BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

IN THE MATTER OF THE APPLICATION BY CROCKER WIND FARM, LLC FOR A PERMIT OF A WIND ENERGY FACILITY AND A 345 KV TRANSMISSION LINE IN CLARK COUNTY, SOUTH DAKOTA, FOR CROCKER WIND FARM	))))))	EL 17-028

DIRECT TESTIMONY OF

MARK THAYER

ON BEHALF OF

CROCKER WIND FARM, LLC

Q1. Please state your name and business address for the record.

A1. My name is Mark Thayer. I am an Emeritus Professor in the Department of Economics at San Diego State University, San Diego, CA 92182.

Q2. On whose behalf are you testifying on today?

A2. I am testifying on behalf of Crocker Wind Farm LLC, the Applicant in this proceeding.

Q.3. What is the purpose of your direct testimony?

A3. The purpose of my testimony is to discuss the relationship between wind farms and surrounding property values

Q.4. Please provide a summary of your qualifications

A4. I received my Ph.D. in Economics from University of New Mexico in 1979. My field of expertise is environmental, natural resource, and energy economics. I am currently an emeritus professor in the Department of Economics at San Diego State University. I have thirty-five years of experience in both university and government service and extensive experience integrating environmental and energy related matters into decision making at the state and federal level. I have published numerous research articles in professional journals such as the *American Economic Review, Journal of Political Economy, Journal of Environmental Economics and Management, Land Economics, Natural Resources Journal, Journal of Urban Economics, Economic Inquiry, Journal of Sports Economics, and Journal of Human Resources*. I have been a principal investigator on projects funded by entities such as the California Air Resources Board, California Energy Commission, U.S. Environmental Protection Agency, U.S.

Geological Survey, the South Coast Air Quality Management District, the National Science Foundation, and numerous private entities. My recent research has focused on projects related to energy efficiency (both program development and evaluation) and the assessment of the impact of wind farms and solar photovoltaic energy on residential property values.

Q5. Have you attached a resume or CV.

A5. Yes, please see Appendix A for my entire curriculum vitae.

Q6. As a co-author please provide a summary of the Lawrence Berkeley National Laboratory (LBNL) studies.

A6. LBNL conducted the following large-scale studies to determine whether or not wind developments had a significant effect on nearby property values.

- "The Impact of Wind Power Projects on Residential Property Values in the United States: A Multi-Site Hedonic Analysis" (B. Hoen, R. Wiser, P. Cappers, M. Thayer, and G. Sethi), December 2009 – analysis of 7,459 home sales.
- "A Spatial Hedonic Analysis of the Effects of Wind Energy Facilities on Surrounding Property Values in the United States" (B. Hoen, J.P. Brown, T. Jackson, R. Wiser, M. Thayer, and P. Cappers), August 2013 – analysis of 51,262 home sales, with 1,198 within one mile of a turbine.

The 2009 LBNL study focused on property value concerns for wind energy that fall into three categories. Each of these effects could impact property values and the effects are not mutually exclusive.

- Area Stigma – concern that surrounding areas will appear more developed.

- Scenic Vista Stigma – concern over decrease in quality of scenic vistas from homes.
- Nuisance Stigma – concern that factors that occur in **close** proximity will have unique impacts.

The 2013 LBNL study focused only on area stigma and nuisance stigma.

Q7. Please provide a brief explanation of the empirical methodology used to examine the impact of wind farms on nearby property values.

A7. The wind turbine / property value relationship was primarily studied using a statistical method called the Hedonic Price Model. The hedonic pricing model has been used by economists and real estate practitioners for over 40 years and has the following attributes:

- Uses actual market data to infer value – there is no attempt to appraise values.
- Designed to place an economic value on specific characteristics of a home (e.g., value of an additional bathroom, a pool, or view of wind turbines).
- Uses a large # of home sales (many thousands).
- Controls (holds constant) a large number of possibly confounding variables (everything under the sun).
- Uses data from a large area to obtain enough variation in all characteristics.
- Can use data from a restricted period of time (cross-sectional analysis) or an extended period of time (time-series analysis) – note that this latter case requires adjustment to constant dollars.

- Can be used effectively to appraise homes due to extensive data set – however, constantly updating the data set is expensive and time consuming.
- Hedonic pricing is essentially a very large "Paired Sales" analysis with sufficient home sales and controls.

