State of Oregon Department of Environmental Quality

- Draft -

Summary Report

DEQ Modeling Analysis of Visibility and Acid Deposition Impacts and Benefits from DEQ's Rule Concept for the PGE Boardman Power Plant

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Table of Contents

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Overview of DEQ's Visibility Assessment and Draft Rule Proposal for the Boardman Coal-Fired Power Plant

I. Executive Summary

Over the next several decades, DEQ must develop a series of Regional Haze plans to meet Clean Air Act requirements for incrementally reducing haze pollution in federal Class I areas.[1] DEQ has developed the proposed 2008 Regional Haze Plan to take the next step in haze reduction, and will update the Regional Haze plan again in the 2013-2015 timeframe. The proposed 2008 Regional Haze plan accomplishes three main things:

1. It provides an analysis of current visibility conditions in Class I areas a forecast of expected haze levels in 2018, and an analysis of how well Oregon is meeting the Reasonable Progress "glide path" for haze reduction;

2. It describes actions for reducing air pollution at three older, major industrial facilities in Oregon that can have a significant impact on visibility in one or more wilderness areas. These actions are part of the Regional Haze requirement called "BART" or Best Available Retrofit Technology. Oregon's BART analysis is described in more detail below; and

3. It identifies a list of emission source categories (such as other large industrial facilities, and forestry burning) that DEQ will be evaluate for visibility impacts in the next regional haze planning cycle.

The most significant action contemplated for the 2008 Regional Haze plan is DEQ's rule concept for requiring emission controls at the Boardman coal-fire power plant. This proposed action would provide the largest environmental benefit of any strategy proposed in the 2008 plan, and would have the largest fiscal impact.

This report discusses DEQ's analysis of visibility impacts on Class I wilderness areas caused by emissions from the PGE Boardman Coal-Fired Power Plant. The report also describes visibility and acid deposition impacts on the Columbia River Gorge National Scenic Area caused by emissions from the Boardman plant. It summarizes DEQ's analysis of emission control options for SO_2, NOx, and particulate (PM), and describes DEQ's conclusions and recommendations for emission control technology requirements at the Boardman plant, which includes control technology to satisfy federal requirements for BART for SO_2, and NOx, as well as DEQ's recommendation for additional NOx controls.

II. DEQ Visibility Impact Assessment of the PGE Boardman Power Plant

As described below, the PGE Boardman power plant has a significant visibility impact in 14 national parks and wilderness areas in Oregon and Washington, as well as the Columbia River

[1] Class I areas are national parks and wilderness areas designated by Congress that receive special visibility protection under the Clean Air Act, and are the focus of the federal Regional Haze Rule.

Gorge National Scenic Area. In addition, NOx and SO_2 emissions from the Boardman power plant contribute to acid deposition in these areas, and well as the Columbia River Gorge.

DEQ conducted a modeling analysis to evaluate the visibility impacts caused by NOx, SO_2, and particulate matter emissions from the Boardman plant. This modeling was conducted for 14 Class I areas that were within 300 km of the plant, in accordance with federal guidance, and modeling protocol developed by DEQ (see page 9). The Columbia Gorge was included, even though it is not a designated Class I area. In addition, Crater Lake National Park Class I area was included for informational purposes, even though it is beyond 300 km. Maximum actual daily emissions from the plant during the 2003-2005 evaluation period were used in the modeling analysis.

Figure 1 below shows a map of the 14 Class I areas within 300 km radius of the PGE Boardman power plant. **Table 1** below shows the modeling results, expressed as deciviews, for the 14 Class I areas in Oregon, Washington, and Idaho, and in the Columbia Gorge and Crater Lake National Park. These are the peak impacts based on the 98th percentile during the 2003-2005 baseline period (see page 8 for description of the modeling protocol).

The model produces results in terms of *deciviews*. A deciview (dv) is a measure of visibility impairment. A 1.0 dv change is considered a perceptible change to the human eye. Visibility impacts from the Boardman plant ranged from 1 dv to 4.6 dv.

