similar result at a different site. The

3 same story. I won't repeat it. So, to summarize,

4 CALPUFF using constant ammonia with the old chemistry

5 is over-predicting quite a bit. This is one of the

6 concerns of the electric power industry in particular

7 related to best available record for technology

8 demonstrations that are due soon. This is really the

9 reason why there's been a request to review and approve

10 at least on a case-by-case basis the new chemistry for

11 these types of applications. The ISORROPIA 2.1

12 improves things substantially. Use of seasonally

13 varying ammonia also improves performance. The reason

14 is ammonia tends to be highest in the summer and lowest

15 in the winter, and the wintertime is when a lot of

16 nitrate forms because it likes to form at low

17 temperatures. So, the variability is quite important

18 in terms of ammonia. EQUIS faced chemistry, the land

19 managers have expressed a lot of interest in this

20 because they've always wanted to have an EQUIS faced

21 chemistry capability for these classified assessments

22 and in this office now. ALM is less important for us

23 it appears, than for the MESOPUFF scheme. The degree

24 of overprediction with ISORROPIA is less than MESOPUFF

25 scheme. That's fine. That might be the reason why.

1 The second study we did was with the
2 Cumberland field study. The aircraft flying through a
3 plume, this has been described earlier in the meeting,
4 and I'm not going to get into talking about the data so
5 much. What we did is -- we extracted what we could
6 from the dataset. There are some significant
7 limitations to the data, but I'll summarize it here.
8 If you look at say the -- this gray area, this is the
9 amount of NOx that's been converted to nitric acid plus
10 nitrate, and you see with MCHM=6, which is a new
11 chemistry, the performance is better than with the old
12 chemistry where it's not matching the observations so
13 well, especially at greater distances.

14 This is another day in the study,
15 similar sort of result here. The new chemistry does
16 less well but still is reasonable. The old chemistry
17 doesn't do so badly with this one on this day. And on
18 the third day, here the new chemistry does
19 substantially better than the old chemistry, which
20 doesn't really correct -- predict the correct total
21 nitrate. So, to summarize this, neither reports on
22 this and there's a paper being prepared for this. The
23 -- the observed conversion rates are something of the
24 order about -- the upper limit is estimated at about
25 3.4 percent. The new chemistry is a little bit on the

1 -- a little bit less than that. The old chemistry in
2 MESOPUFF is over the upper limit and the MESOPUFF
3 chemistry is actually under the limit as well, but less
4 close to the computed value. We found that we couldn't
5 really use them to predict the observed nitrate in this
6 case. There was some measuring problems and that's
7 discussed in some of the documents.

8 The final thing I would like to mention
9 in the last four minutes is to talk about some
10 sensitivity tests. The question is we have a couple of
11 evaluations. CMAQ is a well-established model used
12 widely. How well does the new chemistry compute the
13 CMAQ when the inputs provided are the same in terms of
14 the concentrations? There were some differences in
15 ISORROPIA in CMAQ versus that which is in CALPUFF.
16 There were some bug fixes in the CMAQ version. There's
17 -- there's expected to be a new version of ISORROPIA
18 out soon by the model developers of that scheme --
19 that's something that it would be maybe useful to
20 include in CALPUFF in the future as well. What we did
21 is we used the Monte Carlo driver to look at a whole
22 range of conditions. In fact, three million conditions
23 and predict the values out of the CALPUFF sub-routines
24 and the CMAQ's sub-routines, just to say these -- the
25 implementations of these schemes the same in the two

1 models and, in fact, it turns out they are. The ratio
2 of the predictions are less than .01 percent and 99
3 percent of the three million tests done over a large
4 range of temperature and other conditions. For CHEMEQ,
5 because the schemes are different, that's using a
6 different scheme, that doesn't show the same agreement
7 as you would expect it not to. Although 63 percent of
8 the simulations with the old chemistry in CALPUFF were
9 within .01 percent of the ISORROPIA and CMAQ. So, the
10 old chemistry wasn't that bad. There were -- maybe 35
11 percent of the time, it was -- it gave different
12 results. But a lot of times it gave similar results to
13 the new chemistry. This is a scatter plot of that
14 showing CMAQ result versus CALPUFF result, and there's
15 a little bit of scatter but pretty close to being a one
16 -- a one-to-one line. This the old chemistry. There
17 are huge numbers of points along this line. Hundreds
18 of thousands and millions. There's not too many points
19 elsewhere, but it just shows when the old chemistry is
20 wrong, it can be quite wrong. It can be predicting a
21 hundred percent nitrate and ISORROPIA or CMAQ's
22 predicting zero and vice versa. So, although they --
23 it doesn't do poorly all the time, under some
24 conditions it does.

25 Okay, so to summarize CALPUFF Version

1 6.42 includes significant improvements in the
2 chemistry. The evaluation work shows that it does very
3 well for a full year dataset. In Wyoming, it
4 eliminates some of the issues related to large over-
5 prediction of nitrate and in the Cumberland field
6 study, the -- the comparison looked favorable. It
7 looked like it performed better under most conditions
8 than the alternatives and the old chemistry.

9 The conclusion from this is that the new
10 chemistry just based on their origin and pedigree, in a
11 sense, well established algorithms. They're -- they're
12 the peer-reviewed literature. They're used widely by
13 many different models, and they're almost universally
14 accepted as better science by the modeling community.
15 CALPUFF 6.42b is back-ably compatible with Version 5.8.
16 Again, it can be subject to confirmation and additional
17 tests. If it's not, it can be made so, but every test
18 we've done it has been. And we recommend that it
19 should be adopted as replacement for Version 5.8 in
20 that the use of the chemistry in BART applications is
21 something that should be at least considered and
22 allowed if appropriate as a non-guideline tool but one
23 that is ready for use today, and that's when these
24 types of applications have to be made. Okay, thank you
25 very much.

1 **MR. GEORGE BRIDGERS:** Thank you, Joe.
2 That concludes the talks this morning that were
3 scheduled by the AWMA AB-3 Committee or at least their
4 sponsorship. In the 9:45 to 9:55 slot, unfortunately,
5 CV had a family medical emergency and couldn't be with
6 us today. He'll be submitting his comments to the
7 docket, as I had said earlier. So, if you want to call
8 it cap and trade or a little bartering, we're shifting
9 things around just a little bit. Andy Berger's way
10 down the list at 3:45 but we - we had some discussions
11 since -- you don't have a presentation, you just --
12 okay, so he's just going to offer some -- some comments
13 and then we'll get back on track. So, let me just put
14 a stoic thing there.

15 **MR. ANDY BERGER:** Good morning
16 everybody. Thank you, George. My name's Andy Berger.
17 I'm employed by Tri-State Generation and Transmission
18 Association, an electric utility in Denver. CV sends
19 his regards. As George mentioned, he had a family
20 emergency and was not able to attend. My comments
21 being substantially similar to CV's, wanted to
22 consolidate those into one time slot. So, I'll be
23 actually offering comments on behalf of West Associates
24 in CV's place. The comments are what CV would say if
25 he was here. Some prepared comments about CALPUFF and

1 using an updated version of that model, as you heard
2 Joe just describe, the need to do that expeditiously.
3 So, thanks again, George, for accommodating the change
4 in speaker.

5 My comments are on behalf of West
6 Associates as Western Energy Supply and Transmission
7 Associates on the need to adopt specific enhancements
8 to the regulatory version of CALPUFF, as you heard Joe
9 mention a minute ago. Some of us in the electric
10 utility industry have concerns about the application of
11 the model for BART determinations and reasonable
12 progress work under the Regional Haze Rule. You've
13 heard some of the results of -- of previous evaluations
14 described earlier in this conference. West Associates
15 is an association of -- of investor-owned, publically-
16 owned and cooperative electric utilities in the western
17 U.S. West Associates was heavily involved in studying
18 visibility issues for several decades. For example, in
19 the '90s, technical data and information on visibility
20 impairment assembled by West Associate members in EPRI
21 were used by the Grand Canyon Visibility Transport
22 Commission in preparing its report on visibility
23 protection. EPA heavily relied on the Commissioner's -
24 - Commission's report in preparing the Regional Haze
25 Rule. That rule calls for using the CALPUFF model to

1 assess potential visibility impacts on emission
2 controls -- of emissions controls at major point
3 sources. Coupled with met data, the model predicts
4 conversion of SO2 and NOx emissions to sulfate and
5 nitrate particles that degrade visibility. Over the
6 past, as you heard Joe mention, several investigators
7 compelled - compared field measurements of sulfates and
8 nitrates of corresponding values predicted by CALPUFF
9 Version 5.8. Those studies concluded that the -- that
10 model over-predicts particular nitrate formation by as
11 much as a factor of 3 to 4 under wintertime conditions.

12 In the preamble to the 2005 BART Rule,
13 EPA acknowledged that CALPUFF 5.8 may overestimate the
14 amount of nitrate that is produced from NOx emissions
15 from point sources. For example, allow me to quote
16 from the EPA's final rule. "The simplified chemistry
17 in the CALPUFF model tends to magnify the actual
18 visibility effects of that source" and "we understand
19 the concerns of commenters that the chemistry modules
20 of the CALPUFF model are less advanced than some of the
21 more recent atmospheric chemistry simulations. In its
22 next review of the guideline on air quality models, EPA
23 will evaluate these and other newer approaches."

24 At the 9th Modeling Conference in 2008,
25 a study sponsored by the American Petroleum Institute,

1 API recommended using a new chemistry module to reduce
2 CALPUFF 5.8's over-prediction of nitrates. After an
3 April 2010 API and EPA modeling group meeting to
4 discuss various air quality modeling issues, CALPUFF
5 modeler, the developer of the CALPUFF model, Joe Scire,
6 was asked to test and evaluate the new chemistry
7 module. Those tests and evaluations were successfully
8 completed in November 2010, and CALPUFF Version 6.4
9 with the new chemistry and certain code fixes was
10 placed in the public domain on the TRC website.

11 In December 2010, Joe met with federal
12 land managers in Denver and described the evaluations
13 he completed with CALPUFF 6.4 in comparison to 5.8. At
14 that meeting, the federal land managers in attendance
15 reacted positively to the improvements made to the
16 model and offered to perform testing of the model
17 revisions.

18 About a year ago on February 16, 2011,
19 representatives from the TRC modeling group, API, and
20 West Associates met with EPA and federal land managers.
21 The TRC team made detailed presentations on their tests
22 and evaluations using a demonstration of the backward
23 compatibility of CALPUFF 6.4 compared to 5.8 with the
24 chemistry version turned off, as you heard Joe mention
25 a minute ago. At that time, EPA informed West

1 Associates and API that the proposed enhancements to
2 the model with new chemistry will have to go through
3 the standard rule-making process, and that could take
4 upwards of three to four to five years. EPA also
5 recommended that certain additional tests of CALPUFF
6 6.4 be made with plume measurements, and you heard Joe
7 talk about those evaluations. Under a pending consent
8 decree between EPA and the National Parks Conservation
9 Association, by November of this year EPA is required
10 to approve regional haze state implementation plans or
11 SIPs or promulgate federal implementation plans or FIPs
12 if the SIPs are disapproved for various states around
13 the west. West Associates recommends and requests that
14 EPA conduct its own test, evaluation and evaluations of
15 the newer version of the CALPUFF model as soon as
16 practicable before some of these final best-available
17 retrofit technology determinations are made later this
18 year. I understand from one of the talks yesterday
19 that some of that work is underway. If those tests
20 duplicate the finding that Joe described -- findings
21 that Joe described this morning, EPA should move
22 expeditiously to designate CALPUFF 6.42b as a regu --
23 as the regulatory version of the model for BART
24 determinations, at least on a case-by-case basis. Such
25 an

1 approach would be consistent with the process EPA has
2 used with recent changes to the AERMOD model and to do
3 otherwise would mean continue -- continued use of an
4 inaccurate regulatory tool well beyond a decade after
5 problems with that tool are recognized. In the
6 meantime, due to the -- due to the demonstrated
7 superior -- superiority of the chemistry in CALPUFF
8 6.42b, and its more accurate predictions of particulate
9 nitrate formation, EPA should encourage and carefully
10 consider modeling demonstrations using this version of
11 the model.

12 That concludes my comments. Thank you.

13 **MR. GEORGE BRIDGERS:** All right. Let's
14 see if we can get this laptop fired back up. Sorry,
15 just another -- Now we'll have comments on behalf of
16 API by Steve Hanna.

17 **MR. STEVE HANNA:** Okay, thank you.
18 Thank you. As George mentioned, these comments are on
19 behalf of the API and they are a very general
20 comprehensive set of comments because API members are
21 affected by and have to worry about all different types
22 of models and source scenarios and so on. So, this is
23 a little different from most of the talks which focus
24 in on some specific thing, and we're going to try and
25 talk about all subjects. It's sort of an overview of

1 modeling, and we will be providing the written comments
2 by the end of next month. And I'd also like to say
3 that this is a team effort with myself leading a group
4 including Bruce Egan and Bob Paine, and this is managed
5 by Cathy Kalisz of the American Petroleum Institute and
6 the Chair of the Committee is Chris Rabideau and many
7 other members of the Committee are sitting out in the
8 audience here. So, these have been worked on by
9 several people and probably most of the things I'm
10 going to be saying here in the next fifteen minutes or
11 so have been covered in the past two days or will be
12 covered by specific talks future today, but it all
13 comes down to with the increasingly stringent standards
14 that you no longer can have any room for over-
15 predictions or slight problems with the monitoring or
16 the modeling. So, there's a -- there's a lot of
17 concerns with the new standards that we're sure we're
18 working with the best models and they've been
19 thoroughly evaluated and are not over-predicting and
20 also incorporating the monitoring as much as possible.

21 So, how can we continue to improve with
22 this? This is just a lot of general things but I think
23 it's important to set priorities that -- in the past
24 two days people have suggested, well, it'd really be
25 nice to do this and that and -- and the EPA is

1 responded by, well, we'll, yes, thank you. We'll
2 consider all of this, and we're very busy and so on.
3 But I think there needs to be some effort, maybe
4 including the stakeholders as well as the EPA staff and
5 just helping to set the priorities on the things that
6 maybe should be looked at next.

7 There have been comments made at each of
8 the previous Air Modeling Conferences, back to number
9 one probably, on -- and these comments are still
10 appropriate about complete documentation and guidance,
11 workshops and so on. Previously, we had encouraged the
12 collaborations, and there has been quite a bit of that
13 that's happened in the past three years including the
14 NO2 PVMRM type collaborations. It still could be
15 improved, though, obviously. One example is the low
16 wind issues that have been brought up, and there
17 probably needs to be a little more work together on
18 some of those, and I have five of these sort of general
19 slides and then I'll get into the specific technical
20 issues and, of course, the PM 2.5 guidance. At the
21 time we wrote this, we expected there would be the
22 guidance but then we still encouraged having the
23 minimum of 60 days and the API Committee has a thread
24 going through all of these comments encouraging the use
25 of monitoring data together with the modeling data but

1 really not relying on 100 percent on modeling and then
2 various issues about recognizing the accuracy
3 limitations and using actual emissions instead of
4 potential to emit. And there have been several recent
5 studies that have been mentioned already that the API
6 has sponsored like the NO2 work or evaluations, the
7 ambient ratio method that Mark Podrez presented
8 yesterday, the low wind speed study that Bob Paine has
9 mentioned. These are all sponsored by API together
10 with other groups.

11 So, let me get into the technical list
12 of topics and -- broke it down into these categories,
13 so I'll -- I have a couple of slides on each one of
14 these categories and then some comments on each one.
15 And starting out with AERMOD and moving up through the
16 scale of models. There's a few slides on AERMOD,
17 actually, and there's been much talk already about the
18 low wind question, which is primarily been generated by
19 the fact that we're now using anemometers with lower
20 thresholds, so we suddenly have to model with a lot of
21 low winds, and we're discovering that they are over-
22 predicting and there has been suggestions made by the
23 API UR Committee, but in listening to the discussions
24 in the past couple of days, I was thinking that there's
25 really maybe a fives fit -- five phase approach and

1 some of these are hit on here, and Bob Paine has
2 mentioned some of these already, and one is better
3 estimating the use start, which is increasing it.

4 And all of these, by the way, tend to
5 reduce the concentrations because we're seeing big
6 factor of ten over-predictions in the -- the Oak Ridge,
7 the Idaho Falls and some of the AGA low wind cases.
8 Increasing the minimum Sigma V and Sigma W would help
9 quite a bit and are justified by observations. There's
10 that - the interpolation procedure between the pancake
11 and the discrete plume that I think was originally just
12 suggested by Venkatram, was why don't you try this
13 constant and see how it works, and now it appears to be
14 flipping over the -- to the discrete too quickly, so,
15 just a change in that interpolation formula would help
16 a lot. And there seems to be a problem with downwash
17 which can, even at very low wind speeds, it's assuming
18 there's downwash occurring. And from a physical point
19 of view, you would think that as the wind dies, the --
20 the eddies behind the building are going to die also.
21 So, those corrections we would suggest and we will
22 include them in the detailed write-up.

23 The next slide I think Bob used but, you
24 know, we usually say something like, try to model that
25 but actually, if you looked at an hourly average,

1 there's quite a bit of lateral dispersion going on.
2 That's what's spreading the whole thing out laterally
3 and that's, I guess, part of the pancake assumption.
4 But you -- this is something that you probably could
5 model if you use these suggestions.

6 The urban dispersion is another question
7 that's coming up more and more and, currently, AERMOD
8 relies on the PRIME just by looking around at the
9 nearest buildings and doing downwash, but the rest of
10 the community in other countries and agencies are using
11 these new urban dispersion models that account for
12 urban canopy formulas. SCIPUFF's an example of
13 something that does that, and right -- and also right
14 up in the -- some different offices in this building,
15 the research division has moved working on
16 incorporating this exact type of thing, and some new
17 urban models that they're going to be using for Detroit
18 and Atlanta and so on for health studies, and some
19 collaboration between them and OAQPS, and the
20 stakeholders could probably help to just very quickly
21 incorporate and improve urban model.

22 This is a picture of Oklahoma City where
23 there is a big field experiment done with tracers at
24 the black -- the release was at the black dot there,
25 and what I -- this is a model prediction we're seeing

1 here of a Lagrangian particle model and the -- and what
2 we're finding is important to do -- to account for is
3 that large lateral spread you can see a very broad
4 initial spread and you also can see it -- the plume
5 mixing into the wakes of the nearby buildings. So,
6 this can all be in an -- accounted for in -- with
7 current modeling systems.

8 The chemistry we talked a lot about
9 yesterday and various ways of improving the NO2
10 chemistry. Further testing of PVMRM, and then possibly
11 incorporating slightly improved models like SCICHEM.
12 Oh, and then the bottom thing about the -- the field
13 data are really inadequate and is seen to -- one of our
14 major recommendations is somebody "ought to support a
15 field experiment where there are detailed samplers and
16 we know what the emission is" and so on.

17 This hasn't been discussed too much at
18 this meeting so far, but there -- the whole question of
19 how you extrapolate an airport meteorological
20 observation over to an actual site is an open question
21 now, and there are some ways to do this so as you can
22 avoid problems with the current method where if you
23 assume a low roughness at the airport and you go over
24 to another area with higher roughness, the current
25 method you'd end up with higher wind speeds at stack

1 height and really in the atmosphere over a rougher
2 area, you would have lower wind speeds at any given
3 height. So, that sort of goes the opposite direction.
4 And prognostic meteorological models are thought by
5 some to be a silver bullet here but they are -- have
6 some errors also and should be carefully tested.

7 The straight line assumption we've
8 talked about a lot and the current 50 kilometer limit -
9 - this I can see as sort of a catch-22 because 50
10 kilometers is very arbitrary but if we reset it and
11 allow you to decide on the limit based on the current
12 wind speed, it becomes very arbitrary, and who knows
13 what's going to happen and what do you do beyond 20
14 kilometers. So, there's a lot of issues with that.
15 You could just use the Lagrangian Puff model for all
16 distances.

17 The emissions question has been covered
18 in the past two days also. The issue of using
19 allowable emissions, which leads to over-predictions
20 versus the actual, and yesterday Bob Paine talked about
21 the use of the Monte Carlo random estimates of
22 emissions more realistically covered the spread. To
23 switch to CALPUFF, that also comes under this 50
24 kilometer limit and, in principle, the PUFF models
25 ought to work just fine at shorter distances. In fact,

1 SCIPUFF has been evaluated at using the prairie grass
2 data and works just fine. To get somewhat -- some
3 perfect agreement with AERMOD, some work has probably
4 needed with CALPUFF. And there are a lot of other
5 models in the second bullet that's mentioned that are
6 available and used in Europe for regulatory assessments
7 and also in the U.S.

8 The chemistry Joe Scire just talked
9 about and it was covered in other talks. So, it
10 appears definitely this chemistry's being improved and
11 we applaud that development.

12 Now, moving to CMAQ and CAMx, the
13 regional models that -- they aren't really talked about
14 in this conference, and I've heard it said, well, they
15 have their own meeting, like the CMAS meeting. But
16 then after we thought about that a little bit, those
17 are really just technical forums and you don't allow
18 for the -- the public is not allowed at those
19 conferences to just show up like they are here and
20 stand up and make comments that are put into some sort
21 of a public record. So that -- I think that ought to
22 be -- this sort of thing ought to be expanded to
23 include CMAQ and CAMx.

24 The question of Plume-in-Grid model that
25 there -- that's also been covered extensively and it

1 appears that SCICHEM is being considered here.

2 The next topic is prognostic
3 meteorological models, and this seems to be the way
4 everybody's going these days. It seems like a good
5 idea, especially if you can get the grid size down but,
6 remember, these are the models that are forecasting our
7 weather every day, so just think about that. So that
8 the minimum, and there have been studies done, the wind
9 speed uncertainty is the meter per second. There's --
10 mixing depths are uncertain and so on. This was an
11 example of a study I did, I'll show later, where the
12 mixing depths in the afternoon are a little uncertain.
13 And there's a problem with grid resolution when you
14 have terrain around, so you have to watch out for that.
15 So, the bottom line is you shouldn't make major changes
16 unless this is really thoroughly looked at and
17 evaluated.

18 The background concentrations is a big
19 concern with the API, and we're recommending use of
20 properly sited local monitors and more than one so you
21 can really determine the upwind area. And model
22 evaluation and databases -- I think the -- we've heard
23 a lot about the quantile quantile and that this should
24 be expanded. The long-range transport evaluations that
25 were described expanded the set but, as everybody said,

1 it could be modified a little bit and include more
2 significance tests. There's some model acceptance
3 criteria which the military insists that you have in
4 your models, and that would be a lot of fun if you ever
5 had to impose that.

6 So, the final recommendations that --
7 I've covered most of these things -- is about the ARM2
8 be adopted and the tier two methods improvements to
9 PVMRM are still needed. The whole low wind speed needs
10 to be fixed, and there's been some suggestions made,
11 model evaluations improved, improved in monitoring
12 systems, use of actual emissions, and then in
13 continuing the increase of communications and
14 collaborations. And so that's the last slide saying
15 contact Cathy Kalisz if you want information about the
16 API. Thank you.

17 **MR. GEORGE BRIDGERS:** Thank you, Steve,
18 and then the final presentation before the morning
19 break, on behalf of the AF&PA is Ryan Gesser.

20 **MR. RYAN GESSER:** Thank you. I --
21 having only ten minutes and wanting to keep on schedule
22 for the break, I don't have time to deliver my opening
23 monologue this morning. So it's in the record from
24 yesterday, you can go back and check that. So, just
25 suffice to say that again I appreciate the opportunity

1 to provide comments today. I'm Ryan Gesser speaking on
2 behalf of American Forest and Paper Association or
3 AF&PA and, obviously, today I'm focusing on NO2 and
4 SO2. And a similar slide I showed yesterday, in the
5 context of discussing PM 2.5, that the industry is
6 generally well-controlled with respect to that
7 pollutant. I think we would make the case that it's
8 the same for SO2 and NO2 that we're generally well-
9 controlled in industrial operations, although obviously
10 we are major sources. All of the regulatory programs
11 that I alluded to yesterday that require controls for
12 PM 2.5 also require controls for SO2 and NO2 and,
13 likewise, there's regulations coming down the road, be
14 it Boiler MACTs or the various regional haze programs
15 which offer opportunities and may lead to further
16 reductions, not just to particulate but of SO2 and NOx
17 emissions as well.

18 Like many industrial sectors, pulp paper
19 mills can find it difficult to demonstrate compliance
20 with the applicable NAAQS following the current EPA
21 modeling guidance. Yesterday, in the context of PM
22 2.5, I said it was difficult and then proceeded to
23 paint a very bleak picture, I guess. Today I'm saying
24 it's difficult but I'm about to tell a better story or
25 a more optimistic story for -- for how our industries

1 has an outlook on demonstrating compliance with these
2 standards using the models. That said, of course, it's
3 not absolute. There are many mills that will have
4 challenges demonstrating compliance with these
5 standards with the guidance and modeling tools that we
6 have. And many of the same -- the same consequences or
7 implications would apply where there's new projects
8 that can't move forward until the modeling issues are
9 resolved, and that's obviously a concern. And if we're
10 speaking about SO₂, then obviously we have to recognize
11 the SIP development process that's underway. We have
12 draft guidance but not final guidance at this point, so
13 that is obviously a program that mills that aren't
14 undertaking projects for growth will still have to
15 evaluate their impacts under their existing operations.

16 So, again, we find ourselves in a
17 situation of having to explore whether additional
18 controls may be required. I think our outlook in most
19 cases suggests that that's not likely to be the case.
20 Where we do have modeling issues that need to be
21 resolved, we're optimistic that, in most cases, they
22 would be resolved by the on-paper reductions of on-
23 paper permitted limits on our maximum allowable
24 emissions that, again, we have to model under
25 regulatory context where we might have to accept some

1 reduced flexibilities in terms of operations, and
2 especially fuels moving from higher sulfur fuels to
3 lower sulfur fuels, but we're optimistic cautiously
4 that that would -- that would be mainly on paper
5 exercises to do that.

6 Yesterday, we heard the presentation
7 from EPA's AERMOD implementation workgroup or AWIG. In
8 that presentation, they did not call specific attention
9 to our sector. Thank you. But we were included in the
10 report, and so I wanted to take a moment just to
11 acknowledge that, and we're going to talk about -- I'm
12 about to talk about our outlook for answer to an NO2
13 based on some work that we've done. And it looks
14 different than what is presented in the AWIG report,
15 and since that did go into the record and it is part of
16 the report, you might see I wanted to offer some
17 additional information from that. I want to be clear
18 that we don't have a critical review, and we're not
19 trying to be critical of this finding necessarily
20 because, obviously, the report just came out. We
21 haven't fully evaluated it, and we don't fully have all
22 of the inputs to evaluate it, but we reach a different
23 conclusion than you would reach looking at this
24 information. So, we did want to take the opportunity
25 to discuss that.

1 Just to summarize what was reported in
2 those findings, like you saw, they've -- the group
3 looked at various modeling scenarios and cases for the
4 different sectors, and ours wasn't a particularly
5 optimistic picture. In what was called a base case,
6 the impacts for SO2 were found to be up at a level
7 above 900 micrograms. Of course, the standard is
8 closer to 200 micrograms, so that's -- that's not a
9 very optimistic picture. And then in various
10 combinations of control strategies of stack height
11 increases, the results improve but there weren't any
12 scenarios that were shown to get below the NAAQS
13 standards. So, that obviously is -- is a concerning
14 conclusion, and it was a little bit surprising in that
15 that's not what we were expecting, and that's not what
16 we see when we look at our own analyses for typical
17 mills. So, there's some of those details there. You
18 know, if we have the opportunity to review those with
19 the group, I think we'd be happy to do it but, you
20 know, we're going to show some different results here.
21 What I would just note from that report is that the
22 emissions that were modeled totaled about 777 pounds
23 per hour in a base case and 372 pounds per hour in a
24 base case. And that jumped out at us right away that
25 that seemed to be somewhat higher than what we would

1 have expected for -- for a typical mill, but yet it
2 still could have been legitimate. I want to make that
3 clear that when you follow the guidance and model
4 emissions at their full permitted allowable emission
5 rates, you can certainly see emission rates that high
6 if you have a permit condition that allows a very high
7 sulfur fuel such as coal or oil in certain
8 circumstances, and certainly that -- that does exist
9 for some mills, but it's not typical of our -- of our
10 typical process that burns primarily biomass, which has
11 very low SO2 emissions, and also is sort of inherently
12 a closed loop and tends to remove sulfur dioxide from
13 the process just in the inherent way that the process
14 is designed. So, again, we were a little surprised or
15 -- that the results were so high but not surprised when
16 we saw that the emission rates that were being modeled.

17 So, again, I have a number of cases
18 here. I don't have time to go through them all, but
19 what I would point out in summary is that the various
20 ones we looked at had emission rates based on permits
21 or what we think would be acceptable for permits and,
22 in these other cases, they're closer to about a 100
23 pounds per hour or maybe up to 280 pounds per hour in
24 that case. And in those cases when we modeled them,
25 the outputs we got were -- the results at the highest

1 fourth high level, not including a background, were
2 closer to about a 100. Not much higher than a 100 -- a
3 108 in this case, a 118 in the other. And so that,
4 obviously, is below the standard if the yellow
5 highlighting is showing up there, I kind of displayed
6 that as caution because in some cases the background
7 concentration is also on that level. So, just adding a
8 conservative background, we still might have an issue
9 to work through.

10 But one other case in the middle here
11 that did have a higher result is one where we saw
12 emissions on the levels that were shown in the AWIG
13 study. We still got a lower model result overall,
14 although this obviously would have been below the
15 standard, but this is a case where we looked at the
16 permit limits and said, yeah, you know, these permit
17 limits are really high. They might be based on old SIP
18 limits or fuels that aren't burned anymore. So, when
19 we looked at a controlled case that didn't necessarily
20 require controls but would be more representative of
21 emission levels at what might be considered backed or
22 at least some kind of control, those model impacts came
23 well below the standards. So, we saw that as a better
24 sign.

25 It's worth noting, you know, these are

1 sources that when they were originally permitted with
2 the three hour and twenty-four hour NAAQS, they were
3 well less, 50 percent or less than those standards.
4 You would now -- this one would have been two times the
5 current 1-hour NAAQS, so this is a message we already
6 knew that even sources that might have been considered
7 well under the NAAQS in the past under the old
8 standards can have a challenge with the new standards.

9 So, one thing that this leads us to
10 recognize is -- is that the -- the idea of variable
11 emissions processing, we recognize there's a number of
12 implementation challenges but we can see how that would
13 be useful. I'm interested in exploring it to account
14 for that sort of fuel variability where coal or higher
15 sulfur fuels may be fired at some limited times, but
16 most of the time the emissions would be representative
17 of cleaner fuels and, therefore, that distribution
18 would be interesting to represent.

19 I wanted to touch briefly on NO2. This
20 was not a subject of the AWIG study, but I thought I
21 would mention it because we've obviously looked at it
22 from the industry perspective and, you know, the order
23 of emissions that we looked at these various examples
24 are a few 100 pounds an hour, and these are major
25 sources, combustion sources. And when we applied the

1 current tier two methodology, if this had been done by
2 AWIG, I wouldn't have been surprised to see a high
3 result there. We do often see values that exceed the
4 1-hour NO2 standard by a factor of two or more under
5 the tier two assumptions, but if we then go and apply
6 the tier through approach, whether it's OLM or PVMRM,
7 we do see results that are much lower and far below the
8 standard. And this is largely due to accounting for
9 the NO2 to NOx in-stack ratio that's characteristic of
10 our sources. What stack testing we've done usually
11 seems to come out pretty consistently at a ratio of
12 around 2 percent and so that -- that's a very low
13 number even if you modeled at say 5 percent
14 conservatively, which is I think what we had in these
15 studies. You see the results that are a lot more -- a
16 lot lower and that we think more representative.

17 So, the recommendation really is just
18 that we're encouraged to hear about the improvements
19 and attention that these tier three NO2 models are
20 getting. We obviously support their use and -- and to
21 any -- any measures that can be taken to sort of
22 streamline that process, whether that be getting
23 approvals not at a state level and not requiring a
24 case-by-case review in every instance. We think that
25 would be encouraging and help facilitate this process,

1 and as these kind of data become more readily
2 available, I certainly expect that that process to
3 become smoother.

4 So, again, just in summary of the -- the
5 comments here, we appreciate the work that the AWIG
6 group did, but we were a little concerned that it may
7 have overstated our impact. So, we're happy to work to
8 -- to refine that or address that in their report, if
9 it's -- if they're willing to do that. And we also
10 appreciate the efforts that we've heard about to
11 improve the NO2 models and the other issues in model
12 performance that have been -- gotten a lot of attention
13 this week. So, as always, we promote reasonable
14 implementation of the guidance and we're happy to
15 participate in that process. So, I'll conclude there,
16 and thank you very much.

17 **MR. GEORGE BRIDGERS:** Well, thank you
18 Ryan and to all the presenters this morning. We've
19 ended this first session right on time. So, at this
20 time, let's go ahead and take a fifteen minute break
21 and we'll be back at -- at 10:40.

22 (WHEREUPON, a brief recess was taken).

23 **MR. GEORGE BRIDGERS:** We're going to
24 start back up the second session of the morning with
25 Bob Paine from AECOM.

1 **MR. BOB PAINE:** Thank you. The first
2 two ten minute presentations will be presentations
3 sponsored by EPRI. Eladio Knipping and Naresh Kumar
4 were the project administrators. And you're going to
5 see a couple of new terms here, AERMINUTEPLUS and
6 sharp, which we'll go into here. And this
7 AERMINUTEPLUS sort of -- sort of brings back the memory
8 of CTDM which was made CTDMPLUS slide some twenty-five
9 years ago by Steve Perry. And we've augmented their
10 AERMINUTES to make it do some hourly meteorological
11 periods and developed a sub-hourly AERMOD run procedure
12 which we fitted into the acronym SHARP. We selected
13 databases for this evaluation and some test procedures
14 and some preliminary evaluation results. So, why do we
15 want to develop such a capability when we know that we
16 have -- this is obviously a problem for low wind speeds
17 because in under high wind speeds, you have, you know,
18 fairly persistent flows and the wind doesn't fluctuate
19 too much. But you could have a large fluctuation
20 during the course of an hour and if you have the data,
21 why not try to use that data? And then certainly in
22 low winds, we -- low wind speeds -- during the course
23 of a full hour, winds can go in several directions and
24 resulting in multiple concentration called the lobes.
25 This is actually courtesy of Joe Scire. Three years

1 ago, and he presented this AERMOD depiction of a -- the
2 meander or pancake plume in the middle of that source,
3 and the coherent plume above that. Now, the coherent
4 plume in many cases has a much higher concentration
5 than the -- the meander plume and therefore it only
6 goes in one direction. And here's a plume footprint
7 from the Bull Run experiment with a fairly good gassy
8 and plume shape, but if you consider this hour where we
9 had I think at least four lobes. It didn't happen very
10 often but it can happen. We found at Bull Run that
11 most of the time the plumes were reasonably gassy but
12 sometimes, you can get this, and you can't do that with
13 a -- a model like this two slides ago. So, we
14 developed this procedure called AERMINUTEPLUS to take
15 the two minute averages and develop averages that are
16 sub-hourly averages of the winds, and just if you
17 divide two into sixty, well, you can have as few as two
18 periods of thirty minutes long or many as thirty two
19 minutes long, and our procedure will allow the user to
20 take any combination in between as long as the number
21 divides into sixty. The output files of this procedure
22 looked like copies of hourly files but, for example, if
23 you add two thirty minutes files, you'd have two files
24 and the first file would be minutes zero to thirty, and
25 the other one would be minutes thirty one to sixty for

1 each hour of the year. And then you would run AERMOD
2 with each one as many times as you had to get each part
3 of the hour. Then there's a procedure. I'm going to
4 go through these steps here. You take output from
5 AERMINUTEPLUS. You run AERMOD multiple times for each
6 part of the hour. Each run is the same minutes of each
7 hour. We have a bin merge procedure that takes the
8 output concentrations and averages them, and then we
9 also are configuring out the process calm periods
10 consistent with the AERMOD's approach so that if you
11 had more than fifty percent of the periods that were
12 calm, you'd have to make -- that hour would not be able
13 to be used as a definitive hour for AERMOD results.
14 The third step is to take this merge concentration file
15 and put it into a process that we called post-one hour
16 to get the required design concentrations. We had
17 decided to evaluate this procedure then using
18 evaluation databases that had tracer releases from a
19 single stack. We wanted to avoid building downwash
20 wash issues, and we needed obviously sub-hourly
21 meteorological data. We wanted to have databases with
22 significant plume meander otherwise it's not very
23 exciting, and we had two databases we had budget for, a
24 low level release and an elevated release. One
25 emphasized stable conditions, the other unstable, and

1 they were predominantly affected by light winds, and
2 these databases were the Three Mile Island. They
3 actually had a tracer release prior to constructing
4 this facility back in 1971. We -- we had only five
5 hours but they were very interesting hours of very low
6 wind stable conditions and sometimes they had to use
7 smoke handles to figure out which way the wind was
8 blowing, the winds were that light. And then Bull Run
9 and EPRI database from 1982 dominated by unstable
10 conditions, tall stack releases. We used one hundred
11 sixty two hours in the half of the database reserved
12 for development. Now, the Three Mile Island only had
13 one arc of receptors whereas Bull Run had twelve arcs
14 from point five to fifty kilometers.

15 Here's an example of the Three Mile
16 Island set up, and each of these spokes is actually a
17 concentration in -- in every twenty degrees, and you
18 can see that in one hour you have and -- and these rays
19 are the wind directions through the hour and these are
20 the magnitudes of the concentrations at various
21 directions. Obviously, that coherent plume model
22 wouldn't do too well in this case. We ran AERMOD in
23 each case for five-minute averages and so far we've
24 only chosen the five-minute periods, so there are
25 twelve - twelve of those periods within an hour. We

1 directed the plume -- for the 1-hour average runs, we
2 directed the plume toward the stack with the highest
3 concentration to give the model the best chance of
4 succeeding.

5 With the sub-hourly runs, since the wind
6 directions vary, we took them at face value. And we
7 used a variety of tests which I won't go into detail
8 here because of the time limitations, but I'm going to
9 focus on the bias and -- and -- and what I call a
10 goodness of fit like is the plume width too tight, too
11 loose and just right?

12 Now, Three Mile Island, there were five
13 databases. The red bar is the highest on the arc for
14 observed. Blue is the hourly AERMOD and sort of like
15 the greener mustard is the sub-hourly for five minute
16 averages and we can see that the hourly model over-
17 predicted in all cases. The sub-hourly model over-
18 predicted for most cases, slightly under on the first
19 hour. These are all stable hours, very light winds.
20 The average over-prediction ratio for the hourly model
21 was twelve point six for the five minute, sub-hourly
22 model - three point seven, so the -- but the -- one --
23 one way to do the goodness of fit is to say, well, what
24 percentage of the values were more than fifty percent
25 of the peak? Observations fourteen percent. Hourly

1 model only seven percent. The footprint is too tight,
2 too concentrated. The five hourly sub-hourly models a
3 little too loose, and we speculate where maybe if we
4 went to ten minutes, we might get a better fit.

5 Okay, Bull Run overall results. There's
6 a variety of arcs and we noted from previous work on
7 convective conditions that the hourly AERMOD models
8 does well, and we found that in fact the predicted
9 observed ratio is a little bit higher than one overall,
10 but it's -- it's not too bad whereas the five minutes
11 of hourly model was a little low, but we see that also
12 it's -- a footprint is a little loose whereas an hourly
13 model is too tight a little bit. So, we speculated
14 where maybe if we went to a ten minute average we might
15 get a better fit to the sub-hourly model to the
16 observations.

17 So, concluding remarks on this sub-
18 hourly evaluation. We've developed a capability that
19 EPRI will -- it's still evaluating, but we'll certainly
20 consider providing to EPA. We've done a limited
21 evaluation on two databases that featured both stable
22 and unstable light winds. We can see for -- certainly
23 for stable conditions, so we have another stable light
24 wind database adding to the others ones I talked about
25 the first day that indicates AERMOD needs some

1 improvement. Now, one way to do it is to divide the
2 hour up into sub-hour periods, and so this is one
3 approach. We find that in all cases the hourly
4 predicted plume for it is generally too tight
5 especially in stable conditions. The five minute
6 period may be too loose of a fit and you might -- we
7 might try a ten minute period if we have opportunity to
8 do that. Obviously I would recommend further testing.
9 And that's the end of that presentation.

10 **MR. BOB PAINE:** Okay, people have always
11 wanted to know how far is the short range model
12 applicable, and someone came up once with a fifty
13 kilometer distance and we're still trying to figure out
14 where that came from. This is another EPRI funded
15 investigation. I'm talking -- going to talk about the
16 limitations of short range models. Can we make a puff
17 model a plume model equivalent to do some testing on
18 where do the models actually start to diverge and at
19 what distance. And so we looked at both puff and --
20 puff trajectories and concentration comparisons for
21 this study. Obviously, as you know, plume models
22 assume city-state conditions, so we have a lighthouse
23 beam effect. Every hour, the lighthouse beam shifts to
24 a different direction. The previous hour's light beam
25 is forgotten, and worse case conditions, and especially

1 associated with low winds are -- are persistent or what
2 I would say impossible distances, but impossible equals
3 fifty kilometers at this -- at this point. This study
4 tried to more carefully quantify what's a reasonable
5 distance for how far these models are applicable, and
6 I'm looking at both AERMOD and ISC is -- is good
7 representations of a city-state plume model.

8 So, one way to do this is to take a non-
9 city state model like CALPUFF and make it a equivalent
10 to a city-state model for constant meteorological
11 conditions, and then run a year's worth of data hour by
12 hour and see where, at what distance do the models
13 start to diverge in terms of their predictions. Now,
14 we tried to make AERMOD and CALPUFF equivalent and we
15 didn't have enough money to do it -- to make them
16 equivalent. We -- we -- we tried to make the
17 horizontal and vertical dispersion equivalent but
18 AERMOD's formulations, especially for convective
19 conditions is -- it's complicated and in its -- we just
20 gave up in that effort.

21 But we had much better results between
22 ISC and CALPUFF and since ISC and AERMOD are reasonably
23 comparable in flat terrain, we decided to go with ISC
24 versus CALPUFF to do this -- this test of city-state
25 versus non-city-state models. So, we -- we found the

1 best results between ISC and CALPUFF were for non-
2 buoyant sources and flat terrain since there are some
3 plume rise differences between the two models. And we
4 ended up looking at thirty-five out of one hundred
5 meter non-buoyant release heights as being good
6 candidates for testing. The big difference is not
7 exceeding a four percent and usually not two percent
8 for distances beyond two kilometers, and we -- we will
9 give a two kilometer applicability or more to a city-
10 state model.

11 We used two met databases, one year
12 each, and one was a - a sort of a valley orientation,
13 the Willamette Valley for Salem, Oregon with pronounced
14 preference for north or south winds, and then
15 Evansville, Indiana, more of an isotropic wind regime
16 here. This database used pre-ASOS, pre-AERMINUTE but
17 this was fully developed with AERMINUTE 2007 where it
18 says 1986 for Salem. First of all, we conducted a
19 segmented plume analysis by connecting hourly time
20 travel using ten minutes -- ten meter data from each
21 database. After the air parcels left a one hundred
22 kilometer by one hundred kilometer domain, we didn't
23 further track them. We wanted to see, well, how far do
24 these air parcels go after one, two, three, four,
25 etcetera hours. We found that more than ninety percent

1 of the time they don't go much more than twenty or
2 thirty kilometers at most, often less. Even after four
3 or five hours, fifty percent or more could still be
4 within fifty kilometers of the release point if you
5 would consider recirculations, and certainly they --
6 they can travel in non-straight trajectories. For
7 example, Salem, Oregon, we have the twenty kilometer,
8 the thirty kilometer radius distances. After -- after
9 once -- after one hour, most of the air parcels didn't
10 travel more than twenty kilometers, and these are --
11 since these are whole knots, you're going to see
12 basically concentric circles whereas with the AER -
13 AERMINUTE process, Evansville, we're going to see more
14 of a cloud of points, but again, each -- each radius
15 here is ten kilometers further out. Most again are
16 within twenty kilometers, especially even within ten
17 kilometers. Even after five hours, we see that half
18 the -- half the -- half the puffs are still around
19 whereas, of course, the lighthouse model, they are --
20 they are gone every hour. That's Salem, Oregon and
21 this is Evansville. Again, certainly a - a - a non-
22 city-state puff model will give you a -- more of a - an
23 accurate depiction, and here's another way to look at
24 it. After end, you know, one, two, three, four hours
25 going from front to back and the probability of

1 distance travel, after one hour for Salem, Oregon,
2 we're seeing ten percent or less going beyond twenty or
3 thirty kilometers, obviously growing with increased the
4 number of hours of transport. And similarly, we see
5 for Evansville, Indiana.

6 Again, so going out to fifty kilometers,
7 hardly any air parcels get out that far, at least
8 looking at the ten meter winds. But we're assuming in
9 city-state models that they do.

10 Now we're going to the model prediction
11 comparison part. We ran CALPUFF in ISC equivalent
12 mode, assuming flat terrain to get the models
13 equivalent for city-state meteorology. We used polar
14 receptors out to fifty kilometers and looked at certain
15 popular statistics for the daily one-hour max such as
16 the ninety-ninth or ninety-eighth. I'm going to look
17 at the ninety-ninth percentile. The fourth highest for
18 some of the next few slides. Here's the pattern for
19 Salem, Oregon for a source of the middle and the colors
20 are such that they -- the hotter colors are higher
21 concentrations, so you can see that the concentrations
22 would - of course, there's -- there's -- there's a
23 whole in the middle because that source is released at
24 some height above the ground and maximum concentration
25 here may be out, oh, with -- well, within ten

1 kilometers is ten, twenty, thirty, forty and fifty
2 kilometer rings. But you can see when we go to CALPUFF
3 and -- and remember, this is a -- even though we're not
4 doing terrain, this is flat terrain, the winds are
5 influenced by the -- by the valley. And so, when we go
6 to CALPUFF, we're going to see that the lower
7 concentrations creep in because the winds, once they
8 start out, the puffs once they start out, might go to
9 the left or right after one hour of transport. And if
10 we take the ratio of these two concentration patterns,
11 these are the one hour, four -- highest four find
12 that's when our max is at each receptor. The color
13 scheme here on the ratio is such green. This green is
14 from one to one point five. Anything that's gray or
15 blue is below one and there's hardly any of those. So,
16 the ISC versus CALPUFF ratio, well, that is the city-
17 state model to the non-city-state model is showing that
18 we're -- we're conservation, but once we get to the
19 browns, we're -- we're in factions two over, and those
20 start to creep in in several directions, especially
21 along the directions toward which the winds might
22 diverge. Certainly beyond twenty kilometers, I would
23 say, we're getting many directions where we're starting
24 to get factions of two relative over-prediction, model
25 to model over-predictions.

1 Looking at Evansville, more of an
2 isotropic wind pattern. This is -- this is ISC highest
3 forth highest pattern here. Just looking at the color
4 scheme, let me go to CALPUFF. Again, less coverage by
5 the higher concentrations in many directions. The
6 pattern just shrinks because the -- the controlling
7 conditions are not persisted as far as were the city-
8 state models. So, the ratio again, we see hardly any
9 colors that are gray or blue. I've got a little sliver
10 here. Again, we're seeing factor of two model to model
11 over-predictions, ISC versus CALPUFF. It's starting to
12 creep in. Even ten kilometers. It would certainly be
13 on twenty kilometers, so we're seeing that the pattern
14 is that the ratio's start to diverge, especially when
15 you get to, I would say twenty kilometers would be opt
16 in several directions.

17 So, conclusions are we saw some of the
18 results for both of these different meteorological
19 databases, the concentration ratios were close to one
20 within five kilometers, within a factor of two within
21 twenty kilometers, let's say, but beyond twenty
22 kilometers, we saw several directions where we got
23 ratios exceeding two. Sometimes much higher than two.
24 And we didn't even consider terrain. This is just flat
25 terrain but the winds are influenced by terrain for

1 Salem. So, I'm throwing out the idea that from this
2 limited experiment, twenty or thirty kilometers, you
3 know, giving -- giving some generous benefit, might be
4 the extent to which you want to trust a single hour,
5 you know, a city-state single hour's travel. You know,
6 the travel doesn't go much beyond twenty or thirty
7 kilometers in a single hour, and even after four or
8 five hours, with a true city-state model, you get many
9 parcels that are still within fifty kilometers.

10 Our results suggest that you might want
11 to consider really twenty kilometers may be a more
12 reasonable limit for the appropriate applicability of
13 the city-state model. We are working on a new
14 debugging output for AERMOD. It will tell you for each
15 hour, each source, some useful information. The -- not
16 only the wind direction and the winds -- the effective
17 wind speed and the effective SIGMA W and SIGMA V, but
18 also the partial penetration fraction, the meander
19 fraction, the downwash fraction, but also how far does
20 the -- this puff go, this plume go at an hour and how
21 far is it to the receptor? And so that, that debugging
22 information will be useful for users to determine,
23 well, is the model really doing the right thing for
24 this hour for this receptor, the peak receptor for each
25 source for each hour.

1 So, we're looking forward to developing
2 that and -- and -- and providing that to EPA and
3 hopefully getting that into a future version of AERMOD.
4 Okay, I think that's it.

5 **MR. BOB PAINE:** Okay, the last talk in
6 my series will be a model of AOA -- should add an
7 actually monitoring network in North Dakota. Going to
8 talk about why we did this study, describe the
9 database. Model results using, you know, the proposed
10 modeling for NAAQS compliance. Results from
11 refinements and a problem with low wind speed stable
12 conditions. Obviously, we've talked about many issues
13 with modeling versus monitoring, so we decided, well,
14 let's test the model where there are monitors, and
15 where there are multiple sources. So, a real live test
16 of the EPA proposed procedures.

17 We had this opportunity because we had
18 hourly data and many electrical generating stations.
19 This study was, by the way, funded by Base & Electric
20 Power Cooperative. There were two nearby sources and
21 then there were other sources within fifty kilometers.
22 There were five monitors and there was an on-site tower
23 close by the sources. Here's the map showing the --
24 here's the distance scale here. The five monitors are
25 these yellow diamonds. The two source groups here that

1 were close by, and Low Valley and Great Plains Synfuels
2 Plant. A few other EGU's, one on Coyote and the met
3 station I think was one of these two here. Zooming
4 out we have a few other sources. Some of these
5 actually, I'm going to focus on later. Actually, I
6 just -- influenced the concentrations way over here.

7 First run-through we used a lot of
8 emissions of all sources, soon to be constantly
9 emitting. We placed receptors only at the Monterey
10 sites except for a -- some runs that characterized the
11 spacial patterns. Now four of the five monitors were
12 elevations sort of near the local stack base but the
13 fifth was about a hundred meters higher, and we see
14 that, looking at the terrain, this particular receptor
15 here, the monitor here was about a hundred kilometers
16 above, but most of these other ones were close to stack
17 base, but we see the pattern of terrain, the pattern of
18 concentration prediction there was a similar concert of
19 high concentrations in the high terrain. That's
20 interesting, you might say, but look at the
21 concentrations. This particular monitor was about a
22 hundred meters higher in elevation but the
23 concentrations -- these are the design concentrations
24 over a five-year period, they actually had the lowest,
25 although within five percent. There was hardly any

1 gradient of concentration, but the model, look what the
2 model is doing, using liable emissions. Our -- our
3 ratio with terrain included of the model to monitored
4 accounts for both the -- the emission, liable emissions
5 versus actual emissions but this terrain issue was --
6 was highly interesting, even though this monitor
7 actually showed the lowest concentrations. So, we
8 looked into that a little bit more. In fact, we just
9 modeled it as all flat. The actual terrain slope is
10 about two percent anyway. What we modeled was flat and
11 low and behold, everything was more consistent. The
12 concentrations were consistent. The model was
13 consistent even though over-predicting. At least it
14 was relatively consistent. So, that's one -- one, you
15 know, one recommendation is, well, if the terrain isn't
16 that tortuous, just model it as flat. Then we used
17 actual out of the emissions and we got even better
18 results for this. There's one monitor here where we
19 think some of the -- there are -- there's one source
20 that has a bypass stack, and sometimes that stack may
21 have sub-hourly emission parameters that -- that may
22 have to be tweaked to get that a little bit better, but
23 we're seeing the combination of flat terrain and actual
24 emissions makes a big difference in the model
25 performance for these five monitors.

1 So, for all -- overall conclusions are
2 that, well, at the -- one of the monitors, I just said
3 the remaining over-prediction might be associated with
4 uncertainty of exhaust parameters or in bypass stack
5 conditions, but the model performance improves greatly
6 with the use of actual emissions and flat terrain for
7 the -- the slope is reasonably gentle. We have one
8 more significant problem that we looked into, and by
9 the way, this was, this whole study was submitted to
10 the docket that was due December 2nd. It's also going
11 to be in a AW May paper in this June's conference. We
12 found that with very light winds, mechanical mixing
13 heights can be much less than the plume height. We -
14 we saw problematic emissions where the mechanical
15 mixing eye was three meters. And we found some sources
16 that were forty kilometers away or -- or contributing a
17 large amount to the predicted impact. Because those
18 plumes, the stack bases were low enough so that the
19 plumes by that time being assumed to be perfectly level
20 of model, we're hitting the terrain. The plume
21 dispersion was very restricted for plumes above a low
22 mechanical mixing height, and we found that the result
23 was when the plume finally intersected the terrain
24 forty kilometers away, it came up with a high
25 concentration there was somewhat anomalous. Now, what

1 we did is we did the test with a generic tall stack,
2 modeled it with both flat terrain and a one percent
3 slope in all directions, like a very shallow cone. We
4 modeled an entire year in meteorology and got the peak
5 concentration on each ring of receptors up to fifty
6 kilometers, and I'm going to show you the plots for
7 this -- these concentration pattern. The peak
8 concentration is the functional distance for flat
9 terrain and this one percent slope. This is the flat
10 terrain case now. For an elevated stack, you would
11 expect, yeah, the concentration peaks at a reasonably
12 close distance of, well, a kilometer or so, and then if
13 it, you know, tails off with distance.

14 Now, let's add onto that the case where
15 we have a one percent slope and low and behold, what is
16 this? We have a - a bump. When the plume finally hits
17 the terrain some twenty, you know, thirty kilometers
18 away, this is what AERMOD is doing. I don't believe
19 that that's really happening in real life, but this is
20 what the elo -- and we traced this to a stable
21 nighttime hour with extremely low mixing height. So, I
22 -- I -- I'm puzzled. Well, I'm not, maybe I'm not
23 puzzled. I guess, I -- I think it's an issue that has
24 to be looked into, as to do we believe that plumes go
25 perfectly level in areas of very low sloped terrain.

1 And so in each of the identifying an issue that EPA
2 needs to look into.

3 So, conclusions from this test are that
4 AERMOD has an unusual prediction result, and I think
5 the problem is caused by the very low mixing height
6 that leads to compact plumes. Now, you can imagine
7 that if you have low level sources that are closer to
8 low terrain, maybe we're seeing this issue all over the
9 place with light winds, low stacks and we're getting
10 like a slight terrain rise for stacks that are five
11 meters high. Same thing might be happening with all
12 sorts of sources all over the place. When the mixing
13 height is below building obstacles, why doesn't, you
14 know, shouldn't -- shouldn't the mixing heights make
15 other mixing heights respond to the fact that we have a
16 building canopy? It seems like there's a way maybe to
17 get the building canopy into the model.

18 So, then since the plume stays perfectly
19 level, maybe we should have a policy not to consider
20 terrain in such cases because we are getting a better
21 result for both the monitored part of this study I
22 looked at earlier, and we would avoid this bump at
23 thirty kilometers that we saw in this test. That's the
24 end of that talk.

25 **MR. GEORGE BRIDGERS:** Thank you, Bob,

1 for all three of those presentations. Moving right
2 along. Allen, the floor is yours.