The hedonic pricing model requires information on large number of sales and corresponding sales prices and home characteristics, which include

- Quantity Measures (e.g., square feet of living area, lot size, # of bathrooms, bedrooms, etc.).
- Quality Measures (e.g., # of fireplaces, condition of home, presence of pool, air conditioning, scenic vista, etc.).
- Location Specific Variables (e.g., local school quality, demographics, socioeconomic status, distance to important activities, environmental quality measures, etc.).
- Variables of Interest (e.g., view of wind turbines, distance to wind turbines).

Either Qualitative Ratings (e.g. dominance of view of wind turbines) or distance to the nearest turbine at time of home sale is used to measure the possible dis-amenity from wind turbines.

The 2009 LBNL study used home sales data from ten areas surrounding twenty-four wind facilities in nine states. In total, 7,459 residential sales transactions (1,754 pre-announcement, 768 post-announcement / pre-construction, and 4,937 post-construction) were analyzed. The 2013 study utilized 51,276 Home sales

from 27 U.S. counties related to 67 wind facilities, and 1,198 home sales were within one mile of a wind turbine.

Q8. Please provide a summary of the LBNL research findings.

A8. The LBNL research reached to following primary conclusion. Risks of property value impacts are often expected but **all** research suggests that property value impacts related to view and distance are not significantly different from zero. Specifically,

- **Area Stigma – no statistical evidence** that sales prices of homes near wind facilities are significantly affected by those facilities as compared to other homes in the region.
- **Scenic Vista Stigma – no statistical evidence** that sales prices of homes with a view of the turbines are significantly affected (i.e., stigmatized) even if the view is "extreme."
- **Nuisance Stigma – no statistical evidence** that sales prices of homes within a mile of the nearest wind turbine are significantly affected by those facilities as compared to other homes in the region.
- **Timing – no statistical evidence** of a trend in sales prices of homes near turbines that is consistent with scenic vista, area, or nuisance stigma.

In addition, LBNL also provided results from alternative models.

- **Repeat Sales Model** – appreciation rates for homes near the wind farms are not significantly different than appreciation rates for homes located farther from the wind farms.

- **Sales Volume Analysis** – no statistical evidence that the sales volume of homes near wind farms is different than the sales volume of homes located farther from the wind farms.

Q9. Please provide a summary of the recent academic literature on the impact of wind farms on nearby property values.

A9. In addition to the two LBNL studies there have been six large empirical studies completed since December 2009 that examined the impact of wind farms on nearby property values in the United States:

- "Wind Farm Proximity and Property Values: A Pooled Hedonic Regression Analysis of Property Values in Central Illinois" (J.L. Hinman) May 2010 – analysis of 3,851 home sales;
- "The Effect of Wind Farms on Residential Property Values in Lee County, Illinois" (J. Carter), 2011 – analysis of 1,298 home sales;
- "Values in the Wind: A Hedonic Analysis of Wind Power Facilities" (M.D. Heintzelman and C.M. Tuttle), July 2011 – analysis of 11,331 home sales;
- "Impact of the Lempster Wind Power Project on Local Residential Property Values" (M. Magnusson and R. Gittell), January 2012 – analysis of 2,593 home sales;
- "Relationship between Wind Turbines and Residential Property Values in Massachusetts" (C. Atkinson-Palombo and B. Hoen), 2014 – analysis of 122,198 home sales, with 6,081 within one mile of a turbine;

- "Effects of Wind Turbines on Property Values in Rhode Island" (Lang, Opaluch, and Sfinarolakis), 2014 – analysis of 48,554 home sales, with 3,254 within one mile of a turbine; and

These studies all use similar methodologies (hedonic price method) and data and, remarkably, come to the exact same conclusion. Specifically all large-scale, empirical studies of U.S. wind facilities conclude that, post-construction/operation, there is **no identifiable effect** of wind power projects on nearby residential property values. This conclusion is based on the evaluation of 248,560 actual home sales in eight studies.

Three of the studies suggest that there may be negative property value effects in the post-announcement / pre-construction phase. This effect has been labeled "anticipation stigma" by Hinman. However, in all studies these anticipation effects are transitory and disappear once the operation of the wind farms commences.

