REINHOLD ENVIRONMENTAL Ltd.

2019 NOx-Combustion-CCR Round Table Presentation

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Looking Ahead to the Second Decadal Review for the Regional Haze Rule

Bob Paine, AECOM

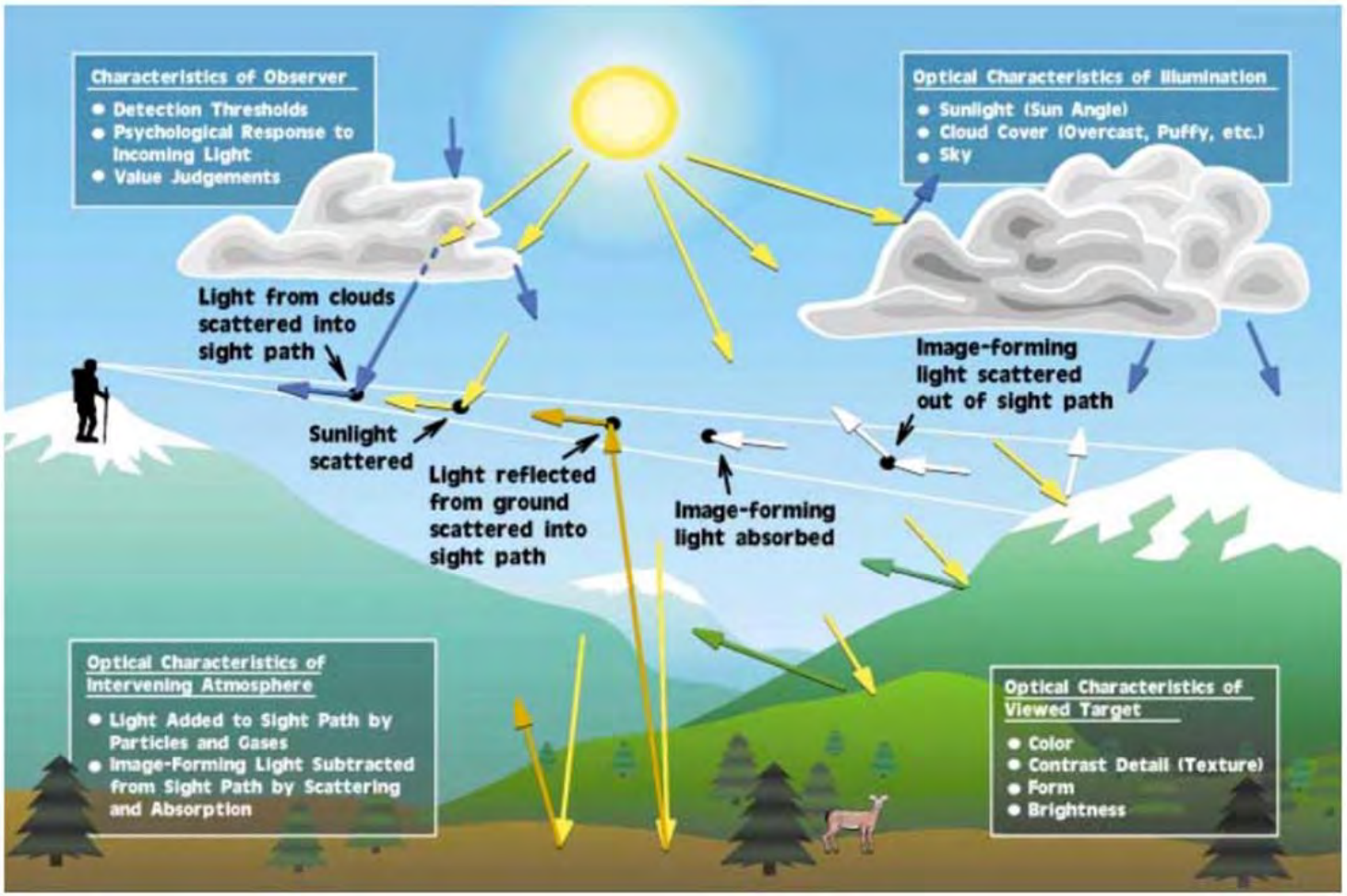
February 12, 2019

Outline of Presentation

- How does haze form?
- Brief review of the Regional Haze Rule
- First Decadal Review – what happened and what did we learn?
- Issues with EPA's revisions promulgated January 10, 2017 for the second decadal review
- Changes with EPA's "reform" of the Regional Haze Rule
- What portion of the haze is really contributed by USA sources?
- Activities in 2019
- Natural conditions – how will we get there?
- Conclusions

- *Disclaimer: the views in this presentation are those of the presenter and do not necessarily reflect those of any regulatory agency, AECOM, or any specific client of AECOM*

How a Scenic Vista is Affected by Haze



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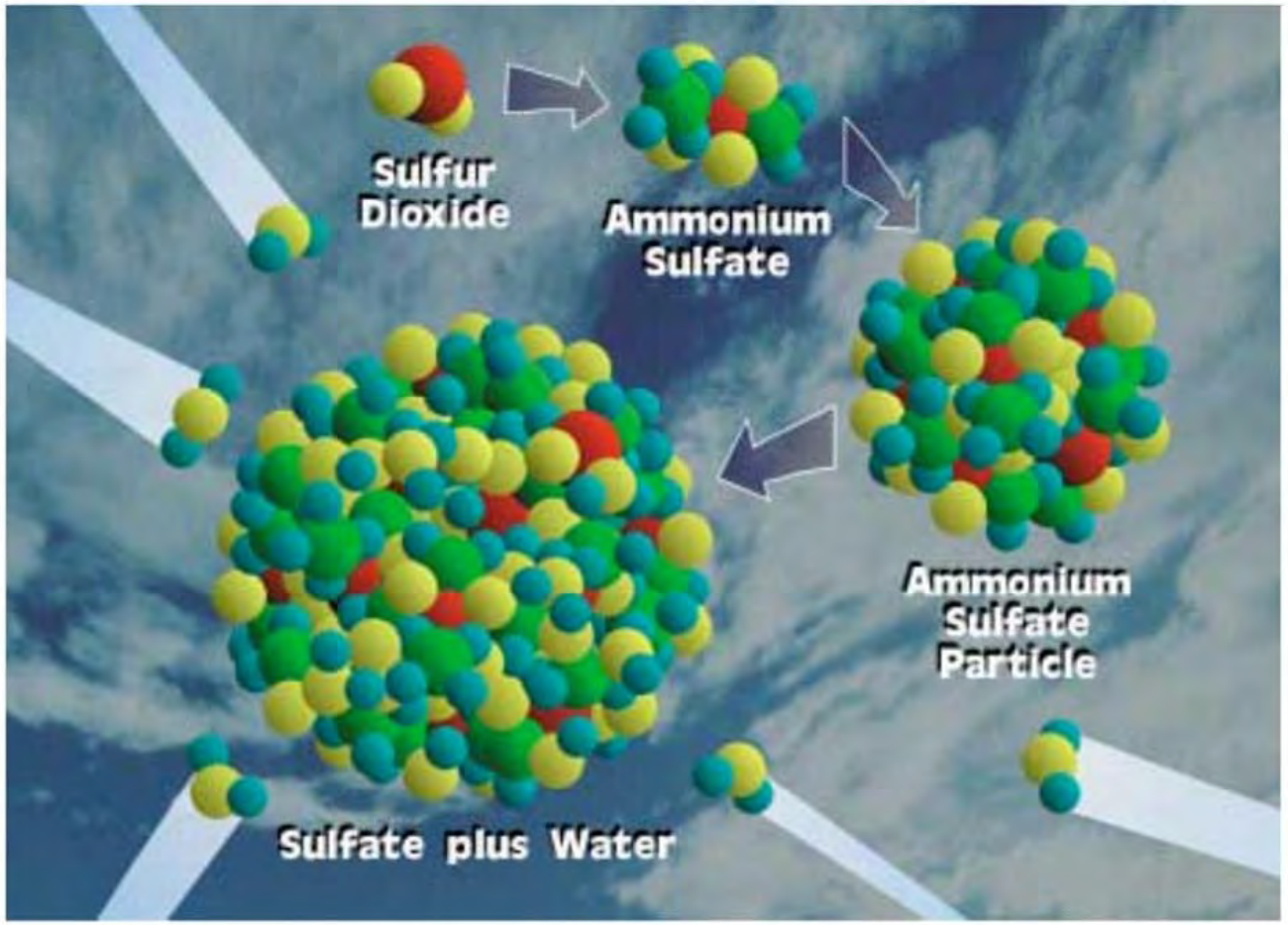
SO_2 Gas to Ammonium Sulfate Particle + Humidity Effects