Figure 1. Map of Class I areas (in yellow) within 300 km radius of PGE Boardman plant

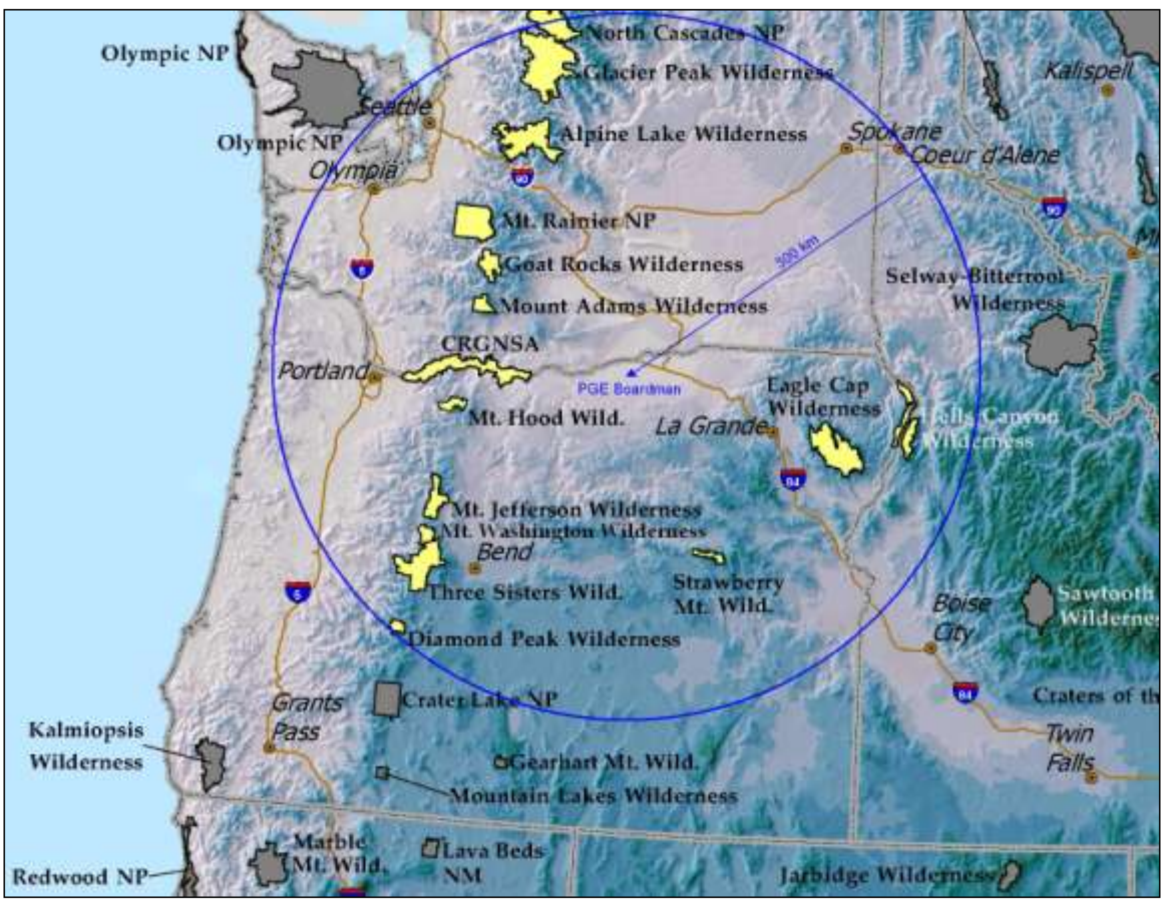


Table 1: Summary of Peak Visibility Impacts by Class I Area by State

Class I Areas Affected	Peak Visibility Baseline* Impact in Deciviews (dv)
Oregon Class I Area	
Mt. Hood Wilderness	4.6
Mt. Jefferson Wilderness	3.1
Three Sisters Wilderness	2.3
Mt. Washington Wilderness	2.3
Eagle Cap Wilderness	2.2
Hells Canyon Wilderness	1.9
Strawberry Mountain Wilderness	1.7
Diamond Peak Wilderness	1.0
Washington Class I Area	
Mt. Adams Wilderness	2.7
Goat Rocks Wilderness	2.4
Alpine Lakes Wilderness	2.2
Mt. Rainer National Park	2.0
Glacier Peak Wilderness	1.4
North Cascades National Park	1.1
Idaho Class I Area	
Hells Canyon (Idaho portion)	1.9
National Scenic Areas (non-Class I)	
Columbia River Gorge (NSA)	3.7
Beyond 300 km (outside blue circle in Figure 1)	
Crater Lake National Park	1.1

** Values reflect the 98th percentile of 3-year baseline period (2003-05)*

In addition to visibility degradation, NOx and SO_2 emissions from the PGE Boardman plant can contribute to acidic deposition in Class I areas and the Columbia Gorge. This topic is discussed on page 20 of this report.

III. DEQ's Proposal for Emission Controls