3 **MR. ALLEN DITTENHOEFER:** Thank you,
4 George. I'd like to acknowledge my co-author, Michael
5 Hirtler, also of Environplan Consulting. On behalf of
6 the coke industry, the American Coke and Coal Chemicals
7 Institute, we prepared a brief presentation to discuss
8 some of the technical issues and challenges in modeling
9 a buoyant line sources. Earlier in the week, I was
10 pleased to see that EPA has listed this modeling as one
11 of its priorities in improvements to AERMOD. This is,
12 you know, is of critical importance to certain
13 industries such as the metals industry where we have a
14 lot of buoyancy associated with heated fugitive
15 emissions, such sources like electric arc furnaces,
16 basic oxygen furnaces and aluminum reduction plants.
17 You've got roof monitors, roof vents and positive
18 pressure baghouses configured in long lines where
19 you've got buoyancy associated with the -- with these
20 emissions. Coke batteries also. You have not only the
21 release or volumetric flow of hot gasses coming out of
22 the leaks from these ovens but you also have the hot
23 surface, which provides convective heat transfer and
24 the applications, of course, with -- now with the 1-
25 hour SO2 and NO2 standards, we need to more accurately

1 model these types of sources. When you model these
2 sources using a non-buoyant volume source
3 configuration, you get large exceedances of the
4 standards. Also, there are obvious PSD new review
5 applications. Next year, EPA is going to be doing its
6 risk and technology review for the coke industry on the
7 pushing batter -- quenching and battery stack mack.
8 So, we need more realistic models to conduct that
9 modeling and so on.

10 Now, as you know, AERMOD does not treat
11 buoyant line sources and previous approaches have used
12 some type of a hybrid approach where you first estimate
13 plume rise using a buoyant line source algorithm and
14 most commonly the EPA BLP model has been used. But
15 then you take those effective stack heights from the --
16 from the plume rise algorithm at BLP and then
17 incorporate them into a dispersion model such as, well,
18 back -- back in the 2005 time frame, ISC was used in
19 the sub-part L Coke oven residual risk studies. Now,
20 of course, we have AERMOD.

21 Now, what are some of the relevant
22 features of BLP? This -- this model was actually
23 developed thirty years ago for the aluminum industry.
24 It treats the enhanced plume rise of buoyant line
25 sources, and -- a line source as compared to a -- an

1 unobstructed stack release, you have one less degree of
2 freedom in the entrainment of ambient air, so you've
3 got enhanced rise compared to a stack plume. You also
4 have -- you get a plume enhancement when you have
5 multiple line sources aligned in parallel. The plume
6 rise is dependent on the wind direction relative to
7 that configuration of line sources, the line source
8 length, the number of parallel lines and their spacing.
9 And BLP is also capable of treating vertical wind shear
10 on plume rise and incorporation of building downwash,
11 but one major drawback of BLP, it does not treat
12 complex terrain. So, many of these types of facilities
13 are located in complex terrain settings. You need to
14 have a model, dispersion model, that can adequately treat
15 complex terrain.

16 Just briefly, what -- to show that the
17 BLP line source of algorithm, plume rise algorithm
18 differs from stack sources. We note that in a line
19 source, we have dependence on the distance, linear
20 dependence whereas in a stack plume, you have a two-
21 thirds dependence, and this -- this illustrates the
22 enhancement that you get on a line source. A key
23 parameter in this modeling is the buoyancy parameter.
24 For a stack buoyancy parameters are fairly easy to
25 define. You can do a stack test and measure the

1 volumetric flow and the temperature, and you know
2 pretty much have it in a -- for a line source,
3 particularly for complex sources like coke batteries,
4 you don't have a well-defined method of calculating the
5 buoyancy parameter. It's a function of the dimensions
6 of the line source and exit velocity and, of course,
7 temperature difference. Now, for coke batteries, you
8 have two components of this buoyancy parameter. You
9 have a convective heat transfer component, and this is
10 -- this is due to the heating of the ambient air
11 surrounding the hot coke oven surfaces, and you have a
12 myriad of surfaces. You have, of course, the top of
13 the oven, you have the sides, and the doors and buck
14 stays and off-tape piping that's found on top of the --
15 of the batteries. So you need to calculate what heat
16 transfer is occurring off of these hot surfaces and
17 then, secondly, there's a volumetric flow associated
18 with the fugitive emissions, and there are a myriad of
19 sources of fugitive emissions along a battery which can
20 extend a hundred meters or so. Whenever you charge an
21 oven, there are door leaks along the battery, topside
22 leaks, every fifteen minutes or so a battery is pushed
23 -- I mean an oven is pushed where massive hot coke is
24 pushed out of the oven onto a quench car. You
25 typically have a movable hood that captures most of the

1 emissions, but when you -- and then that goes to a
2 baghouse, but oftentimes when you undercoke the coal,
3 you don't get a good capture. You get a lot of
4 volatile organic compounds of particulate matter that
5 escape the hood contributing to the volumetric flow
6 which adds to the buoyancy. So, it's critical that we
7 account for this and it's not always a straightforward
8 calculation -- calculation. Like for the fugitive
9 emission component, we often have to relate observed
10 opacities we use in relationships between opacity and
11 PM concentration and then when you calcu -- when -- if
12 you have an emission factor to estimate the PM emission
13 rate, you can back-calculate what the volumetric flow
14 is. So, it's a -- it's not a simple, straightforward
15 process.

16 Now, our proposed procedure is to apply
17 -- it's a two-step process and then, as I said, this
18 has been -- this two-step modeling scheme has been used
19 for a good number of years, but now that we have
20 AERMOD, we need to take advantage of the advanced
21 science that AERMOD offers as opposed to ISC. So, what
22 we've proposed is to use BLP to estimate the hourly
23 line source final plume rise based on line source
24 buoyancy parameters, physical dimensions and source
25 orientation similar to what I -- to what I just

1 described, and then take advantage of the volume source
2 option in AERMOD where you can, on an hour-by-hour
3 basis, use height adjustment factors where you're going
4 to be changing your volume source release height on a
5 hour-by-hour basis based on the predicted plume rise
6 estimates from BLP. And we're currently in the process
7 of testing this procedure and plan to apply it for the
8 1-hour SO2 modeling that's going to be done and we've
9 also had discussions with EPA regarding its possible
10 use in the upcoming risk and technology reviews for the
11 sub-part C, five C residual risk modeling next year.

12 Just to note, so in summary, until EPA
13 develops a buoyant line source algorithm, we've
14 proposed this two-step modeling scheme. It can treat
15 enhanced plume rise from multiple buoyant line sources.
16 It's -- it is more time than resource intensive because
17 BLP requires the use of the Ramet meteorological
18 processor and, of course, AERMIC is used for AERMOD.
19 It's more cumbersome and time-intensive but until a new
20 algorithm is incorporated into AERMOD, this is probably
21 what we'll be using. Okay. Thank you.

22 **MR. GEORGE BRIDGERS:** Thank you. And
23 we'll just keep following right along. We have a
24 presentation from Trinity.

25 **MR. QIGUO JING:** I am Qiguo Jing from

1 Breeze Trinity Consultants. I did this work with my
2 advisor, Akula Venkatram, Marko Princevac, and David
3 Pankratz. In order to understand the disposition of
4 buoyancy mission from open source, we need to know the
5 emissions for sure and some source parameters. You
6 need geometry and urban meteorology. So, the first
7 question is what is the significance of urban boundary
8 layer. This picture shows the difference between rural
9 boundary layer and urban boundary layer. As we can see
10 here, because of the presence of buildings, the wind
11 speed is decreased and the turbulence is increased.
12 And because of the presence of buildings, there's an
13 extra layer, an oven canopy layer. The dysfunction
14 within oven canopy layer is an unsolved issue. It's
15 quite difficult. To be straightforward, if we put
16 stack height -- stack here, and put the same stack
17 here, we will expect different disposition, be heavy.

18 So, tracer study has been done in Palm
19 Springs in California in 2008. This is a stack, let's
20 see, the source parameters and look and see, it's low
21 level and buoyant. Forty-eight assemblers were
22 arranged in-house at a distance from sixty meters to
23 two kilometers, and we did three daytime and four
24 nighttime releases. Meteorology's was collected from
25 this tower. The wind speed indicates that promised

1 wind studies a low wind case. The wind speed is below
2 two meters per second during most of the day, and the
3 same spot indicates the daytime is pretty corrupted.
4 The nighttime is stable.

5 Despite the low wind speed, the
6 turbulent level is pretty high and because the wind
7 speed is low, turbulent level is high, the meandering
8 is important. And this is proved by the spacial
9 variation of observed concentration. Here at this
10 negative means upwind. Five means downwind. We can
11 see the concentration is really all over the place,
12 especially during the nighttime.

13 This is another plot of spacial
14 variation of the low concentration. We can see the
15 daytime concentration falls rapidly -- more rapidly
16 with radio distance being nighttime, and the nighttime
17 concentration adds to one kilometer is significant.
18 Next, we are using AERMOD to model the disposition of
19 one-day emission. This is unique from horizontal
20 diffusion in AERMOD accounts for the meandering and
21 accounting processes are plume rise, building effects
22 and turbulent disposition.

23 These are model performance results.
24 First, we look at the daytime. AERMOD performs really
25 well during the daytime, and it does predict the upwind

1 concentration, which indicates including meandering,
2 the AERMOD model is very important. However, at night,
3 AERMOD tends to only submit to the concentration. The
4 possible reason could be high plume rise, high mixing
5 height of high vertical spray. So, we did some
6 sensitivity studies on nighttime predictions. First,
7 we switched the building downwash off and on, but we
8 didn't see too much difference here because the average
9 plume height is thirty-five meters above the ground.
10 The building is only seven meters, so probably the
11 plume rise way over the building downwash regime. We
12 also used NWS data from airport adding impulse to
13 AERMET. The high wind speed at airport not improve the
14 model wind loss.

15 Next is the sensitivity study on mixing
16 height. We used, as we can see here, use fixed mixing
17 height does not improve the performance. So then we
18 thought about the vertical spray. Probably the
19 vertical spray is too high and this could be true
20 because low winds may be trapped in the shallow stable
21 bungalow layer during the night. So we modified the
22 AERMOD according to wind catch and the past 1985 paper.
23 In their paper, they describe the plume by two parts,
24 the updraft and downdraft. And they say some
25 limitation to these two parts. And we had some

1 limitation to the overall vertical spray. After that
2 the, you know, the (Inaudible) is reduced dramatically,
3 and the model performance is improved.

4 This is my conclusion. AERMOD provides
5 an inadequate description of concentrations associated
6 with the point of release from the level of source
7 during the daytime convective condition. AERMOD's own
8 estimates concentrating during the night when
9 conditions generated by wind shear and a simple
10 modification can -- can improve this performance, and
11 check out our Breeze -- you know, website. If you are
12 interested, we are release parallel version of our
13 newest EPA model in couple of weeks. If you are
14 interested, you can, you know, contact us, and I leave
15 a stack of my salesperson's business card here. Thank
16 you.

17 **MR. GEORGE BRIDGERS:** Oh, everybody's
18 not crazy if they're looking at the agenda. There are
19 two five-minute talks back-to-back but Bob's going to
20 do them combined.

21 **MR. BOB PAINE:** I have an alternative
22 way to do the buoyant line of source modeling in
23 AERMOD. I'm also going to talk about -- a little bit
24 about downwash and low winds, which was brought up
25 earlier today. As we've already heard from Allen, we

1 need a buoyant line of source approach in AERMOD. I'm
2 going to talk about one way to do this, and an actual -
3 - a limited evaluation of that approach, and then a
4 mention of downwash concentrations of low and stable
5 conditions, how these may be affecting routine
6 assessments for 1-hour SO2 NAAQS compliance.

7 The only prudent approach for buoyant
8 line of sources is BLP, although that -- that module is
9 in CALPUFF, and I -- I think I saw a bullet wish list
10 that Roger may have mentioned that EPA intends to
11 augment AERMOD to add this feature, although it would
12 be nice to have a working solution now, and I don't
13 know when the EPA will actually be able to implement
14 this feature. BLP has some limitations besides that it
15 only models 180 receptors and 10 sources, which can be
16 easily fixed, but it has some constraints. The
17 buildings have to be equally long, equally separated
18 and have identical buoyancies. Often at aluminum
19 production facilities, you have the most of the SO2
20 releases are actually not on these buildings, but
21 they're in these clusters of little stacks that are --
22 don't -- don't match the geometry of the long
23 buildings. So, it's -- it's not a good fit. Also, BLP
24 uses a different dispersion procedure, a different -
25 and so it's not a good match to -- to AERMOD. So, the

1 alternative would be, that Allen Dittenhoefer
2 mentioned, was well use BLP to predict the hourly plume
3 height and use -- use AERMOD's hourly volume-source
4 approach, which was a very good feature to put into
5 AERMOD, Roger, for setting the hourly release heights.
6 Now this will work with BLP if the buildings and
7 rooftop dimensions are fairly ideal. They are all
8 equally long, equally separated. They have identical
9 buoyancies. What about point sources interspersed
10 within these rooftop vents? The buoyancy isn't really
11 well-represented. So, I'm going to describe a non-BLP
12 approach that doesn't have this limitation. Use as
13 recommendations communicated by John Irwin some --
14 eight plus years ago to an application in Region Five
15 of -- for a, I think a slag pit and other iron steel
16 types of applications. There was - it was used in a
17 Lake County, Indiana SIP. We've identified this as a
18 potential approach for a limited production facility
19 and what it does is it uses plume rises as recommended
20 by John Irwin for buoyant fire plumes. You can do the
21 -- you can group your emissions into various individual
22 volume sources that are applicable or consistent, have
23 consistent characteristics and emission constant, you
24 know, concentration of sources. And then the details
25 are, I'm going to submit it to EPA, but basically, you

1 would use volume source initial signal y's and signal
2 z's similar to what you'd use for AERMOD and ISC. But
3 the way we do the plume rise is we extract the
4 debugging output from AERMOD for the -- the wind shear,
5 and we would use that to calculate the plume rise from
6 the Irwin-recommended procedure, get the plume height
7 for each hour from each of these volume sources and --
8 and then use AERMOD's capability to do hourly varying
9 volume-source heights to do the rest of the modeling.
10 So, we're using all the meteorology from AERMOD, not
11 from BLP, to do the plume rise and feeding it back into
12 AERMOD. We don't change AERMOD. We just extract the
13 stuff from AERMOD, use an Excel spreadsheet to do all
14 the plume height calculations and put it back in the
15 AERMOD as individual volume sources each hour with
16 individual heights.

17 Now, again, the -- the distribution of
18 buoyancy in many of these cases is not uniform. The
19 emissions are not uniform. The whole area acts as an
20 integrated large heat island and so in one case, we
21 divided an area into four parts to define different
22 emission clusters. Due to the evaluation on a monitor
23 for over two years that was within a kilometer of the
24 plant to indicate whether this approach worked, and the
25 last two years had these observe design concentrations

1 well below the NAAQS of one ninety six, AERMOD
2 predictions without enhanced plume buoyancy rise was a
3 little bit high, I would say. But with this proposed
4 approach of almost shocking good agreement on this year
5 and then again, equal to or over-predicting the
6 monitor. So, we propose this approach for EPA's
7 consideration.

8 The other thing I want to discuss here
9 is, oh, okay, so this is the conclusion that we need an
10 approach. This is -- this is a non-BLP approach
11 because we tried to get away from the -- the source
12 limitations that are built into BLP. We avoid these
13 limitations and use the actual AERMOD meteorological
14 profiles to characterize in an Excel spreadsheet the
15 plume rise.

16 Okay, I'd like to also look at the fact
17 that we've been seeing in -- for buoyant stacks that
18 have heights close to the building heights, not very
19 high above the building heights, that we had large
20 predictions of downwash under almost stable conditions.
21 I mean, almost calm stable conditions. For example, a
22 peak concentration with a wind speed of point three
23 meters per second is severe downwash, I'd have to say.
24 So, I was going to -- I looked back at the AERMOD
25 evaluations and found for AGA, the American Gas

1 Association, three stable experiments with a wind speed
2 of one point eight meters per second, and the observed
3 concentration is in this calm, and the AERMOD
4 concentration is this calm, so I would say in the words
5 of my former Governor, Mitt Romney, this model is
6 seriously conservative.

7 So, what can -- I -- I -- I think
8 there's no way -- there's no way to tell AERMOD --
9 well, there is a way to tell AERMOD you can have a wind
10 speed dependent source that turns on and off with wind
11 speed but it's an issue I think that deserves seriously
12 -- serious -- serious consideration for a seriously
13 conservative issue.

14 So, one type of study that may have had
15 this -- both of these issues affected, has been
16 submitted or mentioned by the American Iron and Steel
17 Institute in meeting last summer, where several sources
18 in northwestern Indiana were modeled and there were two
19 monitors and using just out of the box AERMOD, we found
20 several times higher predictions and observations of
21 two area monitors. These may have been affected by
22 both the -- the downwash under very light winds and the
23 lack of a buoyant volume source capability. So, I
24 think both of these issues are important to consider in
25 refinements to AERMOD. That's it.

1 **MR. GEORGE BRIDGERS:** Thank you, Bob,
2 once again. The next fellow, George.

3 **MR. GEORGE SCHEWE:** Good morning. When
4 I started with the agency back in 1975, we were using
5 1964 meteorological data, and we continued to use that
6 for a number of years, gradually moving into the
7 seventies and the eighties and the nineties, and my
8 concern, I guess, from the transitions from the
9 eighties to the nineties metadata, was we all complained
10 that we had too many calms, and so over the last
11 several years, now we're using AERMINUTE and now we
12 don't have any calms. But we have a lot of light wind
13 speeds.

14 So, my interest in taking a look at the
15 difference between the AERMET and AERMINUTE AERMET,
16 I'll call it, comparisons was to figure out what
17 happened to the wind speeds. Are they lower? Are they
18 higher? Are there a lot more of them or fewer? Oh,
19 and I'd also like to thank my co-author, Dr. Abhishek
20 Bhat.

21 So, I used the AERMINUTE 1159 version,
22 and, oh, I'm sorry 11325 along with AERMET's 11059, and
23 when I refer to AERMET datasets, this is what I'm
24 referring to, datasets generated using straight NWS
25 ISHD, 144, 3280, whatever those regular hourly regular

1 data sets with the upper air soundings from that NOAA
2 website. The AERMINUTE then supplemented that by
3 including the one minute running, two minute averages
4 that are also available from NOAA.

5 The datasets I looked at were for
6 Harrisburg and Dulles, Cape Girardeau, Fargo, North
7 Dakota, Orangeburg and Gainesville. I'd like to thank
8 some of my co-Trinity modelers, Angie in Minneapolis.
9 Aubrey in Florida and Ashley in Kansas City for
10 assisting in putting together some of these datasets.
11 Of course, they didn't have them run in both modes, so
12 I got what they had and then I ran it in the other mode
13 so that I could use those for my comparisons. Just as
14 one example of what we found, this was just comparing,
15 and I know you can't read the numbers on here, the
16 percentages are set up the same. You have to be
17 careful when you generate your wind roses sometimes.
18 So, the first extent there is ten percent but even the
19 wind directions were affected in terms of what we saw
20 with the AERMINUTE-generated data.

21 This is for Cape Girardeau, and you can
22 see that the number of events in some of the wind
23 directions, for example, to the southwest and southeast
24 increased as you included the AERMINUTE data and some
25 of the calms went away. So, just as a comparison and I

1 tried to blow this up as big as I could last night, so
2 I think you can see this, with straight AERMET, of
3 course, you had values in the twenty to twenty five
4 percent range of calms which, of course, takes away a
5 lot of the hours that you want to model.

6 Fargo was not as big of a deal because
7 Fargo has a lot higher wind speeds there and you can
8 see from the average wind speeds across each of those
9 locations, the wind speeds other than Fargo were about
10 a meter per second less, and then when you run the
11 AERMINUTE data, which is all we hoped would happen when
12 we ran the AERMINUTE data, the number of calms went
13 away or went down significantly, I should say, by a
14 factor of two and a factor of more than that for Cape
15 Girardeau. It went down to two percent.

16 Oddly enough, the average wind speeds
17 actually increased across the whole set of model --
18 averaged wind speeds, so the average wind speed across
19 the whole time period actually increased even though
20 the number of low wind speeds increased significantly,
21 so it's kind of an interesting phenomenon.

22 So, the question was, my question was,
23 how does this affect the modeling? And I've been asked
24 this question quite often amongst my fellow modelers.
25 Well, how's this going to affect our modeling? So, I

1 took the standard set of all source dot INP sources
2 that were part of the AERMOD test cases from the AERMOD
3 website listed above there. I added a few more. There
4 were no short stacks, no twenty meter, ten meter,
5 anything in the shorter range. So, I added a few
6 shorter stacks with some comparable type temperatures
7 and velocities and the emission rates that would be
8 comparable to sources that I'm looking at in the state
9 of Ohio right now, where we're looking at small sources
10 with large twenty-four hour and hourly emission rates
11 and trying to compare what those results are compared
12 to perhaps a power plant. So, we're looking at all of
13 it. So, this was the range of sources I looked at.

14 I did leave out the area of polisource.
15 You'll see in that dataset from EPA, there's an area of
16 polisource, too, but it's -- it's kind of an odd one
17 and didn't fit nicely within my receptor grid. My
18 receptor fence line was set at about a hundred and
19 seventy five meters from each of these sources. So,
20 they all sit right on top of each other basically, but
21 they're all modeled independently of each other.

22 Just some examples then of what I saw
23 and you'll see these as the top button... Okay, this
24 is for the sixty-five meter stack, and unfortunately,
25 we did all of our ratios upside down. I should have

1 put the AERMINUTE numbers on top expecting higher
2 numbers and the AERMET numbers on the bottom but I've
3 got the AERMINUTE in the denominator, so a value less
4 than one means that the AERMINUTE values are higher,
5 okay? So, just -- just for your knowledge, so then you
6 can see for -- by averaging period across here, that
7 typically we're seeing higher concentrations until you
8 get out to the longer averaging periods, and that's
9 pretty consistent on the two higher stacks that were
10 within EPA's test cases. For the two test cases that
11 they did not have in there, though, for the shorter
12 stack, you can see there's quite a bit of spread first
13 of all between the five different meteorological
14 stations, but you can still see that there's generally
15 at the lower averaging times you still had higher
16 concentrations. This becomes more pronounced for area
17 sources. If you look at my range here, I don't have
18 anything even close to one. All of the area sources
19 were showing concentrations that are much higher with
20 AERMINUTE, which is probably no surprise. Oddly
21 enough, the area circled did better than the square
22 area that was in EPA's dataset, so that was kind of
23 interesting phenomena there. I actually had some that
24 were, and this just disappeared, George. Okay, I think
25 that holds even better. So, here you can see that the

1 factor of one, the model actually did a little better,
2 at least I think most of the time, thought where it was
3 doing better was in Fargo, North Dakota again, where
4 the low wind speeds are not quite as much of an issue.

5 So, that was basically all I wanted to
6 put together. Just a demonstration showing what kinds
7 of concentrations you get. Four different kinds of
8 source categories at different averaging times. The
9 full paper on this will be, as Bob was mentioning, also
10 presented at the Air and Waste Management Association
11 and it's under review right now. Thank you.

12 **MR. GEORGE BRIDGERS:** Thanks, George.
13 And we have one more talk before our lunch break, which
14 looks like we're right on schedule. So, Sergio.

15 **MR. SERGIO GUERRA:** Yeah, my name is
16 Sergio Guerra with Wenck Associates from the
17 Minneapolis, St. Paul area, and I think it was last
18 November, that I took a class with George Schewe and it
19 was one of those things that I was asking a lot of
20 questions about metadata processing, and I was asking,
21 well, what's the affect of surface roughness and how
22 would we account for this and that, and I remember,
23 maybe George remembers, he said, well, there'll be a
24 paper, you know, so over these few months, like I kind
25 of worked on a case study and the main thing was to try

1 to identify what parameters on the metadata will affect
2 the AERMOD concentrations. So, as we talked in the
3 last couple of days, the metadata is very, very
4 essential into like what type of concentrations we find
5 and to what kind of affects we see on -- on -- on the
6 predicted concentrations in any kind of model, Russian
7 model, Eulerian model, Lagrangian model.

8 So, I divided my talk on three parts,
9 the first part, this is going to be specifically one
10 slice of what I've kind of looked at. The full
11 presentation will be presented at the Air and Waste
12 Management Association on San Antonio this June, but I
13 want to focus also, like George did, on AERMINUTE and
14 kind of what, what we found. So, the first part is
15 going to be kind of a review of what we've already seen
16 on some of the webinars of the SO₂, what we talked
17 about on Tuesday, on what is the purpose of AERMINUTE.
18 Then the second part is going to be, what are the
19 unintended consequences of AERMINUTE. I would say like
20 low speed winds have really affected what we expected
21 to -- to see, and its -- it was all done in good faith
22 in the part of EPA's kind of data that was out there
23 and that is used to complement some of the other
24 affects that -- that were done because of the change in
25 the -- in the way that the calm winds were identified.

1 And then the third part will be just kind of like a
2 recommendation.

3 So, I did the presentation before I
4 heard what happened the last couple of days, so I'm
5 going to jump through some of the slides and I'll come
6 back and forth. So, again, like this will be presented
7 at the Air and Waste Management Association on June,
8 but AERMINUTE. Okay, so basically what happened, I
9 think it was in '96, the meter started to classify
10 winds in a different way. So, there used to be it took
11 a non-threshold for winds and all of a sudden, they
12 decided, well, we don't really care for low winds below
13 three knots, so then they said okay, now anything below
14 three knots is going to be labeled as calm, and as a
15 result, when we take that data and put it into AERMET,
16 that data is basically lost. So, now, so we have a gap
17 between like three knots and two knots.

18 So, then what happened. So, I think
19 Roger or someone mentioned that they stumbled upon
20 these one minute data. That is actually pretty good
21 dataset. Well, I guess James mentioned that it had a
22 kind of some issues that had to be resolved because of
23 the way it's kind of a archived and everything, but I
24 think the AERMINUTE was a very genuine effort into kind
25 of getting back that, that chunk of data that was lost.

1 But, so AERMINUTE was -- it's a pre-
2 processor of this one minute ASOS data that can
3 complement the wind data that we have. It's non-
4 regulatory AERMOD, so it's actually not required, and
5 as we know like light wind conditions may be a
6 controlling factor and this case we're adding the
7 number of calm winds, and concentrations are not
8 calculated for hours of calm or missing meteorological
9 data, and the last bullet, I think, is kind of
10 important to realize, you know, like EPA from -- I
11 mean, on that piece -- quotation from some other
12 presentations from EPA, well, if there was not their
13 intent to add a level of conservatism because it
14 basically was a -- an intent to kind of reclaim some of
15 the data that was lost because of these meteorological
16 kind of shift in the way they classified winds.

17 So, so, what happened? Well, so we did
18 that and now we have this sonic anemometer on the left
19 and basically, there are no moving parts. They're just
20 pulses of sound and based on the difference of
21 reception, you can calculate the wind direction, wind
22 speed. But there's basically, it can identify very,
23 very low winds. So, basically the first one is zero,
24 and on the right we have a (inaudible) anemometer, you
25 know, the ones that have moving parts, and of course,

1 there's -- they're not as -- as accurate. So, anyway,
2 so this is something that I want to focus on because
3 basically, if your station is part of the -- one of the
4 ice-free wind stations, it would not have any
5 threshold. So, you, even the lowest wind that is
6 recorded would be processed into AERMET, so this is
7 kind of one of things that we talked about, and of
8 course, we learned on Tuesday that there's a memo that
9 will address this issue and will set a threshold. But
10 then the threshold's going to be set at one knot, so
11 again we went from three knots every -- like there was
12 a gap from three to two. Well, now we're going down to
13 one knot.

14 So, let me switch here. Like what I did
15 in that paper that I'll be presenting this summer is
16 like I processed metadata in different ways to identify
17 which are the driving parameters that are driving the
18 concentrations. So, the first situation is kind of
19 like the control one where actually we kind of
20 contacted the fuel staff of the National Weather
21 Service and said, okay, where is your met station, you
22 know, because I think Roger mentioned, somebody can
23 look at the aerial imagery and you can think that you
24 know where it is and then you find out that it was
25 another building that was not the right one. So, we

1 went to that process but anyway, what I want to focus
2 on is on the iteration six where we ran AERMET without
3 AERMINUTE and at iteration nine, which is the last one
4 where we ran AERMINUTE but we ran it without the ice-
5 free wind group. Now, by doing that, though, what
6 we're effectively doing is setting a threshold of two
7 knots. So, any winds below two knots are basically
8 ignored. They're not entering to AERMET to be
9 processed into the -- the model. So, I mean, this is
10 the location. It was in Manhattan, Kansas. It could
11 have been anywhere, really, like for the purposes of
12 AERMINUTE.

13 Let me go back through. So, I just want
14 to show here and this has kind of been shown before, I
15 think George had very good slides, but AERMET does
16 pretty good. I mean, if you don't have AERMINUTE,
17 which is iterations fixed in the middle, you have a
18 twenty six percent of calm wind data. So, that's about
19 one fourth of your data that is basically ignored. But
20 when you use AERMINUTE like in the first road. You see
21 that you go down to only like eighty hours of missing
22 data which is about point nine percent of -- of calm
23 wind and point five of missing winds. So, but then
24 what happens if you actually set a threshold at two
25 knots, which is kind of like what you do by not

1 specifying that your station is part of the ice-free
2 wind group. So, if you do that, you have -- you do
3 gain some, you do gain but you lost by the meter cannot
4 reclassification of calm winds, and then you end up
5 with fifteen percent calm winds. So, it's kind of an
6 improvement, and I ran this with -- from different
7 stack scenarios. One was like a short stack
8 representative of like avarice engine, in just shut
9 boiler and the third one was like a tall stack which
10 would be indicative of like maybe a powerpoint,
11 something like that.

12 So, this is what we got for the tall
13 stack, which was the one that was most sensitive
14 according to this one case study, and on the left you
15 see what I called the marigold. So, that's with
16 AERMINUTE and you, I mean, it kind of looks pretty but
17 the bright it is, the higher the concentration. So, we
18 see that it's almost like looking inside the stack, you
19 know, you kind of vary like dense concentrations, not
20 much dispersion going on. And the one on the right has
21 no AERMINUTE, you know, so there we kind of see what
22 we've been used to, you know, kind of like a nice
23 pattern of kind of flowing dispersion going around.
24 When we used the -- again on the left, we have
25 AERMINUTE data and on the right we have the tall stack

1 scenario run with the no-ice free wind group as a
2 scenario, you know, where you don't specified, you have
3 effectively a two knot threshold for the winds that
4 you're processing.

5 So, in that case, we -- we still see a
6 little bit of dispersion. It's not as nicely as the
7 one without AERMINUTE but this is kind of like a
8 virtual interpretation of what's going on. Now, here's
9 really where we can kind of -- the rubber meets the
10 road kind of deal and we talked, I mean, today and
11 yesterday, like to various people like in the API and
12 also the Forest Association of Paper or whatever it
13 was. We talked about how sometimes you can affect,
14 they can have the best type of controls and you have
15 very difficult timing meeting these standards. So, in
16 this case, it's a good interpretation where we identify
17 that the method of processing is actually driving the -
18 - the concentrations, that no matter how tall your
19 stack is, no matter what controls you put, if your
20 method is not processed properly, if you include those
21 very low winds, you will have no -- no way to pass.

22 So, let me see if I can -- So, anyway,
23 in this case, I can -- I just used one grant per second
24 for the emission rate. I mean, this was just kind of
25 like trying to identify the met parameters that were

1 driving the concentration. So, if you use AERMINUTE to
2 get thirteen point one on this scenario. If you don't
3 use AERMINUTE, you get two point one and if you have a
4 threshold of two knots, you get five point four. So,
5 you basically on the 1-hour scenario, you have a fifty
6 eight percent difference between using AERMINUTE and
7 not using AERMINUTE. So, again, if you were to kind of
8 put this into like real emissions and kind of run like
9 even around if you're doing a tour or even the one
10 hours or two, really, what's going to drive your
11 results is while you process your data with AERMINUTE,
12 is your station part of the ice-free wind group or not.

13 So, that's kind of what I just wanted to
14 share today. This is kind of like nothing new. I
15 mean, EPA really already knows about it, and that's why
16 it's been addressed in this upcoming memo. And, well,
17 it is a problem. We've seen it in Minnesota with a lot
18 of facilities. We've had a lot of trouble in helping
19 getting compliance. I think Tyler mentioned yesterday,
20 well, there's been like, what was it, twenty-seven
21 projects that have met compliance. I think that was
22 with the -- with the NO2 standard. But what we don't
23 care about is like all the others that are still kind
24 of tied up in this process trying to figure out how to
25 make their emissions be controlled, how to kind of

1 bring about a run that will actually be a passing run.
2 So, that's kind of one of the things that -- that we
3 cannot -- don't have much data about but, I mean, they
4 might be some pretty excited that maybe didn't happen
5 because of this. So, it's obviously something that we
6 have to address, so how can be address it? Well, I
7 think that what -- like we've talked about for the last
8 couple of days. If we had a first one two knots and we
9 were comfortable with that and I think that it should
10 be kept at two knots, and then once the adjustments on
11 AERMOD are made like we talked about -- I think Bob
12 Paine mentioned about the use star and also the lateral
13 and the horizontal dispersion. Once those effects have
14 been properly validated and -- and -- and incorporated
15 into AERMOD, then it would make more sense to kind of
16 go down and -- and -- and take advantage of these
17 entities out there. But I think that we need to kind
18 of rethink our -- our threshold of one knot and keep it
19 at two knots, and again it does kind of still give you
20 like a more conservative answer but it gives us a
21 little bit of time to figure out what's going on and --
22 and we can try to kind of fix those issues that we're
23 seeing on the over-prediction of AERMOD with low winds.

24 So, that's my talk. Thank you.

25 **MR. GEORGE BRIDGERS:** Well, outstanding.

1 We have the morning in the books now. We will take our
2 lunch break from noon until one.

3 (WHEREAS, the conference concluded for
4 lunch).

5 **MR. BRIDGERS:** Okay. I think we've
6 reached the one
7 o'clock hour, so - oh and I've got to get my tie back
8 out. We've reached the Ides of our public session on
9 the Ides of March so we're going to start the afternoon
10 session with Dana Wood and on behalf of BP. Okay.

11 **MS. WOOD:** Thank you for this time to
12 comment. I'm
13 Dana Wood with BP and I'd like to start out with
14 thanking Doug Blewitt with AQRM for all of his
15 assistance and help with this presentation.
16 Today I'm going to be asking the question: Are EPA
17 regulatory models capable of providing accurate
18 estimates of future air-quality emissions, and I'm not
19 going to answer this question, but I want each of you
20 to draw your own conclusions.

21 Essentially, with a background of 30 parts
22 per billion, you're left with 70 parts per billion for
23 all new and existing sources. You know, if the west
24 and if the model accuracy is about plus or minus a
25 factor of two, compliance with the standard can range

1 from 35 to 140 parts per billion, meaning that several
2 well-controlled sources could pass while very
3 uncontrolled sources I mean could fail, while very
4 poorly controlled sources could pass.

5 AERMOD is very much skewed to over-
6 prediction. You know this analysis kind of ignores the
7 form of the standard, but when it's considered I don't
8 think there's going to be any difference anyway.

9 One thing I do want to note is that NO2
10 background is not really a measure of NO2 but NOY,
11 because the measurements pick up ammonia as NO2 and
12 even with this inflation of the NO2 numbers, we're not
13 really seeing violations of the NO2 standard anywhere
14 in the country right now. I think this further shows
15 the exaggeration or over-prediction of these models.

16 I'd like EPA to kind of look at model
17 evaluation with the American Gas Association database
18 for natural gas fired engines. This is the source
19 that's of biggest concern to us because you've got
20 short stack heights and you're right next to a fence
21 line or, quote, fence line. We don't really have
22 fences. And you know so you're - it's very difficult
23 to meet the standard and these are where we're having
24 more - a lot of the problems. Of course EPA doesn't
25 see this because most of our sources are minor sources

1 and going - you know dealing with the states directly
2 on this problem.

3 This database has used experiments using Sf6
4 tracer gas to help to determine what the emission rates
5 are, so it helps make the emission rates more known as
6 opposed to say Empire ALBO or the Apollo Hawaii
7 databases that have no real emissions data. It also
8 had multiple downwind sampling points as opposed to one
9 or two monitors like what was used in Empire and
10 Apollo. This is a pretty high-quality database for
11 evaluation of total NAAQS and if we do any other future
12 field studies you know, I would recommend that it be
13 something similar to this method that was used.

14 This is just a Q-Q plot of a linear Q-Q plot
15 of all the data in the AGA database parsed by stability
16 classes, observed as on the X-axis, YY is the AERMOD
17 and if you notice there is a bunch of stars that are
18 black on the Y-axis. These are the stability Class F
19 and it shows the AERMOD predicted 225 micrograms per
20 cubic meter while there were absolutely no observed NO2
21 measured. You know there's a multitude of reasons that
22 this could be showing this, but I think the model is
23 showing downwash, but, where there is none.

24 The red squares that you see are for
25 stability Class C and you can see AERMODs primarily

1 under-predicting these sources.

2 This is a graph of the stability classes that
3 are broken out by over-prediction and under-prediction
4 by AERMOD with over-prediction greater than 2: over-
5 prediction less than 2 and then under-prediction less
6 than and more than a factor of 2.

7 So what are the implications of looking at
8 the AGA database for model evaluation? Well, first it
9 shows 60-percent of the time the model over-predicts by
10 more than a factor of 2 and 35-percent of the time the
11 model under-predicts by more than a factor of 2. With
12 this kind of uncertainty, are the models accurate
13 enough? The likelihood of getting anywhere close to
14 right is very minimal and well-controlled sources will
15 probably fail under this scenario.

16 The other issue is with - the wind speeds
17 tested were 1.3 meters per second and EPA is now
18 claiming that the accuracy of the model is valid up to
19 2 meters per second with you know, no backup data to
20 support this. Industry provided model improvements
21 three years ago for light wind speeds. It's been
22 talked about repeatedly here and still this has not
23 been incorporated into the model.

24 Also, AERMOD is a study state model that
25 assumes a plume goes to infinity instantly. These A-

1 physical results should be allowed to be excluded in
2 your analysis. These A-physical results can easily be
3 removed if it exceeds the meteorological persistence or
4 actual trajectory of the plume not to arrive at a
5 receptor. You know you could always use CALPUFF as an
6 alternative for this to address these A-physical
7 results.

8 Now, I'll switch kind of over to AQRV
9 analysis. CALPUFF and industry has spent a
10 considerable amount of money over the past several
11 years to comment and provide a new chemistry mechanism
12 and as of yet, EPA hasn't incorporated this.

13 It can be very difficult from our perspective
14 to use best science or better science in a regulatory
15 setting. We've spent a year and a half waiting to
16 complete an EIS while Wyoming DEQ, BLM and EPA debated
17 whether we could use CALPUFF or CAMx for doing our AQRB
18 analysis. Meanwhile, you know - meanwhile, we can't
19 develop. Even with CAMx there is considerable over-
20 prediction and the models really need to be used in a
21 relative mode.

22 So, in conclusion, I think everyone in this
23 room feels that models must continue to be improved to
24 better reflect reality. This is going to require peer
25 review of EPAs work and better collaboration between

1 the whole modeling community and EPA. It would be
2 great if from this conference, EPA would publish a work
3 plan for public comment and input so that we can all
4 you know just look at how to address these problems.

5 Thank you for your time.

6 **MR. BRIDGERS:** Thank you, Dana. And we
7 can get rid
8 of that one. The next presentation is not by Doug, it
9 is by Nicole.

10 **MS. DOWNEY:** Hello, my name is Nicole
11 Downey. I'll
12 be presenting on behalf of Doug who is sorry he can't
13 be here: he got the flu. And, I'll be talking about
14 issues associated with NO2 model evaluations,
15 specifically the Empire ALBO dataset.

16 As a little background to this, Doug was
17 involved in the original data collection as were
18 several other people who have been in this conference.
19 We're working from a conceptual NO2 plume model where
20 you have this core of NO. This is basically like the
21 PVMRM or the ozone limiting method where you have an NO
22 core and the ozone is mixed in on the sides and then
23 you react to NO2, but the complete version to NO2
24 obviously takes some time and that's going to depend on
25 the meteorological variability, the rate of reaction

1 and your ozone concentration.

2 With AERMOD, the NO2 is calculated, its
3 parameter based on the NAAQS concentration and you have
4 both the issue of dispersion as well as the conversion
5 between NO2 or NO to NO2 that you have to keep in mind
6 when you're making this conversion to No2. So there
7 are a couple of processes going on.

8 And, in this last point, the NO2 model
9 performance, it can be better but it probably shouldn't
10 be if you think about how it's actually a
11 parameterization of NAAQS, and so I'll show you an
12 example of how this parameterization can lead to
13 perhaps overestimates in the conversion rate between No
14 and No2 because you're under-predicting NAAQS and then
15 you end up over-predicting NO2.

16 So, first I'll give you know, we saw from Roger's
17 presentation that they - you know the empire ALBO data
18 that was used to evaluate AERMOD, it's been one of the
19 primary datasets used along with the whole Hawaii
20 dataset and it was an Amoco gas plant data that was
21 collected and I have these dates wrong: it was 1992 and
22 1993, over two years, and it was designed to develop a
23 database for performing OLM calculations to demonstrate
24 compliance.

25 There was an ozone monitor upwind of the

1 plume and there was an ozone monitor downwind of the
2 plume and then there were two NAAQS boxes there as well
3 and then there are also - it's not an isolated source -
4 there are more regional impacts and I think it's
5 important to realize this study was not designed with
6 this in mind, because there's no actual emissions data.
7 No one ever measured the emissions coming out of the
8 plant during this time. This was an exercise to get a
9 permit. This was not actual emissions data used and as
10 we all know, you don't permit with actual emissions,
11 you permit with maximum emissions.

12 So there are at least three different
13 emission inventories for this plant. There's the 2600
14 tons per year based on historical plant operating
15 capacity, a compliance inventory of 1800 tons per year
16 and then in 1995, inventory based on a compliance
17 strategy of about 1500 tons per year. And so there's
18 quite a bit of variability in what could be used in an
19 evaluation and it's not clear what was used and I think
20 some of this gets at the fact that all of these
21 analysis should be publicly available and the data use
22 should be accurately described so that you can recreate
23 what's done.

24 And, basically the idea from this slide to
25 take away is although we have these emissions

1 inventories that doesn't mean that over this time
2 period that the emissions were close to this. There
3 are a lot of things that can happen operationally that
4 make you drift from your permitted levels.
5 And, then, there are a couple of other NO2 databases:
6 we've heard about the Palaau, Hawaii: it's an oil fired
7 turbine. There's not a lot known. We heard that the
8 instrument was very close to the source. The
9 Wainwright, Alaska has also the oil fired electric
10 generators and here you're almost in a different ozone
11 regime. You're up in Alaska. You've got nothing going
12 on, right? I mean is it reasonable to use something
13 that's not even close to a normal chemical regime that
14 you would see in the United States?

15 And as we've all talked about, we need to get
16 out there and collect some data and there needs to be
17 some real data where you measure real emissions and you
18 measure No and NO2 and that's the way to solve this
19 problem.

20 Doug, here, is making the argument that if
21 you do the typical Q-Q plots unpaired in time, unpaired
22 in space, you can mask some compensating errors because
23 it looks like you're making good predictions but in the
24 end, actually, you may be not, and so he suggests that
25 you use you know, the NAAQS NAAQS- the typical Q-Q plot

1 to evaluate total dispersion. The NO2 model
2 predictions compared to the observations where you've
3 kept the right NAAQS pairing so you're - you're
4 evaluating the total dispersion and you're matching the
5 chemistry at the same time. And then, you're No2
6 models compared to NAAQS observations unpaired in time
7 is you know sort of three ways to look at this problem.

8 And, so, I'll show you sort of what the
9 effects of these can be. So the first plot is just the
10 NAAQS, NAAQS plot and this is using the 1995 emissions
11 inventory for Empire ALBO and also other regional
12 sources and you can see that at the high end of the
13 spectrum, AERMOD is under-predicting the concentration
14 of NAAQS relative to the monitor. Okay.

15 Then in the next slide we show NO2 monitored
16 and No2 modeled where these are still paired with the
17 NAAQS measurements, so this isn't just a flat out Q-Q
18 plot. We're actually keeping some of the temporal
19 characteristics here. And you can see that in many
20 cases there's more than a factor of 2 over-prediction
21 in the No2 that's modeled.

22 Now, if you remember that initially you have
23 an under-prediction in NAAQS and now you'll have an
24 over-prediction in NO2, this is an issue because the
25 conversion rate that you calculate from a typical Q-Q

1 plot will lead to more No2 production from NAAQS - from
2 No.

3 And so here's the typical - this is just NO2
4 versus No2 unpaired and it falls within 2 - the factor
5 of 2 bios line, but again this is just a flat out Q-Q
6 plot and we're not taking into account any of these
7 other errors and I think this is a good example of how
8 you need to be very careful in how you look at the data
9 to be sure that you're not masking any compensating
10 errors.

11 So in spite of the uncertainties in the
12 emission data, the NAAQS model performance is under-
13 estimated by almost a factor of 2 and if you keep the
14 NAAQS pairing and evaluate NO2 that way, the No2 model
15 performance is overstated by more than a factor of 2.
16 And that implies that matching No2 conversion with
17 NAAQS dispersion can overstate the No2 formation, so
18 basically, we just have the reactions going a little
19 too fast.

20 If it's compared to the monitoring data
21 independent of time, you basically get this over-
22 prediction of a factor of 2 at the high end and I think
23 I would like to stress on behalf of Doug that it would
24 be really nice if all of this were publicly available
25 and laid out so that everyone could evaluate the

1 database and see what's going on.

2 And why is this important? I think this is something
3 that we've seen before: This is a plot of the observed
4 versus AERMOD from the AGA database and there are
5 different stability classes plotted here so for
6 instance the "F" stability class where you have various
7 stable conditions, you're getting something like oh I
8 don't know, an infinite amount higher. I mean it's
9 very high compared to the observations. It's hard to -
10 200 divided by one, I guess it's not that high, but -
11 so you know, it's important to identify these things
12 because you can mask a lot in a Q-Q plot and it's
13 important to look at this stuff critically and to be
14 sure you're doing the right thing and you are actually
15 - when you're parameterizing these things, a lot of
16 stuff - slough can be taken up by a parameterization,
17 so you need to be sure that you minimize that slough
18 before you make the parameterization.

19 So some conclusions and recommendations that the code
20 review of PVMRM has some formulation problems I guess
21 from the Steve Hanna presentation. I think the
22 conversion of No to NO2 overstates the No2 conversion
23 in this analysis. I think one other thing that I
24 forgot to mention is that there were these two ozone
25 monitors: one upwind and one downwind, and I think

1 Roger showed he tested both of those and it did make a
2 difference depending on which one you use, because the
3 downwind monitor was there to observe scavenging and if
4 you use that, then you'll get again, a different answer
5 because you have lower ozone in order to mix into your
6 plume and so it's very important that you understand
7 you know what the data - how they were originally
8 collected and to keep the people - I think this
9 community seems lucky in the fact that a lot of the
10 people that collected all the data are still in the
11 community and you can ask them. That you know this is
12 important you know, you need to be sure that the study
13 is well laid out and well described and you're using
14 the most appropriate data.

15 I think everyone agrees there's an urgent
16 need to move forward on this NO2 issue and until
17 refined techniques occur, we should find some way to
18 get our arm into the guidance.

19 I think that's it.

20 **MR. BRIDGERS:** Thank you, Nicole. And we
21 wish Doug all the best in recovering from the flu.

22 Okay. Well, the next presentation -
23 we're actually - I'm going to just - I'm going to put a
24 backdrop up for you, Cindy. There you go. We have a
25 presentation by UARG... I'll just let you introduce

1 yourself.

2 **MS. LANGWORTHY:** I am Cindy Langworthy
3 and I'm speaking on behalf of UARG, which is the
4 Utility Air Regulatory Group and I'm going to be
5 talking more policy so no slides.

6 Results from EPA's suite of models and
7 related guidance play a key role in how UARG members
8 operate their existing sources and numerous plans to
9 build new sources. The more EPA tightens its air-
10 quality standards, the greater is the need for
11 accurate, unbiased EPA preferred models and reasonable
12 modeling approaches.

13 When models are called upon to play such
14 an important role in clean air act implementation, that
15 puts a premium on their producing accurate predictions.

16 Forcing regulators and regulated
17 entities to use models that over-predict source impacts
18 by potentially significant amounts create serious
19 problems for and imposes unnecessary costs on
20 industrial sources, the states in which the sources
21 operate and the individuals who are their customers.

22 Today, I'm going to summarize a few of
23 UARG's concerns on modeling related issues and UARG
24 will provide additional information on these issues and
25 others in written comments.

1 First, it is clear that EPA states and industries must
2 rely on models for implementing some provisions of the
3 Clean Air Act. For that reason, it is important that
4 the underlying regulatory models and related modeling
5 tools and any changes to these regulatory models and
6 modeling tools be fully tested and evaluated before EPA
7 accepts their use for regulatory purpose. Not only
8 must such evaluation be done, but it must also be done
9 consistently with how the model is used. For example:
10 if a model's performance is evaluated with actual
11 emissions, then for regulatory purposes, the model
12 should run with actual emissions rather than with
13 combinations of inputs that have not actually occurred
14 and are unlikely to occur in the real world.
15 Similarly, if background concentrations will be
16 accounted for when a model is used in a regulatory
17 context, then background concentrations should also be
18 taken into account when the model is evaluated and
19 monitored air-quality values should be the benchmark
20 against which models are evaluated. Concentrations
21 measured by an EPA-approved monitor at an EPA-approved
22 site should be relied upon and preference to
23 concentrations predicted by a model, even one that had
24 been appropriately evaluated and designated for
25 regulatory room - regulatory use.

1 Next, we want to touch on the process that
2 EPA follows before making changes to the models, that
3 the agency has approved regulatory use. To be clear,
4 UARG members want to see improvements made
5 expeditiously to EPA's guideline models, but such
6 improvements should be carried out under the framework
7 provided by the Clean Air Act.

8 Recall that EPA's modeling guideline is a
9 regulation, therefore, EPA does not have authority to
10 make significant changes to the guideline and the
11 models it references without first giving the public a
12 meaningful opportunity to comment. What this means is
13 that the finalization of modifications to EPA's models
14 must be preceded by the agency first proving the public
15 with documentation on how well the modified models will
16 perform and also giving the public a meaningful
17 opportunity to comment on the proposed changes and
18 related documentation.

19 There have been several recent instances in which such
20 procedures have not been followed, for example: EPA
21 added AERMET to AERMOD through a modeled change
22 bulletin. EPA provided no opportunity for public
23 comment before adopting the - adopting the change. EPA
24 did not provide any information on the model's
25 performance when AERMET is used. And AERMET,

1 apparently, as we've seen, exacerbates an over-
2 prediction problem at low wind speeds. EPA also did
3 not provide notice and a chance for public input before
4 it modified how the GEP stack height limits are to be
5 modeled within AERMOD.

6 Comments over the past couple of days suggest
7 that EPA intends to continue making modifications
8 without following the procedures, which the Clean Air
9 Act requires to be followed. In particular, EPA has
10 suggested that it distinguishes between changes to the
11 codes of the preferred models, apparently, and changes
12 to tools used in conjunction with those models to
13 characterize source emissions through meteorology. EPA
14 apparently plans to allow prior public comment on the
15 former, consistent with the Clean Air Act but not the
16 latter.

17 UARG strongly disagrees with the distinction
18 EPA appears to be making. First, it is unclear where
19 EPA is going to draw the line between which changes
20 will trigger the need for public notice and comment and
21 which will not. Changes to modeling tools can affect
22 the modeling results as much as - or in some cases more
23 than - changes to the model code itself. Any change
24 that alters the modeling results should be made only
25 after the agency has applied evidence concerning model

1 performance in light of the plan changes and has
2 provided the public with a meaningful opportunity to
3 comment.

4 And let me say that we're hearing you know
5 three to five years to do rule making. EPA has
6 demonstrated in other instances the capability of
7 moving much more quickly than that, particularly when
8 it's supplied information to go through proposal and to
9 a final rule.

10 So UARG also requests that EPA simplify, expedite and
11 make more transparent the procedures followed when
12 those outside EPA suggest changes they believe should
13 be made to EPA developed models. For example: the
14 tendency in AERMOD to over-predict concentrations in
15 low wind speed conditions - we've heard a lot about it
16 - it's well-recognized.

17 Although stakeholders have suggested
18 improvements to AERMOD to address this problem, EPA has
19 delayed consideration of - or some would say ignored -
20 those suggestions, thereby inhibiting substantial
21 progress toward addressing this issue with AERMOD.

22 And then we know about the AECOM solution
23 that's been proposed, but EPA has taken no action on
24 the suggested fix. EPA needs to take action now on
25 this issue and it needs to put in place a better

1 program for considering on a timely basis any
2 additional outside suggestions for improving AERMOD and
3 EPA developed models.

4 Over the past couple of days, it has been
5 heartening to hear that EPA wants to work more closely
6 with a broader modeling community, including industry,
7 to address these kinds of modeling issues. It has been
8 far less heartening though to hear EPA's list of
9 obstacles that are in the path of greater cooperation.
10 One such obstacle - about which we have heard a lot -
11 is the lack of sufficient agency resources, which EPA
12 says means that the agency will address only those
13 modeling issues of higher priority. If EPA is truly
14 interested in working with industry, we urge the agency
15 to take industry's concerns into account when
16 determining what issues are of high priority. If a
17 modeling issue is of high priority for industry and if
18 EPA is willing to work with industry on it, then
19 industry will devote resources to addressing that
20 issue. This has been the case with the industry
21 support for development of a fix to improve AERMOD's
22 performance during low wind speeds.

23 If EPA is unwilling to take time to review
24 and consider such work on issues of importance to
25 industry though, then industry may be less interested

1 in using its resources toward working cooperatively
2 with EPA on this type of issue in the future.

3 AERMOD of course was developed with EPA's
4 support. EPA seems even more reluctant to consider
5 implement changes to models that have not been
6 developed by the agency.

7 CALPUFF, for example, is a preferred
8 guideline model that was not developed by EPA. There
9 is general agreement on inadequacies in how CALPUFF
10 treats the formation of nitrate and sulfate. This
11 leads to inaccurate assessments of the contribution of
12 sources of So2 and NAAQS to visibility impairment.

13 For industry, this CALPUFF inadequacy was a
14 high enough priority issue that West Associates and
15 EPRI have helped fund efforts to develop and evaluate
16 improvements to CALPUFFS industry modules.

17 When information on these improvements was
18 shared with EPA, however, EPA indicated that it would
19 be several years before the improvements could be
20 considered for conclusion in the regulatory version of
21 the model.

22 It is neither reasonable nor appropriate for
23 EPA to allow such lengthy delays to occur before it
24 considers where appropriate implements improvements to
25 models used in regulatory decision-making.

1 Finally, because of the importance of the issues raised
2 at this and other modeling conferences and the speed at
3 which technology is advancing, UARG urges that such
4 conferences be held more often and UARG urges that
5 other EPA sponsored events on modeling issues: for
6 example, the yearly meeting with modelers with state
7 and local agencies, be expanded to allow consistent
8 meaningful participation by all stakeholders. And I
9 know that you've said not this year and maybe in the
10 future. We urge you to do it.

11 In addition: In order to assure the public will have
12 real opportunities for input on modeling issues at such
13 conferences and meetings, EPA should make sure that key
14 document on modeling policy are released well ahead of
15 time. For example: We wish that EPA had been able to
16 make the PM 2.5 modeling guidance available prior to
17 this conference.

18 In closing, UARG urges EPA to become more
19 agile and open in its approaches for improving models
20 and modeling tools. Industry and those who work with
21 it possess demonstrated expertise on air quality
22 modeling issues and are eager to work with EPA and
23 other stakeholders to ensure the best modeling tools
24 and procedures are used in all regulatory proceedings.
25 EPA will benefit from such a partnership by taking

1 advantage of the resources that industry is willing to
2 put forward to address key issues. The agency can both
3 gain cutting-edge models and simultaneously gain the
4 practical insights of stakeholders.