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Regional Haze Rule - Review

- The 1999 Regional Haze Rule (RHR) is a very unique rule
- It has the seemingly impossible goal (“heroic”?) to improve visibility conditions in Class I areas to a “natural” state by the year 2064
- This means no pollutant emissions by 2064! A period of 60 years was envisioned in the rule to be “technology forcing” – in 1999, there was no foreseeable way to reach the rule’s goal
- This goal considers a 60-year period starting at 2004, for which the “baseline” conditions were determined from visibility measurements in Class I areas during the initial data gathering period of 2000-2004
- The RHR implementation considers several milestones that are 10 years apart (“decadal reviews”), for which incremental (linear) progress toward the final goal of natural conditions is required


Mandatory Class I Areas
North Cascades
Pasayten
Olympic
Glacier Peak
Cabinet Mountains
Glacier
Alpine Lakes
Mount Rainier
Goat Rocks
Mission Mountains
Bob Marshall
Medicine Lake
Lostwood
Mount Adams
Scapegoat
UL Bend
Mount Hood
Hells Canyon
Gates of the Mountains
Theodore Roosevelt
Mount Jefferson
Eagle Cap
Anaconda Pintler
Mount Washington
Three Sisters
Selway-Bitterroot
Diamond Peak
Strawberry Mountain
Yellowstone
Crater Lake
Red Rock Lakes
North Absaroka
Kalmiopsis
Mountain Lakes
Sawtooth
Washakie
Marble Mountain
Gearhart Mountain
Grand Teton
Teton
Redwood
Lava Beds
Craters of the Moon
Fitzpatrick
Wind Cave
Badlands
South Warner
Bridger
Thousand Lakes
Jarbidge
Caribou
Lassen Volcanic
Yolla Bolly-Middle Eel
Point Reyes
Desolation
Mokelumne
Mount Zirkel
Rawah
Rocky Mountain
Flat Tops
Emigrant
Hoover
Yosemite
Ansel Adams
Capitol Reef
Arches
Eagles Nest
Maroon Bells - Snowmass
Pinnacles
Kaiser
John Muir
Bryce Canyon
West Elk
Black Canyon
Ventana
Sequoia / Kings Canyon
Zion
Canyon-lands
La Garita
Great Sand Dunes
Domeland
Grand Canyon
Mesa Verde
Weminuche
San Rafael
Wheeler Peak
San Pedro Parks
Sycamore Canyon
San Gabriel
Cucamonga
Bandelier
Pecos
San Gorgonio
San Jacinto
Pine Mountain
Petrified Forest
Agua Tibia
Joshua Tree
Mazatzal
Sierra Ancha
Wichita Mountains
Mount Baldy
Bosque del Apache
Superstition
Salt Creek
Galiuro
Gila
White Mountain
Saguaro
Chiricahua
Carlsbad Caverns
Chiricahua
Guadalupe Mountains
Big Bend
Denali
Bering Sea
Tuxedni
Simeonof
Haleakala
Hawaii Volcanoes
Virgin Islands
1/2007
Produced by NPS Air Resources Division
Voyageurs
Isle Royale
Boundary Waters Canoe Area
Rainbow Lake
Seney
Roosevelt Campobello
Moosehorn
Acadia
Great Gulf
Presidential Range-Dry River
Lye Brook
Brigantine Wilderness
Dolly Sods
Otter Creek
Shenandoah
James River Face
Mammoth Cave
Mingo
Hercules-Glades
Great Smoky Mtns
Linville Gorge
Swanquarter
Upper Buffalo
Joyce Kilmer-Slickrock
Shining Rock
Cohutta
Caney Creek
Sipsey Wilderness
Cape Romain
Wolf Island
Okefenokee
Bradwell Bay
Saint Marks
Breton
Chassahowitzka
Everglades
0 125 250 500
Kilometers
NPS Unit
USFS Unit
FWS Unit

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Baseline to Natural Conditions Visual Depiction

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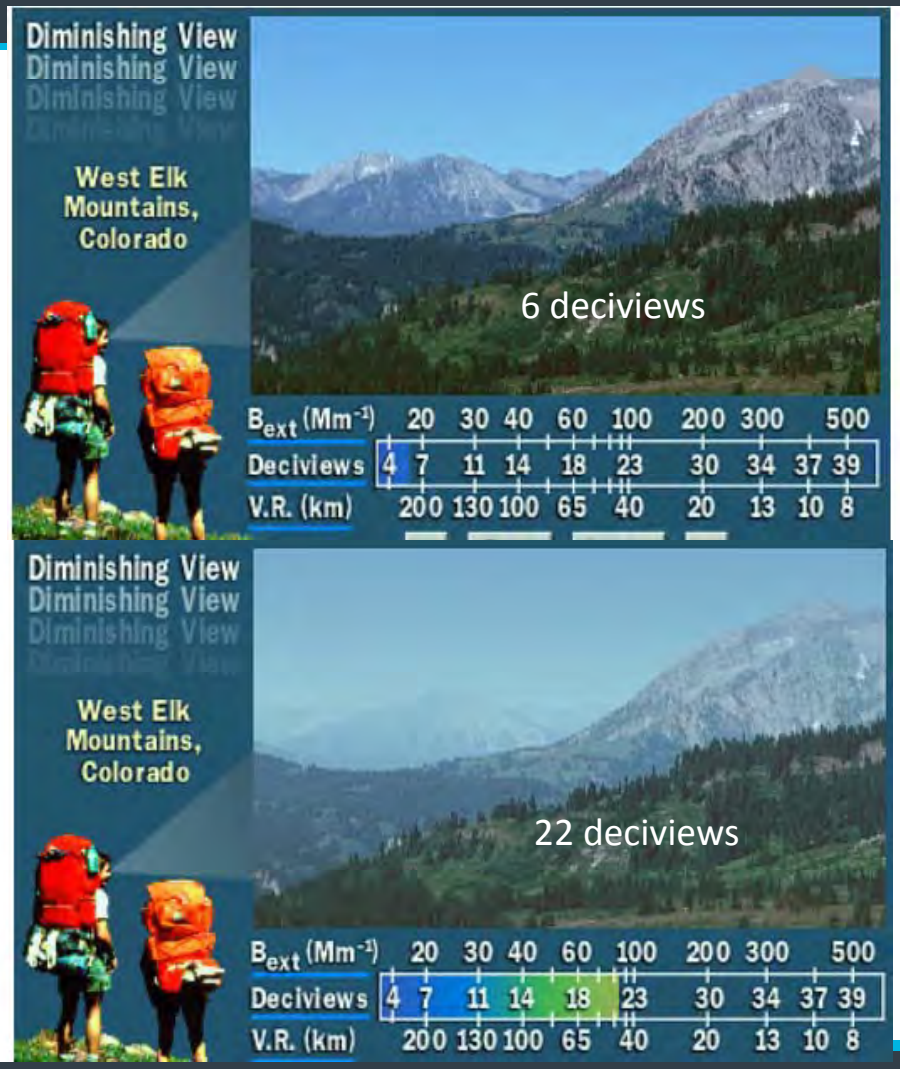
What is a “Deciview”?

- Like the decibell scale, the deciview is a logarithmic scale for denoting the amount of haze (instead of sound levels)
- Every 10 units of deciviews is a factor of 10 increase in haze
- Advantage: under many circumstances, a change of 1 deciview will be perceived to be the same on both clear and hazy days, and 1 dv is barely perceptible to highly trained eyes
- 30 deciviews is quite hazy, while 10 deciviews is 100 times cleaner (http://vista.cira.colostate.edu/Improve/haze-metrics-converter/)
- There is natural haze due to air molecule scattering (called “Rayleigh” scattering) as well as low levels of scattering particles due to natural processes such as windblown dust, wildfires, sea salt, volcanoes, etc.
- The natural levels of haze in deciviews is on the order of 5-10, depending upon the location
- There is some level of dispute about what the natural level should be due to fire suppression in recent decades and quantifying windblown dust; also due to uncontrollable emissions – more on this later

Different Depictions of Deciview Range



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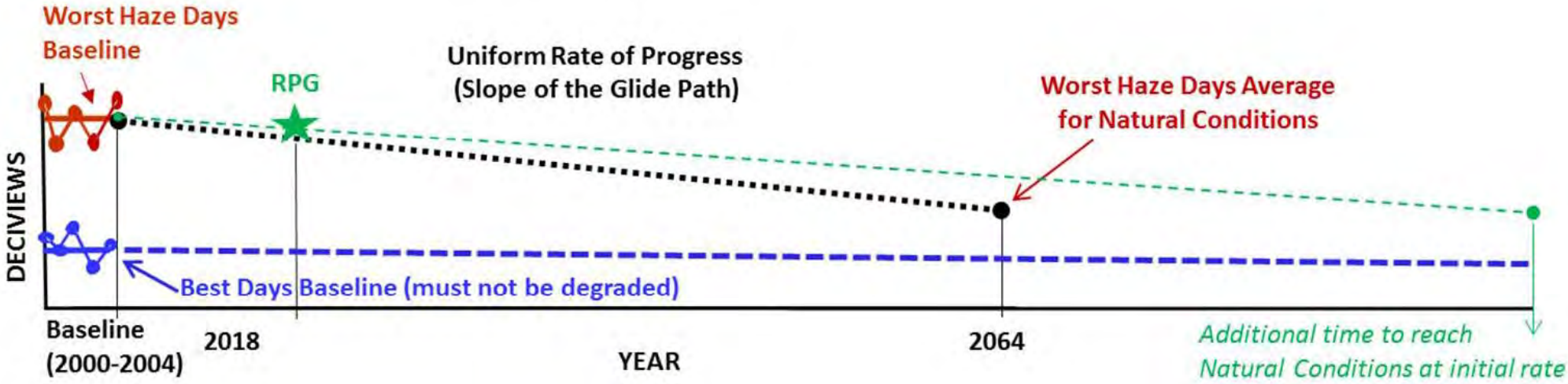
Focus of 1999 Regional Haze Rule: Achieve Natural Conditions by 2064

- Construct a straight-line **Glide Path** using deciview units over time
  - Start point: **Baseline** Worst Visibility Averages for 2000-2004
  - End Point: Worst Visibility under **Natural Conditions,** assigned to 2064
  - Slope: the **Uniform Rate of Progress**

- Prepare State SIP with **Reasonable Progress Goals** (RPGs) for each planning period
  - Do interim RPGs land on the Glide Path?
  - Why not?