DEQ's emission control proposal would reduce about 20,800 tons per year of combined sulfur dioxide (SO_2), oxides of nitrogen (NOx), and particulate matter (PM) pollution from the Boardman plant. The controls would satisfy minimum federal Clean Air Act requirements for BART, as well as provide additional NOx control. DEQ proposes the following suite of emission controls:

<u>**Phase 1 Controls (2011-2014)**</u>

- **NOx Control**: New Low NOx Burners, with modified over fire air control system. These controls would satisfy the minimum federal requirement for BART, and reduce NOx emissions about 46 percent.

- **SO_2 Control**: Semi-dry flue gas desulfurization (SDFGD). These controls would satisfy the minimum federal requirement for BART and would reduce SO_2 emissions by about 80 percent.

- **Particulate Matter (PM) Control**. PM from Boardman do not have a significant impact on visibility in Class I areas [2], therefore BART for particulate is not required. However particulate emissions will be reduced about 29 percent as a side benefit of installing emission controls for SO_2 (Pulse Jet Fabric Filter or PJFF).

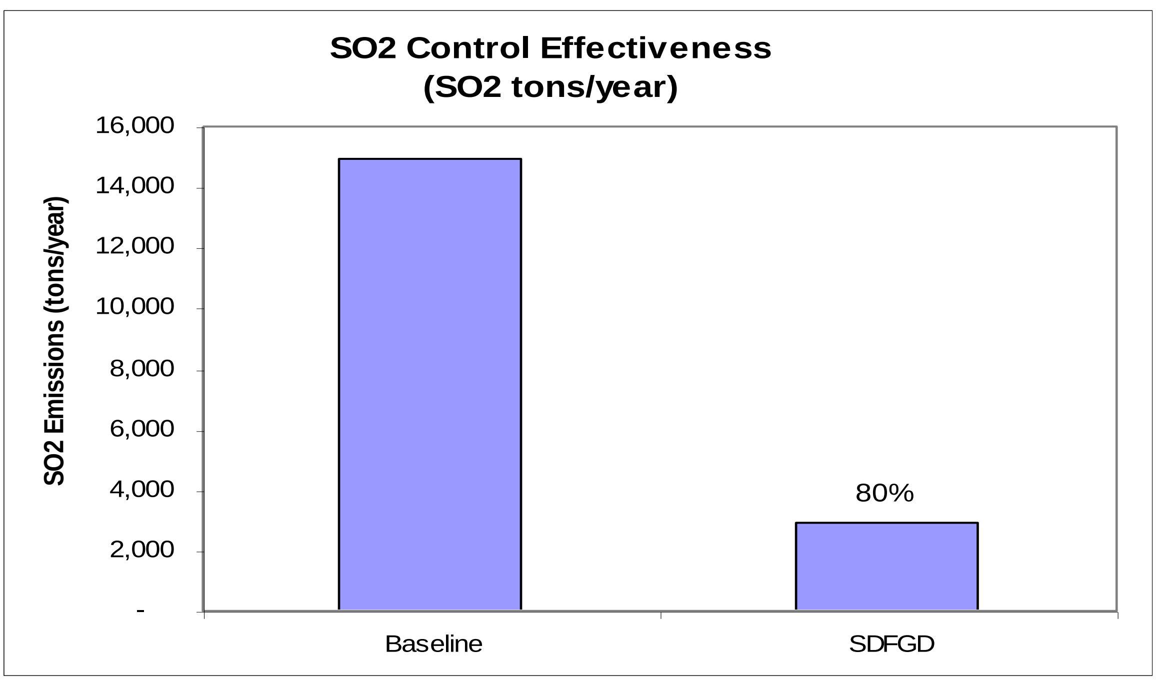
Phase 2 Additional NOx Controls (2016-2018):