5 UARG appreciates the opportunity to speak to
6 you today.

7 Thank you.

8 **MR. BRIDGERS:** Thank you, Cindy, for
9 those comments.

10 All right. Let me make sure we have the right one: we
11 good? Okay. So up next is Mark and I'll let you
12 introduce yourself.

13 **MR. BENNETT:** Thanks, George. Yes, I'm -
14 for the record, I'm Mark Bennett with CH2M Hill, but
15 I'm giving this presentation on behalf of Rio Tinto.
16 And before I proceed with my very short presentation -
17 it's only seven slides - much earlier this morning, but
18 not that early, I got my final presentation into George
19 and so I had whatever; two, three minutes to reflect on
20 what's happened over the last couple of days, so I
21 wanted to get wind of those thoughts on the record to
22 all of you and I was pleased to see that the three
23 previous speakers I think are on exactly the same page:
24 That most of us here and those over the past couple of
25 days are very detail oriented, very technically

1 oriented and we've heard again and again in the last
2 two days that we have to get the details right and
3 believe me, as somebody with a PhD, I understand that.
4 With that said, I'm hoping that we don't lose sight of
5 the forest for the trees, that we keep the big picture
6 in mind and, frankly, I believe that we're all on the
7 same page here - that we all have a common goal of
8 making sure that the regulated community can do their
9 jobs in a manner that's protective of public health.

10 Now, you know, in the past it may have
11 appeared that those two groups were in somewhat of an
12 adversarial relationship, but even with our spirited
13 discussions today, I certainly believe that we are all
14 on the same page so we all want the same thing here and
15 you know, I have many different clients in my role as a
16 consultant, whether it's the mining industry, steel,
17 auto manufacturing or even some of my clients are with
18 the Department of Defense and their job is being
19 prepared to defend our country. They all want to do
20 their job, they all want to do it well and they all
21 want to be protective of the public health.

22 So, that, I think is our common goal
23 here and so with that, I think that we need to - it's
24 always been true, but certainly never more true given
25 the current economic situation, that we need to look

1 for practical and pragmatic solutions and again, I'm
2 somebody who took seven years to finish my PhD looking
3 for all the right details, all the perfect solutions -
4 we can't wait that long I don't think. I think we need
5 to find practical and pragmatic solutions maybe step-
6 wise solutions to come up with as the previous speaker
7 said much more eloquently than I, you know, three years
8 has severe -- severely negative economic impacts to our
9 clients that are in the manufacturing industry here in
10 the country.

11 So with that, let me go ahead, get off my soapbox and
12 talk for Rio Tinto. Again, as we've all said, that the
13 drivers now - it's really causing all of us here in the
14 regulated community to be of concern are the new
15 standards. This certainly requires the performance of
16 AERMOD to be refinements to be expedited and address
17 known deficiencies. The specific issues that are of
18 particular concern to Rio Tinto are of no surprise: the
19 low wind speed that we've heard again and again about:
20 the air minute and how that exacerbates that, the
21 buoyant line sources, pit retention is one in
22 particular we haven't heard about, but is of particular
23 concern to Rio Tinto and then I'm not going to have
24 another slide on it, but again the impacts of frequent
25 updates to AERMOD, delaying projects which again has

1 real world impacts and certainly I nor anybody else is
2 advocating, not fixing, any known deficiencies, but I
3 think if we work in a collaborative spirit maybe those
4 fixes can come in bigger blocks with longer time
5 periods between the fixes.

6 Okay. So low wind speed: we've heard about
7 it again and again, so I'm not going to belabor all the
8 points. The main one being though for the mining
9 industry that for mining operation emissions from the
10 haul roads, which are near ground level sources, are
11 frequently the highest model impact sources and can be
12 the primary driver for approval for a site. And we're
13 referring again back to Bob Paine's proposed fix, from
14 AECOM. Maybe that's not the perfect fix - it doesn't
15 fix everything, but it certainly seems like a practical
16 step-wise improvement that could be implemented fairly
17 quickly. And again, we've heard a lot about the ASOS
18 and AERMINUTE, that this is just exacerbating the over-
19 prediction of those types of sources, so again, I
20 really think - and again I was heartened to hear again
21 and again from industries, so I'm hoping that
22 industry's voice is being heard loud and clear by EPA:
23 That this needs to be fixed and maybe you know "fixed"
24 is the wrong word. I would say needs to be refined so
25 that answers are better - still productive of public

1 health but not over-predicting and not having negative
2 economic impacts.

3 We've heard about AERLINE coming along and
4 this is one way I wanted to mention again you've heard
5 several times about buoyant line sources, so again,
6 haul roads - right now the trucks - the emissions from
7 the trucks, in addition to the fugitive mission from
8 the dust that they're kicking up, we have the NAAQS in
9 particular with the new standard - is going to be
10 difficult to address and if we don't have a buoyant
11 line source approach - and we've heard some over the
12 past few days - some possible approaches; that's going
13 to again exacerbate the problem that we have a
14 neutrally buoyant line source near the ground, low wind
15 speed conditions, the new standard, all the things
16 we're hearing again and again and again. So there are
17 other models out there that can deal with buoyant line
18 sources. We need to have a practical solution to this,
19 again, maybe a step-wide approach expeditiously.
20 So I'll spend - I'm ahead of time so I'll spend a
21 little more time on this one since we haven't heard
22 about this before and I'm not going to raise a huge
23 issue about it, but I just want to make sure that EPA
24 is aware of this. Now, this is the pit retention
25 algorithms, which were added into EPA's ISC model back

1 in 1995. It has to do with estimating impacts for
2 particular emissions originating below grade for open
3 pits. Now, of course, I may have missed it, but I
4 didn't see anything in the AERMOD model about it and
5 the ISC Users Manual, I mean the Manual - it he ISC
6 Users Manual it says - and hopefully I've quoted this
7 correctly: "Pit retention and wet deposition algorithms
8 have not undergone extensive evaluation at this time
9 and their use is optional." These - if you look back
10 to where this came from, the open pit algorithms are
11 derived from a limited set of wind tunnel studies.
12 They came up with some proportionality constants, which
13 again may not be applicable in all cases as is - and
14 I'm going back to the details I suppose in this case -
15 it's being characterized by a rectangular shape with an
16 aspect ratio of 10-to-1.

17 Now, when you scale up from the wind tunnel
18 studies to the actual pits or the theoretical pits that
19 are being representative, they have a disorder of size
20 of you know, 200-some meters by 400-some meters by
21 about 45 meters deep.

22 The challenge that we have at Rio Tinto at
23 their Bingham Canyon Mine in Utah is that it's several
24 you know - they keep digging so it keeps getting
25 bigger, but it was about two and a half miles wide by

1 two and a half miles wide by more than a half a mile
2 deep and we felt that the use of this algorithm was
3 inappropriate and since there was no guidance at all in
4 the document, we had possibly some disagreements over
5 that issue - let's just put it that way.

6 Now, something very interesting and we can
7 certainly provide it to you is that all the pits in the
8 wind tunnel studies were symmetric in shape and this
9 led to there being large recirculation in those pits
10 and the algorithms that were implemented into ISC uses
11 reduced pit area and have the emissions coming out of
12 the upwind side of the pit as you would imagine from
13 large recirculation.

14 At the University of Utah, several years ago
15 - and we've done some more recent studies too - they
16 did some computational fluid dynamic studies with a
17 discretization of a real pit, they didn't see any of
18 this large recirculation at all and they were like,
19 "Hmm, I wonder why that was?" Well, then they went and
20 made it into a regularly shaped pit, one was trapezoid
21 and one was rectangular of the same - roughly the same
22 size and dimensions and depth, and they saw these large
23 re-circulations and this is one of those moments where
24 those of us who spent too many years getting out PhD
25 goes, "Oh my goodness, here's something that's actual

1 application of what I learned back then which I studied
2 bio-variation analysis." And I won't bore you with all
3 the details, but basically, as you break symmetries,
4 various periodic behaviors go away, so this was no
5 surprise to me, but I think that it calls into question
6 these algorithms, because unless you have a real world
7 pit that's very symmetric, it's not going to see these
8 large re-circulations.

9 And I guess my time is up. This is just a
10 figure from that study to show you the size of the pit.

11 And then in conclusion, I was just going to
12 say again, as EPA prepares the new NAAQS, I hope we
13 have continued coordination. Rio Tinto was very happy
14 that - we've heard over the past few days and over the
15 past years, we've heard about increased collaboration
16 between EPA and the regulative community. We believe,
17 as several speakers have said, that EPA has a
18 responsibility to provide tools that accurately
19 evaluate the impacts in order to avoid unnecessary
20 barriers to beneficial economic growth. Rio Tinto has
21 discussed these concerns with their fellow National
22 Mining Associations member companies, which may or may
23 not be providing their own written comments during the
24 public comment period, but Rio Tinto definitely will.

25 So, thank you very much.

1 **MR. BRIDGERS:** Thank you, Mark, for the
2 comments and for the presentation. All right. We'll
3 shift gears here to a TVA talk by Stephen Mueller.

4 **MR. MUELLER:** I'm Steve Mueller and I
5 work with the Tennessee Valley Authority and my
6 presentation today - my comments are regarding modeling
7 for the one-hour So2 standard and the question that I
8 wanted to address initially was whether the tempo
9 resolution of the meteorological information that goes
10 into modeling, such as AERMOD, using AERMOD, affects
11 the outcomes for one-hour So2 levels that are
12 simulated.

13 The objective of what I did was to
14 compare the performance of AERMOD running both and
15 using a standard hourly modeling approach as well as
16 sub-hourly versions based on the work that Bob Paine
17 described earlier today with the air minute plus and
18 the sharp software. I've compared those results
19 against some hourly observations that were available
20 around a point source.
21 This summarizes the modeling. I won't go into the
22 details but again, as I said, we used the AECOM sub-
23 hourly data processing software and essentially modeled
24 the meteorology using 10-minute time steps so six 10-
25 minute periods per hour. We modeled the 800 megawatt

1 coal fired power station and used actual emissions.
2 The modeling was performed for a period of four years.
3 I had to drop a year because there were no ground
4 observations to compare the results with. We used
5 standard National Weather service: a 1-minute surface
6 data and didn't have to do any downwash calculations
7 because it was an uncontrolled source that was modeled.
8 The - this plot here shows the location of the model
9 source, which is the green circle located toward the
10 upper center of the plot. Near the number one: the
11 one, two, three and four represent the So2 monitors:
12 they were located within 50 kilometers of the source.
13 There was another monitor that was located toward the
14 southwest: that was on Mountaintop. We used the data
15 from that site to represent background conditions.
16 There was also winds measure on the summit of the
17 mountain or above the summit of the mountain I used to
18 help me decide when these ground level SO2 monitors
19 were essentially downwind or with a plus or minus 30
20 degrees of a projected plume from the source - the
21 model source.

22 There's another source in this plot, which is
23 a purple source up near three and four and that source
24 was not models and that did affect some of the
25 comparisons with observations, which I'll show you here

1 in a minute.

2 The concentrations that were compared with my
3 results were background corrected.

4 Okay. These plots - the spatial plot shows the
5 distribution of the concentrations that were averaged
6 over the four years that we simulated. It's a 99-
7 percent total daily maximum of one-hour So2 values, and
8 you can see that the left plot represents the standard
9 hourly meteorology in AERMOD. The right plot
10 represents the sub-hourly meteorology and there's very
11 little difference and in this particular case it's very
12 hard to point out or to see where the differences are.
13 There are a number of ridges that run roughly west,
14 southwest through northeast and throughout this model
15 domain. The highest concentrations tend to occur -
16 that is the oranges, the reds and the magenta colors:
17 tend to occur on the tops of those elevated topography.

18 Okay. In this plot, the left plot - the left
19 graph shows a comparison between the annual 99-
20 percentile value or average value at the monitoring
21 sites versus the observed 99-percentile values for all
22 four monitors.

23 Now, site four, which is the purple and it's
24 the point -represented by the points that are farthest
25 below the line, that site is essentially often downwind

1 of the non-model source. And I believe the
2 disagreement here that has affected the models
3 significantly underestimated those concentrations due
4 to the fact that that source was not modeled.
5 So we compare the model results with sites one, two and
6 three: we see that there's generally - the results are
7 either on the line or substantially above the line, in
8 essence representing an average overestimate of about
9 80-percent of the 99-percentile - the annual 99-
10 percentile values in this - for this particular source.

11 The highest point was almost affect free
12 over-predicted by the model.

13 On the right, I compared the modeling by
14 using the sub-hourly meteorology and AERMOD versus the
15 hourly and as you can see, there's not much difference.

16 So although there was some indication before
17 we did this work that the sub-hourly modeling could
18 provide us some benefits for some of these situations,
19 in this particular source or this original source and
20 this particular set of meteorology, that was not the
21 case. Clearly, the sub-hourly modeling, although it
22 may be beneficial in some cases, is not a panacea.

23 This next plot compares the hourly 99-
24 percentile concentrations simulated for all the
25 different receptors in the modeling of the bank, as a

1 function of downwind distance.

2 And the left plot is the one-hour modeling
3 approach and you can see that the concentrations tend
4 to be clustered together and toward the bottom of the
5 plot they tend to peak about two or three kilometers
6 downwind and it gradually tail off, but there's a large
7 number of high concentrations that are scattered well
8 above that cluster in the lower part of the graph that
9 tend to also tail off with downwind distance.

10 If you look at the right plot, the sub-hourly
11 modeling, you see that we - the sub-hourly modeling
12 tends to get rid of some of the highest concentrations,
13 but it also tends to increase the highest
14 concentrations for receptors, particularly those beyond
15 about 10 kilometers.

16 So, clearly, there's a shift here and where
17 the highest concentrations are occurring, but it has
18 not totally reduced that large number of values that
19 are in this case well above 500 parts per billion.

20 The yellow squares in the plots are for
21 comparison purposes. Those are the observations for
22 doing the 4-year period of modeling. As you see at two
23 kilometers, the left plot - the observations are
24 actually below all the model values that were simulated
25 for the entire 4-year period for all the receptors at

1 two kilometers.

2 So, clearly, the model was overestimating
3 concentrations that distance for all receptors
4 regardless of the elevation receptors.

5 Most receptors are also - at 17 kilometers -
6 are also overestimated compared to observations.

7 In the right plot, we see that the 2-
8 kilometer results are actually more centered on the
9 observation, so there's some that are below and some
10 that are above 2 kilometers - the observed 2-kilometer
11 values, but still, at 17 kilometers, most the results
12 are still simulated to be well above the value that was
13 observed with that one receptor or one monitor point.

14 In conclusion, I wanted to say that it's clear that the
15 time scale processing of meteorology is not a panacea,
16 it does not always reduce the simulated concentrations
17 by the model. The tendency in this particular case was
18 for the model to overestimate. For those receptors
19 that are clearly, directly, primarily impacted by the
20 source that I modeled, the overestimates average about
21 80-percent but in some cases were as high as almost a
22 factor of three. And it causes me to ask the question:
23 Is it time for a different modeling paradigm. As we
24 switched from hourly to sub-hourly, we got rid of some
25 of the - we increased meander in the wind field, but we

1 also introduced a lot of ours where the wind is very
2 light, so we're actually swapping one problem for
3 another and we actually have more hours under the sub-
4 hourly processing when the steady state model
5 assumption is less valid.

6 So, I encourage EPA to consider offering
7 alternatives to a steady state modeling approach for
8 near field plume impact evaluations.

9 **MR. BRIDGERS:** Thank you, Steve. We go
10 from one Steve to another Steve. It's all yours.

11 **MR. GOSSETT:** All right. Yes, my name is
12 Steve Gossett. I'm from Tennessee, but I'm originally
13 from North Carolina. I'm glad to be back home. I'm an
14 alumni of the most prestigious school in the Triad. I
15 will not give their name but they do not wear blue,
16 either shade of blue, and they will be playing a first
17 round NCAA tournament game tomorrow at 12:40. I hadn't
18 been there for a while, so looking forward to that
19 tomorrow afternoon. I also want to say that I believe
20 99-percent of you do not know me because I do not know
21 99-percent of you. The reason for that is, I am not a
22 modeler, so everybody keep that in mind as we talk - I
23 am not a modeler, but I do work for Eastman and before
24 I get off that, I want to say that I am a modeling
25 skeptic, and I have been most impressed with this

1 group: some very intelligent people, some smart folks
2 and I'm going to go home still a modeling skeptic.
3 Okay. All right.
4 So Eastman Chemical Company: just a word about Eastman.
5 We were a part of Eastman Kodak from 1920 to 1994 and
6 now spun off - we're a totally separate company. We
7 have two major manufacturing locations in the United
8 States: Longview, Texas and in Kingsport, Tennessee,
9 which is where I work. And I'm going to tell you today
10 about - let me back up here - we have a little problem
11 with the So2 NAAQS, but we're going to solve the
12 problem. I'm going to tell you about that problem and
13 our proposed approach and you'll note, I have a co-
14 presenter, Bob Paine, but he's already talked seven
15 times so unless George yields me about three or four
16 minutes, he won't get to talk. Okay. But you really
17 want to hear what he has to say if we can give him
18 time. All right.

19 We have a monitor in Sullivan County - been
20 operating for 40 years. Guess who runs the monitor -
21 Eastman. We have to by regulation, but we are altered
22 by the state I guarantee you every quarter. We wish
23 that monitor's data was wrong but it's not, it's right,
24 and we have a design value of 196 - the standard is 75.
25 We've had no problem with the So2 standard up until

1 now.

2 Many of you do not have the luxury of a
3 monitor and a lot of you are going to find problems
4 when you start running these models that I'm highly
5 skeptical of, especially when you use this airport data
6 and I don't see how any of you are going to get
7 anything done by 2013 and get it submitted to the EPA,
8 but we have a little more time because we have a
9 monitor. We have to submit a plan by I believe it's
10 February 2014. And so we have this monitor. We were
11 recommended for non-attainment last June and we do have
12 the design value of 196 for the last three years.

13 Now, the little plant there in Kingsport,
14 Tennessee - been there since 1920 - we employ about
15 7,000 Eastman employees. It's the headquarters, the
16 corporate headquarters at Eastman. There are about,
17 oh, probably 2500 contractors that work there. There's
18 probably 5 or 6,000 Eastman retirees in the area.
19 Needless to say, this is a very important facility -
20 very important to the economy, very important to that
21 neck-of-the-woods, and also we are in Kingsport,
22 Tennessee, not Kingston or Kingsport upper northeast
23 tip, and Tennessee does not stop in Knoxville. There's
24 a nice part of Tennessee that goes right on up. It's
25 the most beautiful part of Tennessee. In fact, the

1 last presentation was from east Tennessee because I
2 recognize those lakes because I've fished on all of
3 them.

4 All right. This is the plant. We have three
5 - where is the pointer? There it is. We have three -
6 is there a better one? All right. We have the
7 powerhouse here. This is - this one's a new one,
8 relatively new, nicely scrubbed. Here's the middle-
9 aged one, here's the older one. It's a system of 14
10 coal fired boilers. We're there because there's a lot
11 of coal in southwest Virginia and eastern Kentucky.
12 That coal's been there a long time and we been there a
13 long time, but this plant runs on coal. Okay. So
14 there's - you know where the So₂ is emitted from at
15 that plant? From those three powerhouses.

16 All right. So here's a bigger view of this
17 part of Tennessee. It is in the Tennessee Valley of
18 Ridge and Valley Province I guess is what you'd call
19 it. You all call it complex - I call it hilly. This
20 is the plant - Kingsport, Tennessee. The plant is
21 bigger than the city, almost. We have a nice feature
22 here called Bays Mountain, a thousand foot high.
23 There's a river that cuts across, the south fork of the
24 Holston. Here's the airport. It's a very nice airport
25 for our size of a town - the tri-cities airport. It's

1 seven or eight miles away. There's a lot of hills
2 between that airport and our plant and you know, I'm
3 learning about modeling and I'm learning about surface
4 roughness and even I know that within on kilometer of
5 any MET tower at any airport, the surface is not very
6 rough. I could tell you that around our plant it's
7 rough. We have 10-story buildings. We have mountains
8 and hills. I mean it's - it's rough. All right.

9 Our plan is an elevation of about 1210.
10 Here's the airport up about 1500, so that's the setting
11 and you'll all agree, it's hilly. This is the windrose
12 and the predominant prevailing wind is from the
13 southwest to the northeast. Here's zooming in a little
14 better and you can see the plant here. We have the
15 monitor - the bad monitor right there. We had an
16 upwind monitor called Meadow View there that was - that
17 ran for many years. We had another monitor right there
18 called Skyland Drive. You see these are hills at 1700
19 - this is 500 feet above the valley floor - placed
20 there in the early 80s because they had some smart
21 modelers back then too and the modeling showed that
22 would be an impact area, so they placed a monitor
23 there. Didn't run it very long because it didn't show
24 that it would be any worse than down in the valley so
25 they shut it off. There's a quick plot. We went back

1 and retrieved the data from the state. It ran for a
2 couple of years. There's the annual averages. This is
3 the monitor that is downwind from us. This is the
4 monitor that ran upwind for a long time and you can see
5 that monitor didn't read any higher. Here are the
6 fourth highs for the year for when we had complete data
7 - you can see there for those two years a complete
8 data. No worse than the valley. That's not what the
9 model shows. We ran the AERMOD, we ran out sales.
10 Then we had a real modeler, Bob Paine. He got the same
11 answer we got using the airport data. Remember, the
12 monitor data was just about the same for the data that
13 we have. There the modeled number actually was pretty
14 good, but not in a complex terrain - it was about six
15 times higher.

16 Now, we are going to have to do something
17 about that monitor that's exceeding the standard. We
18 have a project and what we do is going to cost
19 somewhere between \$100-million and \$300-million. We
20 have two basic options and that's going to put So₂
21 controls or convert to gas for that biggest powerhouse
22 that runs half the plant.

23 Now, I told y'all I'm not a modeler but I
24 came up with a model. We're going - this is going to
25 reduce our emissions by 65-percent, overall emissions.

1 Here's my model. There's the design value. Reduce it
2 65-percent, there's a nice linear model and it's just
3 about as good as yawl's I guarantee you. It shows
4 we're going - we have a shot to obtain with that
5 project.

6 Now, I do not want to go to the Eastman
7 executive team and Board of Directors and tell them:
8 "There's this mathematical model out there and it says
9 if we're not going to make it, y'all are going to have
10 to spend twice as much because this model shows some
11 high, high concentrations up on these hilltops and
12 there's downwashes on it also it predicts.

13 Now, so the question is - and I'm probably
14 going to run over here for y'all: Will these plane
15 controls be enough? Common sense and the available
16 monitoring data says yes. AERMOD using the airport
17 data says no.

18 Now, our plan - we've had some advice from
19 Bob Paine and his colleagues and we're going to follow
20 it. That is, we're going to - we're not going to use
21 the airport data. We're going to use on-site data.

22 Now, do y'all know what it takes to get one
23 year of on-site data? Has anybody gone out and gotten
24 one year of on-site MET data? How much did it cost?

25 **MALE:** Half-a-million.

1 **MR. GOSSETT:** We're going to put in what
2 I call an MD - an MDMT: Million Dollar MET Tower.
3 We're going to put - I've got some photographs of it
4 that went out last week. One hundred meter tall, co-
5 located sonar and we're going to get one year on-site
6 MET data. In parallel, we're going to continue running
7 that monitor. The upwind monitor: we're going to
8 reactivate that one that we ran for a couple of years
9 and we're going to locate a fourth monitor in what we
10 think is a downwash settlement. We're going to try the
11 hourly So2 emissions, we're going to evaluate the
12 performance of AERMOD and this other model - I think
13 Bob wrote it and we're going to propose a modeling
14 approach using this evaluation, this guidance.

15 So, now, everybody can't afford a one-
16 million dollar MET tower, but you can see the
17 importance to a facility like this that it's worth it
18 to us to do and luckily, we have the time to do it.

19 Now, here's a close-up of the plant.
20 There's one powerhouse - and by the way that's a wide
21 building. Somebody said something about it's real long
22 and we have another Palace here. You gonna yank me?
23 Okay.

24 All right. When the wind blows for
25 however many hours in here it blows right across these

1 two stacks, those - it shows a downwash area right over
2 here.

3 Now, Bob saw that and said, "I'm not
4 sure I believe that." So we're going to put a monitor
5 right there because I really don't believe y'all got a
6 mathematical algorithm that really knows how wind blows
7 and makes an eddy over a building. I just - I'm just
8 not - I just don't believe it.

9 Here it shows an overall picture, again,
10 the plant. The MET tower, we have a perfect location
11 for it. It's right here in the valley. We own the
12 property. By the way, we used to own a mountain and we
13 gave it to the city and they made a park up there, so
14 we own - we own this property, it's in a perfect
15 location, it's just a stone throw you know from the
16 plant. We are spending quite a bit of money on this
17 thing. I joke a little bit but by the time we finish
18 paying Bob to do all this modeling and everything, it's
19 going to probably get up close to a million by the time
20 we're done. We probably already - I mean the tower
21 itself was \$100,000, just for the tower. That doesn't
22 include anything else. There's the monitor - that's a
23 compliance monitor. Here's the upwind monitor. Here's
24 this other monitor on the - on the ridge and here's
25 that downwash and we're going to - we're going to do

1 all this concurrently for a year. Here's the - here's
2 the tower. The installed it last week. If you've
3 never seen one of these things, go up. It's pretty
4 cool. Here's a picture of it still going up, there's a
5 picture of it all the way up, there's eight guide
6 wires. On March the 9th, I climbed to the top with my
7 camera. I shot back toward the plant - here's the
8 plant. Here's looking Northeast, you can see some
9 hills. There's that big hill. By the way, the model
10 shows this to be all along the flank of this mountain.
11 I like that - the light - the lighthouse beam, boom, it
12 hits right there. There's nobody living on the side of
13 that mountain. You could not stand on the side of that
14 mountain. There's another shot looking to the south.
15 There's the golf course right beside us. More hills.
16 There's a new product center going in right there.
17 Meadow View Conference Center is right there - more
18 hills. There's my legs. There I am looking down on my
19 partner. There's the light on the top of the tower.
20 And I've already told you what the plan is and I'm way
21 over.

22 **MR. BRIDGERS:** Would you want to move on
23 to save some comments?

24 **MR. GOSSETT:** I would.

25 **MR. BRIDGERS:** If everybody would use the

1 schedule, I think we're all right. It's a great
2 presentation.

3 **MR. GOSSETT:** Thank you. I just wanted
4 to change pace for y'all a little bit. It's fun to
5 drive for a little while.

6 **MR. PAINE:** This is Bob Paine with AECOM.
7 As you can imagine, it's very interesting working with
8 Steve as a skeptic. The four monitors actually will be
9 very valuable since they're going to collect hourly
10 emissions data to evaluate the models under various
11 things and also for concurrent regional background,
12 they have to do a modeling study and some of those
13 hills may be actually amendable towards CTDMPPLUS being
14 a discreet entity, so we're going to keep that option
15 alive. I think the value - and it gets to Steve
16 Mueller's issue too, and by the way Steve, this is the
17 other facility that you didn't model. We ought to get
18 together.

19 The vertical temperature difference from
20 this tower is going to be much more accurate than what
21 you would get from AERMODS parameterization without
22 that information. Also the direct turbulence
23 measurements from the tower to the sonar I think will
24 make AERMODS predictions much more accurate, so I - I
25 think this will be optimal data for AERMOD and I'm

1 hopeful that EPA will consider that any facility that
2 wants to do this prior to rushing to judgment on
3 modeling, with whatever data you can throw to AERMOD
4 would be allowed to do this type of program. As
5 expensive as it is, it's much less expensive than the
6 consequences of not having this.

7 So let's see - so we're going to
8 obviously obtain wind measurements up to at least 200
9 meters with a sonar, get the temperature difference,
10 have the tower measurements heights and have continuous
11 Q&A with the Sonar because overlapping 50 and 100-meter
12 concurrent measurements. And we're filing all the
13 regulatory guidance and so we're going to put all this
14 into AERMOD's vertical profiling input, so I'm going to
15 go through this pretty fast.

16 And of course, we're going to have a
17 limited evaluation just to see - and you know, maybe we
18 can even use some of ours, you know, we have - we have
19 a variety of options here, because when we click to see
20 - because we're going to save data every second in case
21 we need to actually figure out how to average the calms
22 during an hour, so we want to have flexibility in doing
23 the averaging of the on-site MET data.

24 We also would like to offer, with
25 Steve's concurrence, this database for comparison to -

1 to MMIF - the MMIF profiles. This would be an
2 excellent comparison type of site to see can you really
3 trust the MIFF profiles for input to AEMOD.

4 And I think - I think that's it, so that
5 was pretty fast.

6 **MR. BRIDGERS:** Thank you, Steve and Bob
7 and just so that everybody understand is that Appendix
8 W would say that we give preference to one year of on-
9 site data over that from the airport. And Steve, if
10 you ever need anybody to change a light bulb, call me,
11 I'd love to come, then I play the golf right down the -
12 down the.

13 **MR. BRODE:** I want to know did Bob ever
14 climb the tower.

15 **MR. BRIDGERS:** Oh, yeah. Has the
16 contractor ever climbed the tower?

17 **BOB:** I'm not the measurement contractor.

18 **MR. BRIDGERS:** So what we'll do - and I
19 know that we ran over, but I thought that that was
20 worth the extra 10 minutes. We'll go ahead and have
21 Ashley talk now and then we'll take our break and then
22 we'll get back on schedule. So -

23 **MS. JONES:** Well, good afternoon. My
24 name is Ashley Jones. I'm with Trinity Consultants and
25 I'd like to recognize my co-author Casey Dubbs. I'm

1 giving a short case study for an aluminum plant with
2 our challenges with the one-hour So2 NAAQS and a lot of
3 these topics have been discussed throughout the last
4 couple of days.

5 I am going to give a brief history on
6 the facility. I think the timeline really shows where
7 the plant has been with the modeling and some of the
8 regulatory actions that we've gone through. The most
9 noteworthy or the initial one is in August 2010: the
10 facility received their PSD permit for a plant
11 expansion. It was under a short timeline and a lot of
12 capital expenditures were going to have to be done to
13 comply with the model. Our challenge of the time was
14 pm10.

15 So we had a couple of stacks - the
16 pipeline stacks that had to be raised to GEP in order
17 to pass initially. Shortly thereafter was the
18 effective date of the one-hour So2 NAAQS and then a
19 couple months later, the client decided to submit an
20 amendment to the PSD permit to optimize these stack
21 changes. Our request was to reduce the stack - the
22 pipeline stacks from 65 meters down to 42 meters. That
23 42 meters is just above the formula height and of the
24 time with version 09292, this was a working solution
25 for us. We did address the one-hour So2 NAAQS

1 obviously because it was after the effective date.
2 However, our amendment request was not reviewed and
3 right away, due to you know resource constraints and
4 workload at the facility, or at the agency.

5 So the release of 11059 and 11103 came
6 and then the agency got to review our amendment request
7 in August of 2011 and when they did their modeling
8 confirmation found we no longer had a passing solution.
9 Not only do we not have a passing solution at the 42
10 meters, we didn't have a passing solution at the 65
11 meters.

12 The plant had to weight the option:
13 "Well, we do have a permit to move forward with our
14 expansion at the 65 meters," but we know these So2 one-
15 hour SIP requirements are right around the corner and
16 65 meters no longer was going to be enough as things
17 stood?

18 So our challenges we originally thought,
19 the reason the stack would be a solution, no longer was
20 likely. We evaluated an So2 emission rate reduction,
21 however, that was very cost prohibitive. Not very
22 common for this industry to have wet scrubbers and
23 would be very expensive. An additional challenge that
24 you've heard talked about was the buoyant line plume
25 source model and we were instructed that we had to use

1 this model and we had to use AERMOD And combine those
2 impacts.

3 As Bob mentioned earlier, there is a
4 receptor limitation around 100 receptors and that did
5 not obviously allow for our full AERMOD receptor grid
6 to be incorporated, so we - our solution was to go
7 ahead and recompile that code to allow for the full
8 receptor grid that we had in AERMOD and then to be able
9 to combine those impacts spatially and contemporarily,
10 we also had to recompile the BOP post-program to output
11 a binary post file so that we could take the binary
12 post file from BLP and one from AERMOD and combine
13 those together.

14 This is just a screen shot of - I'll
15 breeze through the analyst software that allowed us to
16 take those two binary post files and merge them
17 together and then extract out the concentration that we
18 needed for comparison to the NAAQS. This help
19 efficiency greatly and then helped reduce some of the
20 conservatism from initially having just to look at both
21 of the outcomes from each model separately.

22 Once we were able to combine those BLP
23 and AERMOD impacts, you can see here this first row is
24 our original So2 one-hour modeling analysis with
25 version o9292, where we reduced the stack height down

1 to the 42 meters. We were passing the model - you can
2 see the AERMOD concentration of 144 and then combined
3 with BLP and our background, we were below the NAAQS
4 standard. When we had to update the version change to
5 11103 at the 42 meters, we had a significant increase.

6 We were then also instructed that well,
7 we might as well go ahead and update the MET data
8 because that was going to be part of the So2 SIP
9 requirement, so we updated the MET data not only for
10 AERMINUTE, but also for the actual years that were
11 being used because this project has spanned quite a
12 timeframe. That did add an additional 40 micrograms to
13 our impacts as well.

14 And then we have the case where we reran
15 back at the 65 meter height and you can see that we're
16 still well - well over the standard.

17 This is an image of our facility layout.
18 You can see here, this is our - this blue building is
19 the - the influencing building for our GEP height and
20 the lighter outline is our projected length area. I'd
21 say this fits some of the scenarios that we've talked
22 about earlier this morning and likely where our issue
23 is stemming from, however, without any additional
24 guidance or clarification, the facility really felt
25 like we were stuck. We had - we couldn't really do

1 much on the stack height, we couldn't go any further
2 than 65 meters. We didn't have any guidance on being
3 able to take credit for stacks taller than GEP and
4 there were other recent clarification memos that came
5 out, it was kind of discouraging to really pursue and
6 for the client to spend money on evaluating these
7 equivalent building dimensions.

8 So in summary, this is still an ongoing
9 process for this facility. If we are - as things stand
10 and we aren't able to do anything with the stack
11 heights, taken the emission reductions necessary would
12 be pretty detrimental cost to us - to them and our
13 question and comment really is: Is any relief going to
14 come from this pending downwash guidance? Is there
15 going to be grandfathering clauses that would really
16 help or is the So2 one-hour SIP just going to push
17 everybody you know, is that really going to help or
18 not? Will there be credit for taking - be able to take
19 credit for the stacks above BLP height and are there
20 going to be any streamline approaches for equivalent
21 building dimensions?

22 In addition to waiting for this guidance
23 that is very much needed and eagerly awaited for, the
24 facility plans to initiate a field study to better
25 understand their plant's monitored impacts and model

1 impacts. We're not quite as far along as Steve there,
2 but they - something that their next steps are to look
3 into.

4 Obviously, we don't have time for
5 question, but - thank you.

6 **MR. BRIDGERS:** Thank you, Ashley. As I
7 said, let's go ahead and take our break. If we could
8 try to be back right at the 30 mark, that's a good
9 round number for us to get back started. Thank you.

10 [BREAK]

11 **MR. BRIDGERS:** Okay. We have a couple of
12 talks this afternoon on behalf of ERM, so as we take
13 our seats, I'm going to turn the podium over.

14 **MR. YEGNAN:** Thank you, George. Good
15 afternoon, everyone. Glad to see everyone hanging in
16 there on the final day - the afternoon of the final
17 day. My name is Anand Yegnan and I'm at the ERM. Mark
18 Garrison could not be here due to some personal
19 reasons, so I'm going to be doing the talk in his
20 behalf. What I'm going to be trying and do in the next
21 10 minutes or so is talk about some of the experiences
22 that we have had with assisting clients in the
23 electrical ability. Some in the industrial sector, but
24 modeling, preparing for So2 designation and also for
25 employment applications for SO compliance, especially

1 with the one-hour NAAQS. I'm going to try and cover -
2 we already talked extensively about the challenges with
3 the one-hour NAAQS so I won't delve much into that.
4 What has changed, what has remained the same, briefly
5 touch on that more as a recap from the last two days.
6 Talk about the specific antidotes relating to -
7 relating to the challenges with the using model and
8 more particularly for So2 modeling and finally, some
9 recommendations.

10 Here's a map that shows So2 actual
11 emissions greater than 110 per year, based on the last
12 year sub-guidance - draft guidance. And source greater
13 than 110 per year was recommended to be used for
14 designation. As you can see it has a whole number of
15 sources and once you start modeling these sources every
16 day, it ends up being that way. It's not going to be a
17 pretty picture, so it's something to think about.

18 A quick sensitivity analysis. Here it's
19 an auxiliary boiler/process heater, small to medium
20 size boiler. With no background, again, I will not
21 delve too much into the numbers. The color codes are
22 intended to show what the results are. The red is in
23 exceedance of the NAAQS; yellow is more than 50-percent
24 of the NAAQS; green is in compliance with the NAAQS.
25 Along the row you see the - along the road it's

1 emission rates, stack heights. Along the columns, with
2 our background it's already a challenge. When you add
3 50-percent of the background - 50-percent of the NAAQS
4 with the background, it makes it all the more
5 challenging. So that is something to think about as -
6 especially for industrial boilers/process heaters,
7 which might be that - which might have a challenge with
8 this.

9 Just a daily - maximum daily average
10 trend of measured - monitoring and measured data for
11 So2. The fourth highest is showing that and also the
12 daily maximum. As you can see, with the - I have no
13 data about 100 micrograms, we're already consuming 50-
14 percent of the NAAQS so you're not left with much room
15 for showing for compliance for sources, so that would
16 play an important role.

17 In terms of using potential experimental
18 PTE's, as you can see this is from a medium size coal
19 fired boiler showing the daily trends of measure - of
20 SIMS measured So2 data. There's quite a bit of
21 variability and even if you have 1000 receptors at
22 which you predict the impacts, it still does not
23 capture the impact if you use actual emissions, but if
24 you have potential emissions, it's going to be over the
25 impacts, so use of potential might be a different

1 answer.

2 So what is the likely outcome that we
3 can see? Again, I'd offer it as new, considering what
4 we have heard in the last two days and many of us who
5 have been working on this for the last two years.

6 Significant non-attainment areas are
7 likely to be seen due to the conservative nature of the
8 standard, conservative approach, which is the use of
9 the monitor and conservative background. All three
10 together make it extremely challenging. One-hour NAAQS
11 results could identify individual sources, unlike
12 regional impacts, which we have seen for ozone and
13 pm2.5. Many hot spots are likely to be shown as non-
14 attainment areas with the model we use model for
15 designation and potentially we might see many pseudo-
16 non-attainment areas based on modeling which might not
17 show up if you just use the monitoring data.

18 So what's remained the same with what we
19 have done in the past and what we are doing right now?
20 At the end of the day, AERMOD is still just a model and
21 extraordinarily complex meteorological process we are
22 trying to simulate using a steady-state model. It's
23 almost like Lagrangian process being trapped in a semi-
24 state model, which is something to consider. The
25 presentation of MET data - that has always been a

1 difficult issue even before the one-hour NAAQS and it
2 continues to be an issue and will potentially in the
3 near future.

4 Modern sensitivities. Many times it
5 might predict things which are not physically real and
6 that is - that I'll touch on briefly. So that is
7 something which has been the case but the use of model,
8 to potentially to remain an issue even in the future.
9 Just to go a little bit further, just the use of model
10 - I show it here - what we are showing is that you have
11 a profile measurement in the top half of the picture
12 and MMD, which is Model Meteorological Data: in the
13 bottom half, although the prints are similar, you can
14 see broader patterns of similar, but if you look at
15 specific days, specific hours, it might not be similar
16 and they are quite different actually and that's where
17 the concern is. Overall trends might show comparable
18 results, but with the nature of the standard that we're
19 looking at, even isolated individual events could point
20 to an exceedance and a non-obtainment.

21 So what's different? The stringency of
22 the standard, I think we are beginning to get how
23 stringent the new NAAQS standards are - with the use of
24 the new - with the use of models for the designation,
25 that is something which is new and probably had not

1 been applied on a nationwide scale, but for designation
2 purposes, complex - treatment of complex, of transport
3 and exposure in boundary layer, point to more instances
4 of unusual behavior. That is something which will be,
5 which is a new phenomenon.

6 And one thing which I think Roger talked
7 about on the first day: The models have been used and
8 with the stringency of the standard, things which have
9 worked in the past, pressing the EASY button so to
10 speak, that might not work in the future and that might
11 need to be brought under consideration of how we apply
12 these models and also careful concentrations of
13 sensitivity of input parameters. Which parameters is
14 impact model for instance, that will need to be looked
15 at very closely as we look into the future.

16 I'm going to briefly talk about two
17 examples. The Logan's Peak looks like the favorite
18 topic for this conference, but that's again, quite a
19 bit.

20 Again, to illustrate even further, here
21 is a very simple example. It shows three cases. The
22 first one, A, it shows using AERMINUTE data, as you can
23 see, the vent speed is in the range of .39 meters per
24 second and the character impacts, it's a narrow plume,
25 a concentrated plume. If you limit the wind speed to 1

1 meters per second in this case, the impact size varies
2 quite a bit. And if you take it - that's in Example B.
3 In Example 3, which I think Bob Paine talked about this
4 morning: in terms of using the sub-hourly
5 meteorological parameters, in this case we have used
6 that similar data and use of that reduces impact quite
7 a bit too.

8 So something to think about is how can
9 AERMINUTE, which has been used to process a minute at
10 ridges, how can that be used to better represent the
11 variations within the given mark and how can that go
12 into the model. That might be something in which
13 alleviate some of the problems with the low wind speeds
14 which we are seeing, with the use of AERMINUTE and
15 might predict results, which are more - for lack of
16 better word, realistic.

17 Again, same thing tabulated. As you can
18 see, when we heard about it this morning, again, about
19 it, that in some cases with these low wind speeds you
20 see mechanical mixing heights, which are really
21 unrealistic in many cases. They're like five meters
22 and that's really low and that - that point to two
23 things. First is we need to find a way to plead these
24 low wind speed events and find a way to - find a fix
25 for that or refine it as we heard before. And

1 secondly, we can just use the model that needs to be
2 some kind of an effort to understand the meteorological
3 parameters, which are behind these results and help us
4 understand why we're seeing these high impacts and
5 which would help to find a solution to them in the near
6 future.

7 So summary of the writing of the output
8 from AERMOD, especially for events when we have
9 exceedances or very high values that would be good to
10 have.

11 Again, one more anecdote of value. We
12 are seeing that with the taller stack, the impacts are
13 higher than with the shorter stack and this is an
14 elevated area. What we have done in here is that we
15 have - we have an enhanced version of AERMOD with the
16 latest version. We have made some modifications to
17 write out the meteorological parameters, which are
18 associated with these high predicted events.

19 And it provides a better understanding
20 and as you look at it, you can see that the buoyancy
21 with the taller stack was much lower, almost
22 nonexistent. And because of the ambient temperature
23 which the AERMOD ended up using in there for that
24 particular case. And that - that goes back again,
25 point which I made earlier, to a better understanding

1 of the meteorological parameters which make up the
2 model prediction which would be useful and if AERMOD
3 can write those things out, it would provide for a
4 better understanding of the results.

5 So finally, trying to wrap it up, so
6 what - what is going to be done? Low wind speeds, some
7 - we are treating that by either limiting the wind
8 speed to one meters per second, which probably might be
9 a more realistic representation for a steady state
10 model or find a way to use the sub-hourly values to
11 provide for the variations within the air.

12 And secondly: the treatment of
13 background data. There is some flexibility provided
14 with the guidance from last year with the use of
15 season-by-season by our approach. One of the things
16 which Appendix W talks about is the use of an average
17 background data and especially if you have identified
18 the meteorological conditions which make up the model
19 predictions and trying to better treat what is in there
20 and identify those specific background values and
21 exclude the ones which the sources contributing to
22 that. Then an average of those values could
23 potentially be used as a background value and that
24 might reduce some conservatism in the background value
25 quite a bit.

1 Specifically relating to one-hour So2
2 modeling: Sensitivity analysis is an important piece.
3 It should be an important piece of every analysis that
4 ends up going into the model. And you have to pay very
5 close attention to the meteorological conditions
6 because of - because of issues of low wind speed and
7 other similar parameters which might potentially
8 contribute to the high impacts.

9 Finally, one thing to remember here is
10 as we go through the designation and the implementation
11 process, before we designate areas as nonattainment or
12 come to any conclusions, better understanding or better
13 data of the meteorological parameters of the background
14 values which make up for that designation is an
15 important recommendation that we would make before -
16 because of ramifications of designating area as
17 nonattainment could have - could be big, especially if
18 - for future growth of industry or for even continued
19 operation of the industry and that is something to
20 consider. Use of actual emissions: some we are
21 characterizing, capturing the variability in the actual
22 emissions and instead of using the potential, that
23 might be something to consider very seriously. Use of
24 multicolor simulation or the impact as we told the
25 board before, that might be an option.

1 And finally, sensitivities of fill-in
2 parameters, that needs to be an actual value and
3 documented and some fixes to identify unusual events
4 could help towards a broader implementation of the use
5 of these models for designation and implementation
6 purposes.

7 So, that's what I have.

8 **MR. BRIDGES:** All right, second part.

9 **MR. YEGNAN:** All right. Round two. What
10 I'm going to try and do: this is some work that we have
11 done for the state of Maryland Department of Research
12 program. It's a part of the Department of Natural
13 Resources. We have spent quite some time looking at a
14 broad range of issues as it related to models,
15 including CALPUFF and AERMOD and also the use of
16 prognostic MET data. Even before the MMIF too was
17 available, and I used it in un-regulatory applications
18 so I want to share some of the insights from what we
19 have - experiences that we have learned from that and
20 see if some of those could be used for the future.
21 I'm broadly going to touch on three topics. First is
22 evaluation of CALPUFF 6.4, that is something which we
23 have been using in the more recent years, more recently
24 for some applications. Use of - discuss some trends
25 relating to the - relating to the measure data and also

1 to some modern predictions using previous models and
2 OLM. And how did they combat with the measure data for
3 NO2 and NAAQS ratios in Baltimore, Maryland and finally
4 wrap it up with some experiences with the use of MM5
5 extraction and MM5 profiles and use for a local scale
6 modeling.

7 Starting off with CALPUFF 6.4, the
8 Maryland Department of Natural Resources, Wildlife
9 Research Program, a client that we work with, has been
10 using CALPUFF for regional scale analysis, especially
11 due to value impacts on Chesapeake Bay and in terms of
12 impacts on the nutrient load of the bay. CALPUFF has
13 been used as the modeling tool for these applications
14 and many of these results of these analysis help the
15 Chesapeake Bay Commission and other stakeholders
16 understand the contribution of different sources and
17 the impact of mitigation measures - part of the impact
18 in terms of reducing the nutrient load of the bay.
19 That has been - and we have done some comparisons with
20 the results and the results from SEAMAC in terms of the
21 nutrient loads and in so many cases. The new chemistry
22 with the version 6.4 - based on some preliminary
23 analysis, we find that it - it seems to improve the
24 predictions of the nitrogen load quite a bit and the
25 earlier indications is that it is very promising

1 change. It's a work in progress and evaluations - we
2 have converted to aerosol and gas concentrations - wet
3 deposition estimates from NADP and other sites, we have
4 looked at model evaluations by comparing it to CASNET
5 and NADP monitored, measured data. So earlier
6 indications show that 6.4 is a step in the right
7 direction and it seems to improve model predictions
8 quite a bit.

9 Just to show the modeling domain, as you
10 can see, that's the - that's the extent of the
11 evaluation domain and the modeling domain spans much
12 bigger. It pretty much covers a good portion for the
13 east of Midwest actually and this is the bay and -
14 which is a primary focus area for us as a part of these
15 analysis.

16 Just to give an idea about what we are
17 looking at in terms of emissions, NAAQS emissions range
18 close to seven - I believe it's seven million times and
19 starts in the range of 8.8. We have developed some
20 tools to capture this emissions from these regional
21 scale sources and a model with CALPUFF and that is
22 something which we can - we haven't discussed here but
23 we'll be happy to share those.

24 Earlier, as I mentioned or indicated,
25 preliminary results indicate significant improvements

1 in prediction of nitric acid concentration,
2 particularly nitrate and a event deposition of
3 nitrates, so it's definitely promising to see the
4 change.

5 Now, I'm going to switch gears a bit and
6 talk about some of the measured data in NAAQS monitors,
7 ambient monitors, more in the context of AERMOD. We
8 have two monitors near Baltimore -- one at Old Town,
9 the other one at Essex -- which have recorded data for
10 nearly 20 years now. What we did in this case is
11 modeled the actual emissions from 2009 with AERMOD, the
12 focus being on stationary sources and nearly 438,000
13 pounds per day of NAAQS was modeled in these cases and
14 did some comparisons with how did the modern
15 predictions compare with the measured data at these two
16 monitors. And this shows the - this slide shows the
17 location of the Old Town and Essex. Old Town is right
18 the urban area and Essex is outside of that.
19 Broader trends: this is a mightier trend ranging from
20 '93 to 2009. What we see in here, the different lines
21 in here have different NAAQS concentrations and we are
22 showing ratios of NAAQS to NO2 and I think these trends
23 are similar to what we heard before in the last couple
24 of days where with the higher concentration the ratios
25 are lower. That is NAAQS to - No2 to NAAQS, which kind

1 of makes sense that with the lower concentration that
2 is more ozone available, which converts NAAQS to enter
3 with much greater than the higher concentrations.
4 Looking at meteorological data for this analysis. We
5 looked at Baltimore, BWI and I pulled up data from
6 Sterling, Virginia. Use of AERMINUTE was made so there
7 is a number of missing as it is a number of hours. One
8 thing which we also found as a part of this a
9 significant number of hours where you have really low
10 wind speeds. AERMOD was used even more in this case.
11 The next three slides essentially show trends in the
12 windrose. The first one: this one that we see is the
13 '91 to '95. The next one is with the BWI without
14 collection for AERMINUTE 2005 to 2009 and the trends
15 are much different and the average percentage of
16 missing values and calms is significantly higher as you
17 can see in here, as compared to what we saw in the
18 previous data, so if you use AERMINUTE the trends are
19 much broader trends and fairly comparable to what we
20 saw before with the '91 to '95 data. However, you do
21 see a significant increase in the percentage of the
22 frequency of low wind speeds, which we know is an
23 artifact of using AERMINUTE. So we might need
24 something to do in terms to refine these AERMINUTE
25 results.

1 The next three or four slides, we have - I'm
2 going to show some comparisons between measured and
3 prediction - measured data and between predictions for
4 - in order to do NAAQS. In this case we have used a
5 ratio of .1 and the first one which we see with oil and
6 group as the option. Along the rows we see the hour of
7 the day, along the column different concentration
8 ranges and within each of those blocks we see months in
9 the year, so we have the monthly trend along with the
10 daily - the monthly and the daily trends and the ratios
11 for different NAAQS concentrations.

12 The color-coding is intended to indicate -
13 the red color is - the hard colors are more of higher
14 concentrations, the cooler colors are lower ratios.
15 Let me count that. With PVMRM, it's much different
16 than what we see for OLM group, which again, based on
17 what we heard in the last two days, it's no surprise.
18 The ratios are much lower than that for OLM group and
19 here if you - those are the predicted values. Now, if
20 you compare it with the measured value, these trend
21 seem to indicate that the trends are much closer within
22 measured and predicted values if you use OLM group,
23 enter a in-stack ratio of .1.

24 So that might be something to consider in
25 terms of future guidance of - if - and this might be

1 more case-specific- it might be applicable for
2 Baltimore. It might be different for different areas,
3 but OLM group seems to be a good fit in this case with
4 an in-stack ratio of .1.

5 Similarly, if you use an in-stack ratio of
6 .5, the results are over-predicted - they're much
7 higher in terms of the ratios.

8 And we also looked at comparison between Old
9 Town and Essex. For Essex, the impacts were under-
10 predicted and one of the reasons why we think is
11 because Essex do it - what you see in here are these
12 are - we call it pollution roses, essentially, that is
13 the measured value of- a type of thing prepared using
14 measured value and based on the prediction of the wind.
15 It still shows that the contribution comes pretty much
16 from the Baltimore area, which might be - if we - we
17 haven't accounted for mobile sources in here - that
18 might change the impacts if we account for that.

19 So broadly speaking, one of the observations,
20 OLM group appears to predict better than PVM (ed.
21 PVMRM) model for Baltimore with an in-stack ratio .1.

22 We have seen some problems with AERMET
23 processing, especially with low wind speed and DNR is
24 currently recommending the use of pre-ASOS, but we
25 don't have chemistry being used in AERMOD and with

1 chemistry based on guidance from Region 3, we have - we
2 have been using concurrent ozone and MET data for more
3 recent years. Baltimore analysis points to one of the
4 critical limitations of AERMOD in terms of issues
5 relating to the transport time and - and just the
6 simulating study of a Lagrangian process with a study
7 state model and it might be something to consider for
8 future application - would be use of a Lagrangian
9 model like CALPUFF, even for new scale applications.

10 And finally, validating improvements and
11 treating urban coal. That might be - that's an
12 important issue.

13 Finally, to just wrap it up, as I
14 mentioned, we have been looking at use of prognostic
15 MET data as input to AERMOD similar to what the MMIF
16 would do for quite some time now and many of these have
17 been and do compare the regulatory option in AERMOD
18 using National Weather Service data and we have done
19 some comparisons with the tower data, with the - from
20 nuclear stations and the earlier indications - the
21 results have been fairly encouraging. We have - we are
22 pretty encouraged to see the MMIF too now and hope to
23 evaluate that and provide input and any kind of
24 feedback we might have with the EPA in terms of what we
25 see in comparison to the tools that we have available.

1 And we think finally that use of MM5 and
2 (inaudible) potentially, holds a lot of promise and in
3 particular for cases where the airport is at a far away
4 location in complex situation, but it's - it could
5 potentially be a good surrogate or an alternative to
6 installing a MET tower or- we had to wait for a year.
7 This might provide some good addition insights to - for
8 use in a local scale model.

9 With that I will wrap it up.

10 **MR. BRIDGERS:** Thank you. Okay. For the
11 next step we have Eladio.

12 **MR. KNIPPING:** This should go fast.
13 Hello. I'm going to give an update on the development
14 of the SCICHEM model. If there are a lot of pauses
15 it's because I had throat surgery a few weeks ago, so
16 just bear with me. I am Eladio Knipping. I'm a senior
17 technical manager of the environment sector at the
18 Electric Power Research Institute and we have been
19 sponsoring the development of SCICHEM now for about 14
20 years. Some introductory notes: A new SCICHEM version
21 is forthcoming in a few months. A prior version of
22 SCICHEM has been described in previous presentations at
23 this conference. This version has some but not all of
24 the enhancements of the future version. As such, it
25 has seen limited distribution for example to EPA for

1 testing as a prerelease version.

2 This presentation will provide an update
3 on the status of SCICHEM development overall. First,
4 let me describe a little bit of the origin of SCICHEM.
5 A general overview of the SCICHEM system has been
6 provided earlier in this conference and detailed
7 presentations on SCICHEM have been given at past EPA
8 modeling conferences and at past CMAS conferences as
9 well as other venues. The development of SCICHEM
10 itself started in the late 1990s and all existing
11 versions of SCICHEM at this moment are based on a 1998
12 version of the SCIPUFF model. As you recall from
13 yesterday's presentation, SCICHEM is SCIPUFF with
14 chemistry.

15 Testing and evaluation of past SCICHEM
16 versions has been documented in EPRI reports. These
17 EPRI reports are publicly and freely available at
18 EPRI.com. If you should want to download these
19 reports, you can contact an EPRI customer assistance
20 center through our website for information on how to
21 download them and also to obtain a legacy version,
22 which is even older than the version described
23 yesterday version of SCICHEM.