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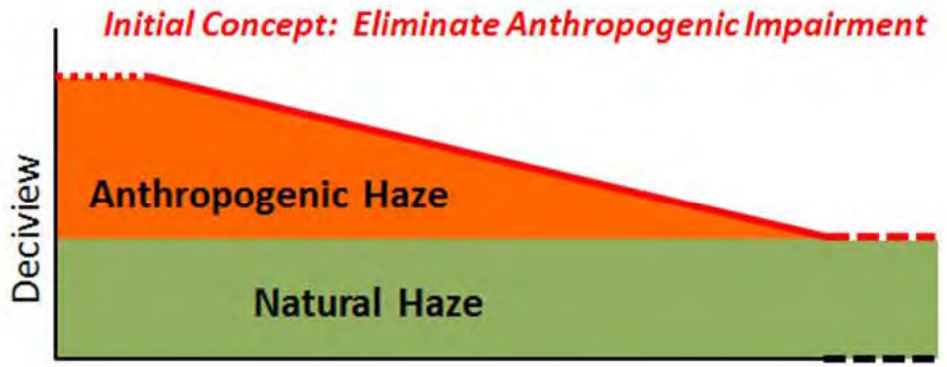
Moving from Concept to Reality: Here is the Concept

- **CONCEPT: Assumptions for Achieving Natural Conditions at 2064**
- Chemical species mass captured on IMPROVE particulate monitors, converted to deciviews, quantifies visibility as measured
- Natural Conditions (haze in the absence of all human emissions) are constant and expressed as deciview average for the worst haze days
- All anthropogenic impacts can be eliminated, or reduced to be “not perceptible” at monitors, by 2064, in a linear fashion with checkups every 10 years
- Natural condition deciview estimates assigned to 2064 can be refined by states with EPA approval

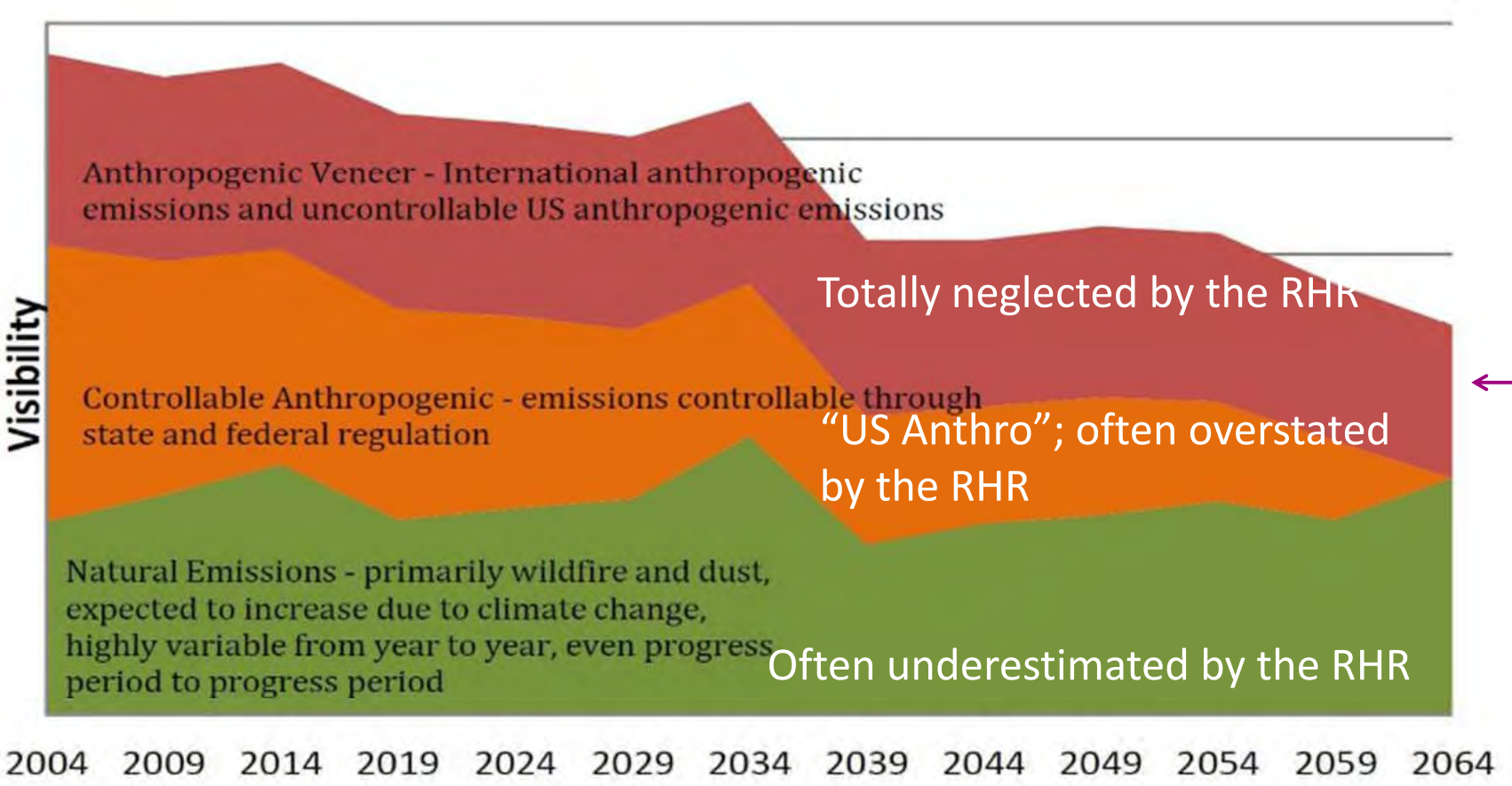


Moving from Concept to Reality: Here is the Reality

REALITY: Both Natural Conditions and Causes of Haze are changing

- Natural sources in West overwhelm anthropogenic emissions on haziest days
- Using 2018 RPGs calculated through modeling, Western States set RPGs above the Glide Path due to larger amounts of haze from uncontrollable emissions
- "Public" considers Glide Path the benchmark of progress and challenged RPGs and URPs
- *Progress is not a straight line – more on this later for emission controls*
- Western visibility improvements are relatively modest
- Current western visual range is already very good: ~111 miles vs. ~58 miles at eastern IMPROVE monitors
- Haze Algorithm was refined and estimates of Natural Conditions will change
- Climate change, global economy, and political decisions affect natural sources

Trend in Emissions Toward 2064



U.S. portion of this remaining uncontrollable veneer may or may not become controllable with future unknown technology

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What Emissions Can Be Controlled by the RHR?

	Source	Controllability	Trend	Variability
Anthropogenic	US Anthropogenic	Some emissions are controllable	Downward as sources are controlled	Relatively stable
		Some emissions will remain after all reasonable controls implemented	Could rise because of population increases	Relatively stable
	International Anthropogenic	Not controllable by state or federal regulations	Likely increasing due to increased development worldwide and rising population	Relatively stable
Natural	Fire, Dust, Sea Salt	Natural, not controllable	Increases due to climate change and other human changes to the environment	Highly variable
	Volcanic	Natural, not controllable	Unpredictable	Highly variable
	Other Natural Sources	Not controllable	Potentially affected by climate change, e.g., changes in temperature	Relatively stable

Table Note: Shaded areas represent emissions that states cannot control.