DEQ's proposed additional NOx controls would reduce emissions by about 84 percent, and bring the level of NOx emission reduction in line with reductions required for SO_2.

Both SO_2 and NOx emissions from Boardman play a significant role in visibility impacts on Mt. Hood and other Class I areas, as well as the Columbia River Gorge National Scenic Area. Additional NOx control is needed to minimize Boardman's air quality impacts in the affected wilderness areas as well as in the Columbia River Gorge.

Figures 2-5 show the estimated emission reductions achieve for SO2, NOx, and PM from DEQ's proposal.

Figure 2. Expected Reduction in SO_2 Emissions



**Baseline emissions, for the purposes of the BART modeling, reflect PGE's actual SO2, NOx, and PM emissions during the 2003-2005 timeframe. This timeframe was used for all BART sources.*

[2] Also no significant impact in the Columbia River Gorge National Scenic Area.

Figure 3. Expected Reduction in NOx Emissions from Phase 1 and Phase 2 controls

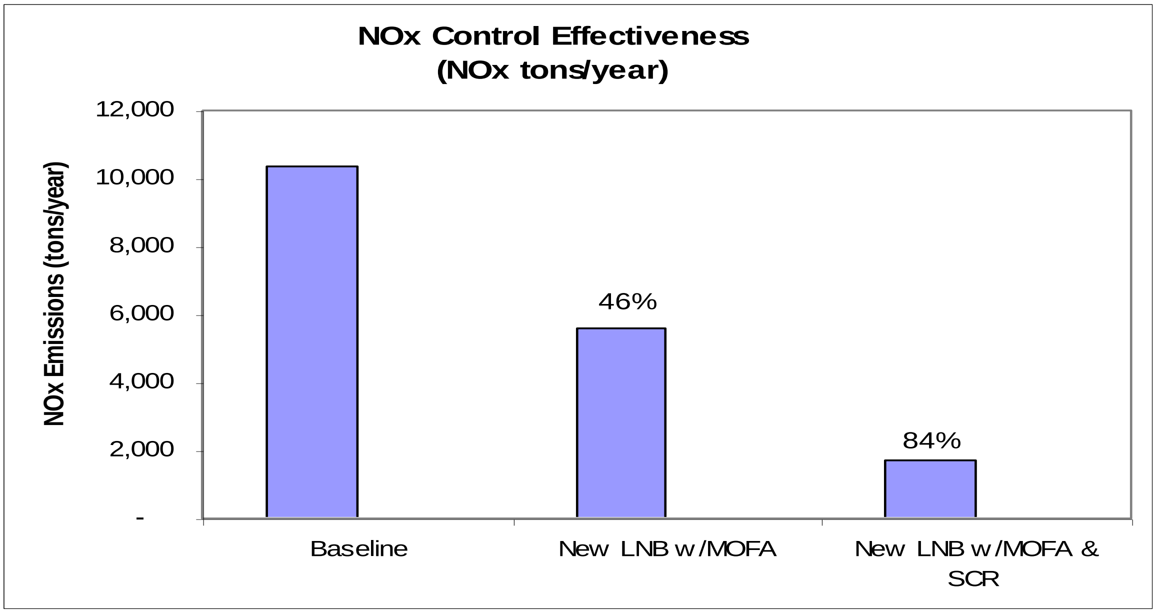


Figure 4. Expected Reductions in Particulate

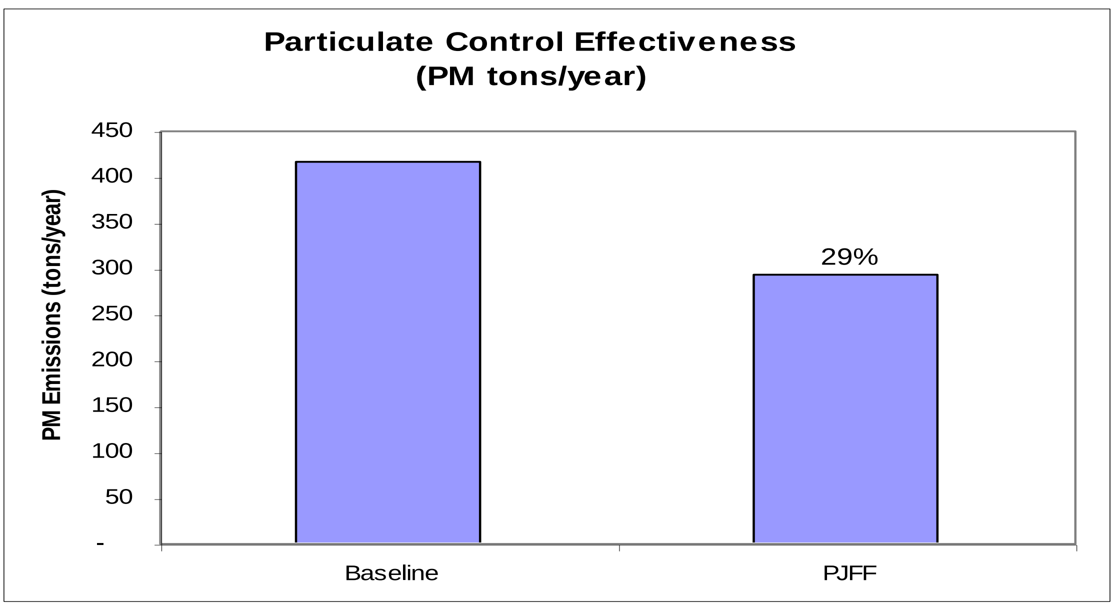
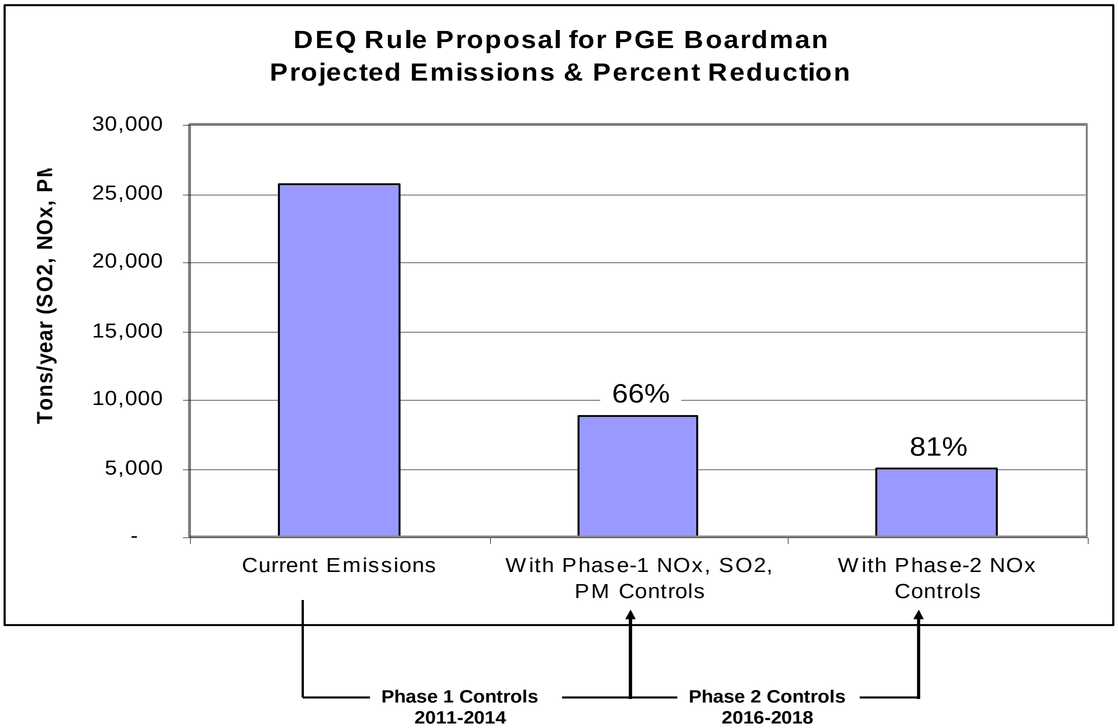