24 Now, SCICHEM has branched into two
25 models. First of all the stand-alone air dispersion

1 model SCICHEM - SCIPUFF with chemistry but also the APT
2 branch. In the 2000s, EPRI invented the SCICHEM model
3 into the EPA CMAQ model as a proved grid module for
4 sub-group treatment of industrial plumes. This big
5 version of SCICHEM is known by the name Advanced Plume
6 Treatment, APT, which leads to the acronym CMAQ APT. A
7 version of CMAQ APT was publicly released via the CMAQ
8 center and it was based on version 4.6 of the CMAQ
9 model. This version was based also on the sectional
10 MADRID aerosol treatment for the treatment of
11 particulate matter and as mentioned yesterday, it used
12 carbon for the gas based chemistry.

13 Further development of APT continued
14 using the CMAQ 4.7.X branch of the host model. This
15 added the option of model aerosol treatment consistent
16 with EPAs CMAQs AERMOD modules, which are the aerosol
17 modules within the CMAQ model. It added the ability to
18 run in parallel processors and the University of North
19 Carolina tested this version and provided useful
20 feedback to help refine the model development. CMAQ
21 APT based on CMAQ 4.7.1 was not released to the public
22 as development efforts focused on releasing an APT
23 version with - that is compatible with CMAQ 5.0 as the
24 host model and this is what was referred to in
25 yesterday's presentation as the upcoming release of

1 CMAQ APT. If you should want a CMAQ 4.7.1 version of
2 APT, we could make that available to you, but we would
3 encourage to just wait until the CMAQ 5.0 APT version
4 is available, which will become the most current
5 version of the model and it will be released in an
6 interim release of 5.8 in upcoming months, which will
7 also make available other modules contributed to the
8 community to the CMAQ system.

9 So what we've had is SCICHEM has
10 developed in over the 2000s by focusing efforts on
11 SCIPUFF on transporting the dispersion modules of
12 SCICHEM and APT by focusing on the chemistry
13 treatments.

14 So the chemistry elements of SCICHEM
15 underwent refinement through continued development of
16 APT. Similarly, the transporting of dispersion
17 elements of SCICHEM underwent refinement through
18 continued development of SCIPUFF in the 2000s. The
19 evaluation of APT and SCIPUFF during this period has
20 been documented in the period review of scientific
21 literature. However, this branching of the code has
22 led to an effort to reconcile the two codes into one
23 uniform code for the stand-alone dispersion model,
24 because now there's confusion as to who has the right
25 chemistry and who has the right transport and "What

1 version am I working with," has led to a little bit of
2 confusion. We want to avoid that confusion.
3 At the end of this reconciliation there will be only
4 one stand-alone model, however, the two units will
5 remain in order to emphasize whether the chemistry is
6 on or off, so the SCIPUFF SCICHEM equivalency may be
7 thought of as: SCIPUFF is SCICHEM with chemistry off or
8 SCICHEM is SCIPUFF with chemistry on. The pre-released
9 version of SCICHEM which was provide to EPA and others
10 for pre-released testing does not have a graphic user
11 interface. This is one of the - one of the important
12 user considerations that we have also taken into
13 account with the release of the next version, which
14 will include a basic graphics user interface. It won't
15 have you know a very fancy graphics user interface, but
16 it will have the basic graphics user interface. This
17 release version will be available in Windows and Unix
18 Linux versions. The Unix Linux versions can also be
19 run from a command line interface. The release version
20 will be able to take advantage of multiple cores on a
21 single machine, so if you have a dual processor, four-
22 core on each processor, it can run it on all eight
23 cores and it will include user manuals and
24 documentation on evaluation and testing as well as a
25 test case for users to run. The new release of SCICHEM

1 will become available to the community in upcoming
2 months. We are working hard to get this out as soon as
3 possible. The model will be free, open source and
4 public domain.

5 So as some of you that are familiar with
6 SCIPUFF may know, it did have some development that was
7 based on Department of Defense funding, but the model
8 has been approved for release as a free open source
9 public domain model and this includes all of the
10 development of model that has been sponsored by a
11 variety of different agencies include DOD and EPRI.

12 As derivative products of SCICHEM may be
13 developed since it will be available to the whole
14 entire community, we can - what we want to clarify is
15 that EPRI will remain the custodian of the core SCICHEM
16 model and I would like to acknowledge Sage Management
17 and Environ as the current model developers. We have
18 Biswanath Chowdhury and Ralph Morris here of Environ.
19 Just being from Sage if you both will stand up it would
20 be nice. I guess Ralph already left, Biswantath. All
21 the hard technical transporting disbursement questions;
22 please send them over to him. Distribution of the core
23 SCICHEM model will be through EPRI.com and through
24 other linked portals. We haven't discussed this, but
25 we are considering linking it through the websites of

1 the model developers: the CMAS Center and as
2 appropriate through the EPA model clearing house. We
3 encourage the community to test, evaluate and apply the
4 model as appropriate and to provide feedback that will
5 allow for future refinements so that you know as with
6 all the models, we are continuously looking to refine
7 our ability to simulate the atmosphere.

8 And as an appendix, I'm not going to go over
9 this right now because I am about at the limit of what
10 I can handle. I have included some selected
11 enhancements to SCICHEM that are related to the
12 transport and dispersion and again you can contact me
13 or Biswanath and we'll be happy to go over these
14 enhancements that are not in the current pre-released
15 version that was provided to EPA, but that will be
16 taken into account in the final - in the - in the final
17 release that will be available in - in the upcoming
18 months. And all that is just shown in order for you to
19 know that it's there for you to view at your leisure.

20 Any questions? Fantastic.

21 **MR. BRIDGERS:** Thank you, Eladio and best
22 wishes as you continue to recover from your surgery.
23 Just for everyone's reference - I know he had a handful
24 of slides there that he had to step through - probably
25 by five o'clock this afternoon, depending on how the

1 open mic session goes, all these presentations will be
2 posted on the SCRAM website, so you can look at them at
3 your leisure.

4 So now, we're going to have a couple
5 talks by Steve Hanna. Let me make sure I got the right
6 one there. The floor is yours.

7 **MR. HANNA:** Thank you. Before I get
8 started on this one, I was just thinking over the break
9 about a possible solution to this downwash low wind
10 problem and it occurred to me basic science principals
11 of you're going to have the recirculation form only if
12 the wind speed is larger than the turbulence speed and
13 since - even AERMOD has a minimum turbulence speed of
14 about you know whatever it is, half a meter per second.
15 That means you can set a criteria when the wind drops
16 below a half a meter per second, then downwash turns
17 off and then you can have - use their usual
18 extrapolation thing and assume you have full downwash
19 at say two meters per second and then do a
20 interpolation between two solutions between half and
21 two, so I'll leave that solution with you.

22 But this particular talk, I thought I'd
23 - since there's a lot of discussion of evaluations and
24 PUFF models, I thought I'd give this example of a
25 CALPUFF and SCIPUFF comparison that was done by myself

1 and Joe Chang. This was a few years ago, but the - I'm
2 going to emphasize the statistical evaluation and
3 methods and sort of the approach to this. And this
4 work was sponsored by the Defense Reduction Agency,
5 who's been sponsoring most of the SCIPUFF development
6 in the past 10 years or so.

7 So now, instead of looking at these huge long-range
8 transport ETEX 1000 kilometer, we drop back to two
9 mesoscale field experiments involving trace of releases
10 sponsored by Department of Defense - they're called
11 DIPOLE PRIDE 26 - they have these cute names that they
12 dream up for all experiments and at Nevada test site in
13 OLAD and these DIPOLE PRIDE was an instantaneous PUFF
14 release, only 14 trials and OLAD was a line source with
15 11 trials. Because the military is more interested in
16 dosage for health effects of chemical agents or
17 something, then we're not looking at concentrations
18 over 10 seconds - it's the total dosage over the period
19 and the ARC MACS for each trial: we have the Boot
20 software that we've been developing over the years in
21 sort of the standard performance measures, but the key
22 thing here I wanted to emphasize was the significance
23 test that we use and also mention that because the
24 military forces you to have model acceptance criteria,
25 we came up with some - even though we didn't feel like

1 it was appropriate to assign specific things - so we
2 came up with acceptance criteria and they apply the
3 same validation standards to dispersion models as they
4 do to tanks or combat boots, so what are the acceptance
5 criteria? Check it out that yes, it does or doesn't
6 pass the acceptance criteria.

7 So here's the two sites. The first one, a
8 Nevada test site, it's a 30 kilometer domain and
9 there's mountains to the west. It's a big, flat valley
10 as there is out there and these were releases of either
11 from the north end or the south end of the domain of
12 FS6 PUFFS and then there were three sampling lines and
13 those are shown by the three lines with 30 samplers on
14 each line and there were right meteorological surface
15 sites on an upper air site and the Doug Way was the
16 OLAD and those were instantaneous line sources also on
17 - in a flat valley but with some pretty big mountains
18 10 kilometers away.

19 This shows you the observed winds and
20 whenever you measure observed winds on a mesoscale
21 network, you discover that they're all in disagreement
22 with each other. This just happens every place, but
23 this shows a typical variability of one to two meter
24 per second and wind direction variability of about 60
25 degrees. We applied a CALMET - and these are the

1 interpreted wind fills. SCIPUFF has its own diagnostic
2 wind model and we ran that for input to SCIPUFF, then
3 we ran both models with the CALMET inputs and just to
4 show you what we got, these are scatter plots which you
5 can just barely see, but up in the top right CALPUFF is
6 on the top and SCIPUFF is in the middle and a Navy
7 model is on the bottom, but they're sort of similar
8 scatter with the CALPUFF And SCIPUFF - the line of best
9 agreement goes through approximately the middle and
10 they have about the same amount of scatter and with the
11 DOUGWAY, the OLAD test models all seemed to under-
12 predict the higher values, but there's still similar
13 agreement among the models and this tabulates some of
14 the performance measures and if you look down at the
15 bottom at the high, the observed - the DIPOLE PRIDE was
16 modeled fairly well by each model and at OLAD was
17 under-predicted by a factor of two and the geometric
18 means and factor of two and so on are there.

19 So what we found is that there was good
20 performance at the DIPOLE PRIDE 26. At OLAD we're not
21 sure why there's the under-predictions - that might
22 have had something to do with some elevated sources
23 with unstable conditions, but the key thing that we
24 always emphasize in these evaluations is when you go
25 from sight to sight you notice difference in

1 performance. So it might be 30-percent over at one
2 site, 50-percent under at another site and then the
3 important thing is to look at the total group of sites.
4 My two models' performance was about the same and the
5 middle bullet is the important thing that we applied
6 the Boot model evaluation a significant difference
7 criteria and there's no significant difference between
8 the performance measures for CALPUFF and SCIPUFF. Now,
9 part of this is due to the fact that we're only 14
10 trials and 3 arcs, so there aren't a whole lot of data.
11 And the references couple - the paper where this is
12 described and then some recent papers on the model
13 acceptance criteria so I guess now I need to go to the
14 other one.

15 Thank you and George is getting pretty fast
16 up here as the meeting goes -
17 This - continuing on, we switch over also now talking
18 about evaluations of prognostic meteorological models
19 of field observations and this is some studies that
20 also were funded by the Defense Threat Reduction Agency
21 over about the past 10 years and it's focusing on the
22 boundary layer of variables because usually the
23 meteorological values are evaluated of more things of
24 interest to forecasters like rainfall and whether the
25 front goes through on time, things like that, so the -

1 there was a seminal paper - a review paper by Nelson
2 Seaman in 2000, at atmospheric environment in which he
3 reviewed all the methods and recommended approaches for
4 evaluating the forecast models for boundary layer
5 inputs that go into the dispersion model. For example,
6 the SCIPUFF model wants surface fluxes, PBL height. It
7 likes TKE turbulence to be fed directly into it. So do
8 the MET model outputs agree well with each other with
9 the field data and so on, and I'm going to summarize
10 just briefly two studies. One in which we compared MM5
11 and RAMS from the SARMAP domain, OTAG domain and ASOS
12 domain and all these data we got from Tom Tesche and
13 Dennis McNally and the SIRAN evaluations and other one
14 was the OMEGA COAMPS and MM5 models for the Iraq 1991
15 scenario where they were - the army was blowing up
16 munitions dumps and there was some chemical agents and
17 the second study is using the IHOP data: That's not the
18 pancake house. There was a big study and Department of
19 Energy and so on of boundary layers and the HO stands
20 for H₂O, it's the international H₂O project where they
21 measured a lot of different boundary layer parameters in
22 Kansas and Oklahoma on a large domain.

23 So looking at just a summary of the first
24 study, for those four models and four domains, roughly
25 what we can see is the - for the mean wind speed and

1 the boundary layer with the winds - mean winds about 3
2 meters per second, the mean bias is only a meter per
3 second and 10-degrees, but the RMS, the Root Mean
4 Square error is typically 2 meters per second and 60-
5 degrees for wind directions and we seem to find this
6 everywhere, whether you go to urban areas over the
7 ocean - there's similar amounts and this is sort of a
8 fundamental uncertainty in the atmosphere that the
9 models can't beat. The vertical temperature gradients
10 are underestimated and these are 10-year old models,
11 primarily because of poor vertical resolution and
12 they've improved since then.

13 Now, to get to the IHOP study, it took place
14 over a couple months in 2002 and we picked three test
15 days. This is a picture of the domain. Some of these
16 sites are the DOE's routine sites and others are the
17 Oklahoma Mezzo Network and others were set out
18 specifically and they measured surface fluxes and did a
19 lot of slow rise radio signs and so on. And the
20 meteorological models that were run - MM5 Penn State,
21 Dave Stauffer was leading this aspect of it and ran MM5
22 with agnostic grid down to 4 kilometers and ANSEP, Jeff
23 McQueen and his group ran WRF NMN for the scenarios.
24 So here's the MM5 modeling domain with the 4 kilometer
25 nest over Oklahoma and Kansas and the WRF NMN, which

1 doesn't really show too much, but this is the figure
2 they gave me.

3 First of all the vertical profile
4 comparisons: There were slow rise radius signs. Every
5 three hours five different sites and this is an example
6 of the type of thing we got. This is one vertical
7 profile and you often found here that WRF was 30-
8 percent too high: In fact, that was a consistent thing
9 and led the NCEP to go back in and change their PBL
10 approximation method, which was based on a level that
11 the TKE dropped a certain fraction of what it was at
12 the surface. At night, you're in serious trouble with
13 all these models because you have a really - often a
14 really strong surface and version and one of the models
15 got it that the others - the other didn't.

16 In this case WRF has - our MM5 is an elevated
17 version WRF doesn't, so there is a lot of uncertainty
18 in the mixing depths: As just a typical example of the
19 wind speed over a day at one of the sites. This is as
20 height of 60 meters and the RMSC typically was found to
21 be about 2 meters per second here for both MM5 and WRF.
22 The TKE, which was of great interest to SCIPUFF because
23 it can accept TKE as a - which is a turbulent like
24 $\text{SIGMA } U\text{-square plus SIGMA } V\text{-square plus SIGMA } W\text{-square}$
25 and that was not too bad during the day. At night,

1 again, there were big problems with using the MET model
2 output at TKE. So as I said, the minimum or inherent
3 uncertainty is about 1 meter per second. The largest
4 bias is at night. Wind direction is proportional of
5 one divided by the wind speed - the wind direction
6 error. The mixing depth 20-percent error during the
7 day plus or minus 100-percent at night and TKE has some
8 problems. And these are incidentally in general
9 agreement with the Seaman 2000 review paper and these -
10 at the end here I put the references as well as the
11 reference for the Seaman paper, so you know this is
12 sort of a template possibly for doing Mezzo scale
13 comparisons.

14 Thank you.

15 **MR. BRIDGERS:** Thanks, Steve. Just a few
16 more talks and then we'll have another break. Let's
17 see if it will work. Okay. David. And a special
18 thank you for David making it. I know there was some
19 challenges getting here, but, welcome.

20 **MR. LONG:** Good afternoon. I'm David
21 Long. I'm a senior engineer in the Air Quality
22 Services section of the Environmental Services with the
23 American Electric Power Service Corporation. I'd also
24 like to acknowledge my co-authors on this work: Pete
25 Catizone, Mike Anderson, Steve Zale and Mike Newman

1 from TRC who have done an excellent job of taking this
2 from a proof of concept position into something that is
3 - we're getting real close to being ready for primetime
4 with it. The background of this work came about as a
5 result of some questions from our engineering people
6 about one of our plants in Texas and wanting to know
7 what kind of an SO2 limit they'd have to meet for the
8 one-hour standard and looking at the area, it was sort
9 of, "Well, there's a lot of stuff down in that region
10 and we better figure out what background is and when we
11 went looking just sort of at the rough cut number for
12 what's the closest monitor, there's one monitor in that
13 region at Longview Airport and it's design value for
14 2008 to 2010 was 66 parts per billion. Not really
15 something that's going to make a good background number
16 in a fairly heavily industrialized area.

17 Well, we went and went ahead and Texas
18 was very good about supplying us with the hourly data
19 from that monitor and when we started looking at the
20 hourly data, there were just hour after hour of very
21 low values followed by a handful of hours with very
22 high values, then went back to very low values again
23 and sort of - something's hitting that monitor was sort
24 of the conclusion you drew from it and it made it real
25 clear to us that sort of the initial proxy is suggested

1 in the guidance that EPA proposed last year - used the
2 design value for a nearby monitor just really wasn't
3 appropriate in this case.

4 Now, the area that we're looking at - as I
5 mentioned we do - there's a number of industrial
6 sources and these are just the power plants in the
7 region that we actually used in our work and this was
8 mentioned by one of our speakers a little bit earlier,
9 there is a chemical plant in this area too. He's
10 going, "Yeah." And really we didn't find a whole lot
11 other than what we can attribute to the utility sources
12 and as you'll note I've got two different colors up
13 here: The black sources are coal fired plants and the
14 orange sources are gas and oil fired facilities. Now,
15 I will not the gas and oil facilities don't use that
16 much oil. In fact, we own all three - all three of the
17 gas oil facilities shown on here and in looking through
18 the operating records of those facilities, only one
19 unit at the Lieberman plant burned any oil in the
20 three-year period that we're looking at here and it
21 just burned oil for a short period of time in 2010.
22 You know, I mentioned about the spikiness of the hourly
23 data. When I was doing the proof of concept work, this
24 was a plot that I made and as you can see, we go along
25 less than 10 most of the time and all of a sudden

1 here's a 95, here's a 78, you know, very spikey in its
2 performance, which does indicate very much things
3 hitting that monitor from a source, so it was - let's
4 see if we can try and figure out what sources are -
5 what sources might be doing this.

6 The initial method was to use a two-hour
7 average: the hour of the high value plus the hour
8 before and we've selected a 10 part per billion
9 threshold just to try and make it easier to work with
10 the data rather than trying to look at all 8760 hours
11 in the year. The initial cut would be if the wind
12 direction was within a 15-degree either side of the
13 direction from the monitor to the source, we'd
14 attribute it. And the wind direction was determined
15 based on the one-minute data set average over the hour.
16 If the - if we didn't meet the first condition, then we
17 looked at the maximum and minimum one-minute wind
18 directions for the two-hour period and if those fell
19 within 30 degrees of either side of the - the direction
20 of the source from the monitor, we would attribute it.

21 Now, obviously, you know, this is - we're
22 trying to get just a rough cut, so we had a third
23 criteria. If the first two conditions don't work, look
24 at the one-minute data itself for both hours and see
25 how many of the values that's within the plus or 15 -

1 plus or minus 15 degree sector of the source and if it
2 was greater than 10-percent or more, then you could
3 say, "Yeah, that source probably did have and it was
4 having an impact on that value."

5 And then our final cut was if none of that
6 worked, professional judgment or some additional
7 analysis, which I will show you one value that was
8 extremely high that we couldn't get rid of that went
9 through - we took through this process and it really
10 demonstrates just what this one-minute data can really
11 do in examining this.

12 Our initial results when I was doing proof of
13 concept, I was working with one month of data and you
14 could do it in an excel spreadsheet. When we started
15 looking at three years of data, that really wasn't
16 going to work and the folks at TRC have developed some
17 computer programs that we're still refining to do the
18 analysis of all the data. However, we went in through
19 this initial process, we did find some shortcomings and
20 we've made changes and as I mentioned, one value from
21 2009 was taken to its ultimate conclusion since steps
22 one through three didn't tell us anything about this
23 value and it was up - I believe it was like a 79 value.
24 It was right up around the standard. And when we did
25 this, it showed the shortcoming of using everything

1 based on just block hour values, but it also shows the
2 capability of using the one-minute data and some of the
3 things that you're capable of doing.

4 Our initial results on the one-minute - on
5 the steps one through three came out with when we
6 looked at - if - if there - if we screened out all the
7 upwind sources, the three-year 99-percentile went from
8 66 to 14, so it really, really helped.

9 Then if we look at this high - the high value
10 that we couldn't get rid of, here's that 75 I've
11 mentioned, and it was - it definitely raised some
12 curiosity - what was going on that that 75 was still
13 hanging around after we put it through all this. Well,
14 one of the fellas - and I'm not sure which one it was,
15 but from up at - yeah - went through it and start - did
16 the initial hour block looking at Martin Lake, which
17 seemed to be one of our favorite sources to pick up at
18 that monitor, came out and just went a few kilometers
19 around the monitor, which started raising some
20 questions and they started putting in an offset,
21 working down into that first hour and when they put a
22 20-minute offset in, it just about ended up with a
23 direct hit on the monitor.

24 So it really does go to show that when you
25 can refine and have a higher resolution of the MET

1 data, you can see things that just hourly MET data
2 really doesn't show and it's not that there's anything
3 wrong with the hourly MET data, it's just the
4 resolution isn't fine enough.

5 After we went through this first round, we
6 started looking at okay what works and what doesn't
7 work? One of the things that we started to look at
8 very early on was we're only using two hours and the
9 wind speeds may not be all that high, so should we look
10 at more hours and we - when we started doing that, we
11 started to find transport distance and the travel time
12 are very important to being able to identify what
13 sources are impacting a monitor to given time. And we
14 also have taken the method to consider a percentile of
15 hours in the source bin as well as simply the
16 percentile of just filtered daily high values for
17 determining candidate background values.

18 Now, here, this is looking at a travel time
19 instead of just a two-hour block, up to 12 hours and
20 when we take a look at all valid concentrations, we
21 find that the three-year average is 85 with upwind
22 sources. When we're looking at the maximum with no
23 upwind sources, that 85 becomes 25 and that's at the
24 100th percentile. When we look at the form of the
25 standard - the 99th percentile of daily maximum and

1 here's our 66 design value - when we - with the
2 filtering, it drops to 11.

3 And we were talking a little bit earlier
4 today at lunch about that 11 value and it was mentioned
5 that there - if we wanted to start doing more of the
6 step 4 analysis, we could probably knock the 11 down by
7 a good bit. And we also look at it just from the
8 percentile of the valid hours in each case and when
9 it's looking at all valid concentrations, the 99th
10 percentile value is 15. After we filter it, it drops
11 to 5. So there you know it is - we're just believing
12 this is a very good methodology for filtering the data.
13 If you don't have multiple monitors in an area and have
14 one that really is sitting in a fairly clean spot.
15 And this is a table where we're looking at just who's
16 doing what at what time looking at all valid - just the
17 all valid hours characterization and this is year-by-
18 year data and using the 15 degree sectors. We
19 ultimately concluded that really 30 degrees is probably
20 the better way to look at this. But when you see year-
21 by-year - when we look at no upwind sources, what you
22 end up seeing if you're looking at the 99th percentile
23 values, something akin to the form of the standard, you
24 know you're seeing - here's roughly 6, 6 -- we look at
25 2010 - okay, it's up to 7. And when you look at the

1 three-year average of it, it's 6 parts per billion
2 looking at the 99th percentile of the valid hourly
3 values with no upwind sources. When you open it up to
4 30 degrees: that value drops to 4.6. And the 100th
5 percentile value drops to 32.6 from 82.2, so you're
6 definitely screening more hours out and being able to
7 say, "Yes, there was a specific source that was in our
8 - under consideration that was impacting that hour."

9 What's our conclusions? Well, the use of -
10 and here I'm calling it the 65 data sets, which that's
11 the format - is very - is viable. It's - we believe
12 this is a viable technique that transit times up to 12
13 hours should be considered to maximize the capture of
14 source impacts on one-hour monitored values. If you're
15 considering upwind sources with a long transport time,
16 the angle between the average wind direction and source
17 direction should be 30 degrees in order to allow for
18 the plume meander that's going to occur. And the Step
19 4 analysis, it should be available in the methodology
20 because you may not be able to find every hour and have
21 it conform to the, you know, the block hour
22 requirements as we saw earlier. And consideration
23 should be given to grouping sources and this would - we
24 think that would be useful if you have a large number
25 of sources within a 10 or 15 maybe 20 degree sector

1 coming out - possibly grouping them rather than trying
2 to say well, it was this source here when 15 or 30
3 degree sectors we're using are overlapping so much
4 amongst the sources. And while we did this work for
5 one-hour SO₂, we think it should be valid for any
6 pollutant with a one hour averaging time and quite
7 possibly for other short - fairly short averaging
8 times. You know, obviously, if we're looking at 12
9 hours, we're not really doing something with this
10 that's going to be real - probably real good for 24
11 hours, but that might be something to test at some
12 point in the future.

13 Thank you.

14 **MR. BRIDGERS:** All right. Do you want me
15 to turn the microphone on?

16 **MR. COLOMBARI:** Do you want me to use
17 that keyboard?

18 **MR. BRIDGERS:** Either the up or the down
19 microphone.

20 **MR. COLOMBARI:** Okay. Thanks. Hi, I'm
21 Toni Colombari with Trinity Consultants and I'm going
22 to be giving a presentation a little bit different than
23 others. We're not going to look at a specific
24 situation but sort of a broad category of all the
25 different things you can look at to help you meet the

1 NAAQS and some of these that maybe we haven't looked at
2 that much in the past.

3 So I'm just going to give a really brief
4 background and then I'll jump right in to the list. So
5 this is sort of the three main categories of things
6 that we'll put into the model. We have all our source
7 parameters, which includes you know stack height,
8 emission rate, velocity, building height, building
9 location and that brings in downwash and all those
10 things. Then we have our MET data and I'll have wind
11 direction, wind speeds, low wind speeds, temperature
12 and then we have our receptors, ordinance on those,
13 terrain data, elevation receptors and all those come
14 together and that's how we get our model concentration.

15 So we're going to sort of walk through a
16 list of how these five different things and really have
17 some sub-categories of what in those original blocks we
18 can change.

19 So the first one is to re-characterize
20 ambient air as not being ambient air. Some of these
21 seem pretty obvious, you know, put up "No Trespassing"
22 signs. Put up a fence line so that you can count your
23 property line as your fence line. I know there's been
24 a little bit of discussion. I haven't seen this gone
25 too far about what happens if your worse-case receptor

1 is over open water and then one of the more unique ones
2 would be to actually look into purchasing land where
3 your maximum model concentrations are showing up if
4 that's nearby and then you can just fence it off or
5 maybe purchase the sort of clean air mineral rights to
6 that land and then you could just exclude those
7 receptors from your analysis.

8 Number 4 is to re-evaluate your MET data
9 or your monitoring data like we just saw if you just -
10 you have all this background data but maybe your
11 sources that you're modeling is actually contributing
12 to that and sort of take a look and try to pull out the
13 ones that are already being considered in your model.

14 We also looked at considering on-site
15 MET data, although that may cost you a million dollars.

16 Look at whether - you know, don't always
17 look at the closest airport. Just because it's five or
18 ten miles away doesn't mean it's the best MET data for
19 where your facility is. If you're in really complex
20 terrain and the airport is in a really flat area, then
21 that may not be very representative and sometimes you
22 have to look a little bit further away.

23 And then the last one would be to look
24 at pairing background concentrations and time,
25 especially for the 24-hour standard, but even with the

1 one-hour standards, your model concentration and your
2 monitoring concentrations are not always going to
3 overlap at the same time and you can really see huge
4 reductions in your you know modeled results.

5 Number three is to look at building
6 changes. For a green field facility, you can look at
7 rearranging the buildings before you actually build
8 them to see what is our downwash going to be and try to
9 minimize that as much as possible. You could also look
10 at just knocking down some buildings. If you're getting
11 a lot of downwash and you don't really need those
12 buildings, just get rid of them. And then one of the
13 more unique ones is actually look at increasing
14 building height because that will increase your
15 equation 1 GEP height and not necessarily adding a
16 whole story, but something like a parapet to the top of
17 your building could actually let you raise your stack a
18 little bit higher.

19 You can look at pursuing alternative
20 models or switches within the model. We heard a lot
21 about using CALPUFF for complex winds and we know that
22 justification for that is really difficult, but it's
23 something you definitely could pursue.

24 And then one that's not thought of a lot
25 is rethink rural versus urban coefficients. A lot of

1 times a state agency will just block out areas and say,
2 "If you're here, you need to model urban coefficients
3 with "X" population, but if you have really tall stacks
4 and they're sort of releasing above or the plume rise
5 is going above the urban boundary layer, then you may
6 want to rethink whether the urban or the rural
7 coefficients are really appropriate and that can get
8 really complicated since that urban boundary layer is
9 going to be changing by hour, so that can get really
10 detailed analysis, but that's just one more thing that
11 can sort of come into play and could help facilities
12 sort of show lower modeled concentrations.

13 And then the number one is to actually
14 look at - and this may sound crazy - but lowering stack
15 height. If you have really tall stacks that aren't
16 having a lot of downwash, they're having impacts really
17 far away from the facility, they're all going to be
18 heading probably the same area, so you know, each one
19 of your stacks are probably having three times the
20 impact since they're all hitting the same area. You
21 lower one or two of those stacks, their individual
22 concentrations might go up, but the overall impact to
23 your facility could go down by you know a factor of a
24 third - half to two-thirds, maybe less, depending on
25 how many stacks you have. Or you know the alternative

1 to just chopping off part of your stack, you could just
2 look at selectively adding control equipment to just a
3 few of the stacks or one of the stacks, such as like a
4 wet scrubber that's going to decrease the amount of
5 plume rise you get. That could have the same affect.
6 You'll have a lower emission rate, but you'll also have
7 lower flow rate, lower temperature, lower plume rise
8 and the plume should sort of separate and not really
9 hit that same area and that can sort of have the same
10 impact of really lowering your facilities total impact.

11 So just some conclusions: As we've seen, and
12 people have been saying time and time again, these new
13 standards are really tough. We'd love to see some
14 updates to Appendix W and some new models and some
15 changes to GEP equations in the model, but right now
16 this is what we have to work with and we need to also
17 look at just all these other inputs and see what else
18 can we change, what else can we sort of manipulate to
19 you know pass the model - to pass modeling, to pass
20 permit modeling with the models we currently have. A
21 lot of these alternatives aren't going to work, you
22 know, you can't always just increase your boundary.
23 Your property line - you can't always chop off a stack,
24 but some of these might and there's a lot more we
25 didn't include here. This was you know at first a list

1 of ten but I had to chop it down. And then just make
2 sure you apply any and all reasonable means and maybe
3 some unreasonable ones - try to make them reasonable.
4 So just a few acknowledgments: just some other people
5 in Trinity that helped develop this list and many more
6 that we didn't include.

7 Made it quick for you.

8 **MR. BRIDGERS:** Okay. Up next we have
9 Justin. I hope you - do you have a power point - okay.
10 That was the one presentation I didn't have so let me
11 just put up a stoic slide. So up next we have Justin
12 Walters with Southern Company.

13 **MR. WALTERS:** All right. Good afternoon.
14 I have the - I think the distinction of being the last?

15 **MR. BRIDGERS:** The last requested.

16 **MR. WALTERS:** My name is Justin Walters
17 and I'm speaking today as a representative of Southern
18 Company, a leading energy supplier in the Southeastern
19 United States. As a company that generates
20 electricity, Southern facilities are frequently the
21 subject of air quality modeling for regulatory
22 purposes: From PSD permitting to state implementation
23 plans to federal regulatory programs.

24 Over the years, we have witnessed an
25 increasing reliance by EPA on models. Models have

1 historically been used in the PSD world in a
2 deterministic manner, but were primarily used to
3 address standards that were well above background and
4 with long averaging times. Now, with short-term
5 standards that approach values that are closer to
6 background concentrations, the models require a level
7 of accuracy and precision beyond their current
8 capability. Surprisingly, models are increasingly
9 being given greater deference than ambient
10 measurements. Continuing to apply modes with existing
11 but outdated guidance is inappropriate. As an example,
12 EPA's September 22nd, 2011 draft guidance for one-hour
13 SO2 NAAQS SIP submissions requires that all major So2
14 sources demonstrate through modeling that they are not
15 causing or contributing to violations of the one-hour
16 NAAQS regardless of the presence of monitoring data
17 that may show attainment. For sources that cause or
18 contribute to model exceedances of the NAAQS, federally
19 enforceable emission limitations are required that when
20 modeled demonstrate attainment of the standard. Such a
21 prescriptive requirement for such a stringent one-hour
22 standards necessitates, among other things, the use of
23 an unbiased model.

24 AERMOD has not been thoroughly evaluated
25 for performance in simulating the maximum daily one-

1 hour concentration at the 99th percentile, nor has it
2 been evaluated for the 99th percentile in the case of
3 NO2.

4 Prescribing emission limits for such a
5 stringent standard from the results of an unproven
6 model could result in significant and unnecessary cost
7 and burdens on Southern Company, the state's in which
8 we operate and our customers.

9 Should EPA finalize and or codify its
10 modeling requirements for SIPS and middles for the one-
11 hour SO2 NAAQS, EPA should give states discretion to
12 use modeling and analysis tools to help demonstrate
13 situations where sources have a low probability of
14 violating the standard.

15 EPA's draft guidance requires that
16 sources model at their highest potential to omit for
17 all hours of the year. The vast majority of sources do
18 not operate at full load 24 hours a day, 365 days a
19 year. States should therefore have a discretion to
20 allow sources to demonstrate perhaps through
21 application of the emissions variability processor or
22 MVEP that you heard about on Wednesday: The less
23 restrictive emission limits will still achieve the
24 NAAQS.

25 Okay. Switching topics: Modifications

1 to preferred models such as AERMOD that are bug fixes
2 are welcome and we applaud that effort, but
3 modifications that result in changes to model
4 concentrations must go through notice and comment rule
5 making before being implemented in preferred models.
6 Appendix W states that, and I quote: "A preferred model
7 should be operated with the options listed in Appendix
8 A as recommendations for regulatory use. If other
9 options are exercised, the model is no longer
10 preferred. Any other modification to preferred model
11 that would result in a change in the concentration
12 estimates, likewise, alters its status as a preferred
13 model."

14 The guideline also states that: "For the
15 preferred AERMOD model, building wake affects are
16 simulated for stacks less than good engineering
17 practice height using methods contained in the PRIME
18 downwash algorithms, therefore, the recent change in
19 AERMOD noted in model change bulletin number four that
20 alters the prime downwash algorithms to apply to stacks
21 that are greater than or equal to the GEP formula
22 height relegates the model to non-preferred status."
23 Because as we have seen earlier today, this change has
24 been shown to cause significant increase in modeled
25 concentrations, therefore, this is not simply a bug

1 fix, but must be subject to notice and comment rule
2 making. Along that same line, EPA needs to evaluate
3 the performance of AERMOD with the AERMINUTE processor.

4 On Tuesday, during a presentation on the
5 CALPUFF model, Roger Brode made the argument that for
6 demonstrating the performance of CALPUFF for complex
7 winds, the CALMET processor is an integral part of the
8 CALPUFF modeling system, since that model is the source
9 of the complex wind fill input. Similarly then, for
10 evaluating the performance of AERMOD, EPA must consider
11 the entire AERMOD system, including AERMET, and since
12 EPA has now recommended its use, AERMINUTE. We have
13 seen evidence at this conference that AERMOD
14 significantly over-predicts at low wind speeds. The
15 use of AERMINUTE often leads to a significant increase
16 in the number of low wind speed hours modeled. EPA's
17 justification for implantation of AERMINUTE and AERMOD
18 is that it is more technically sound. However, the
19 scientifically or technically justified change to a
20 model component does not always lead to overall model
21 performance. EPA should avoid the appearance of a
22 double standard when it comes to model performance
23 evaluation.

24 If EPA considers that CALMET is an
25 integral part of CALPUFF and that the two must be

1 evaluated together, then it stands to reason that prior
2 to EPA recommending its use, AERMINUTE should be
3 included in a performance evaluation of AERMOD,
4 demonstrating that its conclusion leads to improved
5 model performance in a wide range of meteorological
6 conditions, particularly, the low wind speed and stable
7 conditions that are most affected by the AERMINUTE
8 processor. Once its evaluation is complete, the model
9 changes should be submitted for public notice and
10 comment.

11 Finally, EPA should wholeheartedly
12 engage not only at the regional, state and local
13 agencies, but also the private sector including
14 consultants and industry to achieve goals in improving
15 the performance of both preferred and alternative
16 models. We have heard a number of times, including at
17 this meeting, that the air quality modeling group is
18 understaffed and underfunded. You have willing
19 partners in the modeling community. Please work with
20 the modeling community in implementing model
21 improvements and updates.

22 During this conference, we have heard
23 several presenters discuss their efforts in desired
24 improved guidance, models and modeling tools, many with
25 similar frustrations, that their effort is mired in the

1 model of clearinghouse process. EPA should engage and
2 provide a clear path forward for approving tools and
3 model improvements that come from the modeling
4 community such as the tools and model improvements we
5 heard discussed during this conference. In fact,
6 evaluation of the performance of AERMOD in conjunction
7 with some of these tools could be incorporated into the
8 evaluation that EPA must conduct on the performance of
9 AERMOD with AERMINUTE.

10 I appreciate that opportunity to speak
11 today. Meetings of the modeling community and EPA such
12 as this one are increasingly important since there are
13 so many pending modeling and regulatory implementation
14 issues to address. We encourage EPA to engage the
15 modeling community on a more frequent basis.

16 Unfortunately, the private sector has not been invited
17 to participate in this year's regional, state and local
18 modelers workshop, however, we do look forward to being
19 included in such opportunities to engage EPA in the
20 future.

21 In conclusion, with standards becoming
22 so stringent and with an increasing reliance on models
23 in the regulatory process, we feel that it is
24 imperative that EPA assure that the performance of its
25 guideline models is unbiased and does not lead to gross

1 over-predictions that could force costly and
2 unnecessary actions to be taken. Second, if EPA
3 determines that modification to the model formulation
4 beyond bug fixes or modifications that cause changes in
5 model concentrations are warranted and necessary, EPA
6 must perform a model performance evaluation for those
7 modifications and submit it for public notice and
8 comment.

9 Finally, we encourage the air-quality
10 modeling group to be transparent and open and engage in
11 C-collaboration with the modeling community to leverage
12 resources and promote community model development.

13 Thank you.

14 **MR. BRIDGERS:** Well, thank you Justin for
15 your comments. I think that - do we want to take the
16 10-minute break or do we want to open it up? I mean
17 that's kind of up to us. If we want to take a 10-
18 minute break, just come back at 4:10 and we'll have
19 open mic for anybody else that wants to make public
20 comments and then we'll close the conference. So let's
21 take the break.

22 (WHEREUPON, a brief break was taken.)

23 **MR. BRIDGERS:** We've about finished our
24 break time. As everybody is taking their seat for this
25 last session, I'll offer as an opportunity for anyone

1 in the audience or others that have thoughts or
2 comments during the course of this conference to make
3 statements. Please understand that we do welcome all
4 comments to be submitted to the document, so you don't
5 have to speak today and I think Tyler had made the
6 comment earlier to someone that they're not officially
7 a part of the document until we submit - at least your
8 comments are not officially part of the document until
9 we submit the transcripts and probably what we'll do is
10 once we get the transcripts back from our contractor
11 here, as we review them and identify individuals that
12 spoke and gave comments or presented, we'll share those
13 with you so you can scan those too before we put them
14 in the docket. You know, you know what you said better
15 than we did. So at this time, the microphones are
16 open. Please identify yourself, whatever corporation
17 you're with and have at it.

18 **MR. LEBEIS:** Hi. I'm Mike Lebeis with DTE
19 Energy and actually I had a question earlier in the
20 conference related to intermittent sources and the
21 different categories of intermittent sources that you
22 know were suggested in the March 1st, 2011 memo. Well,
23 it turns out that one of our plants we had an issue
24 where the diesel generators got - like dragged along
25 with the one-hour NO2 standard came along and as an

1 interim measure, we had to agree to extremely high
2 stack heights on some diesel generators that average
3 operating maybe like five hours a year, typically.
4 With the March 1st guidance, we were able to go back
5 in, remodel them at an annual average emission rate and
6 actually it turns out that I had to come down here for
7 the permit to get issued, so it's interesting how when
8 you finally leave town, that's when everything gets
9 finalized and so I actually got the good news on
10 Tuesday that the permit did get finalized after going
11 through a 30-day public comment period, also some
12 response to comments and things like that, but those
13 things were resolved and the permit was issued on
14 Tuesday. So there is hope for intermittent sources out
15 there.

16 **MR. BRIDGERS:** Thank you.

17 **MR. SCHEWE:** George Schewe, Trinity. How
18 long will the interim SO2 and NO2 seals be interim?

19 **MR. FOX:** This is Tyler Fox, OAQPS. I
20 just want to be clear, this isn't a question and answer
21 period. This is a public comment period, so you can
22 submit comments, but we're not answering questions.

23 **MR. SCHEWE:** Okay. We'll play Jeopardy.
24 We would like to comment that we're concerned about how
25 long the interim seals may be interim. Thank you.

1 **MR. BRIDGERS:** Thank you for the comment.
2 Going once, going twice. Do you want to just check one
3 more time?

4 **MR. FOX:** Yeah, I'll make one more
5 request that the microphone is open for anyone that
6 does want to make a comment to be submitted to the
7 docket when the transcripts are submitted. And if not,
8 like I said earlier, please feel free to make written
9 comments to the docket. Do you want to say anything in
10 closing?

11 **MR. BRIDGERS:** I just want to thank
12 everybody for their active participation and have safe
13 travels back to where you're going and we appreciate
14 everything and we'll be following up with, as George
15 said, any follow up on the transcript itself and expect
16 that you'll hear back from us in terms of any response
17 related to this conference and we appreciate all the
18 input and again, we'll be in contact soon.

19 And I officially close this public
20 hearing.

21 (WHEREUPON, the hearing was concluded.)

22

23

24

25

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

CAPTION

The foregoing matter was taken on the date, and at the time and place set out on the Title page hereof.

It was requested that the matter be taken by the reporter and that the same be reduced to typewritten form.

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15
- 16
- 17
- 18
- 19
- 20
- 21
- 22
- 23
- 24
- 25

<hr/> \$ <hr/>	10-percent 217:2	1700 166:18
\$100,000 170:21	10-story 166:7	180 107:15
\$100-million 167:19	10th 4:2 9:17 11:5 11:11 12:2	1800 134:15
\$300-million 167:19	10-to-1 153:16	1920 163:5 164:14
<hr/> 0 <hr/>	10-year 211:10	196 163:24 164:12
01 50:2 50:9	11 206:15 220:2 220:4 220:6	1964 112:5
09292 175:24	110 181:11 181:13	1971 80:4
<hr/> 1 <hr/>	11059 15:21 112:22 176:5	1975 112:4
1 29:11 45:25	11103 176:5 178:5	1976 20:17
97:24 185:25	11325 112:22	1982 80:9
195:5 195:23	1159 112:21	1985 20:14 105:22
196:4 196:21	118 73:3	1986 85:18
213:3 225:15	11th 6:8	1989 22:8
1.3 130:17	12 219:19 221:12 222:8	1990s 199:10
1.8 31:6	12:40 162:17	1991 210:14
10 107:15	1210 166:9	1992 133:21
156:24 160:15	14 165:9 198:19 206:14 209:9 218:8	1993 133:22
174:20 180:21	140 128:1	1994 163:5
206:6 206:18	144 112:25 178:2	1995 134:16 136:10 153:1
207:18 209:21	15 4:3 44:22 216:25 217:1 220:10 220:18 221:25 222:2	1998 199:11
215:25 216:8	1500 134:17 166:10	1999 44:14
221:25 235:17	15-degree 216:12	1-hour 23:24 25:13 74:5 75:4 81:1 102:8 107:6 125:5
10:40 76:21	16 55:18	1-minute 157:5
100 60:1 72:22	168 29:6	1st 236:22 237:4
73:2 73:2	17 44:17 44:18 44:18 161:5 161:11	<hr/> 2 <hr/>
74:24 177:4		2 75:12 130:4
182:13		130:5 130:6
1000 182:21 206:8		130:10 130:11
100-meter 173:11		130:19 136:20
100-percent 213:7		137:4 137:5
100th 219:24 221:4		137:13 137:15
108 73:3		137:22 161:7
10-degrees 211:3		
10-minute 156:24 235:16		

161:10 211:4 212:21 2,000 29:9 2.1 31:16 43:23 47:11 2.5 59:20 68:5 68:12 68:22 147:16 20 31:3 31:4 64:13 193:10 221:25 200 10:6 71:8 138:10 173:8 2000 210:2 213:9 2000s 200:2 201:10 201:18 2002 211:14 2005 54:12 98:18 194:14 2007 85:17 2008 54:24 103:19 214:14 2009 193:11 193:20 194:14 217:21 200-some 153:20 2010 29:24 55:3 55:8 55:11 175:9 214:14 215:21 220:25 2011 11:15 14:11 29:24 55:18 176:7 229:12 236:22 2012 4:3 2013 164:7 2014 6:10 164:10 20-minute 218:22 20-percent 213:6	22 14:10 220 18:16 225 129:19 22nd 229:12 24 222:10 230:18 24-hour 224:25 25 20:5 219:23 2500 164:17 26 206:11 208:20 2600 134:13 280 72:23 2-kilometer 161:10 2nd 94:10 <hr/> 3 3 54:11 186:3 197:1 209:10 211:1 3,600 38:16 3.2 26:14 3.4 48:25 3:45 52:10 30 127:21 157:19 180:8 207:8 207:13 212:7 216:19 220:19 221:4 221:17 222:2 300 29:8 29:12 29:13 30-day 237:11 30-percent 209:1 30th 5:23 6:3 32.6 221:5 3280 112:25 35 50:10 128:1	35-percent 130:10 36 30:1 32:23 365 230:18 372 71:23 39 185:23 <hr/> 4 4 11:15 16:11 54:11 211:22 211:24 220:6 221:19 224:8 4.4 17:12 4.6 200:8 221:4 4.7.1 200:21 201:1 4.7.X 200:14 4:10 235:18 40 16:5 19:17 19:19 20:10 21:23 26:18 163:20 178:12 400-some 153:20 42 175:22 175:23 176:9 178:1 178:5 438,000 193:12 45 153:21 4-year 160:22 160:25 <hr/> 5 5 75:13 164:18 196:6 220:11 5.0 44:16 200:23 201:3 5.8 51:15 51:19 54:9 54:13 55:13 55:23 201:6 5.8's 55:2
--	---	--

<p>50 22:4 25:16 64:8 64:9 64:23 74:3 157:12 173:11 182:13</p> <p>500 160:19 166:19</p> <p>50-percent 181:23 182:3 182:3 209:2</p> <p>53 45:25</p> <p>5th 15:1</p> <hr/> <p style="text-align: center;">6</p> <hr/> <p>6 43:21 220:24 220:24 221:1</p> <p>6,000 164:18</p> <p>6.4 12:13 43:21 55:8 55:13 55:23 56:6 190:22 191:7 191:22 192:6</p> <p>6.42 51:1</p> <p>6.42b 43:12 43:20 43:22 44:4 51:15 56:22 57:8</p> <p>60 59:23 207:24 211:4 212:20</p> <p>60-percent 130:9</p> <p>63 50:7</p> <p>65 175:22 176:10 176:14 176:16 178:15 179:2 221:10</p> <p>65-percent 167:25 168:2</p> <p>66 214:14 218:8 220:1</p> <hr/> <p style="text-align: center;">7</p> <hr/> <p>7 30:15 220:25</p>	<p>7,000 164:15</p> <p>70 127:22</p> <p>700 44:18</p> <p>75 163:24 218:10 218:12</p> <p>76 44:18</p> <p>777 71:22</p> <p>78 216:1</p> <p>79 217:23</p> <hr/> <p style="text-align: center;">8</p> <hr/> <p>8 21:24</p> <p>8.8 192:19</p> <p>800 156:25</p> <p>80-percent 159:9 161:21</p> <p>80s 166:20</p> <p>82.2 221:5</p> <p>85 22:3 27:13 219:21 219:23</p> <p>8760 216:10</p> <hr/> <p style="text-align: center;">9</p> <hr/> <p>9:45 52:4</p> <p>9:55 52:4</p> <p>900 71:7</p> <p>90s 53:19</p> <p>91 194:13 194:20</p> <p>93 193:20</p> <p>95 194:13 194:20 216:1</p> <p>96 119:9</p> <p>99 50:2 158:6 158:19 159:9 159:23</p> <p>99-percent 162:20 162:21</p>	<p>99-percentile 158:21 159:9 218:7</p> <p>99th 219:25 220:9 220:22 221:2 230:1 230:2</p> <p>9th 54:24 171:6</p> <hr/> <p style="text-align: center;">A</p> <hr/> <p>AA 8:20</p> <p>AB-3 9:12 9:15 9:17 9:22 9:23 10:4 10:14 10:25 11:1 11:13 13:15 13:20 14:17 14:25 28:16 42:11 52:3</p> <p>Abhishek 112:19</p> <p>ability 42:16 180:23 200:17 204:7</p> <p>able 6:19 11:21 13:21 26:25 32:7 52:20 79:12 107:13 147:15 177:8 177:22 179:3 179:10 179:18 202:20 219:12 221:6 221:20 237:4</p> <p>absolute 69:3</p> <p>absolutely 129:20</p> <p>absurd 38:1</p> <p>accept 69:25 212:23</p> <p>acceptable 72:21</p> <p>acceptance 67:2 206:24 207:2 207:4 207:6 209:13</p> <p>accepted 51:14</p>
--	---	--

accepts 141:7	54:13	77:25 80:3 80:16
access 42:7 42:13	acknowledgments	83:18 91:7
accidental 29:1	228:4	92:5 92:5
accidents 29:3	acronym 77:12	92:24 93:7 98:22
accommodate 15:7	200:6	107:13 107:20
accommodating	across 19:18	114:17 114:19
53:3	114:8 114:17	116:23 117:1
according	114:18 116:6	119:20 120:4
105:22 123:14	165:23 169:25	121:19 122:24
account 37:16	act 29:23 31:1	124:17 126:1
62:11 63:2 74:13	140:14 141:3	133:10 135:24
101:7 117:22	142:7 143:9	136:18 138:14
137:6 141:18	143:15	139:23 141:13
145:15 196:18	action 144:23	160:24 161:8
202:13 204:16	144:24	162:2 162:3
accounted 63:6	actions 175:8	167:13 172:8
141:16 196:17	235:2	172:13 173:21
accounting 75:8	active 10:6	184:16 192:13
104:21	238:12	215:7 224:2
accounts 93:4	acts 109:19	224:11 225:7
104:20	actual 18:13	225:13 225:17
accuracy 60:2	23:11 45:20	226:13 236:19
127:24 130:18	54:17 60:3 63:20	237:6 237:9
229:7	64:20 67:12 93:5	adapted 44:2
accurate 57:8	93:9 93:17 93:23	adapting 142:23
86:23 121:1	94:6 107:2	add 5:25 32:24
127:17 130:12	110:13 131:4	78:23 91:6 95:14
140:11 140:15	134:6 134:9	107:11 120:13
172:20 172:24	134:10 141:10	178:12 182:2
accurately	141:12 153:18	added 115:3 115:5
97:25 134:22	154:25 157:1	142:21 152:25
155:18	178:10 181:10	200:15 200:17
achieve 39:17	182:23 189:20	adding 73:7 82:24
230:23 233:14	189:21 190:2	105:12 120:6
acid 44:21 48:9	193:11	225:15 227:2
193:1	actually 4:25 9:9	addition 147:11
acknowledge 15:18	10:14 11:12	152:7 179:22
70:11 97:4	11:21 12:10 15:2	198:7
203:16 213:24	28:23 28:24	additional 8:8
acknowledged	35:22 38:7	51:16 56:5 69:17
	38:9 39:3 42:9	70:17 140:24
	43:13 49:3 52:23	145:2 176:23
	60:17 61:25	178:12 178:23

217:6	103:2	194:24 232:3
address 7:3 13:13	advocating 151:2	232:12 232:15
39:23 76:8 121:9	AECOM 76:25	232:17 233:2
126:6 126:6	144:22 151:14	233:7 234:9
131:6 132:4	156:22 172:6	AERMINUTE-
144:18 145:7	AEMOD 174:3	generated 113:20
145:12 148:2	AER 43:14 44:2	AERMINUTEPLUS
150:16 152:10	86:12	77:5 77:7
156:8 175:25	aerial 121:23	78:14 79:5
229:3 234:14	AERLINE 152:3	AERMINUTES 77:10
addressed 125:16	AERMET 12:18	AERMOD 12:5 12:16
addressing 9:1	105:13 112:15	15:17 15:21 25:7
11:18 144:21	112:15 112:23	25:17 25:22
145:19	114:2 116:2	26:18 26:24 27:4
adds 101:6 104:17	119:15 121:6	57:2 60:15 60:16
adequate 41:24	122:2 122:8	62:7 65:3 70:7
99:14	122:15 142:21	77:11 78:1
adjustment 102:3	142:25 142:25	79:1 79:5
adjustments	196:22 232:11	79:13 80:22
39:2 126:10	AERMET's 112:22	81:14 82:7 82:25
Administrator	AERMIC 102:18	84:6 84:14 84:22
8:12	AERMINUTE 12:18	90:14 91:3 95:18
administrators	85:17 86:13	96:4 97:11 98:10
77:4	112:11 112:15	98:20 101:20
adopt 53:7	112:21 113:2	101:21 102:2
adopted 51:19	113:24 114:11	102:18 102:20
67:8	114:12 116:1	104:18 104:20
adopting 142:23	116:3 116:4	104:24 105:2
advanced 54:20	116:20 118:13	105:3 105:22
101:20 200:5	118:17 118:19	106:4 106:23
advancing 147:3	119:8 119:24	107:1 107:11
advantage	120:1 122:3	107:25 108:5
101:20 102:1	122:4 122:12	109:2 109:4
126:16 148:1	122:16 122:20	109:10 109:12
202:20	123:16 123:21	109:12 109:13
adversarial	123:25 124:7	109:15 110:1
149:12	125:1 125:3	110:13 110:24
advice 168:18	125:6 125:7	111:3 111:8
advisor, Akula	125:11 151:18	111:9 111:19
	178:10 185:22	111:25 115:2
	186:9 186:14	115:2 118:2
	194:6 194:14	120:4 126:11
	194:18 194:23	126:15 126:23
		128:5 129:16
		129:19 130:4