Regional Haze Rule – Review of Possible Emission Controls

- The assessment for each decadal review involves a thorough examination of possible emission controls at targeted facilities for the purpose of reducing visibility impairment at Class I areas
- The required emission controls have nothing to do with whether the facility is in compliance with local air quality standards, but whether it can reduce its impact on visibility in very distant areas
- Assessment of the feasibility of controls and the expected visibility improvement is technically very complicated and subject to significant disagreement among experts as to the effectiveness, cost, and need for the controls
- This aspect of the RHR can make continued operation of facilities very expensive for controls such as SCR
- Affected facilities must consider very expensive controls that are not beneficial to the facility operation – in fact they could result in the facility closing and going bankrupt, although the rule is not supposed to make that happen

Control Technology (4-Factor) Analysis

- Facilities with large emissions of SO_2 and NOx and within relatively close proximity to Class I areas are possibly subject to a control technology analysis
- **Step 1:** identify available control technologies to control the pollutant of interest.
- **Step 2:** eliminate technically infeasible control options.
- **Step 3:** determine the control effectiveness (% of pollutant removed) for the feasible options.
- **Step 4:** evaluate 4 factors for each of these feasible options, which are:
- *Factor 1:* cost of compliance (cost to install and operate the controls)
- *Factor 2:* time necessary for compliance (period involved in studying, designing, procuring, installing, and operating the controls; must be within five years)
- *Factor 3:* energy and non-air quality impacts (side effects that operation of the controls cause that will result in a need for more energy or other effects such as waste disposal, water consumption, etc.)
- *Factor 4:* remaining useful life (limitations in the life of the source less than 20 years could affect the cost effectiveness of the controls).

Control Technology Analysis, continued

- Facilities have to consider all reasonable SO_2 and NOx controls that are feasible for retrofit (e.g., SNCR or SCR for NOx, FGD for SO_2)
- All controls that are considered to be cost-effective (less than $5,000 per ton removed, in 1999 dollars) according to EPA cost rules are likely to be required to be implemented
- These controls could cost as much as hundreds of millions of dollars, and could hasten retirement of the units
- For example, SCR on a single 500-MW coal-fired unit could cost $200 million
- Controls might be avoided if the affected units might be retired within a few years or if the modeled visibility benefits are low
- One proposal might be to avoid new controls if a unit will be retired by the time of the following decadal review – say, by 2038
- The visibility benefit test still has to be defined for the second decadal review

First Decadal Review

- The first decadal review involved a focus on sources installed before NSPS (1962-1977) – low-hanging fruit for controls: Best Available Retrofit Technology, or “BART”
- This review has been very contentious and there are lessons learned to be implemented in future decadal reviews
- The results of the first review have been, in the eyes of industry, an overreach in some cases by EPA to establish expensive emission controls with arguably small improvements in visibility
- Disagreements between EPA and the states regarding the required controls were litigated, and EPA won most of these decisions (except in Texas). One of these EPA victories occurred in Oklahoma, involving Scott Pruitt, who was the state attorney general at the time.

Lessons Learned from First Decadal Review

- Large haze reductions in the East were accomplished anyway with CAIR/CSAPR and nationwide with MATS
- But…the baseline conditions included visibility impairment caused by uncontrollable sources: international emissions, natural wildfires, and windblown dust; the endpoint natural conditions did not consider these uncontrollable sources
- Therefore, the progress toward natural conditions required during the first decadal review was arguably overstated because the baseline conditions were contaminated by uncontrollable haze effects
- There were also extensive arguments between sources subject to potential emission controls and EPA (and environmental groups) regarding the actual cost of the controls
- Industry feels that EPA significantly underestimated the costs in order to justify additional controls (typical cost threshold was $5,000 per ton of pollutant removed – 1999 dollars)

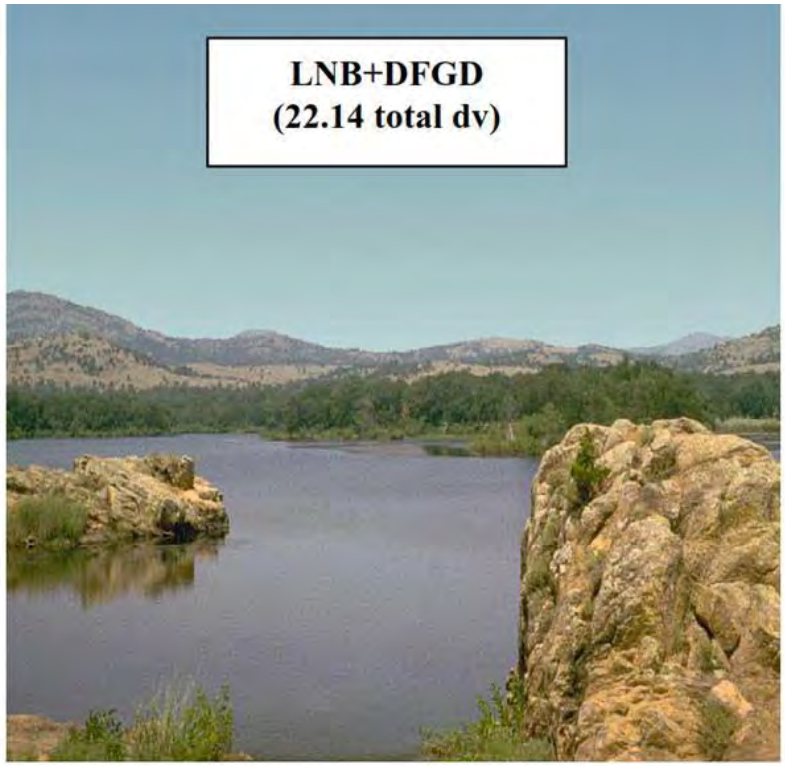
Example of Visibility Difference Between State and EPA

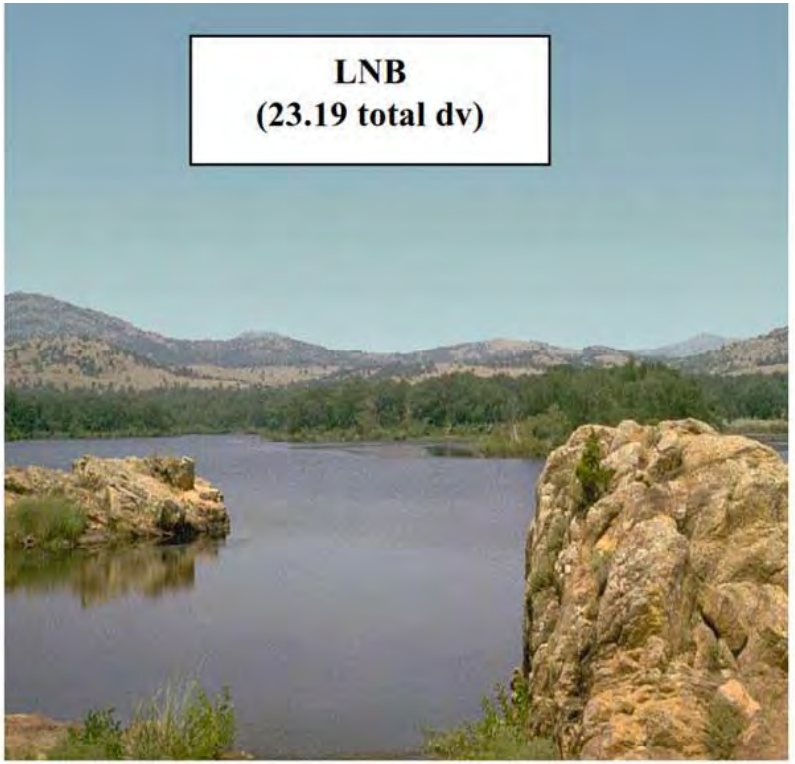
Question: which scene has less haze?

From EPA docket EPA-R06-OAR-2010-0190-0038

Example of Visibility Difference Between State and EPA

Cost of Dry FGD Controls: $279 million per year; 1.05 delta-deciview change





Average of the worst 20% haze days; from EPA docket EPA-R06-OAR-2010-0190-0038

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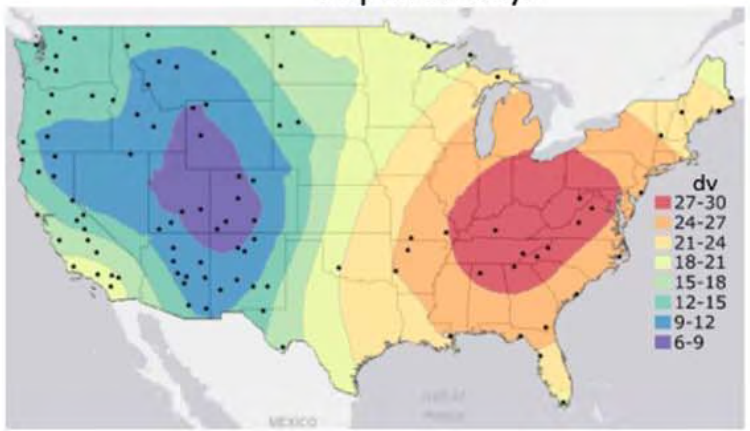
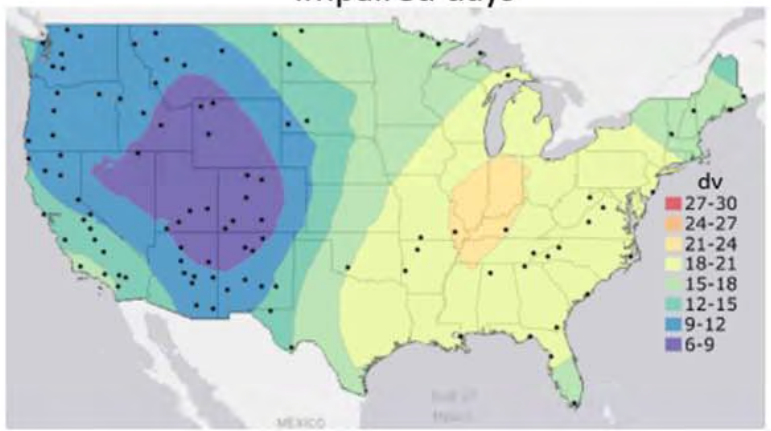
Results after 10 Years of the Regional Haze Rule: Biggest Changes in the East

First Implementation Period: Visibility is Improving

2000-2004
Visibility (dv) on 20% most impaired days



2011-2015
Visibility (dv) on 20% most impaired days



From Westar/WRAP presentation at December 5, 2017 RHR meeting.