Figure 5 below shows the combined affect of the complete rule concept. Phase 1 controls for SO_2/PM and NOx would reduce total combined emissions about 66 percent. Adding Phase 2 NOx controls would increase the reduction in total combined emissions to about 81 percent.

Figure 5. Expected timeline and emission reduction from DEQ Boardman rule concept (Combined SO_2, PM, NOx Reductions)



IV. Visibility Analysis and Improvement

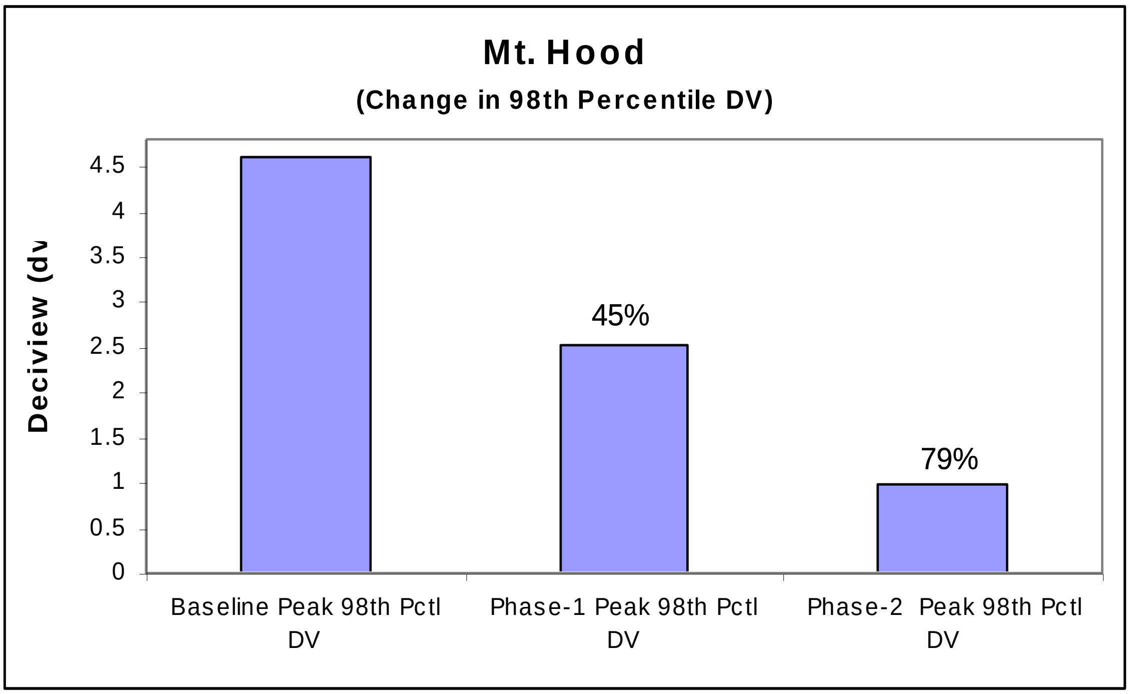
In 2006, DEQ worked closely with state air agencies in Washington and Idaho, as well as the U.S. Environmental Protection Agency, the U.S Forest Service, and the National Park Service/US Fish & Wildlife to develop a modeling protocol for evaluating visibility impacts from BART eligible sources. The BART Modeling Protocol established as the official procedure and criteria for determining whether a source has a significant impact on visibility. A significant impact was defined as 0.5 dv or greater (0.5 deciview is barely perceptible by about 50 percent of observers). This threshold was identified in EPA's BART modeling guidance as the default value, and is roughly equivalent to the 5 percent extinction threshold used for new sources under the PSD New Source Review rules. DEQ applied this analysis to all of Oregon's BART eligible sources, including PGE Boardman, to determine which would be subject to BART control requirements.