Based on this extensive literature, the planned wind projects in South Dakota will not significantly reduce the sales prices of properties in the neighborhood of the wind facilities.

Q10. Please describe any large-scale statistical studies focused on farm real estate?

A10. There have been zero large-scale statistical studies of farm (raw, vacant) land conducted in the US or Canada, probably because of a lack of transactions. There have been some "studies" in the alternative literature (see discussion below of the Kielisch, 2011 and Gardner, 2009) but these are based on extremely small samples, are completely unscientific, and useless from a benefit-cost perspective.

In addition, Sunak and Madlener (2012) examine land values in Germany (actually the land value portion of the overall assessment) but this study is likely not relevant for South Dakota. So the answer to the question is no.

Q11. Please describe how community characteristics affect real estate price trends and hedonic method estimates?

A11. Community characteristics could have either positive (e.g., expanding population, expanding economic opportunities, etc.) or negative (de-population, lack of jobs, abandoned homes, etc.) effects upon housing price trends. In either case these characteristics should not prevent good statisticians from determining the value/cost of proximity to a turbine or having a view of a turbine because the comparison is between homes near to turbines versus homes far from turbines, homes with views versus homes without views, etc.

Q12. Please describe any other literature.

A12. There is an alternative "literature" characterized by

- Small, unrepresentative, non-transparent samples in which the data selection process is undefined.
- Anecdotal information.
- Data sets that are a mis-matched combination of sales, appraisals, and assessments.
- Analysis of vacant land rather than residential home values.
- Insufficient controls for important influences.
- Inappropriate analytical methods.

This alternative literature does not possess the required scientific rigor and thereby should be considered useless for determining the effect of wind turbines on nearby residential property values.

This alternative literature has formed the basis for testimony by Michael McCann, who has offered basically the same testimony in a multitude of settings – specifically, residential properties located within three miles (or possibly greater distances) of wind turbines will experience a minimum 25 – 40 percent reduction in value for homes.

- Note that this is a minimum expected loss as McCann has on several occasions suggested that the loss could be significantly greater. In fact, in a publication/statement entitled "I Predict a Series of Rural Ghettos – Abandoned, Unmaintained Homes (Ill)," McCann stated in 2010 that the only thing worse than wind turbines for creating the physical and health-driven need to relocate is a nuclear reactor meltdown (e.g., Chernobyl) and indicated that damages to homes could be in the 60 – 80 percent range. Of course, no justification was provided for that damage range.
- The expected reductions in value are based on (1) McCann's own "analysis;" (2) an alternative literature; and (3) McCann's willful mis-interpretation / mis-understanding of the existing hedonic literature in which he demonstrates a complete lack of knowledge concerning statistics and hedonic methods and draws erroneous conclusions that are exactly opposite of the conclusions drawn by the authors of specific reports.

Overall, McCann's studies are cursory investigations using raw averages and paired sales methods. Each of these analyses is beset with the same range of problems (e.g., small samples, undefined sample selection methods, simple statistical measures, failure to account for obvious confounding factors, subjective monetary adjustments applied inconsistently, etc.). Conclusions of such work are without foundation and completely lacking in scientific rigor. In addition, Results are based on specific locations, specific local influences, and specific adjustment factors and, even if done with scientific rigor, would not be transferable to any other situation. Moreover, McCann's work completely lacks any sensitivity or robustness analysis. Only one assessment procedure is provided, one that always agrees with his initial previous work and never explores the impact on his conclusions of different samples, different selection methods, and/or different adjustment factors.

In addition to McCann's own work he also relies on an alternative "literature" on the effect of wind turbines on nearby residential property values. This literature includes studies conducted by Kielisch (2011), Gardner (2009), and Lansink (2012). As indicated above, this alternative literature is characterized by:

- small, unrepresentative, non-transparent samples in which the data selection process is undefined.
- anecdotal information.
- data sets that are a mis-matched combination of sales, appraisals, etc.
- reliance on of vacant land values rather than residential home values (e.g., Kielisch; Gardner; Sunak and Madlener; Jensen, et al; Gibbons).

- insufficient controls for important influences; and
- inappropriate analytical methods.