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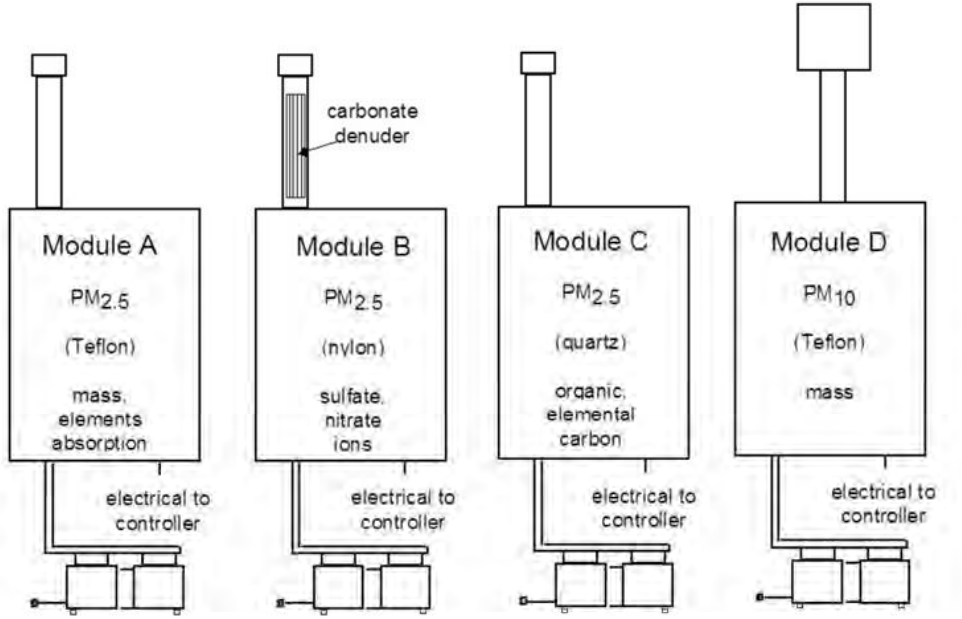
Lessons Learned from First Decadal Review, continued

- There were extensive arguments about the estimated visibility improvements (using modeling) for certain controls, especially NOx controls with Selective Catalytic Reduction (very expensive), targeted for coal-fired plants
- Industry noted that EPA required a visibility model, CALPUFF, to be run with very conservative assumptions that biased the results toward more nitrate haze impacts than were likely to occur
- Industry and the model developer submitted a more accurate version of CALPUFF (version 6.42) several years ago that EPA and the FLMs refused to approve
- Certain expensive NOx controls targeted a small aspect of the haze issue, which focuses primarily upon winter during periods of minimal park visitation

IMPROVE Monitoring (Interagency Monitoring of Protected Visual Environments)



Haze level is *computed* from particulate matter concentrations and humidity for the following species: sulfates, nitrates, coarse and fine soil, elemental carbon, organic carbon, sea salt, NO_2 gas conc., Rayleigh scattering (air molecules)

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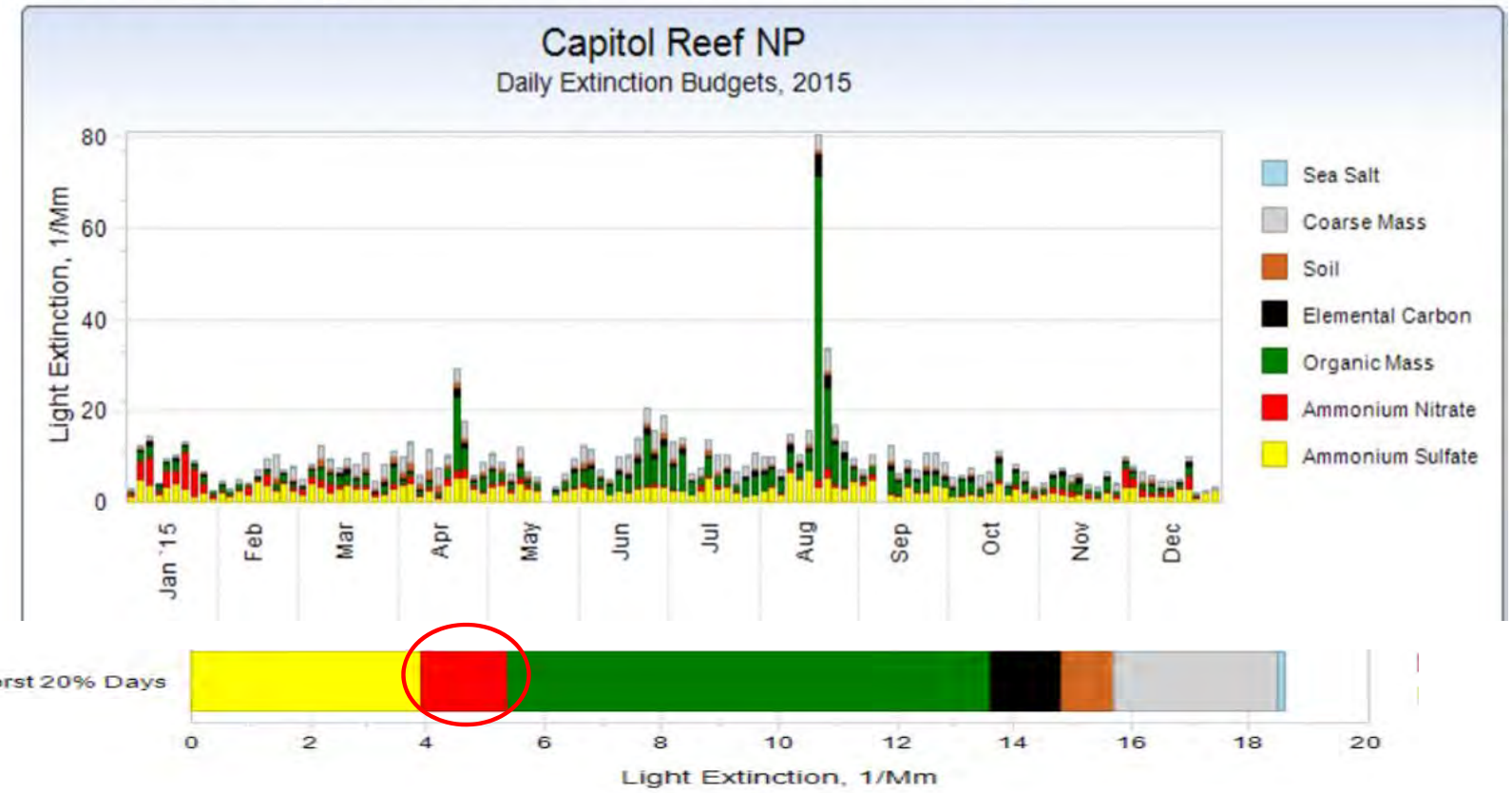
Haze Composition Example for Capitol Reef, Utah - 2015

Daily Aerosol Composition in 2015 at Capitol Reef NP, UT



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Modeling Platforms to be Used for Further RHR Reviews

- Due to the removal of CALPUFF as an EPA-approved model, it makes sense to move to a more advanced visibility modeling platform
- Recently, EPA and the Federal Land Managers have been focusing upon more accurate photochemical grid models (PGMs) to support the quantification of visibility improvements with the proposed emission changes
- It would be appropriate to start using PGMs such as CAMx* for determining visibility impacts of single facilities, or regional emissions
- Individual facilities can try to use modeling to quantify their impacts to determine if candidate control options are inconsequential for consideration of emissions controls
- An “inconsequential” visibility improvement was mentioned in the 1999 RHR as 0.1 deciview (only 5-10% of a noticeable change)

* CAMx: Comprehensive Air quality Model with eXtensions

Visibility Improvement Available to Reach Natural Conditions

- EPA and the FLMs acknowledged lessons learned during the first decadal review
- They include the fact that the baseline conditions include haze impacts that are uncontrollable – international emissions and natural emissions from wildland fires and windblown dust
- EPA is trying to adjust baseline conditions to remove these uncontrollable emissions
- However, this effort is not completely satisfactory due to the inability to deal with days with partial effects from these uncontrollable sources
- Also, the adjustments do not attempt to account for the impacts of internationally-caused haze