DEQ's modeling results shows that the proposed rule concept for the Boardman plant would result in significant visibility improvements in all 14 Class I wilderness affected by the Boardman power plant, as well as the Columbia River Gorge National Scenic Area.

The charts below summarize these improvements for all 14 Class I areas evaluated under the BART analysis. The figures show the change in visibility (deciviews), using the 98^{th} percentile impact level. The use of the 98^{th} percentile follows EPA's recommended approach for modeling BART sources, as it effectively captures source contributions to visibility impairment, while minimizing the effects of unusual meteorology, and accounts for the measurement limitations and uncertainties inherent in such modeling. It is considered a statistically robust indicator of peak visibility impacts.[3] In this analysis, the three-year 2003-2005 period was used (1,096 days) and the 98th percentile, represented by the 22nd highest daily value, was compared to the 0.5 deciview significance threshold.

Figures 6-19 show for each Class I area the peak visibility impacts at the 98th percentile and their corresponding percent reductions relative to "Baseline" achieved under DEQ's proposed Phase 1 and Phase 2 emission controls. "Baseline" levels in this case reflect the visibility impacts resulting from Boardman's actual emissions in 2003-2005. Figure 20 shows the same for the Columbia River Gorge NSA.

Figure 6. Mt. Hood Wilderness reduction in peak visibility impact



[3] EPA says in their modeling guidance "if the 98th percentile value from your modeling is less than your contribution threshold, then you may conclude that the source does not contribute to visibility impairment and is not subject to BART." Federal Land Managers also support the use the 98th percentile for BART source modeling.