130:24 133:2 133:18 136:13 138:4 142:21 143:5 144:14 144:18 144:21 145:2 146:3 150:16 150:25 153:4 156:10 156:10 156:14 158:9 159:14 167:9 168:16 169:12 172:25 173:3 177:1 177:5 177:8 177:12 177:23 178:2 183:20 187:8 187:15 187:23 188:2 190:15 193:7 193:11 194:10 196:25 197:4 197:15 197:17 200:16 205:13 229:24 231:1 231:15 231:19 232:3 232:10 232:11 232:13 232:17 233:3 234:6 234:9 AERMODs 129:25 AERMOD's 79:10 84:18 106:7 108:3 109:8 145:21 173:14 AERMODS 172:21 172:24 aerosol 43:23 44:10 45:6 45:7 192:2 200:10 200:15 200:16 AF&PA 67:19 68:3 affect 114:23 114:25 117:21	118:1 124:13 143:21 157:24 159:11 227:5 affected 13:17 13:21 14:9 23:9 57:21 80:1 111:15 111:21 113:19 118:20 159:2 233:7 affecting 107:5 affects 118:5 118:24 156:10 231:15 afford 169:15 afternoon 5:21 6:15 8:11 66:12 127:9 162:19 174:23 180:12 180:15 180:16 204:25 213:20 228:13 afterwards 8:18 AGA 61:7 110:25 129:15 130:8 138:4 against 28:10 141:20 156:19 aged 165:9 agencies 62:10 147:7 203:11 233:13 agency 4:1 112:4 142:3 142:14 143:25 145:11 145:12 145:14 146:6 148:2 176:4 176:6 206:4 209:20 226:1 agenda 8:15 9:21 12:2 106:18	agents 206:16 210:16 agile 147:19 agnostic 211:22 ago 7:25 11:12 15:20 16:10 45:21 53:9 55:18 55:25 77:9 78:1 78:13 98:23 108:14 130:21 154:14 198:15 206:1 agreement 18:10 50:6 65:3 110:4 146:9 208:9 208:13 213:9 ahead 7:24 9:11 76:20 147:14 150:11 152:20 174:20 177:7 178:7 180:7 214:17 aid 5:3 air 4:2 9:15 23:2 44:20 44:23 54:22 55:4 59:8 85:21 85:24 86:9 87:7 99:2 100:10 113:1 117:10 118:11 119:7 140:4 140:9 140:14 141:3 142:7 143:8 143:15 147:21 150:20 156:17 188:11 199:25 207:15 213:21 223:20 223:20 224:5 228:21 233:17 aircraft 48:2 airport 63:19
--	---	--

63:23 105:12 105:13 164:5 165:24 165:24 165:25 166:2 166:5 166:10 167:11 168:16 168:21 174:9 198:3 214:13 224:17 224:20 air-quality 127:18 141:19 235:9 akin 220:23 Alan 20:14 22:7 Alaska 18:7 135:9 135:11 ALBO 129:6 132:15 133:17 136:11 Alcoa 25:4 algorithm 17:9 98:13 98:16 99:17 99:17 102:13 102:20 154:2 170:6 algorithms 26:11 51:11 152:25 153:7 153:10 154:10 155:6 231:18 231:20 aligned 99:5 alive 172:15 Allen 97:2 97:3 106:25 108:1 alleviate 186:13 allow 13:16 26:13 54:15 64:11 65:17 78:19 143:14 146:23 147:7 177:5 177:7 204:5	221:17 230:20 allowable 64:19 69:23 72:4 allowed 36:17 51:22 65:18 131:1 173:4 177:15 allowing 17:22 allows 72:6 alluded 68:11 ALM 46:10 46:15 47:22 alone 46:23 already 5:19 11:7 12:3 15:6 17:14 60:5 60:17 61:2 74:5 106:25 118:15 125:15 163:14 170:20 171:20 181:2 182:2 182:13 203:20 224:13 altered 163:21 alternative 26:13 106:21 108:1 131:6 198:5 225:19 226:25 233:15 alternatives 51:8 162:7 227:21 alters 143:24 231:12 231:20 aluminum 25:11 97:16 98:23 107:18 175:1 alumni 162:14 am 102:25 140:2 162:21 162:23 162:24 171:18 175:5 198:16	202:1 204:9 ambient 60:7 99:2 100:10 187:22 193:7 223:20 223:20 229:9 amendable 172:13 amendment 175:20 176:2 176:6 American 54:25 58:5 68:2 97:6 110:25 111:16 128:17 213:23 ammonia 45:5 45:7 45:17 45:19 46:6 46:7 46:19 46:21 46:24 47:4 47:13 47:14 47:18 128:11 Amoco 133:20 among 208:13 229:22 amongst 114:24 222:4 amount 4:6 8:24 26:9 33:22 48:9 54:14 94:17 131:10 138:8 208:10 227:4 amounts 140:18 211:7 analyses 16:22 26:6 46:5 71:16 analysis 18:13 41:16 85:19 128:6 131:2 131:9 131:18 134:21 138:23 155:2 177:24 181:18 189:2 189:3 191:10 191:14 191:23
---	---	---

192:15 194:4 197:3 217:7 217:18 220:6 221:19 224:7 226:10 230:12 analyst 177:15 analyze 43:3 analyzed 29:22 34:10 analyzing 33:7 Anand 180:17 and/or 10:9 Anderson 213:25 Andy 52:9 52:15 52:16 anecdote 187:11 anemometer 36:11 36:23 120:18 120:24 anemometers 60:19 Angie 113:8 angle 22:18 22:25 23:15 24:22 221:16 announce 5:11 14:24 annual 10:19 25:21 25:23 158:19 159:9 167:2 237:5 anomalous 94:25 ANSEP 211:22 answer 70:12 126:20 127:19 139:4 167:11 183:1 237:20 answering 237:22 answers 4:16 39:12 151:25	antidotes 181:6 Antonio 118:12 anybody 151:1 168:23 174:10 235:19 anymore 73:18 anyone 235:25 238:5 anything 88:14 115:5 116:18 119:13 153:4 164:7 170:22 179:10 217:22 219:2 238:9 anyway 23:4 93:10 121:1 122:1 124:22 128:8 anywhere 122:11 128:13 130:13 AOA 91:6 A-physical 131:2 131:6 API 43:14 55:1 55:3 55:19 56:1 57:16 57:19 57:20 59:23 60:5 60:9 60:23 66:19 67:16 124:11 Apollo 129:6 129:10 apparently 143:1 143:11 143:14 appearance 232:21 appeared 149:11 appears 47:23 61:13 65:10 66:1 143:18 196:20 appendix 174:7 188:16 204:8	227:14 231:6 231:7 applaud 65:11 231:2 applicability 85:9 90:12 applicable 68:20 83:12 84:5 108:22 153:13 196:1 applicants 13:17 13:20 application 29:15 32:17 53:10 108:14 155:1 197:8 230:21 applications 29:11 29:16 47:11 51:20 51:24 97:24 98:5 108:16 180:25 190:17 190:24 191:13 197:9 applied 74:25 143:25 185:1 207:25 209:5 apply 10:16 69:7 75:5 101:16 102:7 185:11 204:3 207:2 228:2 229:10 231:20 applying 17:13 appreciate 6:24 9:7 67:25 76:5 76:10 234:10 238:13 238:17 appreciates 148:5 approach 57:1 60:25 75:6 79:10 83:3 98:12 107:1 107:3 107:7
--	--	---

108:4 108:12	201:2 201:3	226:15 227:21
108:18 109:24	201:12 201:16	argument 135:20
110:4 110:6	201:19	232:5
110:10 110:10	AQRB 131:17	arm 139:18
152:11 152:19	AQRM 127:14	ARM2 67:7
156:15 160:3	AQRV 131:8	army 210:15
162:7 163:13	arbitrary 64:10	arranged 31:14
169:14 183:8	64:12	103:22
188:15 206:3	arc 80:13 81:13	arrive 131:4
229:5	97:15 206:19	artifact 194:23
approaches	archived 119:23	Ashley 113:9
54:23 98:11	arcs 80:13 82:6	174:21 174:24
140:12 147:19	209:10	180:6
152:12 179:20	area 28:22	ASOS 120:2 151:17
210:3	34:17 34:23	210:11
appropriate 15:10	44:20 45:1 45:20	aspect 153:16
51:22 59:10	48:8 63:24	211:21
90:12 139:14	64:2 66:21	assembled 10:24
146:22 146:24	109:19 109:21	53:20
204:2 204:4	111:21 115:14	assemblers 103:21
207:1 215:3	115:15 116:16	assess 54:1
226:7	116:18 116:21	assessment
appropriately	116:22 117:17	12:14 28:19
141:24	154:11 164:18	assessments 47:21
approval 13:19	166:22 170:1	65:6 107:6
151:12	178:20 187:14	146:11
approvals 75:23	189:16 192:14	assign 207:1
approve 47:9	193:18 196:16	assigned 31:6
56:10	214:8 214:16	assistance 127:15
approved 142:3	215:4 215:9	199:19
203:8	220:13 224:20	Assistant 8:11
approving 234:2	226:18 226:20	assisting
approximately	227:9	113:10 180:22
11:16 208:9	areas 12:22	Associate 53:20
approximation	32:6 36:5	associated
212:10	44:19 95:25	32:22 84:1
April 5:23 6:3	183:6 183:14	94:3 97:14 97:19
55:3	183:16 189:11	100:17 106:5
APT 200:1 200:6	196:2 211:6	
200:6 200:7	226:1	
200:13 200:21	aren't 27:1 65:13	
200:22 201:1	69:13 73:18	
	179:10 209:10	

132:14 187:18	attention 70:8	173:21 182:9
Associates	75:19 76:12	188:16 188:22
43:17 52:23 53:6	189:5	194:15 216:7
53:7 53:14 53:17	attribute	216:15 219:21
55:20 56:1 56:13	215:11 216:14	221:1 221:16
117:16 146:14	216:20	237:2 237:5
association 52:18	Aubrey 113:9	averaged 114:18
53:15 56:9	audience 4:21	158:5
68:2 111:1	58:8 236:1	averages 78:15
117:10 118:12	augment 107:11	78:15 78:16 79:8
119:7 124:12	augmented 77:9	80:23 81:16
128:17	August 11:15	113:3 167:2
Associations	12:21 29:24	averaging 38:1
155:22	175:9 176:7	116:6 116:8
assume 63:23	auspice 28:16	116:15 117:8
83:22 205:18	authority 13:18	173:23 222:6
assumed 44:7	142:9 156:5	222:7 229:4
94:19	authority's 13:22	avoid 16:8
assumes 130:25	auto 149:17	21:16 63:22
assuming 61:17	auxiliary 181:19	79:19 96:22
87:8 87:12	availability 12:6	110:12 155:19
assumption 62:3	12:7	202:2 232:21
64:7 162:5	available 13:6	AW 94:11
assumptions 75:5	13:9 47:7 65:6	awaited 179:23
assure 147:11	76:2 113:4	aware 8:21
234:24	134:21 137:24	17:15 152:24
Atlanta 62:18	147:16 156:19	away 23:21
atmosphere 64:1	168:15 190:17	24:18 29:10
204:7 211:8	194:2 197:25	71:24 94:16
atmospheric 54:21	199:17 201:2	94:24 95:18
210:2	201:4 201:7	110:11 113:25
attainment 183:14	202:17 203:1	114:4 114:13
229:17 229:20	203:13 204:17	134:25 155:4
attempt 39:17	221:19	166:1 176:3
attend 5:17	avarice 123:8	198:3 207:18
10:8 52:20	average 38:2 38:2	224:18 224:22
attendance 9:7	61:25 81:1 81:20	226:17
55:14	82:14 105:8	AWIG 70:7 70:14
Attendee 9:19	114:8 114:16	73:12 74:20 75:2
	114:18 158:20	76:5
	159:8 161:20	AWMA 9:12 10:5
		10:10 45:21 52:3

axis 19:12 19:15	barely 208:5	102:3 102:5
<hr/>	barriers 155:20	145:1 234:15
<hr/> B <hr/>	BART 51:20	batter 98:7
back-ably 51:15	53:11 54:12	batteries 97:20
back-calculate	56:23	100:3 100:7
101:13	bartering 52:8	100:15
backdrop 139:24	base 71:5 71:23	battery 98:7
backed 73:21	71:24 91:19	100:19 100:21
background 45:7	92:12 92:17	100:22
66:18 73:1	based 18:13 20:15	bay 191:11 191:12
73:6 73:8 127:21	44:10 45:17	191:15 191:18
128:10 132:16	51:10 64:11	192:13
141:15 141:17	70:13 72:20	Bays 165:22
157:15 158:3	73:17 101:23	beam 83:23
172:11 178:3	102:5 120:20	83:23 83:24
181:20 182:2	133:3 134:14	171:11
182:3 182:4	134:16 156:16	bear 198:16
183:9 188:13	181:11 183:16	beat 211:9
188:17 188:20	191:22 195:16	beautiful 164:25
188:23 188:24	196:14 197:1	beautifully 6:9
189:13 214:4	199:11 200:8	become 76:1
214:10 214:15	200:9 200:12	76:3 147:18
219:17 223:4	200:21 203:7	201:4 203:1
224:10 224:24	212:10 216:15	becomes 6:1 23:15
229:3 229:6	218:1	64:12 116:16
back-to-back	bases 94:18	219:23
106:19	basic 10:14 97:16	becoming 234:21
backup 130:19	167:20 202:14	beginning 15:5
backward 55:22	202:16 205:10	32:19 33:9 33:14
bad 30:11 30:14	basically 12:12	184:22
50:10 82:10	16:11 16:12	behalf 52:23 53:5
166:15 212:25	27:12 30:6 34:21	57:15 57:19
badly 48:17	34:25 39:8 86:12	67:19 68:2
baghouse 101:2	108:25 115:20	97:5 127:10
baghouses 97:18	117:5 119:8	132:12 137:23
Baltimore 191:3	119:16 120:14	140:3 148:15
193:8 194:5	120:19 120:22	180:12 180:20
196:2 196:16	120:23 121:3	behavior 25:22
196:21 197:3	122:7 122:19	185:4
bank 159:25	125:5 132:20	behaviors 155:4
bar 81:13	134:24 137:18	
	137:21 155:3	
	basis 47:10 56:24	

behind 61:20 187:3	best-available 56:16	Bill 20:14
behold 93:11 95:15	better 8:3 11:22 32:8 33:24 35:12 35:16 36:6 36:8 36:9 36:10 36:25 36:25 37:8 39:25 42:1 42:2 42:24 45:19 46:12 46:15 46:17 46:23 46:23 48:11 48:19 51:7 51:14 61:2 68:24 73:23 82:4 82:15 84:21 93:17 93:22 96:20 116:21 116:25 117:1 117:3 131:14 131:24 131:25 133:9 144:25 151:25 165:6 166:14 179:24 186:10 186:16 187:19 187:25 188:4 188:19 189:12 189:12 196:20 214:10 220:20 236:14	billing 110:18 billion 127:22 127:22 128:1 160:19 214:14 216:8 221:1 bin 79:7 219:15 binary 32:9 177:11 177:11 177:16 Bingham 153:23 biomass 72:10 bios 137:5 bio-variation 155:2 Biswanath 203:18 204:13 Biswantath 203:20 bit 4:5 4:12 4:15 5:1 6:11 9:11 10:1 12:6 18:22 23:5 23:9 30:2 33:25 36:22 37:10 44:13 46:17 47:5 48:25 49:1 50:15 52:9 59:12 61:9 62:1 65:16 67:1 71:14 82:9 82:13 93:8 93:22 106:23 110:3 116:12 124:6 126:21 134:18 170:16 170:17 172:4 182:20 184:9 185:19 186:2 186:7 188:25 191:24 192:8 193:5 199:4 202:1
belabor 151:7		
believe 11:3 11:25 13:6 13:18 14:12 20:21 37:3 95:18 95:24 144:12 149:3 149:6 149:13 155:16 159:1 162:19 164:9 170:4 170:5 170:8 192:18 217:23 221:11		
believed 34:13		
believes 14:17		
believing 220:11		
benchmark 141:19		
beneficial 155:20 159:22		
benefit 42:15 42:18 90:3 147:25		
benefits 159:18		
Bennett 11:2 148:13 148:14	beyond 29:8 57:4 64:13 85:8 87:2 88:22 89:21 90:6 160:14 229:7 235:4	
Berger 52:15 52:16	Bhat 112:20	
Berger's 52:9	bias 81:9 211:2 213:4	
beside 171:15	bigger 151:4 153:25 165:16 165:21 192:12	
besides 107:14	biggest 128:19 167:21	
best 10:15 10:16 28:5 30:12 41:18 47:7 58:18 81:3 85:1 124:14 131:14 139:21 147:23 204:21 208:8 224:18		

215:8 220:3	76:25 77:1 83:10	boxes 134:2
220:7 222:22	91:5 96:25	BP 127:10 127:13
223:24 224:22	106:21 112:1	BPIPPRIME 24:5
225:18	117:9 126:11	BPIPPRM 17:17
black 62:24 62:24	151:13 156:16	23:16
129:18 215:13	163:14 167:10	branch 32:1 34:20
bleak 68:23	168:19 169:13	36:21 200:2
Blewitt 127:14	170:3 170:18	200:14
BLM 131:16	172:6 174:6	branched 199:24
blob 35:6	174:13 174:17	branching 201:21
block 218:1	177:3 186:3	break 67:19 67:22
218:16 219:19	Bob's 106:19	76:20 117:13
221:21 226:1	body 210:21	127:2 155:3
blocks 151:4	boiler 68:14	174:21 180:7
195:8 223:17	123:9 181:20	180:10 205:8
Bloom 45:20	182:19	213:16 235:16
blow 114:1	boiler/process	235:18 235:21
blowing 80:8	181:19	235:22 235:24
210:15	boilers 165:10	breeze 103:1
blows 169:24	boilers/process	106:11 177:15
169:25 170:6	182:6	Bridgers 4:4 5:12
BLP 25:7 25:15	books 127:1	9:8 28:14 52:1
25:25 26:1 26:11	boom 171:11	57:13 67:17
26:11 98:14	Boot 206:19 209:6	76:17 76:23
98:16 98:22 99:9	boots 207:4	96:25 102:22
99:11 99:17	BOP 177:10	106:17 112:1
101:22 102:6	bore 155:2	117:12 126:25
102:17 107:8	bottom 45:22	127:5 132:6
107:14 107:23	63:12 66:15	139:20 148:8
108:2 108:6	116:2 160:4	156:1 162:9
109:11 110:12	184:13 208:7	171:22 171:25
177:12 177:22	208:15	174:6 174:15
178:3 179:19	boundary 103:7	174:18 180:6
blue 36:11	103:9 103:9	180:11 198:10
81:14 88:15 89:9	185:3 209:22	204:21 213:15
162:15 162:16	210:4 210:19	222:14 222:18
178:18	211:1 226:5	228:8 228:15
board 168:7	226:8 227:22	235:14 235:23
189:25	Bowline 18:3	237:16 238:1
Bob 58:4 60:8	box 29:13 111:19	238:11
61:1 61:23 64:20		BRIDGES 190:8
		brief 76:22

97:7 175:5 223:3 235:22 briefly 74:19 99:16 181:4 184:6 185:16 210:10 bright 123:17 bring 16:5 22:23 24:1 126:1 brings 26:15 77:7 223:9 Britter 20:16 21:5 22:1 27:12 broad 10:10 63:3 190:14 222:24 broader 41:19 145:6 184:14 190:4 193:19 194:19 broadly 190:21 196:19 Brode 174:13 232:5 broke 60:12 broken 130:3 brought 12:2 13:12 45:11 59:16 106:24 185:11 browns 88:19 Bruce 58:4 buck 100:13 budget 79:23 budgets 7:5 bug 49:16 231:1 231:25 235:4 build 140:9 225:7 building 12:5	12:16 15:17 17:13 18:16 19:5 19:14 19:14 19:15 19:16 19:21 20:4 20:6 20:6 20:19 20:21 21:2 21:10 21:20 22:3 22:5 22:6 22:17 22:25 23:3 23:12 23:13 23:17 23:18 23:24 24:1 24:6 24:6 24:8 24:22 26:19 27:25 28:2 28:6 61:20 62:14 79:19 96:13 96:16 96:17 99:10 104:21 105:7 105:10 105:11 110:19 121:25 169:21 170:7 178:18 178:19 179:7 179:21 223:8 223:8 225:5 225:14 225:17 231:15 buildings 15:23 16:1 17:9 17:16 17:22 17:23 18:9 19:8 19:9 20:7 26:3 26:4 27:2 62:9 63:5 103:10 103:12 107:17 107:20 107:23 108:6 166:7 225:7 225:10 225:12 built 110:12 bulb 174:10 Bull 78:7 78:10	80:8 80:13 82:5 bullet 64:5 65:5 107:9 120:9 209:5 bulletin 16:11 17:1 142:22 231:19 bump 95:16 96:22 bunch 41:1 129:17 bundle 27:24 bungalow 105:21 buoyancies 107:18 108:9 buoyancy 97:14 97:19 99:23 99:24 100:5 100:8 101:6 101:24 103:4 108:10 109:18 110:2 187:20 buoyant 18:15 85:2 97:9 98:11 98:13 98:24 102:13 102:15 103:21 106:22 107:1 107:7 108:20 110:17 111:23 150:21 152:5 152:10 152:14 152:17 176:24 burdens 230:7 burned 73:18 215:19 215:21 burns 72:10 business 106:15 busy 19:11 59:2 button 115:23 185:9 BWI 194:5 194:13
--	--	--

bypass 39:24 93:20 94:4	12:12 25:8 25:15 25:24 26:11	65:12 65:23 131:17 131:19
by-year 220:21	29:11 29:15 29:25 30:11	candidate 219:17
<hr/>	30:14 31:9 31:18	candidates 85:6
C	31:24 34:15	canopy 62:12
calcu 101:11	34:19 37:7 37:23	96:16 96:17
calculate	38:6 38:14 39:17	103:13 103:14
100:15 109:5	40:6 40:8	Canyon 53:21
120:21 136:25	40:12 41:13	153:23
calculated 19:7	41:17 43:11 44:3	cap 27:13 52:8
120:8 133:2	44:16 45:23 46:3	capability
calculating 100:4	47:4 49:15 49:20	47:21 77:15
calculation 101:8	49:23 50:8 50:14	82:18 109:8
101:8	50:25 51:15	111:23 144:6
calculations	52:25 53:8 53:25	218:2 229:8
109:14 133:23	54:8 54:13 54:17	capable 99:9
157:6	54:20 55:2	127:17 218:3
California 103:19	55:4 55:5 55:8	capacity 134:15
calm 79:9 79:12	55:13 55:23 56:5	Cape 113:6 113:21
110:21 111:3	56:15 56:22 57:7	114:14
111:4 118:25	64:23 65:4	capital 175:12
119:14 120:7	84:9 84:14 84:22	capture 101:3
120:8 122:18	84:24 85:1 87:11	182:23 192:20
122:22 123:4	88:2 88:6	221:13
123:5	88:16 89:4 89:11	captured 24:11
CALMET 33:23	107:9 131:5	captures 100:25
33:24 35:4	131:9 131:17	capturing 189:21
39:8 39:11 39:13	146:7 146:9	car 100:24
39:18 39:23	146:13 190:15	carbon 200:12
39:24 40:1	190:22 191:7	card 106:15
40:2 40:2 40:9	191:10 191:12	care 119:12
40:14 40:14	192:21 197:9	125:23
40:17 40:22	205:25 208:5	careful 5:7 43:20
40:23 40:24 41:2	208:8 209:8	113:17 137:8
41:9 207:25	225:21 232:5	185:12
208:3 232:7	232:6 232:8	carefully 57:9
232:24	232:25	64:6 84:4
calms 112:10	CALPUFFS 146:16	Carlo 49:21 64:21
112:12 113:25	CALTECH 44:11	
114:4 114:12	camera 171:7	
173:21 194:16	CAMx 30:12	
CALPUFF 12:7	30:16 31:3 31:10	
	32:21 33:2 34:24	
	41:18 43:24	

Carolina 162:13 200:19	191:21 193:13 198:3	35:10
carried 142:6	case-specific	certain 32:5 33:2
case 17:24	196:1	35:3 36:5 37:9
18:13 24:14 26:6	Casey 174:25	55:9 56:5 72:7
26:11 27:5 32:17	CASNET 192:4	87:14 97:12
38:18 45:16	catch 105:22	212:11
46:10 49:6	catch-22 64:9	certainly 37:6
68:7 69:19	categories	46:3 72:5 72:8
71:5 71:23 71:24	60:12 60:14	76:2 77:21 82:19
72:24 73:3 73:10	117:8 223:5	82:22 86:5 86:21
73:15 73:19	236:21	88:22 89:12
80:22 80:23	category 222:24	149:13 149:24
83:25 95:10	Cathy 58:5 67:15	150:15 151:1
95:14 104:1	Catizone 9:13	151:15 154:7
109:20 117:25	9:14 213:25	CH2M 148:14
120:6 123:14	caught 34:20	Chair 9:15 11:1
124:5 124:16	cause 37:5 229:17	11:2 58:6
124:23 145:20	231:24 235:4	challenge 74:8
153:14 158:11	caused 96:5	153:22 175:13
159:21 160:19	causes 41:12	176:23 182:2
161:17 173:20	161:22	182:7
175:1 178:14	causing 16:7	challenges 69:4
184:7 186:1	27:20 150:13	74:12 97:8 175:2
186:5 187:24	229:15	176:18 181:2
193:10 194:10	caution 73:6	181:7 213:19
195:4 196:3	cautiously 70:3	challenging 182:5
202:25 212:16	cavity 23:19	183:10
215:3 220:8	24:11	chance 81:3 143:3
230:2	C-collaboration	Chang 206:1
case-by-case	235:11	change 4:11 15:20
47:10 56:24	cell 32:24 40:10	15:24 15:25
75:24	center 32:2	16:10 16:11
cases 17:7 31:7	157:10 171:16	16:18 16:20
31:13 61:7 69:19	171:17 199:20	16:24 17:1 17:21
69:21 71:3 72:17	200:8 204:1	19:23 21:13
72:22 72:24 73:6	centered 161:8	21:15 27:4 27:15
78:4 81:17 81:18	central 29:7	32:11 32:11
83:3 96:20		32:18 40:4 41:12
109:18 115:2		53:3 61:15
116:10 116:10		109:12 118:24
136:20 143:22		142:21 142:23
153:13 159:22		143:23 172:4
161:21 185:21		174:10 178:4
186:19 186:21		

192:1 193:4 196:18 212:9 223:18 227:18 231:11 231:18 231:19 231:23 232:19 changed 32:18 34:7 41:25 181:4 changes 5:15 6:7 32:5 33:9 44:3 46:9 57:2 66:15 141:5 142:2 142:10 142:17 143:10 143:11 143:19 143:21 143:23 144:1 144:12 146:5 175:21 217:20 225:6 227:15 231:3 233:9 235:4 changing 102:4 226:9 character 185:24 characteristic 75:9 characteristics 108:23 136:19 characterization 220:17 characterize 110:14 143:13 characterized 92:10 153:15 characterizing 189:21 charge 100:20 check 67:24 106:11 207:5 238:2 CHEMEQ 50:4	chemical 43:25 135:13 163:4 206:16 210:16 215:9 Chemicals 97:6 chemistry 44:6 44:16 45:4 45:5 45:6 45:7 45:9 45:13 45:23 46:4 46:14 46:16 46:21 46:23 47:4 47:10 47:18 47:21 48:11 48:12 48:15 48:16 48:18 48:19 48:25 49:1 49:3 49:12 50:8 50:10 50:13 50:16 50:19 51:2 51:8 51:10 51:20 54:16 54:19 54:21 55:1 55:6 55:9 55:24 56:2 57:7 63:8 63:10 65:8 131:11 136:5 191:21 196:25 197:1 199:14 200:1 200:12 201:12 201:14 201:25 202:5 202:7 202:8 chemistry's 65:10 Chesapeake 191:11 191:15 Chet 6:11 6:14 9:8 14:22 chop 227:23 228:1 chopping 227:1 chosen 80:24 Chowdhury 203:18	Chris 58:6 chunk 119:25 Cindy 139:24 140:2 148:8 circle 157:9 circled 116:21 circles 86:12 circumstances 72:8 city 62:22 84:9 85:9 88:16 89:7 113:9 165:21 170:13 city-state 83:22 84:7 84:10 84:24 86:22 87:9 87:13 90:5 90:8 90:13 claiming 130:18 clarification 16:20 16:25 27:15 178:24 179:4 clarify 203:14 class 29:11 117:18 129:18 129:25 138:6 classes 129:16 130:2 138:5 classified 47:21 120:16 classify 119:9 class-run 46:5 clauses 179:15 clean 140:14 141:3 142:7 143:8 143:15 220:14 224:5 cleaner 74:17
---	--	--

<p>clear 33:8 40:21 70:17 72:3 134:19 141:1 142:3 151:22 161:14 214:25 234:2 237:20</p> <p>clearing 204:2</p> <p>clearinghouse 13:11 13:13 13:15 13:19 13:23 234:1</p> <p>clearly 31:23 159:21 160:16 161:2 161:19</p> <p>click 173:19</p> <p>client 175:19 179:6 191:9</p> <p>clients 149:15 149:17 150:9 180:22</p> <p>climb 174:14</p> <p>climbed 171:6 174:16</p> <p>close 31:20 35:1 49:4 50:15 89:19 91:23 92:1 92:16 95:12 110:18 116:18 130:13 135:2 135:8 135:13 170:19 189:5 192:18 214:3 235:20 238:19</p> <p>closed 72:12</p> <p>closely 32:15 145:5 185:15</p> <p>closer 46:25 47:1 71:8 72:22 73:2 96:7 195:21 229:5</p>	<p>closest 214:12 224:17</p> <p>close-up 169:19</p> <p>closing 6:17 147:18 238:10</p> <p>cloud 86:14</p> <p>clouds 45:15</p> <p>cluster 160:8</p> <p>clustered 160:4</p> <p>clusters 107:21 109:22</p> <p>CMAQ 43:24 44:11 44:16 49:11 49:13 49:15 49:16 50:9 50:14 65:12 65:23 200:3 200:6 200:7 200:7 200:8 200:14 200:17 200:20 200:21 200:23 201:1 201:1 201:3 201:8</p> <p>CMAQs 200:16</p> <p>CMAQ's 49:24 50:21</p> <p>CMAS 65:15 199:8 204:1</p> <p>co 163:13 169:4</p> <p>coal 72:7 74:14 97:6 101:2 157:1 165:10 165:11 165:13 182:18 197:11 215:13</p> <p>coal's 165:12</p> <p>COAMPS 210:14</p> <p>coarse 34:4 36:2</p> <p>co-author 15:18 97:4 112:19</p>	<p>174:25</p> <p>co-authors 213:24</p> <p>code 15:24 15:25 55:9 138:19 143:23 177:7 201:21 201:23</p> <p>codes 143:11 181:21 201:22</p> <p>codify 230:9</p> <p>coefficient 45:11</p> <p>coefficients 225:25 226:2 226:7</p> <p>coherent 78:3 78:3 80:21</p> <p>coke 97:6 97:6 97:20 98:6 98:19 100:3 100:7 100:11 100:23</p> <p>collaborate 8:5</p> <p>collaboration 62:19 131:25 155:15</p> <p>collaborations 59:12 59:14 67:14</p> <p>collaborative 6:6 14:17 151:3</p> <p>colleagues 168:19</p> <p>collect 135:16 172:9</p> <p>collected 103:24 133:21 139:8 139:10</p> <p>collection 132:17 194:14</p> <p>Colombari 222:16 222:20 222:21</p>
---	--	---

color 88:12 89:3 181:21 195:13	16:23 27:14 42:7 127:12 131:11 132:3 142:12 142:17 142:23 143:14 143:20 144:3 155:24 179:13 231:4 232:1 233:10 235:8 236:6 237:11 237:21 237:24 238:1 238:6	committee 9:12 9:16 9:19 10:4 10:7 10:7 10:11 13:15 14:7 28:16 52:3 58:6 58:7 59:23 60:23
Colorado 45:3		common 14:1 149:7 149:22 168:15 176:22
color-coding 195:12		commonly 98:14
colored 34:17	commenters 54:19	communicated 108:13
colors 87:19 87:20 89:9 158:16 195:13 195:14 215:12	comments 4:22 4:24 5:18 6:12 6:22 10:22 11:5 11:7 11:22 11:24 12:25 15:17 15:18 15:19 39:23 42:4 52:6 52:12 52:20 52:23 52:24 52:25 53:5 57:12 57:15 57:18 57:20 58:1 59:7 59:9 59:24 60:14 65:20 68:1 76:5 140:25 143:6 148:9 155:23 156:2 156:6 171:23 235:15 235:20 236:2 236:4 236:8 236:12 237:12 237:22 238:9	communications 67:13
column 35:14 195:7		community 6:6 7:6 13:8 42:14 51:14 62:10 132:1 139:9 139:11 145:6 149:8 150:14 155:16 201:8 203:1 203:14 204:3 233:19 233:20 234:4 234:11 234:15 235:11 235:12
columns 182:1		compact 96:6
combat 191:2 207:4		companies 155:22
combination 78:20 93:23		company 43:17 163:4 163:6 228:12 228:18 228:19 230:7
combinations 71:10 141:13		comparable 24:21 26:5 26:9 84:23 115:6 115:8 184:17 194:19
combine 46:17 177:1 177:9 177:12 177:22		compare 115:11 156:14 157:4 159:5 193:15 195:20 197:17
combined 106:20 178:2		
combustion 74:25	Commission 53:22 191:15	
comes 7:7 20:12 58:13 64:23 196:15 232:22	Commissioner's 53:23	
comfortable 126:9	Commission's 53:24	
coming 6:19 7:2 8:23 9:5 22:21 38:22 41:4 41:13 42:4 62:7 68:13 97:21 134:7 152:3 154:11 222:1		
command 202:19		
comment 5:10 5:22 7:7 13:22		

compared 41:3 54:7 55:23 98:25 99:3 115:11 136:2 136:6 137:20 138:9 156:18 158:2 159:13 161:6 194:17 210:10	complex 45:1 99:12 99:13 99:15 100:3 165:19 167:14 183:21 185:2 185:2 198:4 224:19 225:21 232:6 232:9	87:24 88:10 89:19 92:18 93:1 94:25 95:5 95:7 95:8 95:11 101:11 104:9 104:11 104:14 104:15 104:17 105:1 105:3 108:24 110:22 111:3 111:4 123:17 125:1 133:1 133:3 136:13 177:17 178:2 193:1 193:24 194:1 195:7 223:14 225:1 230:1 231:11
compares 159:23	compliance 68:19 69:1 69:4 91:10 107:6 125:19 125:21 127:25 133:24 134:15 134:16 170:23 180:25 181:24 182:15	
comparing 25:8 113:14 192:4	complicated 84:19 226:8	
comparison 44:15 51:6 55:13 87:11 113:25 158:19 160:21 173:25 174:2 177:18 196:8 197:25 205:25	comply 175:13	concentrations 15:23 16:6 17:4 19:8 21:23 25:9 45:10 46:11 49:14 61:5 66:18 79:8 79:16 80:20 87:21 87:21 88:7 89:5 92:6 92:19 92:21 92:23 92:23 93:7 93:12 106:5 107:4 109:25 116:7 116:16 116:19 117:7 118:2 118:4 118:6 120:7 121:18 123:19 124:18 141:15 141:17 141:20 141:23 144:14 158:2 158:5 158:15 159:3 159:24 160:3 160:7 160:12 160:14 160:17 161:3 161:16 168:11 185:12
comparisons 83:20 112:16 113:13 157:25 191:19 193:14 195:2 197:19 212:4 213:13	component 100:9 101:9 232:20	
compatibility 55:23	components 100:8	
compatible 51:15 200:23	compounds 101:4	
compelled 54:7	comprehensive 57:20	
compensating 135:22 137:9	computational 154:16	
complained 112:9	compute 49:12	
complaints 46:2	computed 49:4	
complement 118:23 120:3	computer 217:17	
complete 33:10 59:10 131:16 132:23 167:6 167:7 233:8	concentrated 82:2 185:25	
completed 55:8 55:13	concentrating 106:8	
	concentration 16:9 19:13 19:13 19:17 19:18 22:13 24:6 24:12 38:2 38:3 73:7 77:24 78:4 79:14 80:17 81:3 83:20	

<p>192:2 193:21 194:3 195:11 195:14 206:17 219:20 220:9 224:3 224:24 225:2 226:12 226:22 229:6 231:4 231:25 235:5</p> <p>concentric 86:12</p> <p>concept 214:2 215:23 217:13</p> <p>conceptual 132:19</p> <p>concern 29:2 66:19 69:9 112:8 128:19 150:14 150:18 150:23 184:17</p> <p>concerned 76:6 237:24</p> <p>concerning 43:10 71:13 143:25</p> <p>concerns 10:17 13:14 39:10 47:6 53:10 54:19 58:17 140:23 145:15 155:21</p> <p>concert 92:18</p> <p>conclude 37:3 41:14 76:15</p> <p>concluded 54:9 127:3 220:19 238:21</p> <p>concludes 52:2 57:12</p> <p>concluding 82:17</p> <p>conclusion 51:9 70:23 71:14 106:4 110:9 131:22 146:20</p>	<p>155:11 161:14 214:24 217:21 233:4 234:21</p> <p>conclusions 27:3 41:17 89:17 94:1 96:3 127:20 138:19 189:12 221:9 227:11</p> <p>concurrence 173:25</p> <p>concurrent 172:11 173:12 197:2</p> <p>concurrently 171:1</p> <p>condition 72:6 106:7 216:16</p> <p>conditions 49:22 49:22 50:4 50:24 51:7 54:11 79:25 80:6 80:10 82:7 82:23 83:5 83:22 83:25 84:11 84:19 89:7 91:12 94:5 106:9 107:5 110:20 110:21 120:5 138:7 144:15 152:15 157:15 188:18 189:5 208:23 216:23 233:6 233:7</p> <p>conduct 56:14 98:8 234:8</p> <p>conducted 85:18</p> <p>cone 95:3</p> <p>conference 4:2 5:22 6:2 6:8 7:8 9:18 10:2 11:5 11:12 11:15 11:19 11:20 12:3 12:24 14:15 15:2 45:22 53:14 54:24 65:14</p>	<p>94:11 127:3 132:2 132:18 147:17 171:17 185:18 198:23 199:6 232:13 233:22 234:5 235:20 236:2 236:20 238:17</p> <p>conferenced 9:19</p> <p>conferences 9:24 9:25 10:20 43:4 59:8 65:19 147:2 147:4 147:13 199:8 199:8</p> <p>configuration 35:3 38:24 40:22 41:22 41:25 98:3 99:7</p> <p>configurations 31:2 39:6</p> <p>configured 40:3 97:18</p> <p>configuring 79:9</p> <p>confirmation 17:21 51:16 176:8</p> <p>conform 221:21</p> <p>confusion 201:24 202:2 202:2</p> <p>conjunction 143:12 234:6</p> <p>connecting 85:19</p> <p>consensus 7:19 14:1</p> <p>consent 56:7</p> <p>consequence 16:22</p> <p>consequences 69:6 118:19 173:6</p>
--	---	--

conservation 56:8 88:18	24:24 42:11 57:1 79:10 93:11 93:12 93:13 93:14 108:22 108:23 116:9 143:15 147:7 200:15 212:8	143:7 169:6 204:22
conservatism 120:13 177:20 188:24		continued 57:3 112:5 155:13 189:18 200:13 201:15 201:18
conservative 47:1 73:8 111:6 111:13 126:20 183:7 183:8 183:9	consistently 75:11 141:9	continues 184:2
conservatively 75:14	consolidate 52:22	continuing 43:16 67:13 209:17 229:10
consider 57:10 59:2 78:8 82:20 86:5 89:24 90:11 96:19 111:24 145:24 146:4 162:6 173:1 183:24 189:20 189:23 195:24 197:7 219:14 232:10	constant 44:7 45:8 45:14 46:7 46:20 47:4 61:13 84:10 108:23	continuous 173:10
considerable 131:10 131:19	constantly 92:8	continuously 204:6
consideration 110:7 111:12 144:19 185:11 221:8 221:22	constants 153:12	contractor 174:16 174:17 236:10
considerations 202:12	constraints 107:16 176:3	contractors 164:17
considered 45:19 51:21 66:1 73:21 74:6 128:7 146:20 221:13 224:13	constructing 80:3	contrary 27:10
considering 15:1 145:1 183:3 203:25 221:15 224:14	consultant 149:16	contribute 10:21 189:8 229:18
considers 146:24 232:24	consultants 10:12 103:1 174:24 222:21 233:14	contributed 201:7
consistent	Consulting 97:5	contributing 94:16 101:5 188:21 224:11 229:15
	consuming 182:13	contribution 16:7 146:11 191:16 196:15
	contact 67:15 106:14 199:19 204:12 238:18	control 71:10 73:22 121:19 227:2
	contacted 121:20	controlled 68:9 73:19 125:25 128:4
	contained 231:17	controlling 89:6 120:6
	contemporarily 177:9	controls 54:2 54:2 68:11 68:12 69:18 73:20
	content 44:5 44:7 45:13 46:18	
	context 68:5 68:21 69:25 141:17 193:7	
	continue 6:4 57:3 58:21 131:23	

124:14 124:19 167:21 168:15 convective 82:7 84:18 97:23 100:9 106:7 conversion 43:25 48:23 54:4 133:4 133:6 133:13 136:25 137:16 138:22 138:22 convert 167:21 converted 48:9 192:2 converts 194:2 cool 171:4 cooler 195:14 cooperation 145:9 cooperative 53:16 91:20 cooperatively 146:1 Coordinating 10:4 coordination 155:13 copies 78:22 core 132:20 132:22 202:22 203:15 203:22 cores 202:20 202:23 corner 23:5 176:15 corporate 164:16 corporation 213:23 236:16 correct 7:4 28:5 37:9 37:25 38:5	39:2 43:7 48:20 48:20 corrected 39:4 158:3 correcting 32:6 corrections 42:11 61:21 correctly 17:6 153:7 correlated 41:5 correspond 32:16 correspondence 13:23 corresponding 54:8 corrupted 104:3 cost 167:18 168:24 176:21 179:12 224:15 230:6 costly 235:1 costs 140:19 co-Trinity 113:8 Council 10:5 count 195:15 223:22 countries 62:10 country 128:14 149:19 150:10 County 108:17 163:19 couple 5:15 6:25 9:20 9:23 12:1 19:10 26:15 28:15 40:25 49:10 60:13 60:24 77:5 106:13 118:3 119:4 126:8	133:7 135:5 143:6 145:4 148:20 148:24 167:2 169:8 175:4 175:15 175:19 180:11 193:23 205:4 209:11 211:14 Coupled 54:3 couples 44:4 course 10:12 18:19 28:5 41:20 59:20 69:2 71:7 77:20 77:22 86:19 87:22 97:24 98:20 100:6 100:12 102:18 113:11 114:3 114:4 120:25 121:8 128:24 146:3 153:3 171:15 173:16 236:2 courtesy 77:25 cover 181:1 coverage 89:4 covered 34:23 58:11 58:12 64:17 64:22 65:9 65:25 67:7 covers 28:22 28:23 192:12 Coyote 92:2 crazy 106:18 226:14 create 22:20 140:18 creates 23:21 credit 18:23 26:24 179:3 179:18 179:19
---	---	---

creep 88:7 88:20 89:12	216:22 217:5	76:1 77:20 77:21
criteria 67:3 205:15 206:24 207:2 207:5 207:6 209:7 209:13 216:23	cute 206:11	79:21 84:11 85:20 91:18 105:12 112:5 113:1 113:20 113:24 114:11 114:12 118:22 119:15 119:16 119:20 119:25 120:2 120:3 120:9 120:15 122:18 122:19 122:22 123:25 125:11 126:3 129:7 129:15 130:19 132:17 133:17 133:20 134:6 134:9 134:21 135:16 135:17 137:8 137:12 137:20 139:7 139:10 139:14 156:23 157:6 157:14 163:23 164:5 167:1 167:6 167:8 167:11 167:12 167:12 168:16 168:17 168:21 168:21 168:23 168:24 169:6 172:10 172:25 173:3 173:20 173:23 174:9 178:7 178:9 182:10 182:13 182:20 183:17 183:25 184:12 185:22 186:6 188:13 188:17 189:13 190:16 190:25 191:2 192:5 193:6 193:15 194:4 194:5 194:18 194:20
critical 35:22 36:16 70:18 70:19 97:12 101:6 197:4	cuts 165:23	
critically 138:13	cutting-edge 148:3	
cross 40:15	CV 52:5 52:18 52:24	
CTDM 77:8	CV's 52:21 52:24	
CTDMPLUS 77:8 172:13	<hr/> D <hr/>	
cube 20:8 22:18	daily 87:15 158:7 182:9 182:9 182:12 182:19 195:10 195:10 219:16 219:25 229:25	
cubic 129:20	Dakota 91:7 113:7 117:3	
Cumberland 44:14 48:2 51:5	Dana 127:10 127:13 132:6	
cumbersome 102:19	dark 40:15	
curiosity 218:12	dashed 19:19 21:5 21:12 25:14	
current 11:1 43:16 43:21 43:23 45:4 63:7 63:22 63:24 64:8 64:11 68:20 74:5 75:1 149:25 201:4 203:17 204:14 229:7	data 8:2 18:4 18:4 18:5 18:7 18:8 18:11 25:5 26:10 29:24 30:1 30:18 30:23 34:11 34:12 34:13 35:4 35:4 35:16 36:10 36:14 36:24 36:25 37:22 39:17 40:17 40:24 41:19 41:23 42:7 42:13 42:14 43:1 44:5 44:23 45:15 45:19 48:4 48:7 53:19 54:3 59:25 59:25 63:13 65:2	
currently 10:6 62:7 102:6 196:24 227:20		
curve 24:19		
custodian 203:15		
customer 199:19		
customers 140:21 230:8		
cut 214:11 216:11		

195:3 197:2	dates 133:21	December 55:11
197:15 197:18	datums 37:21	94:10
197:19 209:10	Dave 211:21	decent 35:18
210:9 210:12	David 11:2	decide 64:11
210:17 214:18	103:2 213:17	157:18
214:20 215:23	213:18 213:20	decided 79:17
216:10 216:15	day 9:3 14:25	84:23 91:13
216:24 217:10	40:6 48:14 48:17	119:12 175:19
217:13 217:15	48:18 66:7 82:25	decision-making
217:18 218:2	104:2 180:16	146:25
219:1 219:1	180:17 181:16	decrease 4:8
219:3 220:12	183:20 185:7	227:4
220:18 221:10	193:13 195:7	decreased 22:14
223:10 223:13	212:19 212:25	103:11
224:8 224:9	213:7 230:18	decree 56:8
224:10 224:15	days 6:20 9:6	deep 153:21 154:2
224:18 229:16	9:23 30:21 58:11	defend 149:19
database 13:5	58:24 59:23	Defense 149:18
13:9 80:9	60:24 64:18 66:4	203:7 206:4
80:11 82:24	118:3 119:4	206:10 209:20
85:16 85:21 91:9	126:8 143:6	deference 229:9
128:17 129:3	145:4 148:20	deficiencies
129:10 129:15	148:25 149:2	33:18 150:17
130:8 133:23	152:12 155:14	151:2
138:1 138:4	175:4 181:5	define 99:25
173:25	183:4 184:15	109:21
databases 18:2	193:24 195:17	defined 40:16
66:22 77:13	211:15 230:18	definitely
79:18 79:21	daytime 103:23	65:10 155:24
79:23 80:2 81:13	104:3 104:15	193:3 218:11
82:21 85:11	104:24 104:25	221:6 225:23
89:19 129:7	106:7	definition 16:9
135:5	deal 38:10	17:4 38:20 41:24
dataset 22:10	114:6 124:10	definitive 79:13
44:13 44:14	152:17	degrade 39:13
44:14 44:17 48:6	dealing 129:1	54:5
51:3 115:15	debated 131:16	degree 22:18
116:22 119:21	debugging 90:14	23:14 47:23 99:1
132:15 133:20	90:21 109:4	217:1 220:18
datasets 112:23	decade 57:4	
112:24 113:5	decades 53:18	
113:10 133:19		
date 14:13 175:18		
176:1 193:9		

221:25 222:3	dependence	designate 56:22
degrees 36:19	99:19 99:20	189:11
80:17 157:20	99:21	designated 141:24
207:25 211:5	dependent 33:21	designating
216:19 220:19	99:6 111:10	189:16
221:4 221:17	depending 46:2	designation
delayed 11:23	139:2 204:25	180:24 181:14
144:19	226:24	183:15 184:24
delaying 150:25	depiction 78:1	185:1 189:10
delays 146:23	86:23	189:14 190:5
deliver 67:22	depletion 44:9	designed 28:24
Delta 22:20 23:1	deposition	72:14 133:22
delve 181:3	44:21 44:22	134:5
181:21	153:7 192:3	desired 233:23
demonstrate 17:24	193:2	Despite 104:5
68:19 133:23	depth 154:22	detail 81:7
229:14 229:20	213:6	148:25
230:12 230:20	depths 66:10	detailed 55:21
demonstrated 57:6	66:12 212:18	61:22 63:15
144:6 147:21	Deputy 8:11	199:6 226:10
demonstrates	DEQ 131:16	details 30:21
217:10	derivative 203:12	42:9 71:17
demonstrating	derived 153:11	108:24 149:2
69:1 69:4	describe 53:2	150:3 153:14
232:6 233:4	91:8 105:23	155:3 156:22
demonstration	108:11 199:4	determination
55:22 117:6	described 48:3	21:21
demonstrations	53:14 55:12	determinations
47:8 57:10	56:20 56:21	53:11 56:17
Dennis 210:13	66:25 102:1	56:24
denominator 116:3	134:22 139:13	determine 31:19
dense 123:19	156:17 198:22	66:21 90:22
Denver 52:18	199:22 209:12	129:4
55:12	description 106:5	determined 216:14
Department 149:18	deserves 111:11	determines 30:6
190:11 190:12	design 40:8 79:16	235:3
191:8 203:7	92:23 109:25	determining
206:10 210:18	163:24 164:12	145:16 219:17
depend 132:24	168:1 214:13	deterministic
	215:2 220:1	229:2

detrimental 179:12	diamonds 91:25	195:7 195:11
Detroit 62:17	die 61:20	195:15 196:2
develop 18:8	dies 61:19	196:2 203:11
20:22 77:15	diesel 236:24	210:21 212:5
78:15 131:19	237:2	215:12 222:22
133:22 146:15	difference	222:25 223:16
228:5	36:20 85:6 93:24	236:21
developed 17:9	100:7 103:8	differs 99:18
20:20 39:18	105:8 112:15	difficult 10:8
77:11 78:14	120:20 125:6	68:19 68:22
82:18 85:17	128:8 139:2	68:24 103:15
98:23 144:13	158:11 159:15	124:15 128:22
145:3 146:3	172:19 173:9	131:13 152:10
146:6 146:8	208:25 209:6	184:1 225:22
192:19 201:10	209:7	diffusion 104:20
203:13 217:16	differences	diffusive 33:3
developer 55:5	41:6 49:14	34:23
developers	85:3 158:12	digging 153:24
42:19 49:18	different 4:15	dilute 33:16
203:17 204:1	6:7 7:6 11:17	dilution 32:22
developing 18:3	11:24 12:22 23:6	32:23 32:25
91:1 206:20	25:25 28:8 29:17	dimensional 20:22
development 39:20	31:3 31:4 31:5	dimensions 12:5
65:11 69:11	32:3 32:14 34:10	100:5 101:24
80:12 145:21	35:24 40:20 45:4	108:7 154:22
198:13 198:19	45:18 47:2	179:7 179:21
199:3 199:9	50:5 50:6	dioxide 72:12
200:13 200:20	50:11 51:13	DIPOLE 206:11
200:22 201:15	57:21 57:23	206:13 208:15
201:18 203:6	62:14 70:14	208:20
203:10 206:5	70:22 71:4 71:20	direct 172:22
235:12	83:24 89:18	218:23
developmental	103:17 107:24	directed 81:1
18:4	107:24 109:21	81:2
developments	116:13 117:7	direction 17:19
6:7 12:11 43:10	117:8 119:10	32:4 35:10 36:14
develops 102:13	121:16 123:6	41:4 41:10 41:11
devote 145:19	134:12 135:10	64:3 78:6
diagnostic 208:1	138:5 139:4	83:24 90:16 99:6
diameter 38:6	149:15 159:25	120:21 192:7
	161:23 182:25	207:24 213:4
	184:16 184:21	
	191:16 193:20	
	193:21 194:15	

213:5 216:12 216:13 216:14 216:19 221:16 221:17 223:11 directions 77:23 80:19 80:21 81:6 88:20 88:21 88:23 89:5 89:16 89:22 95:3 113:19 113:23 211:5 216:18 directly 39:10 44:5 129:1 161:19 210:7 Directors 168:7 disagreement 159:2 207:21 disagreements 154:4 disagrees 143:17 disappeared 116:24 disapproved 56:12 disbursement 203:21 discontinuities 16:18 discontinuity 21:16 27:2 discouraging 179:5 discover 207:21 discovering 60:21 discreet 172:14 discrete 61:11 61:14 discretion 230:11 230:19 discretization	154:17 discuss 12:15 55:4 70:25 97:7 110:8 190:24 233:23 discussed 11:16 15:2 22:8 49:7 63:17 155:21 175:3 192:22 203:24 234:5 discussing 68:5 discussion 38:12 205:23 223:24 discussions 11:19 52:10 60:23 102:9 149:13 disorder 153:19 dispersion 36:2 62:1 62:6 62:11 84:17 94:21 98:17 99:14 107:24 123:20 123:23 124:6 126:13 133:4 136:1 136:4 137:17 199:25 201:11 201:16 201:23 204:12 207:3 210:5 displaced 40:10 display 39:21 displayed 73:5 disposition 103:3 103:17 104:18 104:22 distance 83:13 83:19 84:5 84:12 87:1 91:24 95:8 95:12 95:13 99:19 103:22	104:16 160:1 160:9 161:3 219:11 distances 22:14 48:13 64:16 64:25 84:2 85:8 86:8 distinction 143:17 228:14 distinguishes 143:10 distribution 25:17 74:17 109:17 158:5 198:25 203:22 Dittenhoefer 97:3 108:1 diverge 83:18 84:13 88:22 89:14 diversion 31:25 divide 78:17 83:1 divided 109:21 118:8 138:10 213:5 divides 78:21 division 62:15 DNR 196:23 docket 4:24 5:7 5:19 5:25 52:7 94:10 236:14 238:7 238:9 document 147:14 154:4 236:4 236:7 236:8 documentation 39:1 59:10 142:15 142:18 202:24 documented
---	--	---

15:25 190:3 199:16 201:20 documents 49:7 DOD 203:11 DOE's 211:16 dollar 169:2 169:16 dollars 224:15 domain 28:23 44:25 55:10 85:22 158:15 192:9 192:11 192:11 203:4 203:9 207:8 207:11 210:11 210:11 210:12 210:22 211:15 211:24 domains 210:24 dominated 80:9 done 12:13 20:16 21:20 25:4 29:11 32:5 34:3 41:7 41:8 42:5 43:11 50:3 51:18 62:23 66:8 70:13 75:1 75:10 82:20 102:8 103:18 118:21 118:24 134:23 141:8 141:8 154:15 164:7 170:20 175:12 183:19 187:14 188:6 190:11 191:19 197:18 205:25 214:1 door 100:21 doors 100:13 dosage 206:16 206:18	dot 62:24 115:1 double 232:22 Doug 45:20 127:14 132:8 132:12 132:16 135:20 137:23 139:21 207:15 DOUGWAY 208:11 downdraft 22:23 105:24 Downey 132:10 132:11 download 199:18 199:21 downwash 12:16 15:17 16:13 16:16 17:2 17:22 18:24 18:25 19:23 19:25 21:15 22:24 25:25 26:1 27:4 28:11 61:16 61:18 62:9 79:19 90:19 99:10 105:7 105:11 106:24 107:4 110:20 110:23 111:22 129:23 157:6 169:10 170:1 170:25 179:14 205:9 205:16 205:18 223:9 225:8 225:11 226:16 231:18 231:20 downwashes 168:12 downwind 22:13 24:2 36:18 104:10 129:8 134:1 138:25 139:3 157:19 158:25 160:1 160:6 160:9	167:3 Dr 112:19 draft 14:10 69:12 181:12 229:12 230:15 dragged 236:24 dramatically 32:18 106:2 draw 39:12 127:20 143:19 drawback 99:11 dream 206:12 drew 214:24 drift 135:4 drive 29:25 125:10 166:18 172:5 driver 49:21 151:12 drivers 150:13 driving 41:23 121:17 121:17 124:17 125:1 drop 24:20 157:3 206:8 droplets 44:1 dropped 212:11 drops 24:13 205:15 220:2 220:10 221:4 221:5 DTE 236:18 dual 202:21 Dubbs 174:25 due 11:22 15:6 42:6 47:8 57:6 57:6 75:8 94:10 100:10 109:22 159:3
--	---	--