A Better Way to Determine the Haze Reduction to Natural Conditions

- It is too complicated to deal with estimating the effects of sources we cannot control or predict for the future – international emissions and uncontrollable natural emissions
- A better approach is to simply “zero out” USA emissions with modeling – that’s the best we can do for emissions reductions that the USA can control
- There is also arguably a residual set of emissions that needs to remain for our ability to live normally under “natural conditions”, but zeroing out USA manmade emissions is the upper limit to the amount of haze reduction possible
- Actually, EPA has already done this modeling analysis, as we will see in later slides

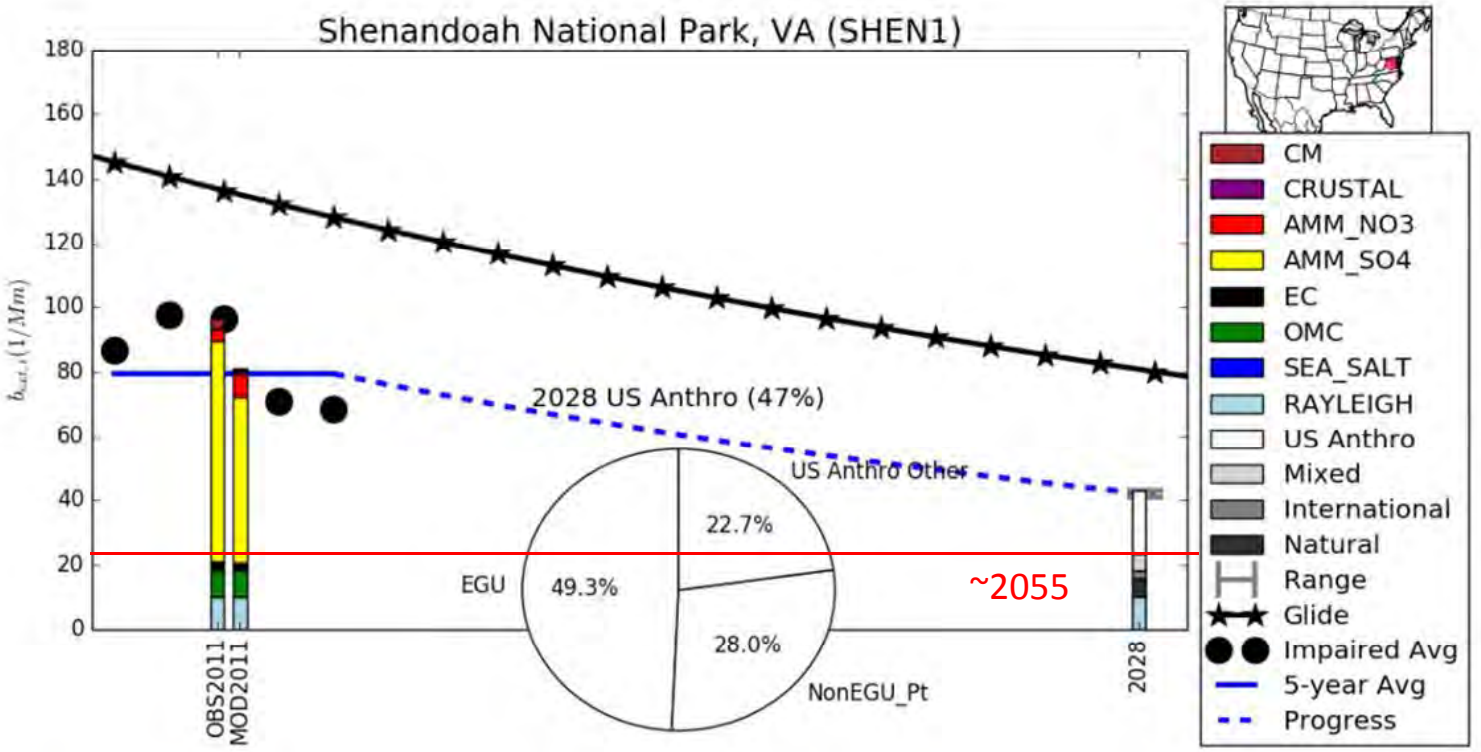
The Goals for 2028 and How to Get There Need to be Reviewed

- A key issue is – how can we meet the 2028 haze milestone at each Class I area, and can we agree on what that milestone is (Reasonable Progress Goal)?
- Another key issue is: how many facilities will be asked to do a 4-factor analysis to meet the RPG? Can units to be retired by 2038 be exempted?
- This depends upon what more is needed for visibility improvement after “on the books” controls are applied
- A “quota” (from the 1/10/17 rule) of having 80% of the possible emissions from large stationary sources targeted by 2028 is unnecessarily high in many cases (“inclusiveness fraction”)
- The Trump EPA will allow a lower fraction; each state has the latitude to determine (but need to justify) their own list of sources to target

How to Determine What Sources Should Conduct 4-Factor Analysis

- EPA 2016 guidance says to target 80% of all emissions
- However, other EPA modeling work indicates that only a small fraction of haze is due to USA anthropogenic emissions
- How to determine what fraction of sources to target, then?
- Suggestion: consider the EPA-projected progress (from modeling) by 2028 and then determine how much more is needed to reduce the impact of USA anthropogenic emissions
- Add some margin to account for uncertainty and some controls rejected due to various factors
- Look at Appendix B of EPA 2017 Modeling: Documentation for the EPA's Preliminary 2028 Regional Haze Modeling https://www3.epa.gov/ttn/scram/reports/2028_Regional_Haze_Modeling-TSD.pdf

EPA Visibility Modeling Report Analysis for Shenandoah



← Mixed: Boundary Conditions, fugitive dust

Figure B-90: 2011 IMPROVE observations, 2011 CAMx model predictions, 2028 modeled projection, and 2028 sector contributions at Shenandoah National Park (VA).

From https://www3.epa.gov/ttn/scram/reports/2028_Regional_Haze_Modeling-TSD.pdf.

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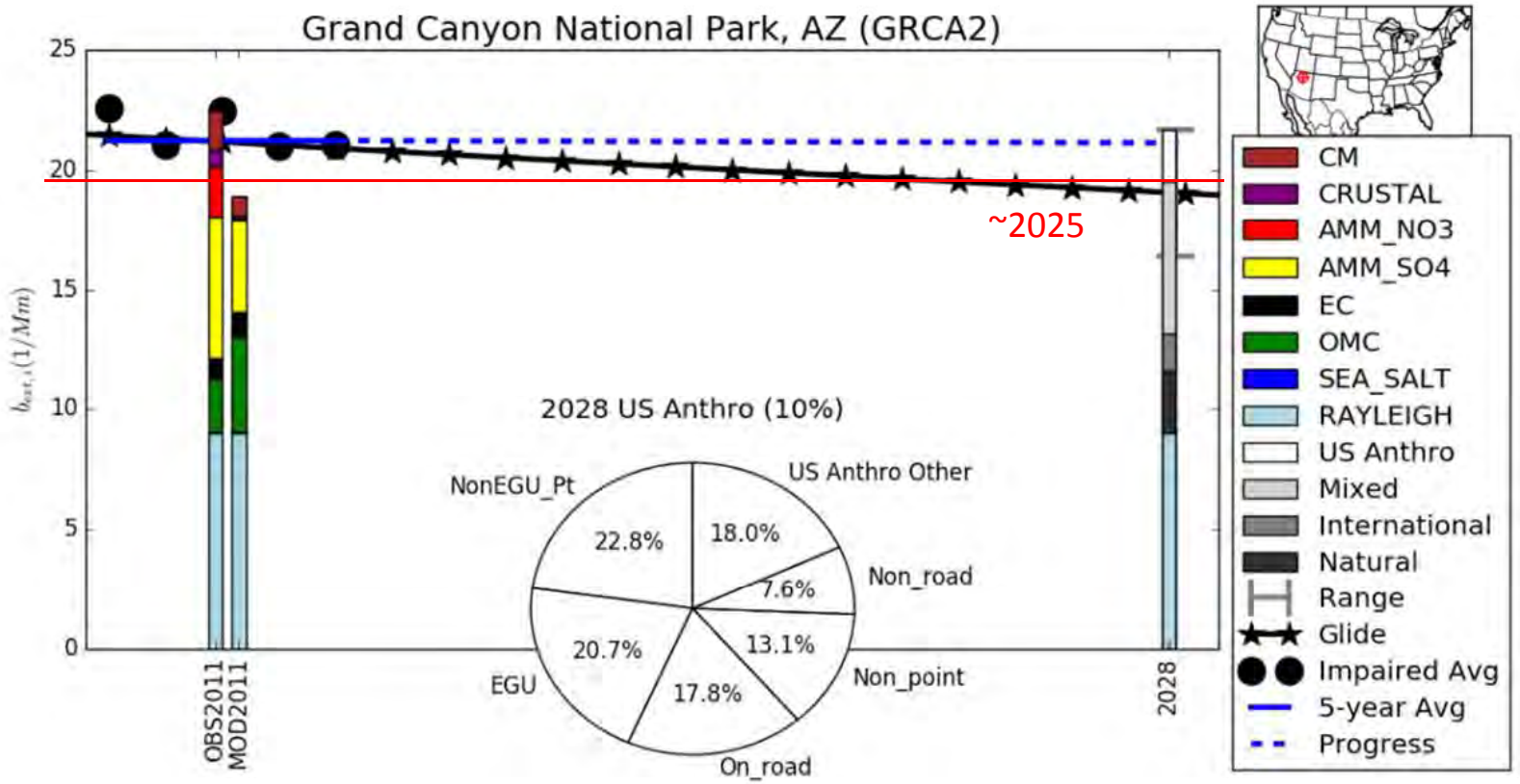
EPA Visibility Modeling Report Analysis for Grand Canyon



← Mixed: Boundary Conditions, fugitive dust

From https://www3.epa.gov/ttn/scram/reports/2028_Regional_Haze_Modeling-TSD.pdf.