McCann also relies on three studies that were conducted in European countries (Sunak and Madlener in Germany, Gibbons in the United Kingdom, and Jensen, et al in Denmark). Each of these studies finds significant impacts of wind turbines on nearby property values, even though they utilize a variety of methods. It is not clear that these studies are relevant to wind turbine developments in the United States due to differences in homeowner and community compensation levels (significantly greater in the United States), the overall impact on the local environment (likely smaller in the United States due to more extensive review processes), and the working landscape (more large scale developments in the United States with established approval processes).

Finally, McCann consistently mis-interprets of hedonic and/or statistical studies. For example, McCann makes a completely false statement (and repeats everywhere) about the Hinman (2010) study. He states that "values near wind farm appreciated $13,524 after operation, following $21,916 decline measured under anticipation stigma theory. (Net loss of $8,392 pre- vs. post operation / Hinman, Pg. 120.)" In the example that Mr. McCann is referring to, Hinman is explaining how to calculate the price effects using a two-stage model (the two stages are pre-announcement and post-construction so note that there is no allowance for the anticipation period). Hinman's basic conclusion is that homes near wind farms suffered from a "location effect" and were depressed **prior** to wind farm development (-$21,916) and appreciated after development (+$13,254)

more than homes farther away. Note this means that proximity to wind turbines did not decrease property values – rather proximity increased property values. This is exactly what the 2009 Hoen, et al study found. Note that there is no discussion of "anticipation effect" in this Hinman calculation. On Page 121 of Hinman, she does examine a three-stage model in which the anticipation stage is included. In this case, homes near wind farms started out selling for less (-$20,323) than homes farther away (location effect), depreciated (-$3,977) more than properties farther away during the post-announcement/pre-construction stage (anticipation effect), but appreciated $11,931 more than homes farther away post-construction. Either McCann is being completely disingenuous or he misunderstood the examples in Hinman.

McCann draws a completely incorrect conclusion from Table 7 in the 2013 Hoen, et al study. The table provides evidence that homes within a mile of a turbine (post-construction) sell for approximately 28% less than homes more than three miles from a turbine. The point of this table is to demonstrate explicitly that simplistic comparisons (like appraisers do with their paired sales analysis and McCann did in the Lee County, Dekalb County, and Livingston County studies) can lead to uninformed, erroneous conclusions. In this case, homes within one mile are (for example) smaller, on larger lots, and are older than homes outside three miles. There are many other possible differences between the groups of homes as well (e.g., sales timing, census tract variables, as measures of neighborhood quality, etc.). When one accounts for all these differences the 28% sale price difference disappears – that is why one uses a sophisticated empirical

model rather than a simple comparison with inadequate controls. Yet, McCann argues that the 28% difference is the "smoking gun" and it is obvious that Hoen, et al (2013) has used statistics to eliminate a true price effect.

McCann makes a similar error when he examines the MPAC study (2012). MPAC conducted a two-part study, one that compared assessed values to sales vales (for assessment equity purposes) and a second one that examined actual sales transactions vis-à-vis proximity to industrial wind turbines (IWT). In the first study MPAC presents a histogram that examines assessment/sales ratios by proximity to an IWT. The point is to show that, regardless of proximity to an IWT, the assessment/sales ratios are very close to one, so there is no apparent equity issue in the assessments. McCann ignores the purpose of the histogram and focuses on the magnitude of sales prices by proximity to wind turbines. The histogram shows that homes outside 5 kilometers sell for over $220,000 and homes that are within 1 km distance sell for around $170,000 (approximate $50,000 or 22% loss in the McCann world). However, this difference does not control for potential differences in the homes by proximity. When these home characteristic differences are taken into consideration (the purpose of the second portion of MPAC study) there is **no significant difference in home sale prices by proximity to an IWT**. When apprised that his conclusion was exactly opposite the conclusion offered by the authors of the MPAC report McCann has stated that he was only looking at the data and that it seemed implausible to him that any confounding variables were relevant. Further he argued that for the MPAC conclusions to be correct that wind farms would have to be constructed on

lower priced land. In fact, most studies have found this to be the case (e.g., Hinman, 2011; Hoen, et al, 2009); that is, there is a significant location effect prior to wind farm development.