176:3 180:18	easier 216:9	58:3 59:3
183:7 191:11	easily 107:16	84:20 119:24
209:9	131:2	187:2 201:22
Dulles 113:6	east 165:1 192:13	231:2 233:25
dumps 210:16	eastern 165:11	efforts 76:10
duplicate 56:20	Eastman 162:23	146:15 200:22
during 5:10	163:4 163:4	201:10 233:23
5:21 77:20 77:22	163:5 163:21	Egan 58:4
104:2 104:12	164:15 164:16	EGU's 92:2
104:25 105:21	164:18 168:6	eight 11:25
106:7 106:8	easy 99:24 185:9	21:1 22:12 22:15
134:8 145:22	economic 149:25	27:7 108:14
155:23 173:22	150:8 152:2	111:2 125:6
201:19 212:25	155:20	166:1 171:5
213:6 232:4	economy 164:20	202:22
233:22 234:5	ed 196:20	eighteen 36:11
236:2	eddies 61:20	eighties 112:7
dust 152:8	eddy 170:7	112:9
dwell 16:3	edge 22:21	eighty 122:21
dynamic 154:16	23:17 24:2	EIS 131:16
dysfunction	effect 22:16	either 11:18 32:9
103:13	22:20 23:1 45:10	33:10 159:7
<hr/>	46:9 46:13 83:23	162:16 188:7
E	effective 17:18	207:10 216:12
<hr/>	22:9 24:25	216:19 222:18
eager 147:22	26:2 27:25	elaborate 7:1
eagerly 179:23	28:2 28:7	Eladio 77:3
earlier 25:4 48:3	90:16 90:17	198:11 198:16
52:7 53:14 96:22	98:15 175:18	204:21
97:9 106:25	176:1	electric 43:18
148:17 156:17	effectively 33:15	47:6 52:18
177:3 178:22	122:6 124:3	53:9 53:16 91:19
187:25 191:25	effects 16:16	97:15 135:9
192:5 192:24	20:9 28:12 46:17	198:18 213:23
197:20 199:6	54:18 104:21	electrical
215:8 220:3	126:13 136:9	91:18 180:23
221:22 231:23	206:16	electricity
236:6 236:19	efficiency 177:19	228:20
238:8	effort 6:6 11:6	elements 201:14
early 15:4	11:9 14:17	201:17
38:21 148:18		
166:20 219:8		

<p>elevated 24:17 79:24 95:10 158:17 187:14 208:22 212:16</p> <p>elevation 92:22 161:4 166:9 223:13</p> <p>elevations 92:12</p> <p>eleven 18:17 21:9</p> <p>eliminate 16:18</p> <p>eliminates 51:4</p> <p>elo 95:20</p> <p>eloquently 150:7</p> <p>else 151:1 170:22 227:17 227:18 235:19</p> <p>elsewhere 50:19</p> <p>emergency 5:18 28:25 29:1 52:5 52:20</p> <p>emission 54:1 63:16 72:4 72:5 72:16 72:20 73:21 93:4 93:21 101:9 101:12 101:12 104:19 108:23 109:22 115:7 115:10 124:24 129:4 129:5 134:13 137:12 176:20 179:11 182:1 223:8 227:6 229:19 230:4 230:23 237:5</p> <p>emissions 25:6 38:16 38:17 54:2 54:4 54:14 60:3 64:17 64:19 64:22 67:12 68:17 69:24 71:22 72:4 72:11</p>	<p>73:12 74:11 74:16 74:23 92:8 93:2 93:4 93:5 93:17 93:24 94:6 94:14 97:15 97:20 100:18 100:19 101:1 103:5 108:21 109:19 125:8 125:25 127:18 129:7 134:6 134:7 134:9 134:10 134:11 134:25 135:2 135:17 136:10 141:11 141:12 143:13 151:9 152:6 153:2 154:11 157:1 167:25 167:25 169:11 172:10 181:11 182:23 182:24 189:20 189:22 192:17 192:17 192:20 193:11 230:21</p> <p>emit 38:14 60:4</p> <p>emitted 165:14</p> <p>emitting 92:9</p> <p>emphasize 202:5 206:2 206:22 208:24</p> <p>emphasized 79:25</p> <p>empire 129:6 129:9 132:15 133:17 136:11</p> <p>employ 164:14</p> <p>employed 52:17</p> <p>employees 164:15</p> <p>employment 180:25</p> <p>encourage 6:1 8:4 15:7 57:9</p>	<p>162:6 201:3 204:3 234:14 235:9</p> <p>encouraged 17:20 59:11 59:22 75:18 197:22</p> <p>encouraging 59:24 75:25 197:21</p> <p>energy 53:6 210:19 228:18 236:19</p> <p>enforceable 229:19</p> <p>engage 6:4 233:12 234:1 234:14 234:19 235:10</p> <p>engine 123:8</p> <p>engineer 213:21</p> <p>engineering 214:5 231:16</p> <p>engines 128:18</p> <p>enhanced 34:11 34:15 98:24 99:3 102:15 110:2</p> <p>enhancement 99:4 99:22</p> <p>enhancements 44:8 53:7 56:1 198:24 204:11 204:14</p> <p>enhances 187:15</p> <p>ensure 147:23</p> <p>enter 194:2 195:23</p> <p>entering 122:8</p> <p>entertain 4:15</p> <p>entire 42:14 95:4 160:25 203:14 232:11</p>
--	--	---

entirely 32:10	131:16 132:1	70:7 110:6
entities 126:17	132:2 140:9	116:10 116:22
140:17	140:11 141:1	118:22 140:6
entity 172:14	141:6 142:2	142:5 142:8
entrainment 99:2	142:9 142:20	142:13 145:8
Environ 29:21	142:22 142:23	146:3 152:25
30:9 30:10	143:2 143:7	229:12 230:15
34:9 34:10	143:9 143:13	232:16
39:8 41:14	143:18 143:19	EPRI 53:20 77:3
203:17 203:18	144:5 144:10	80:9 82:19 83:14
environment	144:12 144:13	146:15 199:16
198:17 210:2	144:18 144:23	199:17 199:19
Environmental 4:1	144:24 145:3	200:2 203:11
213:22	145:5 145:11	203:15
Environplan 97:5	145:13 145:18	EPRI.com 199:18
Environ's 37:2	145:23 146:2	203:23
EPA 5:13 7:16	146:4 146:8	equal 110:5
7:23 9:17 9:24	146:18 146:18	231:21
11:14 12:14	146:23 147:5	equally 36:3
14:20 15:8 21:20	147:13 147:15	107:17 107:17
26:13 28:19	147:18 147:22	108:8 108:8
29:20 29:25 30:9	147:25 151:22	equals 84:2
30:10 31:18	152:23 155:12	equation 225:15
33:11 34:8	155:16 155:17	equations 227:15
34:9 34:16 35:14	162:6 164:7	equipment 227:2
39:18 39:18	173:1 197:24	EQuIS 43:25
41:14 53:23	198:25 199:7	44:6 45:9
54:13 54:22 55:3	200:3 202:9	45:12 46:16
55:20 55:25 56:4	204:2 204:15	47:18 47:20
56:8 56:9	215:1 228:25	equivalency 202:6
56:14 56:21 57:1	230:9 230:11	equivalent 12:4
57:9 58:25	232:2 232:10	83:17 84:9 84:14
59:4 68:20 82:20	232:12 232:21	84:16 84:17
91:2 91:16	232:24 233:2	87:11 87:13
96:1 97:10	233:11 234:1	179:7 179:20
98:5 98:14 102:9	234:8 234:11	ERM 180:12 180:17
102:12 106:13	234:14 234:19	error 211:4 213:6
107:10 107:13	234:24 235:2	213:6
108:25 115:15	235:5	errors 35:3
120:10 120:12	EPA-approved	37:4 37:9
125:15 127:16	141:21 141:21	37:19 37:20
128:16 128:24	EPAs 131:25	
130:17 131:12	200:16	
	EPA's 20:12	
	35:4 41:24 54:16	

<p>39:16 41:21 64:6 135:22 137:7 137:10</p> <p>escape 101:5</p> <p>especially 34:5 37:8 39:20 48:13 66:5 70:2 83:5 83:25 84:18 86:16 88:20 89:14 104:12 164:5 180:25 182:6 187:8 188:17 189:17 191:10 196:23 224:25</p> <p>essence 159:8</p> <p>essential 118:4</p> <p>essentially 127:21 156:23 157:19 158:25 194:11 196:12</p> <p>Essex 193:9 193:17 193:18 196:9 196:9 196:11</p> <p>established 51:11</p> <p>estimate 20:18 22:1 98:12 101:12 101:22</p> <p>estimated 48:24 137:13</p> <p>estimates 20:23 27:11 64:21 102:6 106:8 127:18 192:3 231:12</p> <p>estimating 61:3 153:1</p> <p>etcetera 85:25</p> <p>ETEX 12:14 28:21 28:21</p>	<p>40:25 206:8</p> <p>ETEX-1 29:4 29:18 33:8 41:15 41:16</p> <p>Eularian 118:7</p> <p>Eulerian 33:4 36:3 43:24</p> <p>Europe 29:7 34:18 35:10 65:6</p> <p>European 28:22</p> <p>evaluate 22:9 28:8 34:3 54:23 55:6 69:15 70:22 79:17 133:18 136:1 137:14 137:25 146:15 155:19 169:11 172:10 197:23 204:3 232:2</p> <p>evaluated 27:22 29:17 44:11 46:9 58:19 65:1 66:17 70:21 141:6 141:10 141:18 141:20 141:24 176:20 209:23 229:24 230:2 233:1</p> <p>evaluating 18:5 28:25 82:19 136:4 179:6 210:4 232:10</p> <p>evaluation 12:14 18:2 18:6 28:19 37:4 42:13 42:18 42:21 42:23 43:5 43:10 43:19 51:2 56:14 66:22 77:13 77:14 79:18 82:18 82:21 107:3 109:22 128:17</p>	<p>129:11 130:8 134:19 141:8 153:8 169:14 173:17 190:22 192:11 199:15 201:19 202:24 206:2 209:6 232:23 233:3 233:8 234:6 234:8 235:6</p> <p>evaluations 12:12 29:20 49:11 53:13 55:7 55:12 55:22 56:7 56:14 60:6 66:24 67:11 110:25 132:14 162:8 192:1 192:4 205:23 208:24 209:18 210:13</p> <p>Evansville 85:15 86:13 86:21 87:5 89:1</p> <p>event 10:24 193:2</p> <p>events 113:22 147:5 184:19 186:24 187:8 187:18 190:3</p> <p>everybody 4:5 4:5 6:18 6:24 8:19 42:15 52:16 66:25 162:22 169:15 171:25 174:7 179:17 235:24 238:12</p> <p>everybody's 66:4 106:17</p> <p>everyone 4:13 6:2 131:22 137:25 139:15 180:15 180:15</p> <p>everyone's 17:15 204:23</p>
---	--	---

everyplace 211:6	115:22 185:17	175:11 176:14
everything 5:5	exceed 75:3	expect 20:9 20:19
6:9 19:21	exceedance 181:23	50:7 76:2
19:24 23:20	184:20	95:11 103:17
44:22 93:11	exceedances	238:15
119:23 151:15	98:3 187:9	expected 14:15
170:18 217:25	229:18	49:17 59:21 72:1
237:8 238:14	exceeding 85:7	118:20
evidence 143:25	89:23 167:17	expecting 71:15
232:13	exceeds 131:3	116:1
exacerbate	excel 109:13	expedite 144:10
17:23 152:13	110:14 217:14	expedited 150:16
exacerbated 21:17	excellent 174:2	expediting 14:18
exacerbates 143:1	214:1	expeditiously
150:20	except 21:3 92:10	53:2 56:22 142:5
exacerbating	excessive 16:6	152:19
151:18	16:9 17:4 19:16	expenditures
exact 33:18 62:16	excited 126:4	175:12
exactly 30:24	exciting 79:23	expensive 173:5
31:20 33:8	exclude 188:21	173:5 176:23
40:4 40:18 41:10	224:6	experiences
148:23	excluded 131:1	180:21 190:19
exaggeration	executive 168:7	191:4
128:15	exercise 134:8	experiment 29:4
examining 217:11	exercised 231:9	41:1 62:23 63:15
example 20:3	exercises 70:5	78:7 90:2
26:16 53:18	exhaust 94:4	experimental
54:15 59:15	exist 28:12	182:17
62:12 66:11	40:1 72:8	experiments 111:1
78:22 80:15 86:7	existing 18:18	129:3 206:9
110:21 113:14	44:12 69:15	206:12
113:23 133:12	127:23 140:8	expertise 147:21
137:7 141:9	199:10 229:10	explain 19:12
142:20 144:13	exit 100:6	23:8 33:2
146:7 147:6	expanded 65:22	explore 69:17
147:15 185:21	66:24 66:25	exploring 74:13
186:2 186:3	147:7	Exponent 15:15
198:25 205:24	expansion	43:17
210:5 212:5		exposure 185:3
212:18 229:11		
examples 74:23		

feed 44:5	87:14 88:1	finally 14:24
feedback 197:24	90:9 91:21	30:22 35:20
200:20 204:4	95:5 125:5	94:23 95:16
feeding 109:11	figure 22:2 28:23	147:1 181:8
feel 16:23 28:4	30:3 30:3 30:5	188:5 189:9
40:1 206:25	30:12 30:19 32:8	190:1 191:3
234:23 238:8	80:7 83:13	197:10 197:13
feels 131:23	112:16 125:24	198:1 233:11
feet 166:19	126:21 155:10	235:9 237:8
fell 216:18	173:21 212:1	finding 56:20
fellas 218:14	214:10 216:4	63:2 70:19
fellow 112:2	figures 42:8	findings 26:3
114:24 155:21	file 78:24	43:4 56:20 71:2
felt 31:20	79:14 177:11	fine 47:25
154:2 178:24	177:12	64:25 65:2 219:4
fence 115:18	files 32:7	finish 150:2
128:20 128:21	37:20 78:21	170:17
223:22 223:23	78:22 78:23	finished 235:23
224:4	78:23 177:16	FIPs 56:11
fences 128:22	filing 173:12	fire 108:20
fetch 24:22	fill 232:9	fired 57:14 74:15
fewer 112:18	fill-in 190:1	128:18 135:6
field 7:21 7:24	fills 208:1	135:9 157:1
8:1 8:8 34:19	filter 220:10	165:10 182:19
35:12 48:2	filtered 219:16	215:13 215:14
51:5 54:7	filtering 220:2	first 9:11 9:16
62:23 63:12	220:12	12:11 19:25
63:15 129:12	final 14:6	28:18 31:18 35:2
161:25 162:8	14:11 30:25 49:8	35:22 44:17
179:24 206:9	54:16 56:16 67:6	76:19 77:1 78:24
209:19 210:9	67:18 69:12	81:18 82:25
225:6	101:23 144:9	85:18 92:7 98:12
fifteen 11:16	148:18 180:16	103:6 104:24
58:10 76:20	180:16 204:16	105:6 113:18
100:22 123:5	204:16 217:5	116:12 118:9
fifth 25:20 92:13	finalization	118:14 120:23
fifty 18:20 79:11	142:13	121:18 122:20
80:14 81:24	finalize 230:9	126:8 130:8
83:12 84:3	finalized 237:9	133:16 136:9
86:3 86:4 87:6	237:10	141:1 142:11
		142:14 143:18
		162:16 177:23
		185:7 185:22

186:23 190:21 194:12 195:5 199:3 199:25 207:7 210:23 212:3 216:16 216:23 218:21 219:5 223:19 227:25 fished 165:2 fit 60:25 81:10 81:23 82:4 82:15 83:6 107:23 115:17 196:3 fits 178:21 fitted 77:12 five 11:24 18:23 24:15 29:17 56:4 59:18 60:25 80:4 80:14 81:12 81:15 81:21 82:2 82:10 83:5 86:3 86:17 88:14 89:20 90:8 91:22 91:24 92:11 92:25 93:25 96:10 102:11 104:10 108:14 114:3 115:19 116:13 122:23 125:4 144:5 186:21 204:25 212:5 223:16 224:17 237:3 five-minute 80:23 80:24 106:19 fives 60:25 five-year 92:24 fix 35:2 126:22 144:24 145:21 151:13 151:14 151:15 186:24 232:1	fixed 67:10 105:16 107:16 122:17 151:23 151:23 fixes 49:16 55:9 151:4 151:5 190:3 231:1 235:4 fixing 151:2 flank 171:10 flat 24:16 24:19 84:23 85:2 87:12 88:4 89:24 93:9 93:10 93:16 93:23 94:6 95:2 95:8 95:9 136:17 137:5 207:9 207:17 224:20 flexibilities 70:1 flexibility 173:22 188:13 FLEXPART 31:9 34:23 flipping 61:14 floor 97:2 166:19 205:6 Florida 113:9 flow 31:25 97:21 100:1 100:17 101:5 101:13 227:7 flowing 123:23 flows 77:18 flu 132:13 139:21 fluctuate 77:18 fluctuation 77:19 fluid 26:16 154:16	fluxes 210:6 211:18 flying 48:2 focus 10:2 44:23 44:24 46:21 57:23 81:9 92:5 118:13 121:2 122:1 192:14 193:12 focused 41:15 41:15 200:22 focusing 28:21 29:18 30:3 68:3 201:10 201:12 209:21 FOIA 13:7 folks 7:11 8:4 8:10 8:25 10:11 10:12 11:3 12:12 163:1 217:16 foot 165:22 footprint 78:6 82:1 82:12 force 235:1 forces 206:24 Forcing 140:16 forecast 210:4 forecasters 209:24 forecasting 66:6 forest 68:2 124:12 149:5 forgot 138:24 forgotten 83:25 fork 165:23 form 47:16 128:7 205:11 219:24 220:23
--	--	--

format 4:14 221:11	fourth 73:1 87:17 122:19 167:6 169:9 182:11	118:10 177:5 177:7 205:18 230:18
formation 46:14 54:10 57:9 137:17 146:10	Fox 237:19 237:19 238:4	fully 70:21 70:21 85:17 141:6
former 111:5 143:15	fraction 90:18 90:19 90:19 212:11	fun 67:4 172:4
forms 47:16	frame 98:18	function 100:5 160:1
formula 16:15 16:17 16:19 17:2 17:6 18:18 18:19 18:21 19:20 21:24 22:4 27:8 27:13 27:23 28:11 61:15 175:23 231:21	framework 142:6	functional 95:8
formulas 62:12	frankly 149:6	fund 146:15
formulation 138:20 235:3	free 122:5 124:1 159:11 203:3 203:8 238:8	fundamental 211:8
formulations 84:18	freedom 29:22 31:1 99:2	funded 43:13 43:18 43:19 83:14 91:19 209:20
forth 16:10 89:3 119:6	freely 199:17	funding 43:14 203:7
forthcoming 198:21	frequency 194:22	furnaces 97:15 97:16
forty 88:1 94:16 94:24	frequent 150:24 234:15	future 42:25 43:4 49:20 58:12 91:3 127:18 129:11 146:2 147:10 184:3 184:8 185:10 185:15 187:6 189:18 190:20 195:25 197:8 198:24 204:5 222:12 234:20
Forty-eight 103:21	frequently 151:11 228:20	
forty-five 22:18 23:14	front 86:25 209:25	
forums 65:17	frustrations 233:25	
forward 6:5 6:7 9:4 13:14 24:2 69:8 91:1 139:16 148:2 162:18 176:13 234:2 234:18	FS6 207:12	
fourteen 11:16 12:21 81:25	fuel 72:7 74:14 121:20	
	fuels 70:2 70:2 70:3 73:18 74:15 74:17	
	fugitive 97:14 100:18 100:19 101:8 152:7	
	full 38:16 42:12 44:17 45:15 51:3 72:4 77:23 117:9	
		<hr/> G <hr/>
		Gail 12:5
		gain 123:3 123:3 148:3 148:3
		Gainsville 113:7
		game 162:17
		gap 119:16 121:12
		Garrison 180:18

gas 110:25 128:17 128:18 129:4 133:20 167:21 192:2 200:12 215:14 215:15 215:17	76:17 76:23 96:25 97:4 102:22 106:17 112:1 112:2 112:3 116:24 117:12 117:12 117:18 117:23 118:13 122:15 126:25 148:13 148:18 163:15 180:14 209:15 237:17 238:14	gives 126:20
gasses 97:21		giving 24:11 90:3 90:3 142:11 142:16 148:15 175:1 222:22
gassy 78:7 78:11		glad 162:13 180:15
gather 7:12		goal 149:7 149:22
gears 4:11 156:3 193:5		goals 233:14
general 13:17 57:19 58:22 59:18 146:9 199:5 213:8	GEP 16:3 16:15 16:17 20:12 20:13 21:21 143:4 175:16 178:19 179:3 225:15 227:15 231:21	golf 171:15 174:11
generally 8:25 68:6 68:8 83:4 116:14 159:6		gone 86:20 168:23 175:8 223:24
generate 113:17	GEP's 20:13	gonna 169:22
generated 60:18 106:9 112:24	Gesser 67:19 67:20 68:1	goodness 81:10 81:23 154:25
generates 228:19	gets 134:20 172:15 237:8	Gossett 162:11 162:12 169:1 171:24 172:3
generating 91:18	getting 13:10 13:24 21:8 23:8 24:7 24:23 26:5 26:8 35:19 75:20 75:22 88:23 91:3 96:9 96:20 119:25 125:19 130:13 138:7 153:24 154:24 209:15 213:19 214:3 225:10	gotten 21:10 24:4 76:12 168:23
Generation 52:17		government 10:11
generators 135:10 236:24 237:2		Governor 111:5
generic 95:1		grade 153:2
generous 90:3		gradient 93:1
gentle 94:7		gradients 211:9
genuine 119:24		gradually 112:6 160:6
geometric 208:17		Grand 53:21
geometry 103:6 107:22	Gina 8:20	grandfathering 179:15
George 4:4 5:12 6:15 9:8 12:1 12:17 13:12 28:14 52:1 52:16 52:19 53:3 57:13 57:18 67:17	Girardeau 113:6 113:21 114:15	grant 124:23
	given 64:2 149:24 186:11 199:7 219:13 221:23 229:9	graph 130:2 158:19 160:8
		graphic 202:10
		graphical 39:21
		graphics 202:14 202:15 202:16

grass 65:1	125:12 140:4	237:4
gray 48:8 88:14 89:9	163:1 195:6 195:16 195:18 195:22 196:3 196:20 209:3 211:23 233:17 235:10	guidances 14:5 guide 171:5 guideline 20:12 21:21 54:22 142:5 142:8 142:10 146:8 231:14 234:25 guidelines 34:4 guys 9:2 9:3
great 4:11 6:14 6:24 7:22 8:2 9:6 92:1 132:2 172:1 212:22	grouping 221:23 222:1	<hr/> H <hr/>
greater 22:15 27:20 48:13 130:4 140:10 145:9 181:11 181:12 194:3 217:2 229:9 231:21	groups 43:13 60:10 91:25 149:11	H2O 210:20 210:20
greatly 94:5 177:19	growing 87:3	half 8:16 18:4 18:5 18:19 19:6 19:21 20:4 20:8 22:3 23:13 24:15 40:10 80:11 86:17 86:18 86:18 131:15 153:25 154:1 154:1 167:22 184:11 184:13 205:14 205:16 205:20 226:24
green 36:13 88:13 88:13 157:9 181:24 225:6	growth 69:14 155:20 189:18	Half-a-million 168:25
greener 81:15	guarantee 163:22 168:3	handed 14:2
grid 32:24 33:5 33:16 40:9 40:11 40:12 40:14 40:17 41:1 41:3 66:5 66:13 115:17 177:5 177:8 200:3 211:22	Guerra 117:15 117:16	handful 9:11 204:23 214:21
grids 40:20	guess 9:14 15:20 17:1 39:22 62:3 68:23 95:23 112:8 119:21 138:10 138:20 155:9 163:20 165:18 203:20 209:13	handle 204:10
gross 234:25	guidance 14:5 14:6 14:10 14:11 14:14 20:13 59:10 59:20 59:22 68:21 69:5 69:12 69:12 72:3 76:14 139:18 140:7 147:16 154:3 169:14 173:13 178:24 179:2 179:14 179:22 181:12 188:14 195:25 197:1 215:1 229:11 229:12 230:15 233:24	handles 80:7
ground 21:22 22:13 87:24 105:9 151:10 152:14 157:3 157:18		hanging 180:15 218:13
group 10:3 10:25 34:21 42:21 55:3 55:19 58:3 71:2 71:19 76:6 108:21 122:5 123:2 124:1		Hanna 57:16 57:17 138:21 205:5 205:7
		happen 6:8 64:13 78:9 78:10 114:11 126:4

135:3	149:9 149:21	214:16
happened 33:7	152:1 206:16	heavy 103:17
33:11 59:13	hear 6:21 46:1	height 16:3 16:15
112:17 119:4	75:18 145:5	16:17 16:19 17:3
119:8 119:18	145:8 151:20	17:7 17:10
120:17 148:20	163:17 238:16	18:1 18:17 18:18
happens 122:24	heard 6:25 8:16	18:19 18:21
207:22 223:25	14:12 16:17 30:2	18:23 18:25 19:4
happy 7:17 9:21	46:1 53:1 53:8	19:6 19:7
13:12 71:19 76:7	53:13 54:6 55:24	19:16 19:16
76:14 155:13	56:6 65:14 66:22	19:20 19:21 20:3
192:23 204:13	70:6 76:10	20:5 20:13 20:20
hard 138:9 158:12	106:25 119:4	21:2 21:3
195:13 203:2	135:6 135:7	21:20 21:22
203:21	144:15 145:10	21:24 22:4
hardly 87:7 88:15	149:1 150:19	22:5 22:6
89:8 92:25	150:22 151:6	22:11 22:15
Harrisburg 113:6	151:17 151:22	23:14 23:23
haul 151:10 152:6	152:3 152:4	24:14 25:11
haven't 14:11	152:11 152:21	26:17 26:20
16:21 27:22	155:14 155:15	26:22 27:6
70:21 150:22	176:24 183:4	27:8 27:9
152:21 192:22	186:18 186:25	27:13 27:23
196:17 203:24	193:23 195:17	28:11 64:1
223:1 223:24	225:20 230:22	64:3 71:10 87:24
having 8:22	233:16 233:22	94:13 94:22
14:2 42:16 59:22	234:5	95:21 96:5 96:13
67:21 69:17	hearing 5:5 144:4	102:3 102:4
128:23 152:1	152:16 238:20	103:16 105:5
173:6 177:20	238:21	105:9 105:16
217:4 226:16	heartened 151:20	105:17 108:3
226:16 226:19	heartening	109:6 109:14
Hawaii 129:6	145:5 145:8	143:4 175:23
133:19 135:6	heat 97:23	177:25 178:15
haze 53:12	100:9 100:15	178:19 179:1
53:24 56:10	109:20	179:19 210:6
68:14	heated 97:14	212:20 223:7
heading 226:18	heater 181:19	223:8 225:14
headquarters	heaters 182:6	225:15 226:15
164:15 164:16	heating 100:10	231:17 231:22
health 62:18	heavily 18:6	heights 16:14
	53:17 53:23	18:11 19:2
		22:3 28:9 85:5
		94:13 96:14
		96:15 98:15

108:5 109:9	218:10 220:1	167:5 167:15
109:16 110:18	220:24	187:13 193:24
110:18 110:19	he's 12:13	194:3 194:16
128:20 173:10	12:19 52:12	195:13 196:7
179:11 182:1	163:14 215:9	208:12 218:25
186:20 237:2	Hi 222:20 236:18	225:18
held 147:4	high 18:16	highest 7:19 31:4
He'll 52:6	23:13 24:3	31:12 31:15
Hello 132:10	24:5 24:11 32:25	47:14 72:25 81:2
198:13	72:5 72:6	81:13 87:17
help 7:8 7:14	72:15 73:1 73:17	88:11 89:2
9:20 14:18 14:19	75:2 77:17 92:19	89:3 151:11
14:20 33:2 38:13	92:19 94:24	158:15 159:11
42:23 61:8 61:15	96:11 104:6	160:12 160:13
62:20 75:25	104:7 105:4	160:17 182:11
127:15 129:4	105:4 105:5	230:16
157:18 177:18	105:13 105:19	highlighting 73:5
179:16 179:17	110:3 110:19	highly 33:3 33:21
187:3 187:5	136:12 137:22	41:5 93:6 164:4
190:4 191:14	138:9 138:10	high-quality
200:20 222:25	145:16 145:17	129:10
226:11 230:12	146:14 160:7	highs 167:6
helped 146:15	161:21 165:22	hill 148:14 171:9
177:19 218:8	168:11 168:11	hills 166:1 166:8
228:5	187:4 187:9	166:18 171:9
helping 59:5	187:18 189:8	171:15 171:18
125:18	208:15 212:8	172:13
helps 129:5	214:22 216:7	hilltops 168:11
here's 78:6 80:15	217:8 218:9	hilly 165:19
86:23 87:18	218:9 219:9	166:11
91:23 91:24	219:16 237:1	Hirtler 97:5
124:8 137:3	higher 18:22 21:9	historical 134:14
154:25 165:8	26:23 26:25 27:8	historically
165:9 165:16	31:6 63:24 63:25	229:1
165:24 166:10	70:2 71:25	history 175:5
166:13 168:1	73:2 73:11 74:14	hit 61:1 218:23
169:19 170:23	78:4 82:9	227:9
170:23 170:24	87:20 89:5 89:23	hits 95:16 171:12
171:1 171:1	92:13 92:22	hitting 36:20
171:4 171:7	111:20 112:18	94:20 214:23
171:8 181:10	114:7 116:1	
207:7 211:24	116:4 116:7	
216:1 216:1	116:9 116:15	
	116:19 123:17	
	138:8 145:13	

216:3 226:20	84:11 84:12 86:9	86:24 87:4
Hmm 154:19	86:20 87:1	90:8 114:5 120:8
HO 210:19	88:9 88:11	122:21 125:10
holds 116:25	90:4 90:7	162:3 169:25
198:2	90:15 90:20	184:15 194:7
Holston 165:24	90:24 90:25	194:9 212:5
home 9:14	95:21 97:25	214:21 216:10
162:13 163:2	109:7 109:15	216:24 219:8
hood 100:25 101:5	115:10 127:7	219:10 219:15
hope 9:3 155:12	156:25 173:22	219:19 220:8
197:22 228:9	176:15 195:6	220:17 221:6
237:14	214:20 214:20	221:13 222:9
hoped 114:11	216:7 216:7	222:11 230:17
hopeful 173:1	216:15 218:1	230:18 232:16
hopefully 4:5	218:16 218:21	237:3
4:16 9:10	221:8 221:20	hour's 83:24 90:5
13:25 91:3 153:6	221:21 222:6	house 204:2
hoping 149:4	226:9 230:1	210:18
151:21	230:11	how's 114:25
horizontal	hour-by-hour	Huber 20:14
19:15 33:13 41:7	102:2 102:5	Huber's 22:7
84:17 104:19	hourly 61:25	huge 50:17 152:22
126:13	77:10 78:22	206:7 225:3
host 200:14	81:14 81:16	hundred 36:13
200:24	81:20 81:25 82:2	50:21 80:10 85:4
hot 97:21 97:22	82:7 82:11 82:12	85:21 85:22
100:11 100:16	82:18 83:3 85:19	92:13 92:15
100:23 183:13	91:18 101:22	92:22 100:20
hotter 87:20	108:2 108:3	115:18 169:4
hour 8:16 23:23	108:5 109:8	Hundreds 50:17
38:4 38:15 71:23	112:25 115:10	Hunt 20:16
71:23 72:23	156:15 156:19	hybrid 98:12
72:23 74:2	156:23 158:9	HYSPLIT 31:5
74:2 74:24 77:20	159:15 159:23	31:14 34:23
77:23 78:8	161:24 162:4	
79:1 79:3 79:6	169:11 172:9	I
79:7 79:12 79:13	214:18 214:20	ice 122:4
79:15 80:18	215:22 219:1	ice-free 121:4
80:19 80:25	219:3 221:2	123:1 125:12
81:19 83:2 83:23	hours 29:5 35:8	I'd 9:16 11:5
	35:8 35:22 37:24	14:24 15:17
	37:25 38:3	
	80:5 80:5	
	80:11 81:19	
	85:25 86:3 86:17	

29:22 58:2	121:15 131:8	162:12 162:13
97:4 110:16	132:11 132:13	162:13 163:2
110:23 112:19	133:11 133:16	163:9 163:12
113:7 127:13	136:8 139:25	164:4 166:2
128:16 174:11	148:11 152:20	166:3 167:23
174:25 178:20	152:20 157:25	168:13 170:3
183:3 205:22	177:14 184:6	170:7 171:20
205:24 213:23	205:21 223:4	172:25 173:14
Idaho 45:3 61:7	223:10 235:25	174:17 174:24
idea 7:22 66:5	238:4	174:25 180:13
74:10 90:1	illustrate 185:20	180:17 180:19
134:24 192:16	illustrates 23:11	180:20 181:1
ideal 108:7	99:21	185:16 190:10
ideas 8:6	I'm 6:20 9:3 9:14	190:21 193:5
identical	9:14 11:2	195:1 198:13
107:18 108:8	15:16 16:1 17:10	198:16 204:8
identified 108:17	18:12 19:1	206:1 210:9
118:25 188:17	19:9 19:25 26:25	213:20 213:21
identify 118:1	30:3 33:1	218:14 221:10
120:22 121:16	39:14 39:22	222:20 222:21
124:16 124:25	41:10 42:12 43:9	223:3 228:17
138:11 183:11	43:12 44:23	236:18
188:20 190:3	44:24 48:4 52:17	image 178:17
219:12 236:11	58:9 68:1 68:3	imagery 121:23
236:16	68:23 68:24	imagine 96:6
identifying 96:1	70:11 74:13 79:3	154:12 172:7
Ides 127:8 127:9	81:8 83:15	immediately 33:15
ignored 122:8	84:6 87:16	33:16
122:19 144:19	90:1 92:5 95:6	impact 76:7 94:17
ignores 128:6	95:22 95:22	151:11 162:8
IHOP 210:17	95:22 106:23	166:22 182:23
211:13	107:1 108:11	185:14 186:1
II 43:17	108:25 112:22	186:6 189:24
I'll 9:25 13:3	112:23 115:8	191:17 191:17
17:1 17:8	119:4 127:12	217:4 226:20
17:24 19:11 20:3	127:16 127:18	226:22 227:10
28:20 31:23	139:23 139:23	227:10
33:24 48:7 52:22	140:3 140:4	impacted 161:19
59:19 60:13	140:22 148:13	impacting
66:11 76:15	148:14 148:15	219:13 221:8
112:16 119:5	149:4 150:1	impacts 54:1
	150:23 151:7	69:15 71:6 73:22
	151:21 152:20	134:4 140:17
	152:22 153:14	
	156:4 162:12	

150:8 150:24	important 7:9	142:6 144:18
151:1 152:2	7:13 25:1	146:16 146:17
153:1 155:19	30:22 32:4 33:13	146:19 146:24
177:2 177:9	37:17 47:17	192:25 197:10
177:23 178:13	47:22 58:23 63:2	233:21 234:3
179:25 180:1	104:8 105:2	234:4
182:22 182:25	111:24 120:10	improves 47:12
183:12 185:24	134:5 138:2	47:13 94:5
187:4 187:12	138:11 138:13	improving 63:9
189:8 191:11	139:6 139:12	145:2 147:19
191:12 196:9	140:14 141:3	233:14
196:18 221:14	164:19 164:20	impulse 105:12
226:16	164:20 182:16	inaccurate 57:4
impairment	189:2 189:3	146:11
53:20 146:12	189:15 197:12	inadequacies
imperative 234:24	202:11 209:3	146:9
implantation	209:5 219:12	inadequacy 146:13
232:17	234:12	inadequate
implement	impose 67:5	63:13 106:5
107:13 146:5	imposes 140:19	inappropriate
implementation	impossible 84:2	41:22 154:3
43:18 56:10	84:2	229:11
56:11 70:7 74:12	impressed 162:25	inaudible 45:12
76:14 140:14	improve 37:10	106:2 120:24
189:10 190:4	58:21 62:21	198:2
190:5 228:22	71:11 76:11	inch 38:9
234:13	105:13 105:17	incidentally
implementations	106:10 145:21	213:8
49:25	191:23 192:7	include 49:20
implemented	improved 59:15	61:22 65:23 67:1
46:8 151:16	63:11 65:10	124:20 170:22
154:10 231:5	67:11 67:11	202:14 202:23
implementing	106:3 131:23	203:11 227:25
141:2 233:20	211:12 233:4	228:6
implements 146:24	233:24	included 70:9
implications 69:7	improvement	93:3 113:24
130:7	28:8 46:24	204:10 233:3
implies 137:16	83:1 123:6	234:19
importance	151:16	includes 43:22
97:12 145:24	improvements	43:25 51:1 203:9
147:1 169:17	46:22 51:1 55:15	223:7
	67:8 75:18 97:11	
	130:20 142:4	

<p>including 17:22 58:4 59:4 59:13 73:1 105:1 113:3 145:6 190:15 232:11 233:13 233:16</p> <p>inconsistent 27:9</p> <p>incorporate 62:21 98:17</p> <p>incorporated 102:20 126:14 130:23 131:12 177:6 234:7</p> <p>incorporating 58:20 62:16 63:11</p> <p>incorporation 99:10</p> <p>incorrect 37:21</p> <p>incorrectly 37:3</p> <p>increase 4:9 4:10 16:6 20:5 20:19 21:7 22:3 22:4 24:5 24:7 24:23 26:18 26:20 26:23 27:6 27:7 67:13 160:13 178:5 194:21 225:14 227:22 231:24 232:15</p> <p>increased 21:23 22:12 87:3 103:11 113:24 114:17 114:19 114:20 155:15 161:25</p> <p>increases 15:22 71:11</p> <p>increasing 61:3 61:8 225:13 228:25 234:22</p>	<p>increasingly 58:13 229:8 234:12</p> <p>Incrementally 46:8</p> <p>independent 18:4 18:6 137:21</p> <p>independently 115:21</p> <p>Indiana 85:15 87:5 108:17 111:18</p> <p>indicate 109:24 192:25 195:12 195:21 216:2</p> <p>indicated 146:18 192:24</p> <p>indicates 37:2 82:25 103:25 104:3 105:1</p> <p>indication 159:16</p> <p>indications 191:25 192:6 197:20</p> <p>indicative 123:10</p> <p>individual 108:21 109:15 109:16 183:11 184:19 226:21</p> <p>individuals 140:21 236:11</p> <p>industrial 68:9 68:18 140:20 180:23 182:6 200:4 215:5</p> <p>industrialized 214:16</p> <p>industries 68:25 97:13 141:1 151:21</p>	<p>industry 10:4 10:12 47:6 53:10 68:5 74:22 97:6 97:13 98:6 98:23 130:20 131:9 145:6 145:14 145:17 145:18 145:19 145:20 145:25 145:25 146:13 146:16 147:20 148:1 149:16 150:9 151:9 176:22 189:18 189:19 233:14</p> <p>industry's 145:15 151:22</p> <p>infinite 138:8</p> <p>infinity 130:25</p> <p>inflation 128:12</p> <p>influenced 88:5 89:25 92:6</p> <p>influencing 178:19</p> <p>information 11:22 13:9 15:11 29:21 29:23 31:1 43:1 53:19 67:15 70:17 70:24 90:15 90:22 140:24 142:24 144:8 146:17 156:9 172:22 199:20</p> <p>informed 55:25</p> <p>inherent 72:13 213:2</p> <p>inherently 72:11</p> <p>inhibiting 144:20</p> <p>in-house 103:22</p>
---	---	---

initial 32:22 32:24 43:14 63:4 109:1 175:9 214:25 216:6 216:11 217:12 217:19 218:4 218:16	instantly 130:25	202:11 202:14 202:15 202:16 202:19
initially 136:22 156:8 175:17 177:20	instead 60:3 189:22 206:7 219:19	interfaced 39:21
initiate 33:12 179:24	Institute 54:25 58:5 97:7 111:17 198:18	interim 201:6 237:1 237:18 237:18 237:25 237:25
INP 115:1	Instituting 43:19	interject 4:23
input 13:16 14:23 32:6 42:23 132:3 143:3 147:12 173:14 174:3 185:13 197:15 197:23 208:2 232:9 238:18	instructed 176:25 178:6	intermittent 236:20 236:21 237:14
inputs 49:13 70:22 141:13 208:3 210:5 227:17	instrument 135:8	internally 11:13
inside 123:18	integral 232:7 232:25	international 210:20
insights 148:4 190:18 198:7	integrated 38:14 109:20	interpolation 40:7 40:13 40:18 40:19 41:7 41:12 61:10 61:15 205:20
insists 67:3	intelligent 163:1	interpretation 124:8 124:16
in-stack 75:9 195:23 196:4 196:5 196:21	intended 181:22 195:12	interpreted 208:1
installed 171:2	intends 107:10 143:7	intersected 94:23
installing 198:6	intensive 102:16	interspersed 108:9
instance 75:24 138:6 185:14	intent 120:13 120:14	intertwined 28:1 28:2
instances 142:19 144:6 185:3	interest 12:20 13:2 47:19 112:14 209:24 212:22	introduc 12:9
instantaneous 206:13 207:16	interested 8:4 8:15 8:18 8:20 11:18 12:22 14:16 74:13 106:12 106:14 145:14 145:25 206:15	introduce 139:25 148:12
	interesting 74:18 80:5 92:20 93:6 114:21 116:23 154:6 172:7 237:7	introduced 21:16 162:1
	interface	introduction 12:9
		introductory 198:20
		invented 200:2
		inventories 134:13 135:1

inventory 134:15 134:16 136:11	38:9 41:18 93:15 108:10 136:17 219:4 237:20	119:22 126:22 132:14 140:23 140:24 145:7
Inversion 12:13	isolated 134:3 184:19	145:13 145:16 145:24 147:1 147:5 147:12
investigation 83:15	ISORROPIA 43:23 46:14 46:16	147:22 148:2 150:17 189:6 190:14 197:4 234:14
investigators 54:6	47:11 47:24 49:15 49:17 50:9 50:21	italics 16:12
investor-owned 53:15	isotropic 85:15 89:2	it'd 58:24
invited 234:16	issuance 14:5	items 7:8
inviting 9:17 9:18	issue 7:13 7:21 23:6 23:10 38:10	iteration 122:2 122:3
involved 9:23 11:11 13:24 14:20 20:15 28:24 53:17 132:17	64:18 73:8 93:5 95:23 96:1 96:8 103:14 111:11 111:13 117:4 121:9 130:16 133:4 136:24 139:16 144:21 144:25 145:17 145:20 146:2 146:14 152:23 154:5 172:16 178:22 184:1 184:2 184:8 197:12 236:23	iterations 122:17
involvement 13:20 42:19	issued 14:13 237:7 237:13	it's 6:21 6:23 9:6 11:8 15:4 17:3 17:19 18:15 18:15 18:16 18:21 18:22 20:20 22:2 23:5 23:9 23:9 23:12 23:12 24:9 24:16 24:18 24:19 25:1 25:10 26:1 26:9 27:17 27:20 28:18 30:24 32:9 33:3 33:7 33:18 36:4 38:7 38:9 40:2 40:10 41:6 41:19 43:2 48:12 51:17 57:25 58:23 61:17 67:23 68:7 68:24 69:2 72:9 73:25 75:6 76:9 79:22 82:10 82:10 82:12 82:19 84:19 89:11 94:10 95:23 100:5
involving 206:9	issues 6:22 7:3 7:17 7:20 8:21 9:2 10:3 10:17 10:23 11:17 12:15 12:18 13:25 14:18 39:1 51:4 53:18 55:4 59:16 59:20 60:2 64:14 69:8 69:20 76:11 79:20 91:12 97:8 111:15 111:24	
Iraq 210:14		
iron 10:2 108:15 111:16		
Irwin 108:13 108:20		
Irwin-recommended 109:6		
ISC 84:6 84:22 84:22 84:23 85:1 87:11 88:16 89:2 89:11 98:18 101:21 109:2 152:25 153:5 153:5 154:10		
ISHD 112:25		
island 80:2 80:12 80:16 81:12 109:20		
isn't 27:16		

101:6 101:7	193:3 195:15	joke 170:17
101:14 101:14	195:17 198:4	Jones 174:23
101:17 102:16	198:15 204:19	174:24
102:19 103:14	206:18 207:8	Joseph 15:18
103:20 107:23	207:9 209:21	judgment 173:2
107:23 107:25	210:20 214:13	217:6
111:11 114:21	219:2 219:3	jump 20:25
115:16 115:16	220:9 220:25	119:5 223:4
117:11 119:23	221:1 221:11	jumped 71:24
120:1 120:3	224:17 224:18	jumps 24:16
120:4 123:5	225:22 237:7	June 118:12 119:7
123:18 124:6	I've 5:19 6:19	164:11
124:16 125:16	65:14 67:7	June's 94:11
126:5 128:7	89:9 114:23	justification
128:22 130:21	116:2 118:10	225:22 232:17
133:10 133:18	127:7 153:6	justified 16:20
134:3 134:4	156:18 165:2	61:9 232:19
134:19 135:6	169:3 171:20	Justin 228:9
137:20 138:8	215:12 218:10	228:11 228:16
138:9 138:10		235:14
138:11 138:12		
139:6 144:8	<hr/> J <hr/>	
144:16 148:17	James 119:21	
149:16 149:23	Janet 8:11	
150:13 153:15	Jeff 211:22	
153:23 155:7	Jeopardy 237:23	
158:6 158:11	Jing 102:25	
158:23 161:14	102:25	
162:10 163:23	job 149:18 149:20	
163:23 164:9	214:1	
164:15 164:24	jobs 149:9	
165:9 165:24	Joe 12:9 13:6	
165:25 166:6	28:16 28:17 43:9	
166:8 166:8	52:1 53:2 53:8	
166:11 168:2	54:6 55:5	
169:17 169:21	55:11 55:24 56:6	
170:11 170:14	56:20 56:21 65:8	
170:15 170:18	77:25 206:1	
171:3 172:1	Joe's 12:10	
172:4 172:7	John 108:13	
173:5 181:16	108:20	
181:17 181:18	joined 8:12	
181:25 182:2		
182:24 183:22		
185:24 190:12		
192:1 192:18		
		<hr/> K <hr/>
		Kalisz 58:5 67:15
		Kansas 113:9
		122:10 210:22
		211:25
		Kentucky 165:11
		key 17:5 17:5
		99:22 140:7
		147:13 148:2
		206:21 208:23
		keyboard 222:17
		kicking 152:8
		kilometer 29:13
		30:1 32:24 34:11
		34:12 36:8 36:24
		64:8 64:24 83:13
		85:9 85:22 85:22
		86:7 86:8 88:2
		95:12 104:17

103:9 103:9	left-hand 35:14	level 4:8 21:22
103:13 103:13	leftovers 12:24	22:13 36:12
103:14 105:21	legacy 199:21	42:20 71:6
185:3 209:22	legitimate 72:2	73:1 73:7
210:4 210:21	legs 171:18	75:23 79:24
211:1 226:5	leisure 204:19	94:19 95:25 96:7
226:8	205:3	96:19 103:21
layering 33:16	length 17:18 22:9	104:6 104:7
layers 210:19	23:10 23:16	106:6 120:13
layout 178:17	23:25 24:4 24:12	151:10 157:18
lead 68:15 133:12	24:14 24:20	212:10 229:6
137:1 232:20	24:21 25:1	levels 36:12
234:25	25:1 26:2 28:1	73:12 73:21
leading 15:21	28:3 28:4 28:7	135:4 156:11
22:21 58:3	99:8 178:20	leverage 235:11
211:21 228:18	lengths 17:17	liable 93:2 93:4
leads 64:19	lengthy 14:6	Lieberman 215:19
74:9 96:6 146:11	146:23	life 95:19
200:6 232:15	less 16:16	light 36:23
233:4	17:12 21:6 30:15	80:1 80:8
leaks 97:22	33:18 36:4	81:19 82:22
100:21 100:22	36:7 47:22 47:24	82:23 83:24
learned 121:8	48:16 49:1	94:12 96:9
155:1 190:19	49:3 50:2	111:22 112:12
learning 166:3	54:20 74:3	120:5 130:21
166:3	74:3 86:2 87:2	144:1 162:2
least 18:10 34:14	89:4 94:13	171:11 171:19
42:19 47:10	99:1 114:10	174:10
51:21 52:3 56:24	116:3 130:5	lighter 178:20
73:22 78:9	130:5 145:8	lighthouse
87:7 93:13 117:2	145:25 162:5	83:22 83:23
134:12 173:8	173:5 215:25	86:19 171:11
236:7	226:24 230:22	likelihood 130:13
leave 106:14	231:16	likely 15:5
115:14 205:21	lesser 20:9	15:8 36:7
237:8	let's 4:7 5:19	69:19 176:20
Lebeis 236:18	57:13 76:20	178:22 183:2
236:18	89:21 91:14	183:7 183:13
led 154:9	95:14 103:19	likewise 68:13
201:22 202:1	154:5 173:7	231:12
212:9	180:7 213:16	limit 48:24
	216:3 235:20	49:2 49:3 64:8

64:11 64:24	152:5 152:11	57:23 59:17
90:12 185:25	152:14 152:17	65:16 66:12 67:1
204:9 214:7	158:25 159:7	71:14 72:14 76:6
limitation 105:25	159:7 176:24	82:3 82:9
106:1 108:12	202:19 206:14	82:11 82:12
177:4	207:14 207:16	82:13 89:9
limitations	208:8 223:22	93:8 93:22
48:7 60:3 81:8	223:23 223:23	106:23 107:21
83:16 107:14	227:23 232:2	110:3 117:1
110:12 110:13	linear 99:19	124:6 126:21
197:4 229:19	129:14 168:2	132:16 137:18
limited 7:4 7:5	lines 22:2	152:21 158:11
14:20 74:15	97:18 99:8	163:10 164:8
82:20 90:2 107:3	193:20 207:12	164:13 166:13
108:18 153:11	207:13	170:17 172:4
173:17 198:25	linked 203:24	172:5 184:9
limiting 45:6	linking 203:25	199:4 202:1
46:19 132:21	Linux 202:18	215:8 220:3
188:7	202:18	222:22 223:24
limits 69:23	liquid 44:5	224:22 225:18
73:16 73:17	44:7 45:13 46:18	live 91:15
73:18 143:4	list 17:11	living 171:12
230:4 230:23	52:10 60:11	Lloyd 12:10 12:14
line 19:19	107:9 145:8	15:14 15:15
19:22 19:24	223:4 223:16	28:14
20:11 20:12	227:25 228:5	load 191:12
20:24 21:5	listed 10:25 11:3	191:18 191:24
21:5 21:12 25:10	13:3 97:10 115:3	230:18
25:14 36:13	231:7	loads 191:21
36:15 45:22 46:5	listen 4:12	lobes 77:24 78:9
50:16 50:17 64:7	listening 60:23	local 29:5
66:15 97:9 98:11	literature	66:20 92:12
98:13 98:24	51:12 201:21	147:7 191:5
98:25 99:5	little 4:5 4:12	198:8 233:12
99:7 99:7	4:14 5:1 6:11	234:17
99:17 99:18	8:10 9:11 10:1	locate 169:9
99:22 100:2	12:5 18:21 19:11	located 99:13
100:6 101:23	22:16 23:5	157:9 157:12
101:23 102:13	23:9 30:2	157:13 169:5
102:15 106:22	33:25 46:17	location 40:9
107:1 107:8	48:25 49:1 50:15	40:15 122:10
115:18 128:21	52:8 52:9	157:8 170:10
128:21 137:5		170:15 193:17
143:19 150:21		

198:4 223:9	50:12 58:16	104:5 104:7
locations 114:9	58:22 60:20	104:14 105:20
163:7	61:16 63:8	106:24 107:4
Logan's 185:17	64:8 64:14	114:20 117:4
logistics 5:2	65:4 66:23	118:20 119:12
long 11:2 17:16	67:4 75:15 75:16	120:23 124:21
20:21 23:12	76:12 92:7 97:14	126:23 143:2
24:21 25:10	101:3 112:12	144:15 145:22
78:18 78:19	112:18 114:5	150:19 151:6
78:20 97:18	114:7 117:19	152:14 186:13
107:17 107:22	125:17 125:18	186:19 186:22
108:8 150:4	128:24 135:3	186:24 188:6
165:12 165:13	135:7 138:12	189:6 194:9
166:23 167:4	138:15 139:9	194:22 196:23
169:21 213:20	144:15 145:10	205:9 214:21
213:21 221:15	151:17 162:1	214:22 223:11
229:4 237:18	164:3 165:10	230:13 232:14
237:25	166:1 175:2	232:16 233:6
longer 58:14	175:11 198:2	lower 24:23 31:14
116:8 151:4	198:14 205:23	60:19 64:2
176:8 176:16	209:10 210:21	70:3 73:13
176:19 231:9	211:19 212:17	75:7 75:16
long-range 13:5	214:9 215:10	88:6 112:17
66:24 206:7	225:11 225:20	116:15 139:5
Longview 163:8	225:24 225:25	160:8 187:21
214:13	226:16 227:21	193:25 194:1
loop 72:12	227:24	195:14 195:18
loose 81:11	lots 33:14 46:1	226:12 226:21
82:3 82:12 83:6	loud 151:22	227:6 227:7
lose 23:1 149:4	love 174:11	227:7 227:7
loss 105:14	227:13	lowering 226:14
lost 119:16	low 18:15 30:15	227:10
119:25 120:15	31:15 47:16	lowest 30:12
123:3	59:15 60:8 60:18	47:14 92:24 93:7
lot 7:14 7:23	60:21 61:7 61:17	121:5
8:16 8:23	63:23 67:9 72:11	luckily 169:18
21:18 21:18	75:12 77:16	lucky 139:9
32:11 32:20	77:22 77:22	lunch 117:13
33:13 33:22 42:5	79:24 80:5 82:11	127:2 127:4
43:1 45:2	84:1 91:11	220:4
47:15 47:19	92:1 93:11 94:18	luxury 164:2
	94:21 95:15	
	95:21 95:25 96:5	
	96:7 96:8 96:9	
	103:20 104:1	
		M

machine 202:21	manuals 202:23	200:11
mack 98:7	Manuel 153:5	matters 32:20
MACS 206:19	manufacturing	33:22
MACTs 68:14	149:17 150:9	max 87:15 88:12
MADRID 200:10	163:7	maximize 221:13
magenta 158:16	map 91:23 181:10	maximum 19:8
magnify 54:17	March 4:3 127:9	20:18 21:6 21:22
magnitude 4:8	171:6 236:22	22:13 24:16
26:20 26:23	237:4	24:19 69:23
magnitudes 80:20	marigold 123:15	87:24 134:11
main 12:2	mark 11:1 60:7	158:7 182:9
117:25 151:8	148:11 148:14	182:12 216:17
223:5	156:1 180:8	219:22 219:25
mainly 70:4	180:17 186:11	224:3 229:25
major 54:2	Marko 103:2	may 6:8 54:13
63:14 66:15	Martin 218:16	68:15 69:18
68:10 74:24	Maryland 190:11	74:15 76:6
99:11 163:7	191:3 191:8	83:6 87:25 90:11
229:13	mask 135:22	93:20 93:21
majority 230:17	138:12	94:11 105:20
MALE 168:25	masking 137:9	107:5 107:10
manage 13:13	mass 24:17	111:14 111:21
managed 58:4	38:21 38:22	120:5 135:24
Management 9:15	38:25	145:25 149:10
117:10 118:12	Massachusetts	153:3 153:13
119:7 203:16	15:16	155:22 155:22
manager 198:17	massive 100:23	159:22 172:13
managers 45:8	match 36:25	202:6 203:6
47:19 55:12	41:9 107:22	203:12 219:9
55:14 55:20	107:25	221:20 224:15
mandatory 14:3	matching 48:12	224:21 226:5
Manhattan 122:10	136:4 137:16	226:14 229:17
manipulate 227:18	material 29:2	237:25
manner 149:9	32:3	maybe 7:24 8:5
229:2	mathematical	13:24 15:11
Manual 153:5	20:23 168:8	25:16 25:18
153:6	170:6	33:18 36:4 39:16
	matter 101:4	45:8 49:19 50:10
	124:18 124:19	59:3 59:6
		60:25 72:23 82:3
		82:14 95:22 96:8
		96:16 96:19
		117:23 123:10
		126:4 147:9