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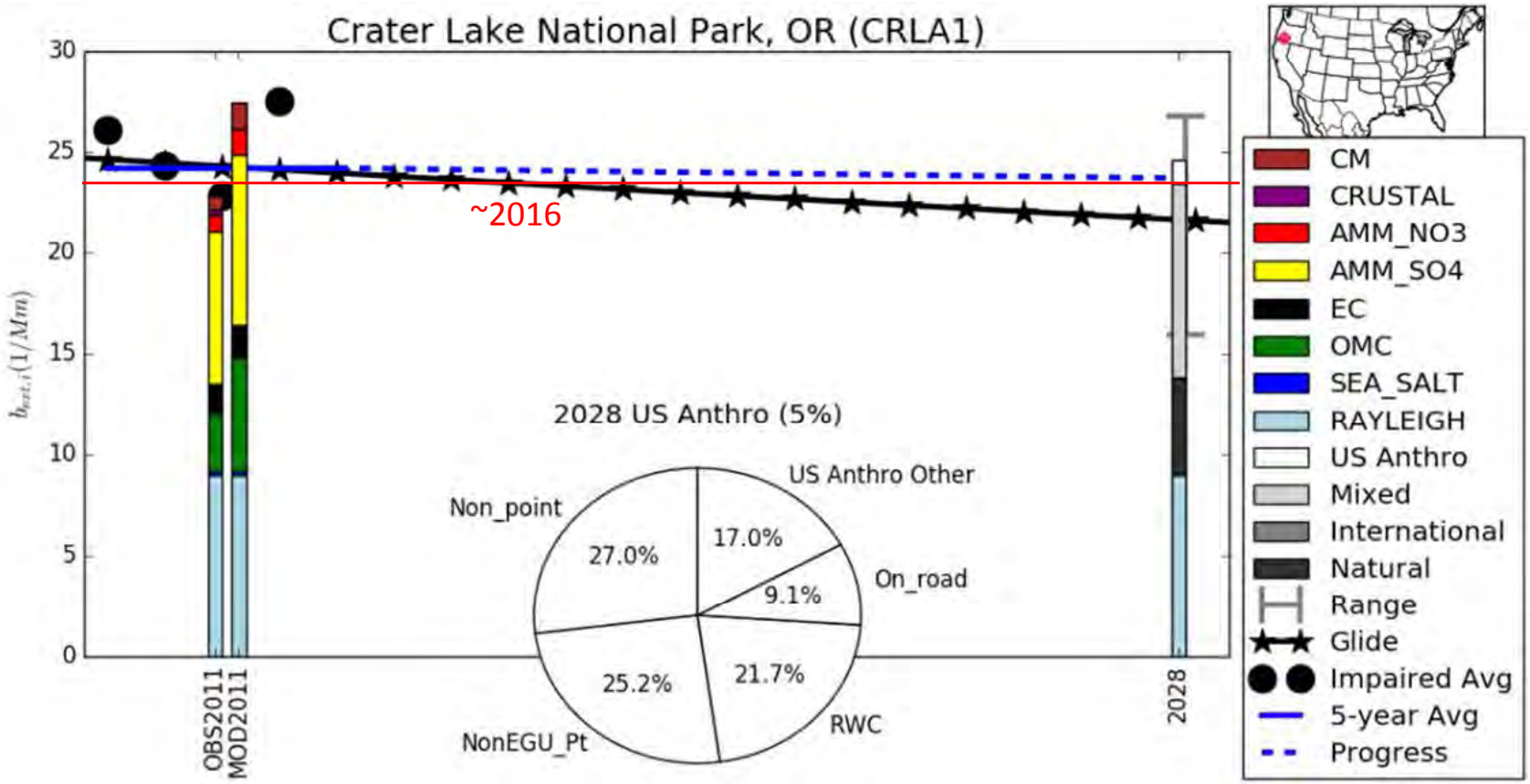
EPA Visibility Modeling Report Analysis for Crater Lake



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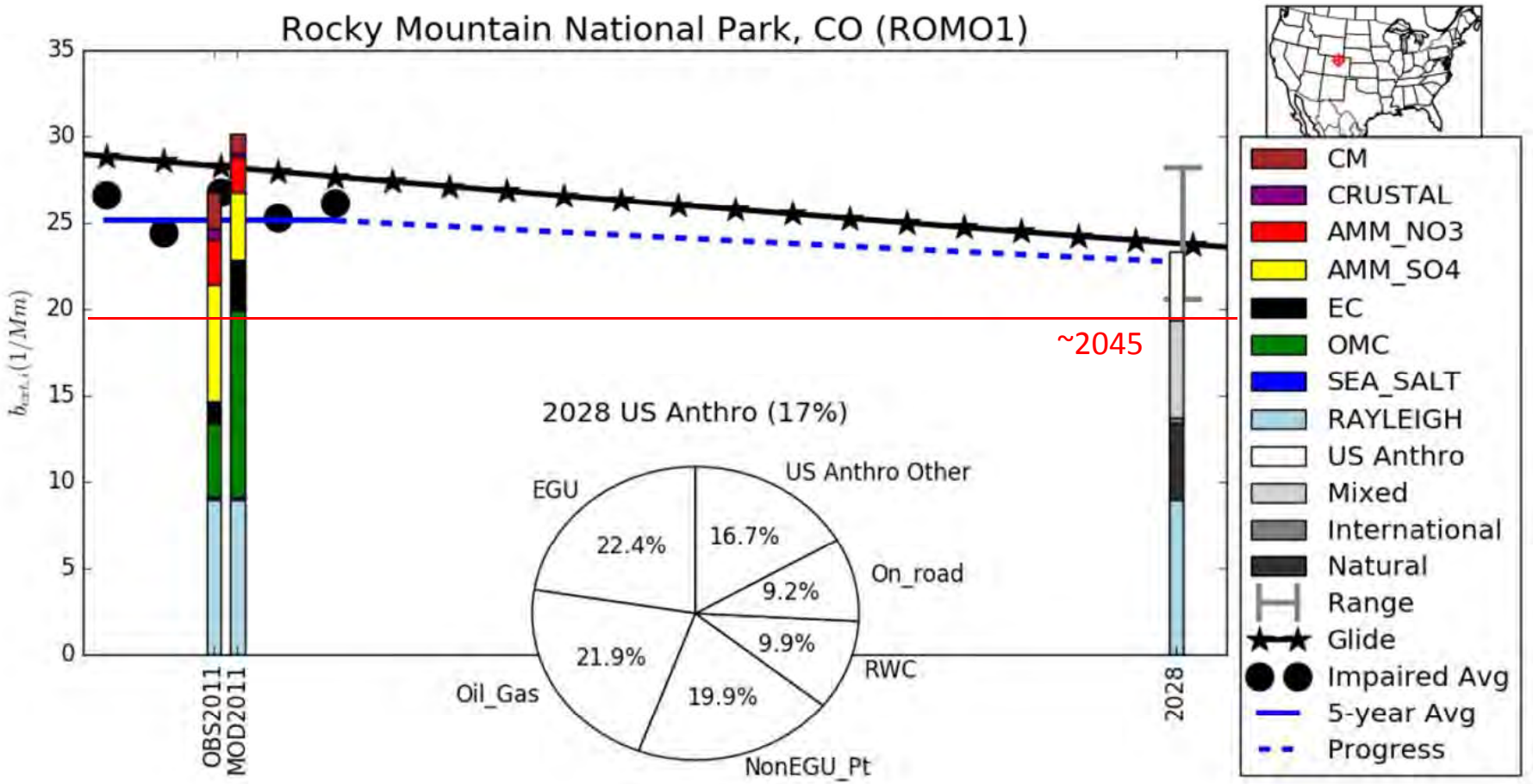
EPA Visibility Modeling Report Analysis for Rocky Mt NP



← Mixed: Boundary Conditions, fugitive dust

From https://www3.epa.gov/ttn/scram/reports/2028_Regional_Haze_Modeling-TSD.pdf.