- McCann has suggested that the Hoen, et al (2009) study indicates negative property value effects from turbine visibility. However, McCann does not grasp the difference between scenic vista (VISTA) and view of turbines (VIEW) in the Hoen, et al (2009) report (see for example, Figures 5 and 6). The correct interpretation is: (1) yes, scenic vista does add appreciably to a home's value and if this vista was eliminated then there would be a reduction in value (see Figure 5); and (2) the Hoen, et al analysis controls for scenic vista in the analysis of turbine view – exactly the point of the hedonic price method. That is, in the analysis of VIEW the hedonic price method controls for the confounding variable VISTA. Given that control, LBNL finds no impact of turbine view on home sale price. Note that if VISTA was not controlled for then VIEW would be positively related to home sale price, exactly counter to McCann's position.

McCann has suggested that that pooling data from multiple sites biases the results in favor on statistical insignificance. However, pooling does not necessarily "broaden the standard deviation (McCann's words)," fostering insignificance. It depends on the compatibility of the pooled areas – if the pooled areas are very similar then the standard deviations are actually narrowed. In fact, there is a test (F-test) that allows a researcher to determine whether or not pooling is permissible from a statistical perspective. Hoen, et al conducted the test and pooling was statistically permissible. In the 2009 Hoen, et al study, the standard

deviations become smaller with pooling – see Appendix F in the 2009 study which shows that the unrestricted models (essentially the un-pooled model) have larger standard deviations than the restricted models (pooled model). Also, note that the Carter (2010) and Heintzelman/Tuttle (2011) studies (among others) do not pool the data across study areas and come to the exact same conclusion as the 2009 and 2013 Hoen, et al studies – the sale prices of nearby properties are not impacted by wind farms.

McCann consistently refers to the Heintzelman/Tuttle study as evidence that wind farms negatively impact residential property values. In fact, the study does find negative impacts from wind farms only in the post-announcement/pre-construction period. The paper has many issues, as described below, but the results are consistent with the larger literature. Specifically, a thorough analysis of Heintzelman/Tuttle suggests evidence in the post-announcement/pre-construction period that wind turbines have negative consequences for nearby property values – however, post-construction the effects disappear. That is, Heintzelman/Tuttle remark that audible and visual effects might have a "strong negative impact" on property values, but do not collect much data that actually tests this, when the turbines are operational. Specifically, their dataset spans through 2009, yet two of the six wind facilities were brought online that year, two others were brought online in 2008 (see Table 1 of Heintzelman/Tuttle), and a fifth had not completed construction (see Footnote 11 of Heintzelman/Tuttle). Only in Lewis County do the authors actually test post construction effects with any veracity; that facility (it was actually built in multiple phases) was brought online in 2006. It is therefore

important to note that in Lewis County, where the only set of post-construction transaction exists in their data, they fail to find statistically significant results (for the continuous variable – as shown in Table 7, Model 1 - while it is this variable, in the other two counties, on which they base their conclusions).

Q13. Please describe the relevance of this literature for the Crocker Wind Project

A13. None of the previous academic research, nor for that matter, any of the "alternative literature," has included South Dakota wind projects. Therefore, to predict what might occur near South Dakota wind facilities requires the **transfer** of existing research. Some of the literature is not relevant to the South Dakota projects. For example, the Atkinson-Palombo and Hoen (2014) and Lang, et al (2014) were conducted in primarily urban areas of Massachusetts and Rhode Island, respectively. Further, the Massachusetts study was focused on small scale wind facilities. Likewise, Hinman (2010), Carter (2011), Magnussen and Gittell (2012), and Heintzelman and Tuttle (2012) examined single wind farms in very specific locations (note there were three developments studied by Heintzelman and Tuttle). Therefore, these would likely have limited transferability to South Dakota.

The LBNL studies were constructed with such transferability in mind. That is one of the reasons that wind facilities from across the US were studied and the data pooled into a single analysis. Thus, these studies seem to be the most apropos to the task. But, it also must be the case that the range of wind facilities studied by LBNL include the type of South Dakota counties in which the proposed facilities are to be constructed. To examine this question in more detail consider Table 1

below, in which some common socioeconomic measures are listed. Population, population per square mile, and median age are from 2014, whereas median income and median home value are 2013 levels. The table include three panels, with the upper panel listing the counties in the 2009 LBNL study, the middle panel the counties in the 2013 LBNL study, and the bottom panel the counties in South Dakota where the proposed wind facilities are to be built, respectively. In general, the South Dakota counties seem to have lower average population/mi^2, median income, and median home value than the average county in either the 2009 or 2013 LBNL studies. But the South Dakota counties look very much like their Minnesota counterparts, especially Cottonwood County and Jackson County. Franklin and Sac counties in Iowa are also quite similar to the South Dakota counties. So the range of counties studied in the LBNL includes counties like those in South Dakota.