<p>150:5 151:3 151:14 151:23 152:19 173:17 221:25 223:1 224:5 224:10 226:24 228:2 237:3</p> <p>McCabe 8:11</p> <p>McCarthy 8:20</p> <p>MCHEM=6 48:10</p> <p>McNally 210:13</p> <p>McQueen 211:23</p> <p>MD 169:2</p> <p>MDMT 169:2</p> <p>Meadow 166:16 171:17</p> <p>mean 6:3 6:4 28:1 32:11 36:6 42:20 57:3 100:23 110:21 120:11 122:9 122:16 123:16 124:10 124:24 125:15 126:3 128:3 135:1 135:12 138:8 153:5 166:8 170:20 210:25 211:1 211:2 211:3 224:18 235:16</p> <p>meander 78:2 78:5 79:22 90:18 161:25 221:18</p> <p>meandering 104:7 104:20 105:1</p> <p>meaning 128:1</p> <p>meaningful 142:12 142:16 144:2 147:8</p> <p>means 39:15</p>	<p>104:10 104:10 116:4 142:12 145:12 205:15 208:18 228:2</p> <p>meantime 57:6</p> <p>meanwhile 131:18 131:18</p> <p>measure 99:25 128:10 135:17 135:18 157:16 182:19 190:25 191:2 207:20 237:1</p> <p>measured 25:5 25:8 26:10 37:1 129:21 134:7 141:21 182:10 182:10 182:20 192:5 193:6 193:15 195:2 195:3 195:20 195:22 196:13 196:14 210:21 211:18</p> <p>measurement 174:17 184:11</p> <p>measurements 45:17 45:20 54:7 56:6 128:11 136:17 172:23 173:8 173:10 173:12 229:10</p> <p>measures 33:20 37:12 43:6 43:7 75:21 191:17 206:21 208:14 209:8</p> <p>measuring 38:19 49:6</p> <p>mechanical 94:12 94:14 94:22 186:20</p>	<p>mechanism 131:11</p> <p>medical 52:5</p> <p>medium 181:19 182:18</p> <p>meet 128:23 214:7 216:16 222:25</p> <p>meeting 10:9 11:14 15:3 48:3 55:3 55:14 63:18 65:15 65:15 111:17 124:15 147:6 209:16 233:17</p> <p>meetings 6:16 8:13 8:18 10:8 10:19 11:13 147:13 234:11</p> <p>meets 124:9</p> <p>megawatt 156:25</p> <p>member 10:9 155:22</p> <p>members 10:6 10:25 13:15 53:20 57:20 58:7 140:7 142:4</p> <p>membership 11:17 13:2</p> <p>memo 5:25 27:15 121:8 125:16 236:22</p> <p>memorandum 16:21 16:25</p> <p>memory 77:7</p> <p>memos 179:4</p> <p>mention 20:11 30:5 39:6 43:5 49:8 53:9 54:6 55:24 74:21 107:4 138:24</p>
--	---	--

152:4 206:23 mentioned 5:20 14:25 30:20 37:19 40:6 52:19 57:18 60:5 60:9 61:2 65:5 107:10 108:2 111:16 119:19 119:21 121:22 125:19 126:12 177:3 192:24 197:14 200:11 215:5 215:8 215:22 217:20 218:11 220:4 mentioning 117:9 merge 79:7 79:14 177:16 merit 30:3 30:4 30:5 30:12 32:8 MESOPUFF 47:23 47:24 49:2 49:2 mesoscale 206:9 207:20 message 74:5 met 21:25 34:13 54:3 55:11 55:20 85:11 92:2 121:21 124:25 125:21 166:5 168:24 169:2 169:6 169:16 170:10 173:23 178:7 178:9 183:25 190:16 197:2 197:15 198:6 210:8 213:1 218:25 219:1 219:3 223:10 224:8 224:15 224:18 metals 97:13 metadata 112:9	117:20 118:1 118:3 121:16 meteorological 37:4 39:14 63:19 64:4 66:3 77:10 79:21 84:10 89:18 102:17 110:13 112:5 116:13 120:8 120:15 131:3 132:25 156:9 183:21 184:12 186:5 187:2 187:17 188:1 188:18 189:5 189:13 194:4 207:14 209:18 209:23 211:20 233:5 meteorology 9:16 34:1 87:13 95:4 103:6 109:10 143:13 156:24 158:9 158:10 159:14 159:20 161:15 Meteorology's 103:24 meter 38:7 66:9 85:5 85:20 87:8 114:10 115:4 115:4 115:24 119:9 123:3 129:20 169:4 178:15 205:14 205:16 207:23 211:2 213:3 meters 18:16 18:16 18:20 18:23 19:3 36:11 36:13 92:13 92:22 94:15 96:11 100:20	103:22 104:2 105:9 105:10 110:23 111:2 115:19 130:17 130:19 153:20 153:20 153:21 173:9 175:22 175:22 175:23 176:10 176:11 176:14 176:16 178:1 178:5 179:2 185:23 186:1 186:21 188:8 205:19 211:2 211:4 212:20 212:21 method 45:6 60:7 63:22 63:25 100:4 124:17 124:20 129:13 132:21 212:10 216:6 219:14 methodology 75:1 220:12 221:19 methods 67:8 206:3 210:3 231:17 Mezzo 211:17 213:12 mic 205:1 235:19 Michael 97:4 micrograms 71:7 71:8 129:19 178:12 182:13 microphone 4:22 5:9 222:15 222:19 238:5 microphones 236:15 middle 23:4 23:4 23:17 73:10 78:2 87:19 87:23
---	--	---

122:17 165:8	155:22	mixed 132:22
208:6 208:9	Minneapolis 113:8	mixing 63:5 66:10
209:5	117:17	66:12 94:12
middles 230:10	Minnesota 125:17	94:15 94:22
Midwest 192:13	minor 128:25	95:21 96:5 96:12
MIFF 35:5 174:3	minus 40:11 40:12	96:14 96:15
mightier 193:19	127:24 157:19	105:4 105:15
Mike 213:25	213:7 217:1	105:16 186:20
213:25 236:18	minute 53:9 55:25	212:18 213:6
mile 80:2 80:12	76:20 77:2 78:15	MM5 30:1 34:11
80:15 81:12	81:15 81:21	34:12 35:4
154:1	82:14 83:5	35:4 35:16 35:25
miles 153:25	83:7 113:3 113:3	36:8 36:13 36:18
154:1 166:1	119:20 120:2	36:22 36:24
224:18	150:20 156:17	36:25 39:17 40:4
military 67:3	156:25 158:1	40:7 40:9
206:15 206:24	186:9 235:18	40:11 40:15
mill 72:1	minutes 44:23	40:17 40:17
million 49:22	49:9 58:10 67:21	40:24 41:3 41:13
50:3 169:2	78:18 78:19	42:1 44:5
169:16 170:19	78:23 78:24	45:15 46:18
192:18 224:15	78:25 79:6	191:4 191:5
millions 50:18	82:4 82:10 85:20	198:1 210:10
mills 68:19	100:22 148:19	210:14 211:20
69:3 69:13 71:17	163:16 174:20	211:21 211:24
72:9	180:21	212:16 212:21
mind 133:5	mired 233:25	MMD 184:12
134:6 149:6	misaligned 38:4	MMIF 29:25
162:22	miss 32:10	33:23 39:8 39:22
Mine 153:23	33:10 36:7	39:24 40:7
mineral 224:5	missed 153:3	40:7 40:8
minimal 130:14	missing 36:20	40:11 40:18 41:2
minimize 138:17	120:8 122:21	41:4 174:1 174:1
225:9	122:23 194:7	190:16 197:15
minimum 59:23	194:16	197:22
61:8 66:8 205:13	mission 103:4	mobile 196:17
213:2 216:17	152:7	mode 33:4 40:3
mining 149:16	mitigation 191:17	41:9 87:12
151:8 151:9	Mitt 111:5	113:12 131:21
	mix 139:5	model 12:12 13:11
		16:10 16:13
		16:16 16:24
		16:25 17:6 17:13
		18:5 18:9

18:24 18:25	105:14 106:3	200:3 200:9
21:13 25:2 25:25	106:13 111:5	200:14 200:15
26:21 27:15 28:4	114:5 114:17	200:17 200:20
31:3 31:21 31:24	117:1 118:6	200:24 201:5
32:21 32:23 33:1	118:7 118:7	201:23 202:4
33:3 33:4 36:3	118:7 122:9	203:3 203:7
36:5 38:14 39:14	127:24 128:16	203:9 203:10
41:21 41:22	129:22 130:8	203:16 203:17
41:23 41:24	130:9 130:11	203:23 204:1
42:13 42:19	130:18 130:20	204:2 204:4
42:22 43:11	130:23 130:24	206:24 208:2
44:12 45:3	132:14 132:19	208:7 208:16
46:4 49:11 49:18	133:8 136:1	209:6 209:12
53:1 53:11 53:25	137:12 137:14	210:5 210:6
54:3 54:10 54:17	141:9 141:11	210:8 213:1
54:20 55:5 55:16	141:16 141:18	223:6 223:14
55:16 56:2 56:15	141:23 143:23	224:3 224:13
56:23 57:2 57:11	143:25 146:8	225:1 225:20
60:20 61:24 62:5	146:21 151:11	226:2 227:15
62:21 62:25 63:1	152:25 153:4	227:19 229:18
64:15 65:24	157:8 157:21	229:23 230:6
66:21 67:2 67:11	158:14 159:5	230:16 231:3
69:24 72:3 73:13	159:12 160:24	231:6 231:9
73:22 76:11	161:2 161:17	231:10 231:13
78:13 80:21 81:3	161:18 162:4	231:15 231:19
81:16 81:17	167:9 167:24	231:22 232:5
81:20 81:22 82:1	168:1 168:2	232:8 232:20
82:11 82:13	168:8 168:10	232:20 232:22
82:15 83:11	169:12 171:9	233:5 233:8
83:17 83:17 84:7	172:17 175:13	233:20 234:1
84:9 84:10 85:10	176:25 177:1	234:3 234:4
86:19 86:22	177:21 178:1	235:3 235:5
87:10 88:17	179:25 181:7	235:6 235:12
88:17 88:24	183:14 183:14	modeled 19:23
88:25 89:10	183:20 183:22	19:25 21:13
89:10 90:8 90:13	183:24 184:7	21:15 39:5 45:16
90:23 91:6	184:9 184:12	71:22 72:16
91:9 91:14	185:14 186:12	72:24 75:13 93:9
93:1 93:2 93:3	187:1 188:2	93:10 95:2
93:12 93:16	188:10 188:18	95:4 111:18
93:24 94:5 94:20	189:4 192:4	115:21 136:16
96:17 98:1	192:7 192:21	136:21 142:21
98:1 98:14 98:17	196:21 197:7	143:5 156:23
98:22 99:14	197:9 198:8	156:25 157:7
99:14 104:18	198:14 199:12	159:4 161:20
104:23 105:2	200:1 200:2	167:13 193:11

193:13 208:16	156:10 156:15	89:8 98:8 107:15
225:4 226:12	156:21 157:2	127:17 128:15
229:20 231:24	159:13 159:17	130:12 131:20
232:16	159:21 159:25	131:23 136:6
modeler 55:5	160:2 160:11	140:6 140:11
162:22 162:23	160:11 160:22	140:13 140:17
167:10 167:23	161:23 162:7	141:2 141:4
modelers 113:8	162:24 163:2	141:5 141:20
114:24 147:6	166:3 166:21	142:2 142:5
166:21 234:18	169:13 170:18	142:11 142:13
modeling 9:18	172:12 173:3	142:15 143:11
10:2 10:3 11:5	175:7 176:7	143:12 144:13
11:12 11:19	177:24 180:24	145:3 146:5
11:20 12:2	181:8 181:15	146:25 147:19
12:6 12:7	183:16 189:2	148:3 152:17
12:16 14:4	191:6 191:13	157:24 159:2
14:5 15:1	192:9 192:11	164:4 172:10
26:17 28:11	199:8 211:24	184:24 185:7
37:14 42:14	224:11 227:19	185:12 190:5
44:25 51:14	227:20 228:21	190:14 191:1
54:24 55:3	229:14 230:10	199:25 204:6
55:4 55:19 57:10	230:12 232:8	205:24 207:3
58:1 58:16	233:17 233:19	208:3 208:11
59:8 59:25	233:20 233:24	208:13 209:4
60:1 63:7	234:3 234:11	209:18 210:4
68:21 69:5	234:13 234:15	210:14 210:24
69:8 69:20	235:10 235:11	211:9 211:10
71:3 91:10 91:13	models 26:13	211:20 212:13
97:8 97:10	28:25 29:17	212:14 225:20
98:9 99:23	30:13 30:16	227:14 227:20
101:18 102:8	31:16 33:15 36:2	228:25 229:6
102:11 102:14	40:20 41:20	229:8 231:1
106:22 109:9	42:10 42:17	231:5 233:16
114:23 114:25	43:24 50:1 51:13	233:24 234:22
132:1 140:12	54:22 57:22	234:25
140:23 141:4	58:18 60:16	model's 42:20
141:6 142:8	62:11 62:17	141:10 142:24
143:21 143:22	63:11 64:4 64:24	Models 4:2 228:25
143:24 145:6	65:5 65:13	modern 184:4
145:7 145:13	66:3 66:6 67:4	191:1 193:14
145:17 147:2	69:2 75:19 76:11	modes 113:11
147:5 147:12	82:2 82:7	229:10
147:14 147:16	83:16 83:18	modification
147:20 147:22	83:21 84:5 84:12	106:10 231:10
147:23 156:6	84:25 85:3	
	87:9 87:12	

235:3	214:23 215:2	morning 5:2 5:3
modifications	216:3 216:13	6:18 8:13 9:13
142:13 143:7	216:20 218:18	15:14 28:17 52:2
187:16 230:25	218:19 218:23	52:15 56:21
231:3 235:4	219:13	67:18 67:23
235:7	monitored 93:3	76:18 76:24
modified 35:8	96:21 136:15	112:3 127:1
45:5 67:1 105:21	141:19 179:25	148:17 178:22
142:15 143:4	192:5 221:14	186:4 186:18
module 44:10	monitoring	Morris 203:18
45:13 55:1	58:15 58:20	mostly 15:23 17:9
55:7 107:8 200:3	59:25 67:11 91:7	mountain 157:17
modules 54:19	91:13 137:20	157:17 165:22
146:16 200:16	158:20 168:16	170:12 171:10
200:17 201:7	182:10 183:17	171:13 171:14
201:11	224:9 225:2	mountains 166:7
moment 70:10	229:16	207:9 207:17
199:11	monitors 44:20	Mountaintop
moments 154:23	44:21 66:20	157:14
money 84:15	91:14 91:22	movable 100:25
131:10 170:16	91:24 92:11	move 56:21 69:8
179:6	93:25 94:2 97:17	139:16 171:22
monitor 25:8	111:19 111:21	176:13
25:14 92:15	129:9 138:25	moved 62:15
92:21 93:6 93:18	157:11 157:18	moving 6:5
109:22 110:6	158:22 172:8	60:15 65:12 70:2
133:25 134:1	193:6 193:7	97:1 112:6
136:14 139:3	193:8 193:16	120:19 120:25
141:21 157:13	220:13	144:7
161:13 163:19	monitor's 45:1	Mueller 156:3
163:20 164:3	163:23	156:4 156:4
164:9 164:10	monologue 67:23	Mueller's 172:16
166:15 166:15	Monte 49:21 64:21	multicolor 189:24
166:16 166:17	Monterey 92:9	multiple 39:12
166:22 167:3	month 58:2 217:13	77:24 79:5 91:15
167:4 167:5	monthly 195:9	99:5 102:15
167:12 167:17	195:10	129:8 202:20
169:7 169:7	months 9:20	220:13
169:9 170:4	117:24 175:19	multitude 129:21
170:22 170:23	195:8 198:21	munitions 210:16
170:23 170:24	201:6 203:2	
183:9 214:12	204:18 211:14	
214:12 214:19		

mustard 81:15	narrow 19:5 20:1 27:22 185:24	network 91:7 207:21 211:17
MVEP 230:22	narrower 20:8	neutrally 152:14
myriad 100:12 100:18	Natick 15:15	Nevada 206:12 207:8
myself 58:3 205:25	National 56:8 121:20 155:21 157:5 197:18	newer 54:23 56:15
<hr/>		newest 106:13
N		Newman 213:25
<hr/>		news 237:9
NOY 128:10	nationwide 185:1	nice 58:25 107:12 123:22 137:24 164:24 165:21 165:24 168:2 203:20
NAAQS 68:20 71:12 74:2 74:5 74:7 91:10 107:6 110:1 129:11 133:3 133:11 133:14 134:2 135:25 135:25 136:3 136:6 136:10 136:10 136:14 136:17 136:23 137:1 137:12 137:14 137:17 146:12 152:8 155:12 163:11 175:2 175:18 175:25 177:18 178:3 181:1 181:3 181:23 181:24 181:24 182:3 182:14 183:10 184:1 184:23 191:3 192:17 193:6 193:13 193:21 193:22 193:25 193:25 194:2 195:4 195:11 223:1 229:13 229:16 229:18 230:11 230:24	natural 128:18 190:12 191:8 nature 183:7 184:18 Navy 208:6 NCAA 162:17 NCEP 212:9 nearby 63:5 91:20 215:2 224:4 nearest 62:9 near-field 34:5 35:21 nearly 12:8 193:10 193:12 necessarily 70:19 73:19 225:15 necessary 41:8 179:11 235:5 necessitates 229:22 neck-of-the-woods 164:21 Needless 164:19 negative 104:10 150:8 152:1 neither 48:21 146:22 Nelson 210:1 nest 211:25	newer 54:23 56:15 newest 106:13 Newman 213:25 news 237:9 nice 58:25 107:12 123:22 137:24 164:24 165:21 165:24 168:2 203:20 nicely 115:17 124:6 165:8 Nicole 132:9 132:10 139:20 night 4:6 4:7 15:3 105:2 105:21 106:8 114:1 212:12 212:25 213:4 213:7 nighttime 95:21 103:24 104:4 104:12 104:16 104:16 105:6 nine 31:5 122:3 122:22 nineties 112:7 112:9 ninety 25:19 25:19 85:25 110:1 ninety-eighth 87:16 ninety-ninth 87:16 87:17 nitrate 44:24
NADP 192:3 192:5		
name's 52:16		
Naresh 77:3		

45:24 45:25 46:14 47:16 48:10 48:21 49:5 50:21 51:5 54:5 54:10 54:14 57:9 146:10 193:2 nitrates 54:8 55:2 193:3 nitric 48:9 193:1 nitrogen 44:21 191:24 NMN 211:23 211:25 No2 4:9 8:17 8:21 59:14 60:6 63:9 68:3 68:8 68:12 70:12 74:19 75:4 75:9 75:19 76:11 97:25 125:22 128:9 128:10 128:11 128:12 128:13 129:20 132:14 132:19 132:23 132:23 133:2 133:5 133:5 133:6 133:8 133:14 133:15 135:5 135:18 136:1 136:5 136:15 136:16 136:21 136:24 137:1 137:3 137:4 137:14 137:14 137:16 137:17 138:22 138:22 139:16 191:3 193:22 193:25 230:3 236:25 237:18 NOAA 113:1 113:4 nobody 171:12	no-ice 124:1 non 84:8 85:1 86:21 120:3 183:13 nonattainment 189:11 189:17 non-attainment 164:11 183:6 183:16 non-BLP 108:11 110:10 non-buoyant 85:5 98:2 non-city-state 84:25 88:17 none 46:21 129:23 217:5 nonetheless 11:23 nonexistent 187:22 non-guideline 51:22 non-model 159:1 non-obtainment 184:20 non-precipitating 45:14 non-preferred 231:22 non-straight 86:6 non-threshold 119:11 noon 127:2 nor 146:22 151:1 230:1 normal 135:13 normally 29:17 north 18:7 85:14 91:7 113:6	117:3 162:13 200:18 207:11 northeast 158:14 164:22 166:13 171:8 northern 45:3 northwestern 111:18 note 71:21 99:18 102:12 128:9 163:13 215:12 noted 37:4 82:6 231:19 notes 198:20 noteworthy 175:9 nothing 125:14 135:11 notice 8:10 129:17 143:3 143:20 208:25 231:4 232:1 233:9 235:7 noting 73:25 November 55:8 56:9 117:18 NOx 48:9 54:4 54:14 68:16 75:9 nuclear 29:2 29:3 197:20 numerous 140:8 nutrient 191:12 191:18 191:21 NWS 105:12 112:24 NWS-84 37:22 NX 40:10 40:11 40:11 NY 40:12
---	---	--

46:4 47:4 48:11 48:16 48:19 49:1 50:8 50:10 50:16 50:19 51:8 73:17 74:7 193:8 193:17 193:17 196:8 211:10 older 165:9 199:22 OLM 75:6 133:23 191:2 195:16 195:18 195:22 196:3 196:20 OMEGA 210:14 omit 230:16 one-day 104:19 one-hour 87:15 156:7 156:11 158:7 160:2 175:2 175:18 175:25 177:24 179:16 181:1 181:3 183:10 184:1 189:1 214:8 221:14 222:5 225:1 229:12 229:15 229:21 236:25 one-minute 216:15 216:17 216:24 217:10 218:2 218:4 ones 7:9 11:7 72:20 82:24 92:16 120:25 188:21 224:1 224:13 225:13 228:3 one's 165:7 one-to-one 50:16 one-year 19:7	ongoing 179:8 on-paper 69:22 on-site 91:22 168:21 168:23 168:24 169:5 173:23 224:14 onto 95:14 100:24 opacities 101:10 opacity 101:10 open 63:20 103:4 147:19 153:2 153:10 203:3 203:8 205:1 221:3 224:1 235:10 235:16 235:19 236:16 238:5 opening 67:22 open-mic 4:18 operate 140:8 140:21 230:8 230:18 operated 231:7 operating 134:14 163:20 215:18 237:3 operation 151:9 189:19 operationally 135:3 operations 68:9 69:15 70:1 opinion 13:19 opportunities 68:15 147:12 234:19 opportunity 6:18 67:25 70:24 71:18 83:7 91:17 142:12 142:17	142:22 144:2 148:5 234:10 235:25 opposed 14:2 20:6 101:21 129:6 129:8 opposite 64:3 opt 89:15 optimal 172:25 optimistic 68:25 69:21 70:3 71:5 71:9 optimize 175:20 optimized 35:11 35:21 option 102:2 172:14 176:12 189:25 195:6 197:17 200:15 optional 153:9 options 39:11 39:13 167:20 173:19 231:7 231:9 orange 215:14 Orangeburg 113:7 oranges 158:16 order 7:11 26:20 26:23 48:24 74:22 103:3 139:5 147:11 155:19 175:16 195:4 202:5 204:18 221:17 ordinance 223:12 Oregon 85:13 86:7 86:20 87:1 87:19 organic 44:10 101:4
---	---	---

organization 11:9	44:4 78:21	144:14
orientation 85:12	79:4 79:8	over-predicted
101:25	90:14 109:4	159:12 196:6
oriented 148:25	177:10 187:7	over-predicting
149:1	213:2	25:17 46:13 47:5
origin 51:10	outputs 72:25	58:19 93:13
199:4	210:8	110:5 133:15
original 35:7	outside 17:14	152:1
35:13 35:14 41:3	144:12 145:2	overprediction
132:17 159:19	193:18	46:2 47:24
177:24 223:17	outstanding	over-prediction
originally	126:25	55:2 81:20 88:24
61:11 74:1 139:7	oven 98:19 100:11	94:3 126:23
162:12 176:18	100:13 100:21	128:15 130:3
originating 153:2	100:23 100:24	130:4 136:20
OTAG 210:11	103:13 103:14	136:24
others 4:21	ovens 97:22	overpredictions
7:25 42:15	overall 73:13	26:7 26:8
46:9 82:24	82:5 82:9 94:1	over-
125:23 140:25	106:1 167:25	predictions 16:1
202:9 211:16	170:9 184:17	61:6 64:19 88:25
211:17 212:15	199:3 226:22	89:11 235:1
222:23 236:1	232:20	over-predicts
otherwise 15:10	overemphasize	54:10 130:9
57:3 79:22	37:15	232:14
ought 63:14 64:25	overestimate	overstate 137:17
65:21 65:22	54:13 159:8	overstated 76:7
172:17	161:18	137:15
ours 71:4 162:1	overestimated	overstates 138:22
173:18	161:6	overview 25:9
ourselves 69:16	overestimates	43:20 57:25
outcome 183:2	133:13 161:20	199:5
outcomes 156:11	overestimating	owned 53:16
177:21	161:2	oxygen 97:16
outdated 229:11	overlap 30:6	ozone 44:9 132:21
outline 15:19	33:22 38:4 38:19	132:22 133:1
178:20	225:3	133:25 134:1
outlook 69:1	overlapping	135:10 138:24
69:18 70:12	173:11 222:3	139:5 183:12
output 41:4	over-predict	194:2 197:2
	25:15 140:17	

P	213:11	234:17
p.m 29:5	papers 10:19 15:12 29:18 43:4 209:12	participating 11:18
pace 172:4	paradigm 161:23	participation 15:8 147:8 238:12
package 28:10	parallel 99:5 99:8 106:12 169:6 200:18	particle 63:1
packed 5:14 38:17	parameter 22:9 28:3 28:7 99:23 99:23 100:5 100:8 133:3	particles 54:5
page 148:23 149:7 149:14	parameterization 133:11 133:12 138:16 138:18 172:21	particular 10:24 15:9 28:20 29:2 29:4 32:17 38:10 44:24 47:6 54:10 92:14 92:21 143:9 150:18 150:22 150:22 152:9 153:2 158:11 159:10 159:19 159:20 161:17 187:24 198:3 205:22
Paine 58:4 60:8 61:1 64:20 76:25 77:1 83:10 91:5 106:21 126:12 156:16 163:14 167:10 168:19 172:6 172:6 186:3	parameters 31:21 32:14 93:21 94:4 99:24 101:24 103:5 103:20 118:1 121:17 124:25 185:13 185:13 186:5 187:3 187:17 188:1 189:7 189:13 190:2 210:21 223:7	particularly 71:4 100:3 144:7 160:14 181:8 193:2 233:6
Paine's 151:13	parameterizing 138:15	particulate 45:25 57:8 68:16 101:4 200:11
paint 68:23	parametrization 133:11 133:12 138:16 138:18 172:21	parties 13:17 13:21
paired 16:7 136:16	parameterizing 138:15	partner 171:19
pairing 136:3 137:14 224:24	parameters 31:21 32:14 93:21 94:4 99:24 101:24 103:5 103:20 118:1 121:17 124:25 185:13 185:13 186:5 187:3 187:17 188:1 189:7 189:13 190:2 210:21 223:7	partners 233:19
Palaau 135:6	parapet 225:16	partnership 147:25
Palace 169:22	parcels 85:21 85:24 86:9 87:7 90:9	pass 34:2 40:17 124:21 128:2 128:4 175:17 207:6 227:19 227:19 227:19
Palm 103:18	park 170:13	passed 6:3 40:4
panacea 159:22 161:15	Parks 56:8	passing 40:14
pancake 61:10 62:3 78:2 210:18	parsed 129:15	
Panel 8:13	partial 90:18	
Pankratz 103:3	participate 10:11 10:20 76:15	
paper 20:17 22:7 22:10 45:21 48:22 68:2 68:18 69:23 70:4 94:11 105:22 105:23 117:9 117:24 121:15 124:12 209:11 210:1 210:1 213:9		

126:1 176:8 176:9 176:10 178:1 pass-through 39:17 40:3 40:22 41:9 past 54:6 58:11 58:23 59:13 60:24 64:18 74:7 105:22 131:10 143:6 145:4 148:24 149:10 152:12 155:14 155:15 183:19 185:9 199:7 199:8 199:15 206:6 209:21 223:2 path 145:9 234:2 paths 35:23 pattern 35:18 87:18 89:2 89:3 89:6 89:13 92:17 92:17 95:7 123:23 patterns 88:10 92:11 184:14 Paul 117:17 pauses 198:14 pay 189:4 paying 170:18 PBL 210:6 212:9 peak 81:25 90:24 95:4 95:7 110:22 160:5 185:17 peaks 95:11 pedigree 51:10 peer 10:18	27:14 131:24 peering 37:15 peer-reviewed 51:12 pending 16:20 56:7 179:14 234:13 penetration 90:18 Penn 211:20 people 5:4 7:2 8:23 16:5 30:20 43:20 58:9 58:24 83:10 124:11 132:18 139:8 139:10 163:1 214:5 227:12 228:4 per 22:5 38:15 66:9 71:23 71:23 72:23 72:23 104:2 110:23 111:2 114:10 124:23 127:22 127:22 128:1 129:19 130:17 130:19 134:14 134:15 134:17 156:25 160:19 181:11 181:13 185:23 186:1 188:8 193:13 205:14 205:16 205:19 207:24 211:2 211:2 211:4 212:21 213:3 214:14 216:8 221:1 percent 16:6 19:17 19:19 20:5 20:10 21:24 22:3 22:4 25:16 26:18 27:13 48:25 50:2 50:3 50:7 50:9	50:11 50:21 60:1 74:3 75:12 75:13 79:11 81:24 81:25 82:1 85:7 85:7 85:25 86:3 87:2 92:25 93:10 95:2 95:9 95:15 113:18 114:4 114:15 122:18 122:22 123:5 125:6 158:7 182:14 212:8 percentage 81:24 194:15 194:21 percentages 113:16 percentile 25:20 87:17 158:20 159:10 159:24 219:14 219:16 219:24 219:25 220:8 220:10 220:22 221:2 221:5 230:1 230:2 perfect 65:3 150:3 151:14 170:10 170:14 perfectly 94:19 95:25 96:18 perform 38:13 55:16 142:16 235:6 performance 31:7 33:20 34:2 34:3 34:14 37:5 37:6 37:12 39:14 47:13 48:11 76:12 93:25 94:5 104:23 105:17
---	--	--

106:3 106:10 133:9 137:12 137:15 141:10 142:25 144:1 145:22 150:15 156:14 169:12 206:21 208:14 208:20 209:1 209:4 209:8 216:2 229:25 232:3 232:6 232:10 232:21 232:22 233:3 233:5 233:15 234:6 234:8 234:24 235:6 performed 36:9 36:9 51:7 157:2 performing 133:23 performs 35:19 104:24 perhaps 115:12 133:13 230:20 period 5:22 36:16 36:16 37:24 83:6 83:7 92:24 114:19 116:6 135:2 155:24 157:2 160:22 160:25 201:19 201:20 206:18 215:20 215:21 216:18 237:11 237:21 237:21 periodic 155:4 periods 38:1 77:11 78:18 79:9 79:11 80:24 80:25 83:2 116:8 151:5 156:25 permit 72:6 73:16 73:16 134:9 134:10 134:11	175:10 175:20 176:13 227:20 237:7 237:10 237:13 permits 72:20 72:21 permitted 69:23 72:4 74:1 135:4 permitting 13:18 13:22 228:22 Perry 77:9 persisted 89:7 persistence 131:3 persistent 77:18 84:1 personal 180:18 perspective 29:10 74:22 131:13 Pete 9:14 213:24 Peterson 12:4 petitions 26:14 Petroleum 54:25 58:5 phase 43:16 43:17 43:25 45:12 60:25 PhD 149:3 150:2 154:24 phenomena 116:23 phenomenal 6:21 phenomenon 114:21 185:5 photographs 169:3 physical 61:18 101:24 131:1 physically 184:5 physics 41:21	pick 31:13 128:11 218:17 picked 211:14 picture 38:8 62:22 68:23 71:5 71:9 103:8 149:5 170:9 171:4 171:5 181:17 184:11 211:15 piece 120:11 189:2 189:3 PIETRO 9:13 pipeline 175:16 175:22 piping 100:14 pit 108:15 150:21 152:24 153:7 153:10 154:11 154:12 154:17 154:20 155:7 155:10 pits 153:3 153:18 153:18 154:7 154:9 placed 55:10 92:9 166:19 166:22 places 37:21 37:22 Plains 92:1 plan 40:10 102:7 132:3 144:1 164:9 166:9 168:18 171:20 plane 168:14 planning 15:1 15:3 42:25 plans 56:10 56:11 140:8 143:14 179:24 228:23
---	--	--

plant 25:9 92:2	166:25 215:24	65:24
109:24 115:12	plots 42:8 95:6	Plume-in-grid
133:20 134:8	135:21 158:4	31:11
134:13 134:14	160:20 208:4	plumes 32:19
164:13 165:4	plotted 138:5	33:16 38:19
165:13 165:15	plumbing 33:5	78:11 94:18
165:20 165:20	plume 24:8	94:19 94:21
166:2 166:6	24:10 24:17	95:24 96:6
166:14 167:22	31:24 32:2 33:19	108:20 200:4
169:19 170:10	34:18 35:9	plus 35:7 35:8
170:16 171:7	44:9 48:3 56:6	39:4 48:9 108:14
171:8 175:1	61:11 63:4	127:24 156:17
175:7 175:10	78:2 78:3 78:4	157:19 212:24
176:12 215:9	78:5 78:6 78:8	212:24 213:7
215:19	79:22 80:21 81:1	216:7 216:25
plants 29:3 97:16	81:2 81:10	217:1
214:6 215:6	83:4 83:17 83:21	PM 59:20 68:5
215:13 236:23	84:7 85:3	68:12 68:21
plant's 179:25	85:19 90:20	101:11 101:12
play 140:7 140:13	94:13 94:20	147:16
174:11 182:16	94:23 95:16	pm10 175:14
226:11 237:23	96:18 98:13	pm2.5 8:21
playing 162:16	98:16 98:24 99:3	14:14 183:13
plead 186:23	99:4 99:5	podium 180:13
please 203:22	99:10 99:17	Podrez 60:7
233:19 236:3	99:20 101:23	point 4:23 16:4
236:16 238:8	102:5 102:15	18:3 21:5
pleased 97:10	104:21 105:4	24:13 24:15 25:6
148:22	105:9 105:11	36:21 40:5
plot 25:13	105:23 108:2	40:5 54:2
50:13 104:13	108:19 109:3	54:15 61:18
129:14 129:14	109:5 109:6	69:12 72:19
135:25 136:9	109:11 109:14	80:14 81:21
136:10 136:18	110:2 110:15	81:22 84:3
137:1 137:6	130:25 131:4	86:4 88:14 106:6
138:3 138:12	132:19 134:1	108:9 110:22
157:8 157:10	134:2 139:6	111:2 122:22
157:22 158:4	157:20 162:8	122:23 125:2
158:8 158:9	176:24 185:24	125:3 125:4
158:18 158:18	185:25 200:5	133:8 156:20
159:23 160:2	221:18 226:4	158:12 158:24
160:5 160:10	227:5 227:7	159:11 161:13
160:23 161:7	227:8	184:19 185:3
	plume-in-grid	

186:22 187:25 222:12 228:9 pointer 165:5 points 21:7 21:11 21:12 40:9 40:11 40:12 40:15 40:15 40:17 41:1 41:3 50:17 50:18 86:14 129:8 151:8 158:24 197:3 poke 42:16 polar 87:13 policy 16:15 21:16 96:19 140:5 147:14 polisource 115:14 115:16 pollutant 68:7 222:6 pollution 196:12 poor 37:5 211:11 poorly 50:23 128:4 popular 87:15 population 226:3 portals 203:24 portion 28:21 192:12 position 214:2 positive 97:17 positively 55:15 possess 147:21 possible 58:20 102:9 105:4 152:12 203:3 205:9 225:9 possibly 10:16 63:10 154:4	213:12 222:1 222:7 post 177:11 177:12 177:16 posted 205:2 post-one 79:15 post-program 177:10 potential 54:1 60:4 108:18 182:17 182:24 182:25 189:22 230:16 potentially 140:18 183:15 184:2 184:8 188:23 189:7 198:2 198:5 pounds 71:22 71:23 72:23 72:23 74:24 193:13 power 29:3 47:6 91:20 115:12 157:1 198:18 213:23 215:6 228:9 powerhouse 165:7 167:21 169:20 powerhouses 165:15 powerpoint 123:10 practicable 56:16 practical 148:4 150:1 150:5 151:15 152:18 practice 231:17 pragmatic 150:1 150:5	prairie 65:1 pre 120:1 pre-AERMINUTE 85:16 preamble 54:12 pre-ASOS 85:16 196:24 preceded 142:14 precipitating 45:14 precision 229:7 predict 48:20 49:5 49:23 104:25 108:2 182:22 184:5 186:15 196:20 208:12 predicted 30:7 38:2 54:8 81:17 81:18 82:8 83:4 94:17 102:5 118:6 129:19 141:23 187:18 195:19 195:22 196:10 predicting 15:22 50:20 50:22 60:22 prediction 51:5 62:25 87:10 92:18 96:4 128:6 130:5 131:20 137:22 143:2 151:19 188:2 193:1 195:3 196:14 predictions 23:22 50:2 57:8 58:15 84:13 105:6 110:2 110:20 111:20 135:23 136:2
--	--	---

140:15 172:24	presentation 4:14	pretty 24:16
188:19 191:1	4:19 12:18 52:11	24:19 30:11
191:24 192:7	67:18 70:6	30:14 30:15
193:15 195:3	70:8 83:9 97:7	31:14 36:1
predicts 54:3	102:24 118:11	41:5 50:15 75:11
168:12	119:3 127:15	100:2 104:3
predominant	132:8 133:17	104:6 116:9
166:12	138:21 139:22	119:20 122:16
predominantly	139:25 148:15	123:16 126:4
80:1	148:16 148:18	129:10 167:13
preference	156:2 156:6	171:3 173:15
85:14 141:22	165:1 172:2	174:5 179:12
174:8	183:25 199:2	181:17 192:12
preferred	199:13 200:25	196:15 197:22
140:11 143:11	222:22 228:10	207:17 209:15
146:7 231:1	232:4	223:21
231:5 231:6	presentations	prevailing 166:12
231:10 231:10	4:17 4:20 5:11	previous 16:15
231:12 231:15	6:13 6:23 9:4	19:22 21:12
233:15	9:10 11:25 12:11	21:25 44:6 53:13
preliminary 77:14	28:15 29:19 39:9	59:8 82:6
191:22 192:25	55:21 77:2	83:24 98:11
premium 140:15	77:2 97:1 120:12	148:23 150:6
prepared 4:21	198:22 199:7	191:1 194:18
48:22 52:25 97:7	205:1	198:22
149:19 196:13	presented 4:19	Previously 59:11
prepares 155:12	5:6 11:7 12:3	PRIDE 206:11
preparing 53:22	12:4 20:17	206:13 208:15
53:24 180:24	24:4 29:20	208:20
prerelease 199:1	30:8 31:8	primarily 60:18
pre-released	31:12 60:7 70:14	72:10 129:25
202:8 202:10	78:1 117:10	161:19 211:11
204:14	118:11 119:6	229:2
Prescribing 230:4	236:12	primary 37:5
prescriptive	presenter 163:14	133:19 151:12
229:21	presenters 5:11	192:14
presence 103:10	76:18 233:23	prime 17:6 17:8
103:12 229:16	presenting 121:15	18:3 20:2
present 11:8 16:2	132:12	23:18 23:22 62:8
19:10	pressing 185:9	231:17 231:20
	pressure 97:18	primetime 214:3
	prestigious	Princevac 103:2
	162:14	

principals 205:10	129:2 135:19	122:1 125:11
principle 64:24	136:7 143:2	125:24 142:1
printing 5:24	144:18 152:13	179:9 183:21
prints 184:13	162:2 163:10	183:23 186:9
prior 80:3 143:14	163:12 163:12	189:11 197:6
147:16 173:2	163:25 205:10	217:9 217:19
198:21 233:1	problematic 94:14	234:1 234:23
priorities	problems 23:8	processed 121:6
14:21 58:23 59:5	23:22 27:20	121:16 122:9
97:11	31:23 35:25	124:20
prioritization	38:23 39:22	processes
7:10	39:25 40:1	104:21 133:7
prioritize 7:8	49:6 57:5	processing
priority 7:19	58:15 63:22	74:11 117:20
145:13 145:16	128:24 132:4	124:4 124:17
145:17 146:14	138:20 140:19	156:23 161:15
private 233:13	164:3 186:13	162:4 196:23
234:16	196:22 213:1	processor 29:25
probability 86:25	213:8	102:18 120:2
230:13	procedure 61:10	202:21 202:22
probably 20:15	77:11 78:14	230:21 232:3
30:23 46:1	78:19 78:21 79:3	232:7 233:8
58:9 59:9	79:7 79:17	processors 200:18
59:17 62:4 62:20	101:16 102:7	produce 40:11
65:3 102:20	107:24 109:6	produced 31:11
105:10 105:18	procedures 27:4	54:14
116:20 130:15	77:13 91:16	producing 140:15
133:9 164:17	142:20 143:8	product 171:16
164:18 168:13	144:11 147:24	production 107:19
170:19 170:20	proceed 148:16	108:18 137:1
184:25 188:8	proceeded 68:22	productive 151:25
204:24 217:3	proceedings	products 203:12
220:6 220:19	147:24	professional
222:10 226:18	process 7:7 13:16	217:6
226:19 236:9	14:18 42:4	profile 184:11
problem 17:15	42:5 42:18 42:23	212:3 212:7
17:24 21:17	56:3 57:1	profiles 110:14
22:24 23:11 26:2	69:11 72:10	174:1 174:3
28:2 28:6 43:7	72:13 72:13	191:5
61:16 66:13	75:22 75:25 76:2	profiling 173:14
77:16 91:11 94:8	76:15 79:9 79:15	
96:5 125:17	86:13 101:15	
	101:17 102:6	

prognostic 64:4 66:2 190:16 197:14 209:18	proper 35:10 37:9	provided 11:4 49:13 130:20 142:7 142:22 144:2 188:13 199:6 200:19 204:15
program 41:25 69:13 145:1 173:4 190:12 191:9	properly 40:2 40:3 41:21 66:20 124:20 126:14	provides 97:23 106:4 187:19
programs 10:21 40:19 68:10 68:14 217:17 228:23	property 34:21 170:12 170:14 223:23 227:23	providing 58:1 82:20 91:2 127:17 155:23
progress 53:12 144:21 192:1	proportional 213:4	Province 165:18
prohibitive 176:21	proportionality 153:12	proving 142:14
project 77:4 167:18 168:5 178:11 210:20	proposal 144:8	provisions 141:2
projected 23:10 23:15 23:18 24:4 28:4 157:20 178:20	proposals 8:6	proxy 214:25
projective 17:17	propose 110:6 169:13	prudent 107:7
projects 14:8 14:8 69:7 69:14 125:21 150:25	proposed 17:18 56:1 91:9 91:16 101:16 101:22 102:14 110:3 142:17 144:23 151:13 163:13 215:1	PSD 98:4 175:10 175:20 228:22 229:1
promise 7:10 7:17 198:2	protection 4:1 53:23	pseudo 183:15
promised 14:14 103:25	protective 149:9 149:21	PTE's 182:18
promising 191:25 193:3	protocols 8:7	public 4:14 5:5 5:10 5:22 6:13 9:10 16:22 55:10 65:18 65:21 127:8 132:3 142:11 142:14 142:16 142:22 143:3 143:14 143:20 144:2 147:11 149:9 149:21 151:25 155:24 200:21 203:4 203:9 233:9 235:7 235:19 237:11 237:21 238:19
promote 10:15 76:13 235:12	proved 104:8 200:3	publically 53:15
promulgate 56:11	provide 10:18 10:22 11:22 13:22 14:22 40:24 68:1 131:11 140:24 142:24 143:3 154:7 155:18 159:18 188:3 188:11 197:23 198:7 199:2 202:9 204:4 234:2	publicly 134:21 137:24 199:17 200:7
pronounced 85:13 116:16		
proof 214:2 215:23 217:12		

publish 132:2	putting 40:14 113:10 218:20	155:5 156:7 161:22 168:13 179:13 180:5 236:19 237:20
puff 33:9 37:9 38:11 38:14 38:15 38:17 38:24 64:15 64:24 83:16 83:19 83:20 86:22 90:20 205:24 206:13	Puttock 20:16	questions 4:16 26:16 117:20 203:21 204:20 214:5 218:20 237:22
puffs 33:14 34:20 34:21 38:25 86:18 88:8	puzzled 95:22 95:23	quick 166:25 181:18 228:7
PUFF's 32:5	PVM 196:20	quicker 13:24
PUFFS 207:12	PVMRM 59:14 63:10 67:9 75:6 132:21 138:20 195:15 196:21	quickly 21:19 25:3 61:14 62:20 144:7 151:17
pull 8:1 224:12	<hr/> Q <hr/>	quite 16:4 17:10 18:6 18:10 25:10 25:15 26:1 26:12 32:25 34:4 35:18 35:23 36:22 36:23 37:10 39:1 39:14 44:13 47:5 47:17 50:20 59:12 61:9 62:1 103:15 114:24 116:12 117:4 134:18 170:16 178:11 180:1 182:20 184:16 185:18 186:2 186:6 188:25 190:13 191:24 192:8 197:16 222:6
pulled 194:5	Q&A 5:20 8:16 173:11	quotation 120:11
pulp 68:18	Qiguo 102:25 102:25	quote 54:15 128:21 231:6
pulses 120:20	Q-Q 129:14 129:14 135:21 135:25 136:17 136:25 137:5 138:12	quoted 153:6
purchase 224:5	quality 4:2 44:20 44:23 54:22 55:4 140:10 147:21 213:21 228:21 233:17	<hr/> R <hr/>
purchasing 224:2	quantify 84:4	Rabideau 58:6
pure 33:21	quantile 25:13 25:13 66:23 66:23	RAD 44:2
purely 11:8	quarter 19:4 163:22	
purple 157:23 158:23	quench 100:24	
purpose 118:17 141:7	quenching 98:7	
purposes 36:6 122:11 141:11 160:21 185:2 190:6 228:22	question 17:5 17:5 43:6 49:10 60:18 62:6 63:18 63:20 64:17 65:24 103:7 114:22 114:22 114:24 127:16 127:19	
pursue 179:5 225:23		
pursuing 225:19		
push 179:16		
pushed 100:22 100:23 100:24		
pushing 98:7		
puts 140:15		

radar 12:23	190:14 192:17	115:25 191:3
radio 104:16	192:19 233:5	193:22 193:24
211:19	ranges 195:8	195:10 195:14
radius 86:8 86:14	ranging 193:19	195:18 196:7
212:4	rank 30:4 30:14	ratio's 89:14
rain 44:1 44:1	30:15 31:4	rays 80:18
rainfall 209:24	31:5 32:13	reach 70:22 70:23
raise 26:25	rapidly 24:13	reached 127:6
152:22 225:17	104:15 104:15	127:8
raised 6:22 39:10	rate 38:11 101:13	reaches 24:9
147:1 175:16	124:24 132:25	react 132:23
218:11	133:13 136:25	reacted 55:15
raising 9:2	176:20 223:8	reaction 132:25
218:19	227:6 227:7	reactions 137:18
Raleigh 15:9	237:5	reactivate 169:8
Ralph 203:18	rated 34:12	readily 76:1
203:20	rates 48:23	ready 51:23 214:3
Ramet 102:17	72:5 72:5	real 23:17
ramifications	72:16 72:20	39:22 91:15
189:16	115:7 115:10	95:19 125:8
RAMS 210:11	129:4 129:5	129:7 135:17
ran 31:18 31:18	182:1	135:17 141:14
32:21 41:1	rather 35:5	147:12 151:1
41:2 45:3 45:4	35:6 37:25 38:25	154:17 155:6
80:22 87:11	141:12 216:10	167:10 169:21
113:12 114:12	222:1	184:5 214:3
122:2 122:4	ratio 18:1	214:24 222:10
122:4 123:6	18:17 19:13	222:10
166:17 167:1	19:15 19:19 20:4	realistic 98:8
167:4 167:9	20:20 21:3 22:11	186:16 188:9
167:9 169:8	23:23 24:14 50:1	realistically
174:19 208:2	60:7 75:9	64:22
208:3 211:21	75:11 81:20 82:9	reality 131:24
211:23	88:10 88:13	realize 120:10
random 35:3 64:21	88:16 89:8	134:5
range 17:14	93:3 153:16	really 6:21
20:2 41:19 49:22	195:5 195:23	6:24 9:6 17:5
50:4 83:11 83:16	196:4 196:5	23:21 26:5
114:4 115:5	196:21	27:1 27:16 27:21
115:13 116:17	ratios 17:10	28:1 30:18
127:25 185:23	21:21 22:15	
	25:12 27:7	
	27:8 89:19 89:23	

32:9 32:25 33:13	105:4 141:3	161:4 161:5
35:18 37:13	162:21 176:19	161:18 177:4
41:23 42:7 42:16	233:1	182:21 223:12
47:8 48:20	reasonable	223:13 224:7
49:5 58:24	48:16 53:11	recess 76:22
60:1 60:25 63:13	76:13 84:4 90:12	re-characterize
64:1 65:13 65:17	135:12 140:11	223:19
66:16 66:21	146:22 228:2	recirculation
73:17 75:17	228:3	154:9 154:13
90:11 90:23	reasonably	154:18 205:11
95:19 104:11	78:11 84:22 94:7	recirculations
104:24 108:10	95:11	86:5
118:20 119:12	reasons 129:21	re-circulations
122:11 124:9	180:19 196:10	154:23 155:8
125:10 125:15	recall 142:8	reclaim 120:14
128:10 128:13	199:12	reclassification
128:21 131:20	recap 181:5	123:4
137:24 150:13	received 29:21	recognize 14:20
151:20 163:16	29:24 31:1	69:10 74:10
170:5 170:6	175:10	74:11 165:2
174:2 175:6	recent 15:20	174:25
178:24 178:25	15:25 54:21 57:2	recognized 57:5
179:5 179:13	60:4 142:19	recognizing 60:2
179:15 179:17	154:15 179:4	recommend 13:21
186:20 186:22	190:23 197:3	51:18 83:8
194:9 212:1	209:12 231:18	129:12
212:13 212:14	recently 28:20	recommendation
214:14 215:2	28:20 29:20	26:12 27:17 42:3
215:10 217:9	190:23	75:17 93:15
217:10 217:15	reception 120:21	119:2 189:15
218:8 218:8	receptor 88:12	recommendations
218:24 219:2	90:21 90:24	13:1 63:14
220:14 220:19	90:24 92:14	67:6 108:13
222:9 223:3	115:17 115:18	138:19 181:9
223:16 224:19	131:5 161:13	231:8
224:20 225:3	177:4 177:5	recommended
225:11 225:22	177:8 223:25	55:1 56:5 108:19
226:3 226:7	receptors 80:13	164:11 181:13
226:8 226:9	87:14 92:9	210:3 232:12
226:15 226:16	95:5 107:15	recommending
227:8 227:10	159:25 160:14	42:12 42:12
227:13	160:25 161:3	
rearranging 225:7		
reason 24:8		
47:9 47:13 47:25		

66:19 196:24 233:2 recommends 56:13 recompile 177:7 177:10 reconcile 201:22 reconciliation 202:3 record 5:12 11:1 47:7 65:21 67:23 70:15 148:14 148:21 recorded 121:6 193:9 records 215:18 recover 204:22 recovering 139:21 recreate 134:22 rectangular 153:15 154:21 red 36:15 81:13 129:24 181:22 195:13 reds 158:16 reduce 55:1 61:5 161:16 167:25 168:1 175:21 177:19 188:24 reduced 70:1 106:2 154:11 160:18 177:25 reduces 186:6 reducing 191:18 reduction 25:11 97:16 176:20 206:4 209:20 reductions	68:16 69:22 179:11 225:4 re-evaluate 224:8 refer 43:21 112:23 reference 204:23 213:11 references 9:22 142:11 209:11 213:10 referred 200:24 referring 112:24 151:13 refine 76:8 186:25 194:24 200:20 204:6 218:25 refined 139:17 151:24 refinement 201:15 201:17 refinements 91:11 111:25 150:16 204:5 refining 217:17 reflect 131:24 148:19 reflects 43:22 regarding 13:11 14:4 39:11 102:9 156:6 regardless 161:4 229:16 regards 52:19 regime 85:15 105:11 135:11 135:13 region 45:2 108:14 197:1 214:9 214:13	215:7 regional 53:12 53:24 56:10 65:13 68:14 134:4 136:11 172:11 183:12 191:10 192:20 233:12 234:17 Register 5:24 regu 56:22 regular 112:25 112:25 regularly 154:20 regulated 140:16 149:8 150:14 regulation 142:9 163:21 regulations 68:13 regulative 155:16 regulators 140:16 regulatory 10:22 27:18 36:6 37:14 53:8 56:23 57:4 65:6 68:10 69:25 120:4 127:17 131:14 140:4 141:4 141:5 141:7 141:11 141:16 141:25 141:25 142:3 146:20 146:25 147:24 173:13 175:8 197:17 228:21 228:23 231:8 234:13 234:23 reiterate 8:9 relate 101:9 related 12:15
--	--	--

<p>39:23 47:7 51:4 140:7 140:23 141:4 142:18 190:14 204:11 236:20 238:17</p> <p>relates 13:5</p> <p>relating 181:6 181:7 189:1 190:25 190:25 197:5</p> <p>relationship 149:12</p> <p>relationships 101:10</p> <p>relative 34:3 36:23 44:12 46:12 88:24 99:6 131:21 136:14</p> <p>relatively 41:17 93:14 165:8</p> <p>release 28:9 32:19 35:22 36:10 36:15 37:1 38:8 38:11 62:24 79:24 79:24 80:3 85:5 86:4 97:21 99:1 102:4 106:6 106:12 108:5 176:5 200:25 201:6 202:13 202:17 202:19 202:25 203:8 204:17 206:14</p> <p>released 27:17 28:20 29:2 29:4 36:17 37:23 38:24 87:23 147:14 200:7 200:21 201:5</p> <p>releases 29:1</p>	<p>79:18 80:10 103:24 107:20 206:9 207:10</p> <p>releasing 38:24 200:22 226:4</p> <p>relegates 231:22</p> <p>relevant 10:23 37:13 98:21</p> <p>reliance 228:25 234:22</p> <p>relied 18:2 18:6 53:23 141:22</p> <p>relief 179:13</p> <p>relies 62:8</p> <p>reluctant 146:4</p> <p>rely 141:2</p> <p>relying 60:1</p> <p>remain 184:8 202:5 203:15</p> <p>remained 181:4 183:18</p> <p>remaining 94:3</p> <p>remarks 82:17</p> <p>remedy 17:18</p> <p>remember 66:6 88:3 117:22 136:22 167:11 189:9</p> <p>remembers 117:23</p> <p>reminder 5:4</p> <p>remodel 237:5</p> <p>removal 45:11 45:12</p> <p>remove 27:18 72:12</p> <p>removed 131:3</p> <p>repeat 13:3 47:3</p>	<p>repeated 5:8</p> <p>repeatedly 130:22</p> <p>replacement 51:19</p> <p>report 30:9 30:9 30:25 37:2 39:8 43:2 43:3 53:22 53:24 70:10 70:14 70:16 70:20 71:21 76:8</p> <p>reported 71:1</p> <p>reports 48:21 199:16 199:17 199:19</p> <p>represent 74:18 157:11 157:15 186:10</p> <p>representation 10:10 188:9</p> <p>representations 84:7</p> <p>representative 73:20 74:16 75:16 123:8 153:19 224:21 228:17</p> <p>representatives 55:19</p> <p>represented 158:24</p> <p>representing 159:8</p> <p>represents 158:8 158:10</p> <p>reproduce 31:19</p> <p>request 13:7 29:23 31:1 45:8 47:9 175:21 176:2 176:6 238:5</p>
---	---	---