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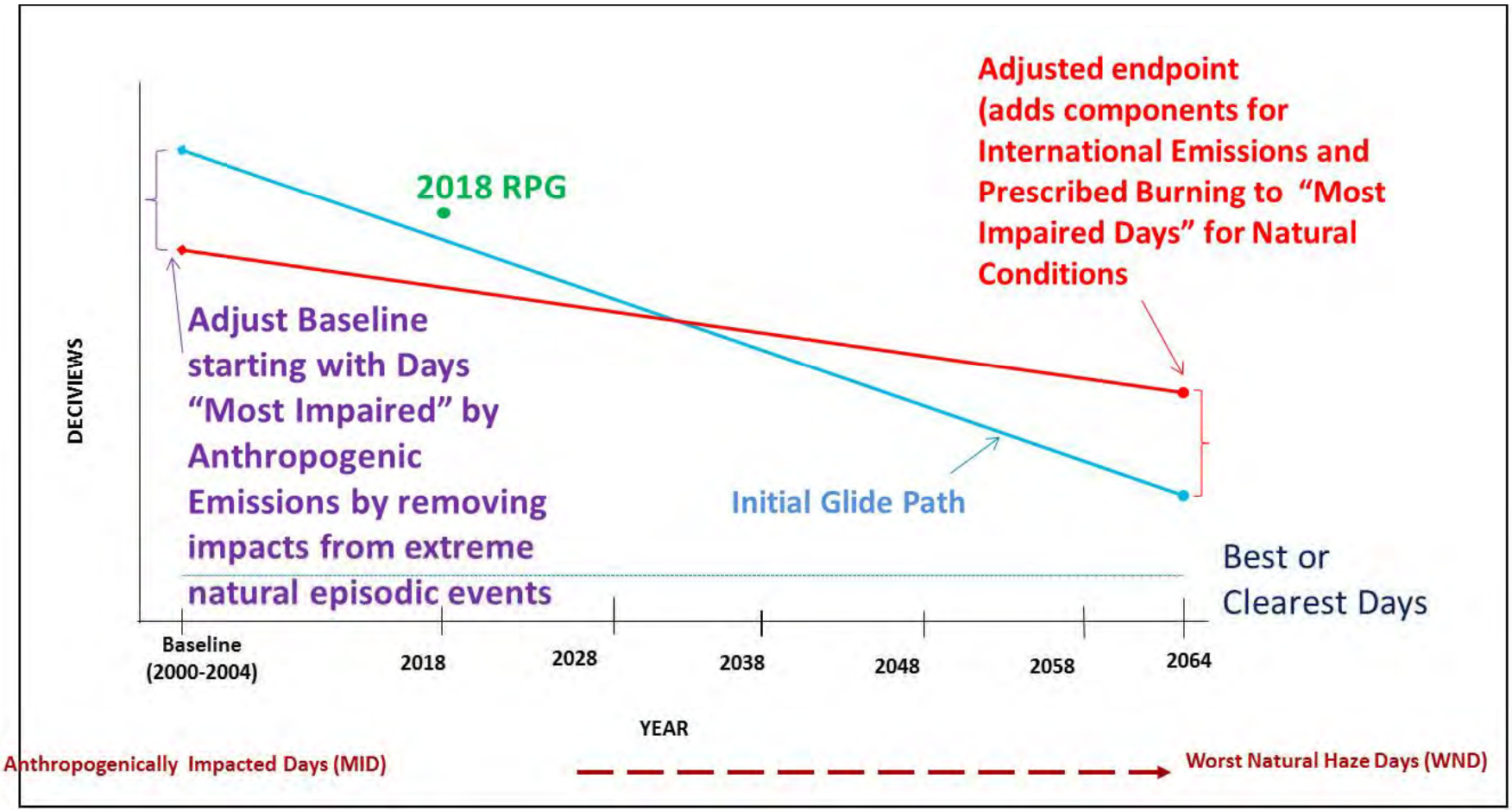
Basic Message from the EPA 2028 Analysis

- Especially in the West, the non-Rayleigh haze is mostly due to:
  - Natural (biogenic, wildfires, sea salt)
  - International (Canada, Mexico)
  - Mixed (all other international, windblown dust)
- US anthropogenic impacts are quite low
- The current glide path concept does not properly consider the portion of haze that is “US Anthro”
- For several Class I areas, especially in the West, the glide path extends below the levels of natural and uncontrollable haze well before 2064
- It’s impossible for US sources to control more than their own emissions
- The goals for emission controls have to address this issue and change the glide path slope accordingly

Uniform Rate of Progress, Reconsidered – but will EPA Adopt This?



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What Will Natural Conditions in 2064 (or Whenever …) Look Like? Remember 1964?

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We Will Not Be Reverting Back to Pre-Industrial Times

Will it Look Like This in 2064?

Or This?

Credit: http://www.thisisfolly.com/html/work/future-folly-2064-envisioning.html

Some Predictions for the Decades to Come

- Gleaned from a recent Tufts Energy Conference (February 2018)
- New cars sold in the USA will be mostly all-electric by 2050, and certainly by 2064
- But, it will take until the 2060s to retire much of the fossil-fuel powered fleet of cars
- Self-driving cars will communicate with each other and help to reduce traffic congestion
- Electric air taxis and shuttles will offer further transportation options and further reduce traffic congestion
- The benefits for near-roadway health issues, urban haze issues, and mitigation of global warming will be substantial

More Predictions …

- By 2050, renewable energy will mostly power the grid due to lower costs for solar / wind and much improved battery storage capacity to smooth out renewable intermittency during this same period
- New emission control technology will emerge to reduce emissions from some of the challenging industrial sectors with low concentration pollutant streams that are hard to control
- Better land use practices will reduce fugitive dust emissions and further reduce global warming
- Home heating and cooling will go to all-electric in the coming decades, but retrofits could be challenging for individual homes unless costs come down, but they could!

How Will This Happen? – Do you Remember the Horse Manure Crisis of the Late 19th Century?

- Horses were essential for the transportation needs of the 19th century, but…
- By the late 19th century, the 100,000 horses in New York City resulted in annual “emissions” of 100,000 tons of manure and 10 million gallons of urine
- Dead horses and manure in the streets led to fly infestations and disease, literally killing people walking the streets
- Conferences on how to deal with the problem ended in frustration – no solutions could be found!
- But, the problem fixed itself…

MORTON STREET, CORNER OF BEDFORD, LOOKING TOWARD BLEECKER STREET, MARCH 17, 1893.

Economics Fixed the Problem, not the Government

- Mayors and city planners were struggling to find legal and regulatory solutions to the Great Manure Crisis, without success
- But, internal combustion technologies matured to the point where automobiles had started to become affordable at scale at the turn of the century
- In the early 1900s, it became cheaper to own a motor vehicle than a horse-drawn carriage
- The number of cars sold in the US rose from about 4,000 per year in 1900 to approaching 400,000 in 1912
- By 1917, the last horse-drawn streetcar in New York had been retired

Easter Parade on Fifth Avenue, NYC - 1900

One car, mostly horse-drawn wagons

Easter Parade on Fifth Avenue, NYC - 1913

One horse-drawn wagon, mostly cars

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Expect These 2019 Activities

- EPA guidance for 2nd decadal review to be issued by spring/summer 2019
- Some RPOs, such as WRAP, are way ahead of EPA; will EPA try to "reform" their approach?
- Visibility modeling platforms will be available in 2019; could be used to assess whether control options have insignificant visibility improvement
- States will have more latitude to make specific decisions about which sources are required to conduct 4-factor analyses, and to *change the glide path slope*
- The "inclusiveness fraction" should take into account the amount of haze already addressed by ongoing programs *and the "US anthro" portion of haze*
- Certain facilities will still be asked to conduct 4-factor analyses, or states will do it for them, but can sources planning retirements by 2038 be exempted?
- Some control actions may have an insignificant visibility impact, and could be set aside as having a trivial benefit at significant cost

Conclusions

- The achievement of natural conditions associated with the RHR will rely upon technological breakthroughs in decades to come
- There are lessons learned from the first decadal review
  - Required improvements were overstated, glide slope needs to be considerable less steep
  - EPA imposed conservative modeling tools (CALPUFF)
  - Visibility modeling will still have a role going forward and improved with PGMs
  - Decadal control technology review is warranted, but reasonable and site-specific cost thresholds should be applied, and planned retirements should be factored in
  - The achievable haze reduction from “US anthro” sources is the maximum possible improvement, and needs to be accounted for in decision making
- Second decadal review will still focus on large individual sources, but other sectors will be targeted for future decadal reviews, and that will be difficult to implement
- Reduced cost and widespread adoption of renewable sources for energy and widespread electrification of everything will be a key step toward natural conditions, maybe close to 2064

AECOM Imagine it. Delivered.

Thank You!

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