Given this information about the types of facilities planned and the previous research on like counties, we would be confident that the LBNL studies would be a reasonable source for a benefit transfer (or damage transfer) effort to South Dakota. This leads to the overall conclusion that, **the planned wind projects in South Dakota will not significantly reduce the sales prices of properties in the neighborhood of the wind facilities.**

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Table 1
Comparative Data

County	State	Population	Population/mi^2	Median Age	Median Income	Median Home Value
Buena Vista	IA	20,578	36	37	46,469	99,744
Lee	IL	34,735	48	42	51,682	140,291
Livingston	IL	37,903	36	40	55,287	102,523
Madison	NY	72,369	110	39	52,300	135,300
Oneida	NY	232,871	192	40	43,702	113,600
Custer	OK	29,500	30	31	45,179	114,228
Umatilla	OR	76,705	24	35	48,514	138,600
Somerset	PA	76,218	71	44	43,429	103,900
Wayne	PA	51,401	70	45	47,932	179,354
Howard	TX	36,651	41	38	47,906	67,485
Benton	WA	184,486	109	35	48,997	176,500
Walla Walla	WA	58,844	47	36	45,875	186,784
Door	WI	27,766	58	49	50,586	187,484
Kewaunee	WI	20,444	60	42	52,929	145,344
Average	**LBNL 2009**	**68,605**	**66.6**	**39.5**	**$49,342**	**$132,510**
Carroll	IA	20,562	36	42	50,074	107,911
Floyd	IA	16,077	32	43	44,152	92,087
Franklin	IA	10,436	18	42	48,715	89,330
Sac	IA	10,035	17	46	48,451	81,367
DeKalb	IL	105,462	166	29	52,867	160,600
Livingston	IL	37,903	36	40	55,287	102,523
McLean	IL	174,06	147	32	61,846	160,300
Cottonwood	MN	11,633	18	44	45,949	83,197
Freeborn	MN	30,840	44	44	46,698	99,683
Jackson	MN	10,629	15	44	52,428	93,644
Martin	MN	20,220	29	45	51,865	98,341
Atlantic	NJ	275,209	491	39	52,127	218,600
Clinton	NY	81,632	79	39	43,892	121,200
Franklin	NY	51,262	31	39	45,580	93,529
Herkimer	NY	63,744	45	42	43,754	89,098
Lewis	NY	27,220	21	40	47,990	103,257
Madison	NY	72,369	110	39	52,300	135,300
Steuben	NY	98,394	71	41	47,046	90,900
Wyoming	NY	41,188	69	40	50,949	96,515
Paulding	OH	18,989	46	40	44,650	89,619
Wood	OH	129,590	210	35	51,680	147,300
Custer	OK	29,500	30	31	45,179	114,228
Grady	OK	53,854	49	38	50,677	111,956
Fayette	PA	134,086	170	43	38,903	89,100
Somerset	PA	76,218	71	44	43,429	103,900
Wayne	PA	51,401	70	45	47,932	179,354
Kittitas	WA	42,522	19	31	43,849	234,150
Average	**LBNL 2013**	**62,766**	**79.3**	**39.9**	**$48,454**	**$118,037**
Clark	SD	3,645	4	45	48,511	72,127
Codington	SD	27,938	41	37	46,361	140,909
Grant	SD	7,241	11	45	48,354	105,054
Average	**SD**	**12,941**	**18.7**	**42.3**	**$47,742**	**$106,030**

Q14. Please provide the references cited in your testimony.

A14. Atkinson-Palombo, C. and B. Hoen (2014) "Relationship between Wind Turbines and Residential Property Values in Massachusetts." Joint report of the University of Connecticut and the Lawrence Berkeley National Laboratory.

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Q15. Does this conclude your written pre-filed direct testimony?

A15. Yes.

Dated this 27th day of September, 2017.

/s/Mark Thayer

Mark Thayer