<p>requested 4:13 4:20 228:15</p> <p>requests 56:13 144:10</p> <p>require 68:11 68:12 73:20 131:24 229:6</p> <p>required 56:9 69:18 79:16 120:4 229:19</p> <p>requirement 14:3 178:9 229:21</p> <p>requirements 176:15 221:22 230:10</p> <p>requires 102:17 143:9 150:15 229:13 230:15</p> <p>requiring 75:23</p> <p>reran 178:14</p> <p>research 21:20 22:7 23:6 43:18 62:15 190:11 191:9 198:18</p> <p>reserved 80:11</p> <p>reset 64:10</p> <p>residual 98:19 102:11</p> <p>resolution 13:25 14:1 14:3 34:1 35:17 36:2 36:8 66:13 156:9 211:11 218:25 219:4</p> <p>resolved 69:9 69:21 69:22 119:22 237:13</p> <p>resource 102:16</p>	<p>176:3</p> <p>resources 7:5 7:16 7:23 14:21 145:11 145:19 146:1 148:1 190:13 191:8 235:12</p> <p>respect 68:6</p> <p>respond 96:15</p> <p>responded 59:1</p> <p>response 28:25 237:12 238:16</p> <p>responses 29:1</p> <p>responsibility 155:18</p> <p>responsible 38:23</p> <p>rest 4:6 4:7 4:8 62:9 109:9</p> <p>restricted 94:21</p> <p>restrictive 230:23</p> <p>result 13:24 14:2 14:7 26:9 33:10 34:16 36:6 40:12 47:2 48:15 50:14 50:14 73:11 73:13 75:3 94:22 96:4 96:21 119:15 214:5 230:6 231:3 231:11</p> <p>resulted 11:13</p> <p>resulting 77:24</p> <p>results 19:9 25:12 27:9 29:19 30:8 31:19 32:12 32:18 35:12 37:10 38:10 39:5 39:25 45:23 46:7 50:12 50:12 53:13 71:11</p>	<p>71:20 72:15 72:25 75:7 75:15 77:14 79:13 82:5 84:21 85:1 89:18 90:10 91:9 91:10 93:18 104:23 115:11 125:11 131:1 131:2 131:7 140:6 143:22 143:24 156:18 157:4 158:3 159:5 159:6 161:8 161:11 181:22 183:11 184:18 186:15 187:3 188:4 191:14 191:20 191:20 192:25 194:25 196:6 197:21 217:12 218:4 225:4 230:5</p> <p>retention 150:21 152:24 153:7</p> <p>rethink 126:18 225:25 226:6</p> <p>retirees 164:18</p> <p>retrieved 167:1</p> <p>retrofit 56:17</p> <p>review 10:19 16:23 27:14 47:9 54:22 70:18 71:18 75:24 98:4 98:6 117:11 118:15 131:25 138:20 145:23 176:6 201:20 210:1 213:9 236:11</p> <p>reviewed 176:2 210:3</p> <p>reviews 102:10</p>
--	--	--

revised 35:13 35:15	RMSC 212:20	211:16
revisions 55:17	road 68:13 122:20 124:10 181:25	routines 44:11
Rex 20:16	roads 151:10 152:6	row 177:23 181:25
rid 132:7 160:12 161:24 217:8 218:10 225:12	Roger 17:17 23:8 24:25 107:10 108:5 119:19 121:22 139:1 185:6 232:5	rows 195:6
ride 38:21	Roger's 27:25 28:3 133:16	rubber 124:9
ridge 61:6 165:18 170:24	role 140:7 140:14 149:15 182:16	rule 53:12 53:25 53:25 54:12 54:16 144:5 144:9 231:4 232:1
ridges 158:13 186:10	Romney 111:5	rule-making 56:3
right-hand 35:15	Ron 12:3	run 6:15 31:3 31:5 31:9 32:16 33:1 33:4 34:8 34:9 35:2 35:7 35:8 35:11 35:13 35:13 35:14 35:16 35:16 37:23 38:15 40:2 41:20 42:10 42:17 42:20 42:22 46:3 46:4 46:5 77:11 78:7 78:10 79:1 79:5 79:6 80:8 80:13 82:5 84:11 113:11 114:10 124:1 125:8 126:1 126:1 141:12 158:13 166:23 168:14 200:18 202:19 202:22 202:25 211:20
rights 224:5	roof 97:17 97:17	
ring 95:5	rooftop 108:7 108:10	
rings 88:2	room 58:14 131:23 141:25 182:14	
Rio 148:15 150:12 150:18 150:23 153:22 155:13 155:20 155:24	Root 211:3	
rise 85:3 96:10 98:13 98:16 98:24 99:3 99:6 99:10 99:17 101:23 102:5 102:15 104:21 105:4 105:11 109:3 109:5 109:11 110:2 110:15 211:19 212:4 226:4 227:5 227:7	roses 113:17 196:12	
rises 108:19	rough 166:6 166:7 166:8 214:11 216:22	
risk 98:6 98:19 102:10 102:11	rougher 64:1	
RIVAD 44:8	roughly 18:14 154:21 158:13 210:24 220:24	
river 165:23	roughness 63:23 63:24 117:21 166:4	
RMS 211:3	round 162:17 180:9 190:9 219:5	
	routine 107:5	

15:19 28:16 28:17 43:9 55:5 65:8 77:25 score 30:12 31:12 31:15 32:8 scores 31:13 31:15 34:25 SCRAM 205:2 screen 12:23 177:14 screened 218:6 screening 221:6 scrubbed 165:8 scrubber 227:4 scrubbers 176:22 seals 237:18 237:25 SEAMAC 191:20 Seaman 210:2 213:9 213:11 seasonal 45:16 seasonally 45:9 47:12 season-by- season 188:15 seat 235:24 seats 180:13 second 7:14 35:11 48:1 65:5 66:9 76:24 104:2 110:23 111:2 114:10 118:18 124:23 130:17 130:19 173:20 185:24 186:1 188:8 190:8 205:14 205:16 205:19 207:24 210:17 211:2 211:3 211:4	212:21 213:3 235:2 secondary 14:14 44:10 secondly 100:17 187:1 188:12 seconds 38:16 206:18 Secretary 11:3 section 26:14 213:22 sectional 200:9 sector 70:9 180:23 198:17 217:1 221:25 233:13 234:16 sectors 68:18 71:4 220:18 222:3 seeing 14:16 26:10 36:22 61:5 62:25 87:2 89:10 89:13 93:23 96:8 110:17 116:7 126:23 128:13 186:14 187:4 187:12 220:22 220:24 seem 195:21 211:5 223:21 seemed 71:25 208:11 218:17 seems 15:9 24:13 61:16 66:3 66:4 75:11 96:16 139:9 146:4 151:15 191:23 192:7 196:3 seen 8:14 9:22 12:25 13:7 14:11 14:16 16:21 26:6	27:10 63:13 118:15 125:17 138:3 143:1 171:3 183:7 183:12 196:22 198:25 223:24 227:11 231:23 232:13 sees 41:13 segmented 85:19 selected 77:12 204:10 216:8 selectively 227:2 semi 7:18 183:23 seminal 210:1 send 38:18 203:22 sending 15:16 sends 52:18 senior 198:16 213:21 sense 22:17 29:14 51:11 126:15 168:15 194:1 sensitive 33:8 33:18 36:3 36:4 123:13 sensitivities 184:4 190:1 sensitivity 31:23 44:15 49:10 105:6 105:15 181:18 185:13 189:2 separate 46:9 163:6 227:8 separated 107:17 108:8 separately 177:21 September 14:10
---	---	---

229:12	8:17 14:14 29:19	115:4 123:7
Sergio 117:14	53:18 54:6	128:20 148:16
117:15 117:16	58:9 60:4	175:1 175:11
series 91:6	77:23 88:20	215:21 222:7
serious 111:12	89:16 89:22	222:7
111:12 140:18	111:17 111:20	shortcoming
212:12	112:11 128:1	217:25
seriously 111:6	131:10 132:18	shortcomings
111:11 111:12	142:19 146:19	217:19
189:23	152:5 153:23	shorter 64:25
service 121:21	154:14 155:17	115:5 115:6
157:5 197:18	233:23	116:11 187:13
213:23	severe 110:23	Shortly 175:17
Services 213:22	150:8	short-term 229:4
213:22	severely 150:8	shot 168:4
session 4:14	Sf6 129:3	171:7 171:14
76:19 76:24	shade 162:16	177:14
127:8 127:10	shallow 95:3	showed 27:5
205:1 235:25	105:20	37:7 68:4 93:7
sessions 5:21	shape 22:19	139:1 166:21
9:12	78:8 153:15	217:25
sets 18:11 42:7	154:8	showing 20:1 23:2
43:1 113:1	shaped 154:20	36:14 50:14 73:5
221:10	shapes 17:13	88:17 91:23
setting 108:5	share 125:14	116:19 117:6
122:6 131:15	190:18 192:23	129:22 129:23
166:10	236:12	182:11 182:15
settings 40:23	shared 146:18	182:19 184:10
41:23 99:13	sharp 77:6	193:22 224:3
settlement 169:10	77:12 156:18	shown 28:22 39:13
setup 34:7	shear 99:9	71:12 73:12
seven 11:25 81:22	106:9 109:4	122:14 183:13
82:1 105:10	She's 8:18	204:18 207:13
148:17 150:2	shift 120:16	215:17 231:24
163:14 166:1	156:3 160:16	shows 20:17 50:19
192:18 192:18	shifting 52:8	51:2 103:8
sevenfold 27:6	shifts 83:23	128:14 129:19
seventies 112:7	shocking 110:4	130:9 157:8
seventy 115:19	short 8:24	158:4 158:19
several 8:13 8:17	83:11 83:16	167:9 168:3
		168:10 170:1
		170:9 171:10
		175:6 181:10

185:21 185:22 193:16 193:16 196:15 207:19 207:23 218:1 shrink 24:12 shrinks 89:6 shut 123:8 166:25 sides 23:3 100:13 132:22 sight 149:4 208:25 208:25 Sigma 61:8 61:8 90:17 90:17 212:24 212:24 212:24 sign 73:24 signal 109:1 109:1 signed 5:25 significance 67:2 103:7 206:22 significant 15:22 16:24 27:5 34:14 48:6 51:1 79:22 94:8 104:17 140:18 142:10 178:5 183:6 192:25 194:9 194:21 209:6 209:7 230:6 231:24 232:15 significantly 114:13 114:20 159:3 194:16 232:14 signs 211:19 212:4 223:22 silver 64:5 similar 43:24 47:2 48:15 50:12	52:21 68:4 92:18 101:25 109:2 129:13 184:13 184:14 184:15 186:6 189:7 193:23 197:15 208:7 208:12 211:7 233:25 similarly 87:4 141:15 196:5 201:16 232:9 simple 10:15 41:17 101:14 106:9 185:21 simplified 54:16 simplify 144:10 simply 219:15 231:25 SIMS 182:20 simulate 183:22 204:7 simulated 156:12 158:6 159:24 160:24 161:12 161:16 231:16 simulating 197:6 229:25 simulation 19:7 44:17 45:18 189:24 simulations 25:7 36:8 50:8 54:21 simultaneously 148:3 single 38:17 38:17 79:19 90:4 90:5 90:7 202:21 SIP 69:11 73:17 108:17 176:15	178:8 179:16 229:13 SIPs 56:11 56:12 230:10 SIRAN 210:13 sit 6:19 6:20 115:20 site 36:10 37:1 45:24 47:2 63:20 141:22 151:12 157:15 158:23 158:25 174:2 174:9 206:12 207:8 207:15 209:2 209:2 sited 66:20 sites 92:10 158:21 159:5 192:3 207:7 207:15 209:3 211:16 211:16 212:5 212:19 sitting 58:7 220:14 situation 69:17 121:18 149:25 198:4 222:24 situations 159:18 230:13 six 21:1 31:10 34:11 81:21 110:1 122:2 122:18 156:24 167:14 sixty 18:22 35:8 78:17 78:21 78:25 80:11 103:22 sixty-five 19:3 115:24 size 66:5
--	---	--

153:19 154:22	slough 138:16	solution 107:12
155:10 165:25	138:17	144:22 152:18
181:20 182:18	slow 211:19 212:4	175:24 176:8
186:1	slugs 38:12	176:9 176:10
skeptic 162:25	small 17:10 32:18	176:19 177:6
163:2 172:8	33:9 38:8	187:5 205:9
skeptical 164:5	115:9 181:19	205:21
skewed 23:21	smart 163:1	solutions 150:1
128:5	166:20	150:3 150:5
Skyland 166:18	smelter 25:5	150:6 205:20
slag 108:15	smoke 80:7	solve 135:18
sleep 4:10	smoother 76:3	163:11
slice 118:10	Snyder 20:14	somebody 63:14
slide 5:3 8:14	Snyder's 18:7	121:22 149:3
17:11 19:25	So2 8:17 8:21	150:2 169:21
35:15 35:15	14:9 43:25	somehow 7:12
61:23 67:14 68:4	54:4 68:4 68:8	someone 5:17
77:8 134:24	68:12 68:16	83:12 119:19
136:15 150:24	69:10 71:6 72:11	236:6
193:16 228:11	97:25 102:8	something's
slides 13:4	107:6 107:19	214:23
16:2 19:10	118:16 146:12	somewhat 4:17
31:8 35:14 59:19	156:7 156:11	65:2 71:25 94:25
60:13 60:16	157:11 157:18	149:11
78:13 87:18	158:7 163:11	somewhere 23:19
119:5 122:15	163:25 165:14	25:19 30:13
140:5 148:17	167:20 169:11	30:17 167:19
194:11 195:1	175:2 175:18	sonar 36:12 36:24
204:24	175:25 176:14	169:5 172:23
slide's 19:11	176:20 177:24	173:9 173:11
slight 58:15	178:8 179:16	sonic 36:11 36:23
96:10	180:24 181:8	120:18
slightly 46:7	181:10 182:11	sorry 41:11 57:14
63:11 81:18	182:20 189:1	112:22 132:12
sliver 89:9	214:7 222:5	sort 48:15
slope 93:9 94:7	229:13 229:13	57:25 59:18 64:3
95:3 95:9 95:15	230:11 237:18	64:9 65:20 65:22
sloped 95:25	soapbox 150:11	72:11 74:14
slopes 18:8	software 156:18	75:21 77:7
slot 52:4 52:22	156:23 177:15	77:7 81:14 85:12
	206:20	92:12 136:7
		136:8 206:3

206:21 208:7	203:8 206:14	215:13 215:14
211:7 213:12	216:3 216:13	216:4 216:5
214:8 214:11	216:20 217:1	218:7 218:17
214:23 214:23	217:3 219:15	219:13 219:22
214:25 222:24	221:7 221:14	219:23 220:21
223:5 223:15	221:16 222:2	221:3 221:15
224:5 224:12	223:6 232:8	221:23 221:25
226:4 226:11	sources 21:18	222:4 224:11
226:12 227:8	25:6 25:10 44:18	229:14 229:17
227:9 227:18	45:2 54:3	230:13 230:16
sorts 96:12	54:15 68:10 74:1	230:17 230:20
sound 120:20	74:6 74:25 74:25	236:20 236:21
226:14 232:18	75:10 85:2 91:15	237:14
soundings 113:1	91:20 91:21	south 85:14
source 18:13	91:23 92:4	165:23 171:14
18:15 18:15	92:8 94:15	207:11
54:18 57:22 78:2	96:7 96:12	southeast 113:23
87:19 87:23	97:9 97:15	Southeastern
90:15 90:25	98:1 98:2	228:18
91:25 93:19 98:2	98:11 98:25 99:5	Southern 228:12
98:13 98:25 99:7	99:7 99:18 100:3	228:17 228:20
99:17 99:19	100:19 102:15	230:7
99:22 100:2	107:8 107:15	southwest 44:19
100:6 101:23	108:9 108:22	113:23 157:14
101:23 101:24	108:24 109:7	158:14 165:11
102:1 102:4	109:15 111:17	166:13
102:13 103:4	115:1 115:8	space 30:4 30:5
103:5 103:20	115:9 115:13	33:21 37:15 40:5
106:6 106:22	115:19 116:17	40:5 135:22
107:1 109:1	116:18 127:23	spacial 40:7
110:11 111:10	128:2 128:3	92:11 104:8
111:23 115:1	128:4 128:25	104:13
117:8 128:18	128:25 130:1	spacing 99:8
134:3 135:8	130:14 136:12	spanned 178:11
140:17 143:13	140:8 140:9	spans 192:11
152:11 152:14	140:20 140:20	spatial 158:4
156:20 157:7	146:12 150:21	spatially 177:9
157:9 157:12	151:10 151:11	speak 4:13
157:20 157:21	151:19 152:5	148:5 185:10
157:22 157:23	152:18 181:15	234:10 236:5
157:23 159:1	181:15 182:15	speaker 53:4
159:4 159:10	183:11 188:21	
159:19 159:19	191:16 192:21	
161:20 176:25	193:12 196:17	
181:12 203:3	207:16 208:22	
	215:6 215:11	

150:6	205:12 205:12	147:5 203:10
speakers 148:23	205:13 210:25	206:4 206:10
155:17 215:8	212:19 213:5	sponsoring 198:19
speaking 38:5	232:16 233:6	206:5
68:1 69:10 140:3	speeds 36:21	sponsorship 52:4
196:19 228:17	61:17 63:25 64:2	spot 104:3 220:14
special 213:17	77:16 77:17	spots 183:13
specialty 9:25	77:22 112:13	spray 105:5
10:20	112:17 114:7	105:18 105:19
specific 7:3 7:16	114:8 114:9	106:1
11:25 14:13 53:7	114:16 114:18	spread 36:4
57:24 58:12	114:20 117:4	63:3 63:4
59:19 70:8	130:16 130:21	64:22 116:12
150:17 181:6	143:2 145:22	spreading 24:10
184:15 184:15	186:13 186:19	62:2
188:20 207:1	188:6 194:10	spreadsheet
221:7 222:23	194:22 219:9	109:13 110:14
specifically 14:9	223:11 223:11	217:14
118:9 132:15	232:14	Springs 103:19
189:1 211:18	spend 152:20	spun 163:6
specified 37:22	152:20 168:10	square 116:21
124:2	179:6	211:4
specifying 123:1	spending 170:16	squares 129:24
spectrum 136:13	spent 11:9	160:20
speculate 82:3	131:9 131:15	St 117:17
speculated 82:13	154:24 190:13	stability
speed 41:11	spikey 216:1	129:15 129:18
60:8 64:12	spikiness 215:22	129:25 130:2
66:9 67:9	spirit 151:3	138:5 138:6
90:17 91:11	spirited 149:12	stable 79:25 80:6
103:11 103:25	spite 137:11	81:19 82:21
104:1 104:5	split 34:21	82:23 82:23 83:5
104:7 105:13	splitting 32:5	91:11 95:20
110:22 111:1	33:12 33:14	104:4 105:20
111:10 111:11	34:11 34:15	107:4 110:20
114:18 118:20	35:11 35:19	110:21 111:1
120:22 144:15	35:21 37:10	138:7 233:6
147:2 150:19	spoke 236:12	stack 16:3
151:6 152:15	spokes 80:16	16:14 18:11
185:23 185:25	sponsored 54:25	18:18 18:23
186:24 188:8	60:6 60:9 77:3	
189:6 196:23		

18:25 19:1	226:21 226:25	227:13 229:3
19:4 19:16 20:13	227:3 227:3	229:5 229:22
21:2 21:22 21:24	231:16 231:20	234:21
22:5 23:4 23:5	staff 11:14	stands 210:19
23:13 23:16	15:8 59:4 121:20	233:1
26:17 26:20	stakeholders 59:4	star 126:12
26:22 26:25 28:9	62:20 144:17	stars 129:17
38:6 38:8	147:8 147:23	start 17:2
63:25 71:10	148:4 191:15	22:24 24:12
75:10 79:19	stand 65:20	33:19 35:9 35:17
80:10 81:2 92:12	171:13 179:9	61:3 76:24 83:18
92:16 93:20	203:19	84:13 88:8
93:20 94:4 94:18	stand-alone	88:8 88:20 89:14
95:1 95:10	199:25 201:23	127:9 127:13
98:7 98:15	202:4	164:4 181:15
99:1 99:3	standard 56:3	218:15 220:5
99:18 99:20	71:7 73:4	started 22:14
99:24 99:25	73:15 75:4	23:19 24:1
103:16 103:16	75:8 115:1	35:6 112:4 119:9
103:16 103:19	125:22 127:25	180:9 199:10
106:15 115:24	128:7 128:13	205:8 214:19
116:12 123:7	128:23 152:9	217:14 218:19
123:7 123:9	152:15 156:7	218:20 219:6
123:13 123:18	156:15 157:5	219:7 219:10
123:25 124:19	158:8 163:24	219:11
128:20 143:4	163:25 167:17	starting 23:20
175:20 175:21	178:4 178:16	29:5 60:15 88:23
176:19 177:25	183:8 184:18	89:11 191:7
179:1 179:10	184:22 185:8	starts 192:19
182:1 187:12	206:21 214:8	state 56:10 75:23
187:13 187:21	217:24 219:25	84:9 85:10 88:17
223:7 225:17	220:23 224:25	89:8 115:8
226:14 227:1	229:20 230:5	130:24 147:6
227:23 237:2	230:14 232:22	162:4 162:7
stacks 16:16	236:25	163:22 167:1
16:19 17:6 17:12	standards 4:10	183:24 188:9
17:13 20:7	16:8 58:13 58:17	190:11 197:7
27:8 27:23 28:11	69:2 69:5	211:20 226:1
96:9 96:10	71:13 73:23 74:3	228:22 233:12
107:21 110:17	74:8 74:8	234:17
115:4 115:6	97:25 98:4	statements 39:7
116:9 170:1	124:15 140:10	236:3
175:15 175:16	150:15 184:23	states 13:19
175:22 179:3	207:3 225:1	
179:19 226:3		
226:15 226:19		

<p>56:12 129:1 140:20 141:1 230:11 231:6 231:14</p> <p>state's 230:7</p> <p>States 135:14 163:8 228:19 230:19</p> <p>station 92:3 121:3 121:21 123:1 125:12 157:1</p> <p>stationary 193:12</p> <p>stations 91:18 116:14 121:4 197:20</p> <p>statistic 30:4</p> <p>statistical 206:2</p> <p>statistics 30:1 33:21 87:15</p> <p>stats 41:24</p> <p>status 14:4 199:3 231:12 231:22</p> <p>Stauffer 211:21</p> <p>stay 15:13</p> <p>stayed 8:15</p> <p>stays 96:18 100:14</p> <p>steady 162:4 162:7 188:9</p> <p>steady-state 183:22</p> <p>steel 108:15 111:16 149:16</p> <p>stemming 178:23</p> <p>step 17:19 38:16 79:14 150:5 192:6 198:11 204:24</p>	<p>220:6 221:18</p> <p>Stephen 156:3</p> <p>steps 79:4 156:24 180:2 217:21 218:5</p> <p>step-wide 151:16 152:19</p> <p>Sterling 194:6</p> <p>Steve 57:16 57:17 67:17 77:9 138:21 156:4 162:9 162:10 162:10 162:12 172:8 172:15 172:16 174:6 174:9 180:1 205:5 213:15 213:25</p> <p>Steve's 173:25</p> <p>stoic 52:14 228:11</p> <p>stone 170:15</p> <p>stood 176:17</p> <p>stop 164:23</p> <p>story 47:3 68:24 68:25 225:16</p> <p>straddling 16:19</p> <p>straight 64:7 112:24 114:2</p> <p>straightforward 101:7 101:14 103:15</p> <p>strategies 71:10</p> <p>strategy 134:17</p> <p>streamline 75:22 179:20</p> <p>streamlines 22:23</p> <p>stress 137:23</p>	<p>stretch 9:14</p> <p>strictly 38:5</p> <p>stringency 4:9 184:21 185:8</p> <p>stringent 58:13 184:23 229:21 230:5 234:22</p> <p>strong 22:21 22:22 22:24 212:14</p> <p>strongly 143:17</p> <p>structure 18:21 19:2 19:20 23:11 23:15</p> <p>structures 20:1 20:25 21:8 27:12 27:21 27:22</p> <p>stuck 178:25</p> <p>studied 27:16 27:19 155:1</p> <p>studies 7:24 8:1 8:8 17:25 27:11 29:12 43:11 54:9 60:5 62:18 66:8 75:15 98:19 104:1 105:6 129:12 153:11 153:18 154:8 154:15 154:16 209:19 210:10</p> <p>studying 53:17</p> <p>stuff 109:13 138:13 138:16 214:9</p> <p>stumbled 119:19</p> <p>sub 82:17 156:22 162:3</p> <p>sub-categories 223:17</p>
---	---	--

sub-G 18:11	11:14	48:7 48:21 50:25
sub-GEP 17:12	substantial	71:1 140:22
19:2	144:20	210:9
sub-group 200:4	substantially	summarizes 156:21
sub-guidance	31:14 32:8 32:12	summary 22:10
181:12	47:12 48:19	31:8 72:19
sub-hour 83:2	52:21 159:7	76:4 102:12
sub-hourly	succeeding 81:4	179:8 187:7
77:11 78:16	successfully 55:7	210:23
79:20 81:5 81:15	sudden 119:11	summer 47:14
81:17 81:21 82:2	215:25	111:17 121:15
82:15 93:21	suddenly 60:20	summit 157:16
156:16 158:10	suffice 67:25	157:17
159:14 159:17	sufficient	superior 57:7
159:21 160:10	27:16 145:11	superiority 57:7
160:11 161:24	suggest 61:21	supplemented
186:4 188:10	90:10 143:6	113:2
subject 51:16	144:12	supplied 144:8
74:20 228:21	suggested 15:4	supplier 228:18
232:1	58:24 61:12	Supply 53:6
subjects 57:25	143:10 144:17	supplying 214:18
submissions	144:24 214:25	support 10:18
229:13	236:22	10:20 14:22
submit 105:3	suggestion 27:23	63:14 75:20
108:25 164:9	suggestions	130:20 145:21
175:19 235:7	6:23 42:10 42:17	146:4
236:7 236:9	60:22 62:5 67:10	supported 41:18
237:22	144:20 145:2	supportive 8:7
submitted 4:24	suggests 69:19	supports 26:10
94:9 111:16	135:24	suppose 153:14
164:7 233:9	suite 140:6	supposed 21:6
236:4 238:6	sulfate 44:1 54:4	sure 9:1 30:9
238:7	146:10	39:14 58:17
submitting 5:18	sulfates 54:7	103:5 137:9
52:6	sulfur 44:21 70:2	138:14 138:17
sub-part 98:19	70:3 72:7	139:12 147:13
102:11	72:12 74:15	148:10 149:8
sub-routines	Sullivan 163:19	152:23 170:4
49:23 49:24	summarize 47:3	205:5 208:21
subsequent 13:4		
subsequently		

218:14 228:2	201:8 232:8	185:6 186:3
surface 97:23	232:11	talking 11:11
117:21 157:5	systems 63:7	14:9 15:20
166:3 166:5	67:12	17:8 24:25
207:14 210:6		28:3 34:5
211:18 212:12	<hr/> T <hr/>	43:12 48:4 83:15
212:14	table 220:15	132:13 140:5
surfaces 100:11	tabulated 186:17	209:17 220:3
100:12 100:16	tabulates 208:13	talks 28:18
surgery 198:15	tail 160:6 160:9	52:2 56:18 57:23
204:22	tails 95:13	58:12 65:9
surprise 116:20	taking 6:24	106:19 180:12
150:18 155:5	112:14 137:6	188:16 205:5
195:17	147:25 179:18	213:16
surprised 72:14	214:1 235:24	tall 80:10 95:1
72:15 75:2	talk 10:1 15:24	123:9 123:12
surprising 71:14	16:5 18:12 28:18	123:25 124:18
Surprisingly	30:25 33:25	169:4 226:3
229:8	37:11 37:18	226:15
surrogate 198:5	43:10 44:22 49:9	taller 179:3
surrounding 44:19	56:7 57:25 60:17	187:12 187:21
100:11	70:11 70:12	tanks 207:4
swapping 162:2	83:15 91:5	team 55:21 58:3
switch 24:13	91:8 96:24	168:7
24:15 64:23	106:23 107:2	Tech 10:5
121:14 131:8	117:13 118:8	technical 10:4
193:5 209:17	126:24 150:12	10:18 10:21
switched 105:7	156:3 162:22	10:23 13:16
161:24	163:16 174:21	14:22 53:19
switches 225:20	180:19 180:21	59:19 60:11
Switching 230:25	181:6 185:16	65:17 97:8
SWWYTAF 44:17	193:6 205:22	198:17 203:21
symmetric 154:8	talked 12:5 12:21	technically
155:7	17:17 63:8	148:25 232:18
symmetries 155:3	64:8 64:20	232:19
symposium 20:17	65:8 65:13 82:24	technique 221:12
Synfuels 92:1	91:12 118:2	techniques 139:17
system 12:6	118:16 121:7	technology 47:7
12:7 165:9 199:5	124:10 124:13	56:17 98:6
	126:7 126:11	102:10 147:3
	130:22 135:15	temperature
	163:14 176:24	
	178:21 181:2	

50:4 100:1 100:7	77:5 84:13	202:24
172:19 173:9	113:19 182:17	tests 32:14
187:22 211:9	186:4 191:11	34:2 37:7
223:11 227:7	191:18 191:20	40:25 44:15
temperatures	192:17 194:24	49:10 50:3 51:17
47:17 115:6	195:25 196:7	55:7 55:21
template 213:12	197:4 197:24	56:5 56:19
tempo 156:8	238:16	67:2 81:7
temporal 136:18	terrain 66:14	Texas 163:8 214:6
ten 7:25 23:12	84:23 85:2 87:12	214:17
23:24 25:19	88:4 88:4	thank 6:14 6:18
25:23 26:7 26:24	89:24 89:25	9:5 9:7 9:8 9:17
46:11 61:6 67:21	89:25 92:14	11:6 15:13
77:2 82:4	92:17 92:19 93:3	43:8 51:24
82:14 83:7 85:20	93:5 93:9	52:1 52:16 57:12
85:20 86:15	93:15 93:23 94:6	57:17 57:18 59:1
86:16 87:2	94:20 94:23 95:2	67:16 67:17
87:8 87:25	95:9 95:10 95:17	67:20 70:9 76:16
88:1 89:12	95:25 96:8 96:10	76:17 77:1 96:25
113:18 115:4	96:20 99:12	97:3 102:21
224:18 228:1	99:13 99:15	102:22 106:15
tend 61:4	167:14 223:13	112:1 112:19
158:15 158:17	224:20	113:7 117:11
160:3 160:5	Tesche 210:12	126:24 127:11
160:9	test 51:17 55:6	132:5 132:6
tendency 144:14	56:14 77:13	139:20 148:7
161:17	84:24 91:14	148:8 155:25
tends 47:14 54:17	91:15 95:1	156:1 162:9
72:12 105:3	96:3 96:23 99:25	172:3 174:6
160:12 160:13	115:2 116:10	180:5 180:6
tenfold 4:10	116:10 202:25	180:9 180:14
Tennessee 25:5	204:3 206:12	198:10 204:21
156:5 162:12	206:23 207:8	205:7 209:15
163:8 164:14	208:11 211:14	213:14 213:18
164:22 164:23	222:11	222:13 235:13
164:24 164:25	tested 20:2	235:14 237:16
165:1 165:17	64:6 130:17	237:25 238:1
165:17 165:20	139:1 141:6	238:11
termination 20:13	200:19	thanking 127:14
terms 30:13	testing 17:21	thanks 28:14 53:3
41:9 41:13 47:18	55:16 63:10	117:12 148:13
49:13 70:1	75:10 83:8 83:17	213:15 222:20
	85:6 102:7 199:1	that's 5:6 5:25
	199:15 202:10	6:1 6:4 6:10 7:2

7:22 8:2 11:9	224:4 225:24	160:6 160:16
16:9 17:3 17:4	226:10 227:4	161:9 164:17
18:13 19:3	235:17 237:8	164:23 165:10
19:6 20:8	themselves 5:11	165:14 165:23
21:24 21:25	theoretic 21:6	166:1 166:25
22:17 22:19 23:6	theoretical 20:18	167:2 168:1
28:4 31:7	22:1 27:11	168:2 168:8
31:12 33:1	153:18	168:12 169:20
38:8 38:19 38:22	thereafter 175:17	170:22 171:4
39:12 40:20 41:7	thereby 144:20	171:5 171:9
43:8 44:11 44:13	therefore 13:18	171:12 171:14
47:25 48:9	74:17 78:5 142:9	171:15 171:16
49:6 49:19	230:19 231:18	171:18 171:19
50:5 51:23 59:13	231:25	182:20 201:24
62:2 62:3 62:7	there'll 117:23	205:23 207:9
65:5 65:25 67:14	there's 5:19 15:9	208:12 208:21
69:9 69:11 69:19	24:15 38:11 43:1	209:7 211:7
71:8 71:8	44:8 47:9	214:9 214:12
71:15 71:15 75:9	48:22 49:16	215:5 219:2
75:12 83:9 86:20	49:17 50:14	223:23 227:24
88:12 88:14 91:4	50:18 58:16	they'd 7:3 214:7
92:19 93:14	58:16 60:16	they're 10:25
95:19 96:23	60:17 60:24 61:9	13:1 16:14
100:14 102:8	61:18 62:1 64:14	28:1 45:19 51:11
111:25 116:8	66:9 66:13	51:11 51:12
122:18 123:15	67:2 67:10 68:13	51:13 62:17
125:13 125:15	69:7 71:17 74:11	72:22 76:9
126:2 126:24	79:3 82:5	106:18 107:21
128:19 132:24	87:22 87:22	115:21 120:19
135:13 135:18	87:22 88:15	121:1 122:8
136:21 139:19	93:18 93:19	152:8 172:9
144:23 149:9	96:16 100:17	186:21 196:6
151:14 152:12	103:12 111:8	206:10 207:21
154:25 155:7	111:8 115:15	208:7 226:4
166:10 167:8	116:12 116:14	226:16 226:17
167:17 167:20	120:22 121:1	226:20 236:6
169:20 170:22	121:8 125:20	they've 47:20
174:4 180:8	128:8 129:21	58:18 71:2
184:16 185:18	134:6 134:13	211:12
186:2 186:22	134:17 135:7	third 7:14
190:7 192:10	136:20 139:15	48:18 79:14
192:10 197:11	157:22 158:10	119:1 123:9
210:17 214:15	159:6 159:15	216:22 226:24
216:25 219:23		thirds 99:21
221:10 221:18		
222:10 223:14		

<p>thirteen 37:24 125:2</p> <p>thirty 34:11 36:19 78:18 78:18 78:23 78:24 78:25 86:2 86:8 87:3 88:1 90:2 90:6 95:17 96:23 98:23</p> <p>thirty-five 85:4 105:9</p> <p>thirtyish 4:17</p> <p>thirty-six 33:17 33:17 34:1 35:7 36:1</p> <p>thoroughly 58:19 66:16 229:24</p> <p>thoughts 148:21 236:1</p> <p>thousand 165:22</p> <p>thousands 50:18</p> <p>thread 59:23</p> <p>Threat 209:20</p> <p>three-hour 38:1</p> <p>three-year 215:20 218:7 219:21 221:1</p> <p>threshold 19:17 121:5 121:9 122:6 122:24 124:3 125:4 126:18 216:9</p> <p>thresholds 60:20</p> <p>threshold's 121:10</p> <p>thrilled 8:22</p> <p>throat 198:15</p> <p>throughout 158:14</p>	<p>175:3</p> <p>throw 170:15 173:3</p> <p>throwing 90:1</p> <p>tie 127:7</p> <p>tied 125:24</p> <p>tier 67:8 75:1 75:5 75:6 75:19</p> <p>tight 81:10 82:1 82:13 83:4</p> <p>tightens 140:9</p> <p>timeframe 178:12</p> <p>time-intensive 102:19</p> <p>timeline 175:6 175:11</p> <p>timely 42:13 145:1</p> <p>Tinto 148:15 150:12 150:18 150:23 153:22 155:13 155:20 155:24</p> <p>tip 164:23</p> <p>TKE 210:7 212:11 212:22 212:23 213:2 213:7</p> <p>today 4:11 4:12 4:25 5:4 5:14 5:17 6:20 9:3 9:5 10:23 11:4 11:8 12:8 12:17 15:16 17:8 37:12 51:23 52:6 58:12 68:1 68:3 68:23 106:25 124:10 125:14 127:16 140:22 148:6 149:13 156:6</p>	<p>156:17 163:9 220:4 228:17 231:23 234:11 236:5</p> <p>Tom 210:12</p> <p>tomorrow 162:17 162:19</p> <p>Toni 222:21</p> <p>tons 134:14 134:15 134:17</p> <p>tool 39:19 51:22 57:4 57:5 191:13</p> <p>tools 8:3 8:8 39:21 69:5 141:5 141:6 143:12 143:21 147:20 147:23 155:18 192:20 197:25 230:12 233:24 234:2 234:4 234:7</p> <p>top 25:16 25:18 30:16 100:12 100:14 115:20 115:23 116:1 171:6 171:19 184:11 208:5 208:6 225:16</p> <p>topic 66:2 185:18</p> <p>topics 11:17 11:24 12:1 12:20 60:12 175:3 190:21 230:25</p> <p>topography 158:17</p> <p>tops 158:17</p> <p>topside 100:21</p> <p>tortuous 93:16</p> <p>total 48:20 129:11 136:1 136:4 158:7</p>
---	--	--

206:18 209:3 227:10 totaled 71:22 totally 160:18 163:6 touch 74:19 142:1 181:5 184:6 190:21 touched 23:9 tough 227:13 tour 125:9 tournament 162:17 toward 81:2 88:21 144:21 146:1 157:9 157:13 160:4 171:7 towards 172:13 190:4 tower 91:22 103:25 166:5 169:2 169:16 170:10 170:20 170:21 171:2 171:19 172:20 172:23 173:10 174:14 174:16 197:19 198:6 town 165:25 193:8 193:17 193:17 196:9 237:8 trace 36:12 206:9 traced 95:20 tracer 28:22 29:4 36:17 37:23 79:18 80:3 103:18 129:4 tracers 62:23 track 52:13 85:23 tracking 44:9	trade 52:8 trading 27:1 traditionally 13:14 trailing 38:22 train 45:1 trained 39:2 trajectories 83:20 86:6 trajectory 33:10 131:4 transcribed 5:7 transcript 238:15 transcripts 236:9 236:10 238:7 transfer 97:23 100:9 100:16 transit 221:12 transition 9:9 transitions 112:8 Transmission 52:17 53:6 transparent 144:11 235:10 transport 13:5 53:21 66:24 87:4 88:9 185:2 197:5 201:25 204:12 206:8 219:11 221:15 transported 36:18 transporting 201:11 201:16 203:21 trapezoid 154:20 trapped 105:20 183:23 travel 24:9 85:20	86:6 86:10 87:1 90:5 90:6 219:11 219:18 travels 238:13 TRC 43:16 55:10 55:19 55:21 214:1 217:16 treat 98:10 99:11 99:14 102:14 188:19 treating 99:9 188:7 197:11 treatment 185:2 188:12 200:4 200:6 200:10 200:10 200:15 treatments 201:13 treats 98:24 146:10 trees 149:5 trend 182:10 193:19 195:9 195:20 trends 182:19 184:17 190:24 193:19 193:22 194:11 194:14 194:18 194:19 195:10 195:21 Trespassing 223:21 Triad 162:14 trial 206:19 trials 206:14 206:15 209:10 tri-cities 165:25 tried 22:2 31:19 45:6 84:4 84:14 84:16 110:11 114:1
---	--	---

trigger 143:20	27:11 153:11	twenty-seven
Trinity 102:24	153:17 154:8	125:20
103:1 174:24	turbine 135:7	twice 168:10
222:21 228:5	turbulence 103:11	238:2
237:17	172:22 205:12	two-dimensional
Tri-State 52:17	205:13 210:7	27:12
trouble 125:18	turbulent 104:6	two-hour 216:6
212:12	104:7 104:22	216:18 219:19
trucks 152:6	212:23	two-step 101:17
152:7	turn 180:13	101:18 102:14
true 39:12	222:15	two-thirds 226:24
40:14 41:9	turned 55:24	Tyler 7:4 14:24
90:8 105:19	turns 50:1 111:10	15:4 125:19
149:24 149:24	205:16 236:23	236:5 237:19
truly 11:10	237:6	type 28:25
145:13	TVA 156:3	29:12 32:21
trust 90:4 174:3	tweaked 93:22	59:14 62:16
try 7:12 10:18	twelve 21:9	98:12 111:14
19:11 23:7 41:20	26:7 29:5	115:6 118:4
57:24 61:12	34:12 35:17	124:14 146:2
61:24 77:21 83:7	35:22 36:7 36:24	173:4 174:2
117:25 126:22	37:25 42:1 80:13	196:13 212:6
169:10 180:8	80:25 80:25	types 47:11 51:24
181:1 190:10	81:21	57:21 98:1 99:12
216:4 216:9	twelfefold 27:7	108:16 151:19
224:12 225:8	twelve-hour 36:15	typical 71:16
228:3	twenty 7:25 18:16	72:1 72:9
trying 6:5	18:20 19:6	72:10 135:21
39:22 70:19	21:1 25:12 42:20	135:25 136:25
83:13 115:11	80:17 86:1	137:3 207:23
124:25 125:24	86:7 86:10 86:16	212:18
180:20 183:22	87:2 88:1	typically 10:1
188:5 188:19	88:22 89:13	100:25 116:7
216:10 216:22	89:15 89:21	211:4 212:20
222:1	89:21 90:2	237:3
Tuesday 12:4 12:8	90:6 90:11 95:17	<hr/>
16:17 17:18 22:8	114:3 114:3	U
118:17 121:8	115:4 122:18	<hr/>
232:4 237:10	twenty-five 77:8	U.S 4:1 5:13
237:14	twenty-four	53:17 65:7
tuned 15:13	74:2 115:10	UARG 139:25 140:3
tunnel 18:7 26:22		140:7 140:23
		142:4 143:17

144:10 147:3 147:4 147:18 148:5 UARG's 140:23 ultimate 217:21 ultimately 220:19 unavoidable 40:21 unbiased 140:11 229:23 234:25 uncertain 66:10 66:12 uncertainties 137:11 uncertainty 66:9 94:4 130:12 211:8 212:17 213:3 unchanged 40:25 unclear 143:18 uncontrolled 128:3 157:7 undercoke 101:2 underestimated 159:3 211:10 underfunded 233:18 undergone 153:8 underlying 141:4 under-predicted 208:17 under- predicting 130:1 133:14 136:13 under- prediction 130:3 130:5 136:23 under-predictions 208:21 under-predicts	130:11 understaffed 233:18 understand 42:9 54:18 56:18 103:3 139:6 149:3 174:7 179:25 187:2 187:4 191:16 236:3 understanding 187:19 187:25 188:4 189:12 understood 31:21 undertaking 69:14 underway 56:19 69:11 underwent 201:15 201:17 unfortunately 6:15 7:23 52:4 115:24 234:16 uniform 109:18 109:19 201:23 unintended 118:19 unique 104:19 224:1 225:13 unit 38:17 215:19 United 135:14 163:7 228:19 units 202:4 universally 51:13 University 154:14 200:18 Unix 202:17 202:18 unless 66:16 155:6 163:15 unlike 183:11	unlikely 141:14 unnecessary 140:19 155:19 230:6 235:2 unobstructed 99:1 unpaired 135:21 135:21 136:6 137:4 unproven 230:5 unqualified 41:17 unrealistic 186:21 unrealistically 17:16 unreasonable 228:3 un-regulatory 190:17 unsolved 103:14 unsplit 34:22 unstable 79:25 80:9 82:22 208:23 unusual 96:4 185:4 190:3 unverified 15:22 unwilling 145:23 upcoming 102:10 125:16 200:25 201:6 203:1 204:17 update 178:4 178:7 198:13 199:2 updated 53:1 178:9 updates 150:25 227:14 233:21 updraft 105:24
---	--	---

upon 119:19 140:13 141:22	153:6 202:25	217:7 217:20
upper 48:24 49:2 113:1 157:10 164:22 207:15	U-square 212:24	217:23 217:23
upside 115:25	usual 205:17	218:9 220:1
upwards 56:4	usually 61:24 75:10 85:7 209:22	220:4 220:10 221:4 221:5
upwind 23:17 66:21 104:10 104:25 133:25 138:25 154:12 166:16 167:4 169:7 170:23 218:7 219:21 219:23 220:21 221:3 221:15	Utah 45:3 153:23 154:14	values 21:8 49:23 54:8 75:3 81:24 114:3 116:4 141:19 158:7 158:21 159:10 160:18 160:24 161:11 187:9 188:10 188:20 188:22 189:14 194:16 195:19 195:22 208:12 209:23 214:21 214:22 214:22 216:25 218:1 219:16 219:17 220:23 221:3 221:14 229:5
UR 60:23	<hr/> V <hr/>	variability 47:17 74:14 132:25 134:18 182:21 189:21 207:23 207:24 230:21
urban 62:6 62:11 62:12 62:17 62:21 103:6 103:7 103:9 193:18 197:11 211:6 225:25 226:2 226:5 226:6 226:8	valid 130:18 162:5 219:20 220:8 220:9 220:16 220:17 221:2 222:5	variable 74:10
urge 145:14 147:10	validated 126:14	variables 209:22
urgent 139:15	validating 197:10	variation 21:2 104:9 104:14
urges 147:3 147:4 147:18	validation 207:3	variations 186:11 188:11
useful 49:19 74:13 90:15 90:22 188:2 200:19 221:24	valley 85:12 85:13 88:5 92:1 156:5 165:17 165:18 166:19 166:24 167:8 170:11 207:9 207:17	varied 23:25
user 14:7 78:19 202:10 202:12 202:14 202:15 202:16 202:23	valuable 172:9	varies 186:1
users 90:22 153:5	value 26:24 31:6 49:4 81:6 116:3 158:20 158:20 161:12 163:24 164:12 168:1 172:15 187:11 188:23 188:24 190:2 191:11 195:20 196:13 196:14 214:13 215:2 216:7 217:4	variety 81:7 82:6 173:19 203:11
		various 55:4 56:12 60:2 63:9 68:14 71:3 71:9 72:19 74:23

warranted 235:5	213:19 231:2	60:21 61:5 62:25
wash 79:20	236:3	63:2 66:19
wasn't 30:9 50:10	we'll 5:16 5:24	68:8 69:9
71:4 215:2	6:12 15:8	69:21 70:3 70:11
217:15	15:10 34:6	70:18 71:20
Waste 9:15 117:10	43:3 52:13 57:15	75:18 76:7 76:10
118:11 119:7	59:1 59:1	76:14 76:23
watch 66:14	76:21 77:6 82:19	83:13 86:13 87:2
watching 8:25	102:21 102:23	87:8 87:10
water 44:5 44:7	156:2 174:18	88:3 88:6
45:13 46:18	174:20 174:21	88:18 88:18
224:1	174:22 192:23	88:19 88:19
WAYLAND 6:14	204:13 213:16	88:23 88:23
ways 31:3 31:5	223:6 235:18	89:10 89:13 91:1
45:4 63:9	235:20 236:9	93:23 94:20 96:8
63:21 121:16	236:12 237:23	96:9 102:6
136:7	238:14 238:18	109:10 112:11
wear 162:15	well-beyond 29:16	115:9 115:12
weather 66:7	well-controlled	116:7 117:14
121:20 157:5	68:6 128:2	120:6 121:12
197:18	130:14	122:6 126:22
webinars 118:16	well-defined	127:9 128:12
website 55:10	100:4	128:23 132:19
106:11 113:2	well-	136:18 137:6
115:3 199:20	established	139:23 144:4
205:2	49:11	149:6 151:12
websites 203:25	well-recognized	152:16 162:2
we'd 8:7 13:2	144:16	163:6 163:11
32:25 33:1 71:19	well-	165:10 167:24
216:13 227:13	represented	168:4 168:9
wedge 22:19	108:11	168:19 168:20
Wednesday 230:22	Wenck 117:16	168:20 168:21
week 76:13 97:9	we're 4:11 5:14	169:1 169:3
169:4 171:2	5:14 6:5 7:17	169:5 169:6
weeks 106:13	9:21 11:8 14:9	169:7 169:9
198:15	17:13 17:20 21:8	169:10 169:11
weight 176:12	23:8 26:8	169:13 170:4
weighting 32:13	26:10 28:10	170:20 170:25
welcome 4:4	28:10 32:17	170:25 172:1
	35:19 42:11	172:14 173:7
	42:25 45:15 52:8	173:12 173:13
	57:24 58:17	173:16 173:20
	58:17 59:2 60:19	178:15 180:1
		182:13 184:18
		187:4 205:4
		206:17 208:20

209:9 214:3	216:8 217:20	26:3 26:4
215:4 215:20	227:11 235:23	26:19 28:2
216:21 217:17	WGS-84 37:23	28:5 153:25
219:8 219:22	whatever 112:25	154:1 169:20
220:11 220:15	124:12 148:19	233:5
222:3 222:8	173:3 205:14	widely 49:12
222:9 223:15	236:16	51:12
237:22 237:24	whenever 10:21	wider 20:25 23:12
west 43:17	14:23 100:20	27:21 33:19
52:23 53:5 53:14	207:20	widest 21:8
53:17 53:20	whereas 18:24	width 17:9 18:1
55:20 55:25	40:13 80:13	18:17 19:5
56:13 56:13	82:10 82:12	20:3 20:20
127:23 146:14	86:12 86:19	21:2 21:3
158:13 207:9	99:20 127:3	21:20 22:11
western 29:7 53:6	WHEREUPON 76:22	22:15 23:23
53:16	235:22 238:21	25:11 27:6 81:10
wet 45:11 153:7	whether 13:8	Wildlife 191:8
176:22 192:2	16:14 39:2	Willamette 85:13
227:4	43:6 69:17	willing 76:9
we've 5:15 9:24	75:6 75:22	145:18 148:1
9:25 26:6	109:24 131:17	233:18
27:10 51:18 64:7	149:16 156:8	wind 18:7 22:19
66:22 70:13	202:5 209:24	22:20 23:1 23:14
74:21 75:10	211:6 224:16	24:22 26:19
76:18 77:9 80:23	226:6	26:22 27:11
82:18 82:20	whole 7:7 49:21	33:19 36:14
91:12 101:22	62:2 63:18	36:21 41:3 41:10
102:8 102:13	67:9 86:11 87:23	41:11 41:11
106:25 108:17	94:9 109:19	59:16 60:8 60:18
110:17 118:15	114:17 114:19	61:7 61:17 61:19
123:22 125:17	132:1 133:19	63:25 64:2 64:12
125:18 126:7	181:14 203:13	66:8 67:9
127:5 127:8	209:10 215:10	77:16 77:17
131:15 135:6	225:16	77:18 77:22 80:6
135:15 138:3	wholeheartedly	80:7 80:19
143:1 144:15	233:11	81:5 82:24 85:15
149:1 150:12	who's 206:5	89:2 90:16 90:17
150:19 151:6	220:15	91:11 99:6
151:17 152:3	wide 10:10	99:9 103:10
152:11 154:15	15:23 16:1 17:16	103:25 104:1
155:14 155:15	17:23 18:9 18:16	104:1 104:1
163:25 168:18	22:25 23:3	104:5 104:6
175:8 178:21		
201:9 206:20		

105:13 105:14	windrose 166:11	21:25 25:4 27:25
105:22 106:9	194:12	30:22 42:5 42:25
109:4 110:22	winds 33:7 36:5	43:2 43:14 43:15
111:1 111:9	36:18 36:22 37:1	43:16 43:19
111:10 112:12	37:8 37:8 40:4	43:22 51:2 53:12
112:17 113:17	40:8 40:16 60:21	56:19 59:17 60:6
113:19 113:22	77:22 77:23	64:25 65:3 70:13
114:7 114:8	78:16 80:1	73:9 76:5 76:7
114:9 114:16	80:8 81:19 82:22	82:6 103:1 108:6
114:18 114:18	84:1 85:14	131:25 132:2
114:20 117:4	87:8 88:4 88:7	145:5 145:18
120:3 120:5	88:21 89:25	145:24 147:20
120:21 120:21	90:16 94:12 96:9	147:22 151:3
121:4 121:5	105:20 106:24	156:5 156:16
122:5 122:18	111:22 118:20	159:17 162:23
122:23 123:2	118:25 119:10	163:9 164:17
124:1 125:12	119:11 119:12	185:10 190:10
130:16 130:21	120:7 120:16	191:9 192:1
143:2 144:15	120:23 122:7	206:4 213:17
145:22 148:21	122:23 123:4	213:24 214:4
150:19 151:6	123:5 124:3	215:7 215:23
152:14 153:11	124:21 126:23	216:9 216:23
153:17 154:8	157:16 207:19	217:16 219:7
161:25 162:1	207:20 211:1	222:4 227:16
166:12 169:24	211:1 225:21	227:21 233:19
170:6 173:8	232:7	worked 58:8
185:25 186:13	winter 47:15	109:24 117:25
186:19 186:24	wintertime	185:9 217:6
188:6 188:7	47:15 54:11	workgroup 70:7
189:6 194:10	wires 171:6	working 12:19
194:22 196:14	wise 150:6	58:18 62:15
196:23 205:9	wish 107:9 139:21	90:13 107:12
205:12 205:15	147:15 163:22	132:19 145:14
207:24 208:1	wishes 204:22	146:1 172:7
208:2 210:25	witnessed 228:24	175:24 183:5
211:5 212:19	wma.org 15:13	202:1 203:2
213:4 213:5	wonder 154:19	217:13 218:21
213:5 216:11	Wood 127:10	workload 176:4
216:14 216:17	127:11 127:13	works 28:9
219:9 221:16	work 5:16 7:10	61:13 65:2 219:6
223:10 223:11	7:16 8:1 8:2	workshop 234:18
223:11 232:9	12:13 20:16	workshops 10:21
232:14 232:16		59:11
233:6		
Windows 202:17		

world 141:14 151:1 155:6 229:1	y'all 167:23 168:9 168:14 168:22 170:5 172:4	you've 21:16 53:12 97:17 97:19 99:2 128:19 135:11 136:2 147:9 152:4 171:2 176:24
worry 57:21	yank 169:22	y's 109:1
worse 21:18 46:7 83:25 166:24 167:8	yawl's 168:3	YY 129:16
worse-case 223:25	Y-axis 129:18	<hr/>
worst 23:23 41:18	year-by 220:17	Z
worth 38:16 73:25 84:11 169:17 174:20	yearly 147:6	<hr/>
wrap 6:17 188:5 191:4 197:13 198:9	year's 84:11 234:17	Zale 213:25
WRF 44:5 211:23 211:25 212:7 212:16 212:17 212:21	Yegnan 180:14 180:17 190:9	zero 35:1 50:22 78:24 120:23
write 187:17 188:3	yellow 73:4 91:25 160:20 181:23	zooming 92:3 166:13
write-up 61:22	yesterday 5:2 5:20 6:25 8:10 8:24 14:12 30:2 38:12 56:18 60:8 63:9 64:20 67:24 68:4 68:11 68:21 70:6 124:11 125:19 199:23 200:11	z's 109:2
writing 187:7	yesterday's 199:13 200:25	
written 58:1 140:25 155:23 238:8	yet 14:16 72:1 131:12	
wrong 34:22 37:24 50:20 50:20 133:21 151:24 163:23 219:3	yields 163:15	
wrote 59:21 169:13	you'll 36:6 46:1 115:15 115:23 136:23 139:4 163:13 166:11 215:12 227:6 227:6 238:16	
W-square 212:24	yours 97:2 162:10 205:6	
Wyoming 44:19 51:3 131:16	yourself 140:1 148:12 236:16	
<hr/> X <hr/>		
X-axis 129:16		
<hr/> Y <hr/>		