Figure 7. Mt. Jefferson Wilderness reduction in peak visibility impact

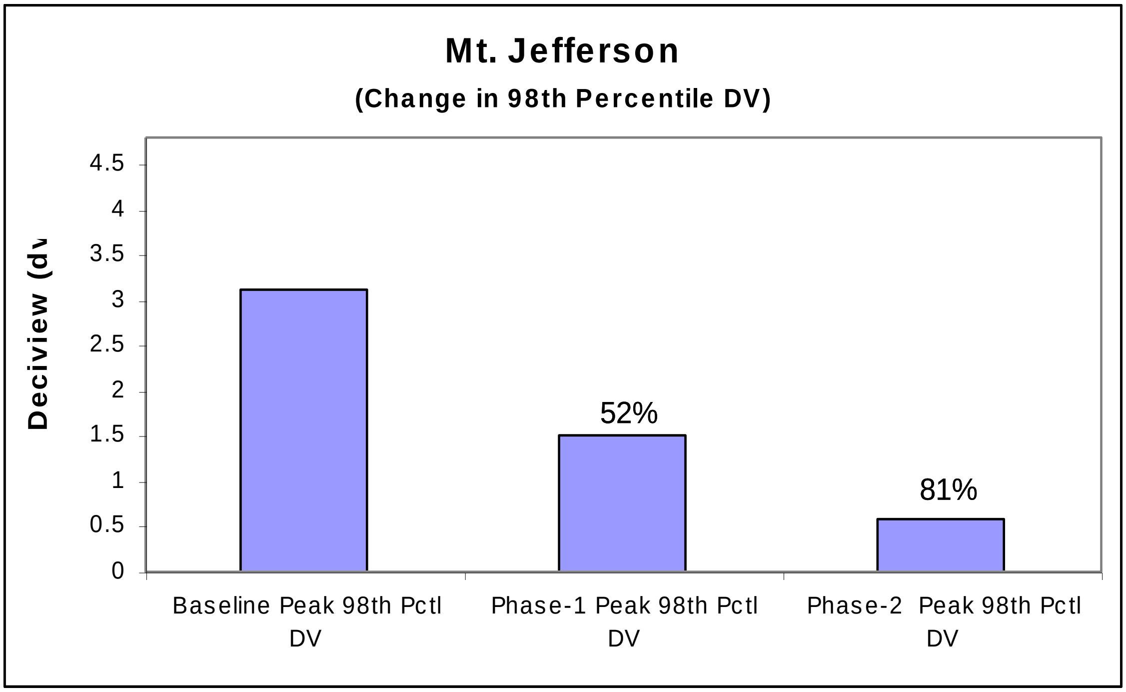


Figure 8. Mt. Adams Wilderness reduction in peak visibility impact

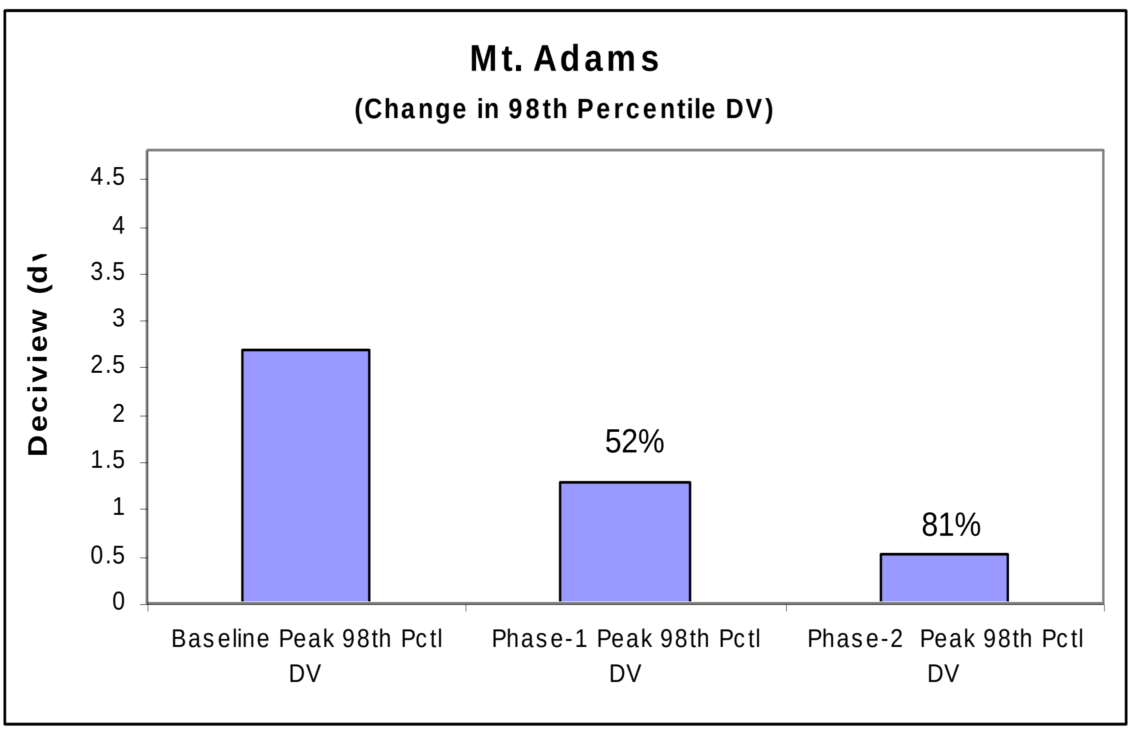


Figure 9. Mt. Washington Wilderness reduction in peak visibility impact

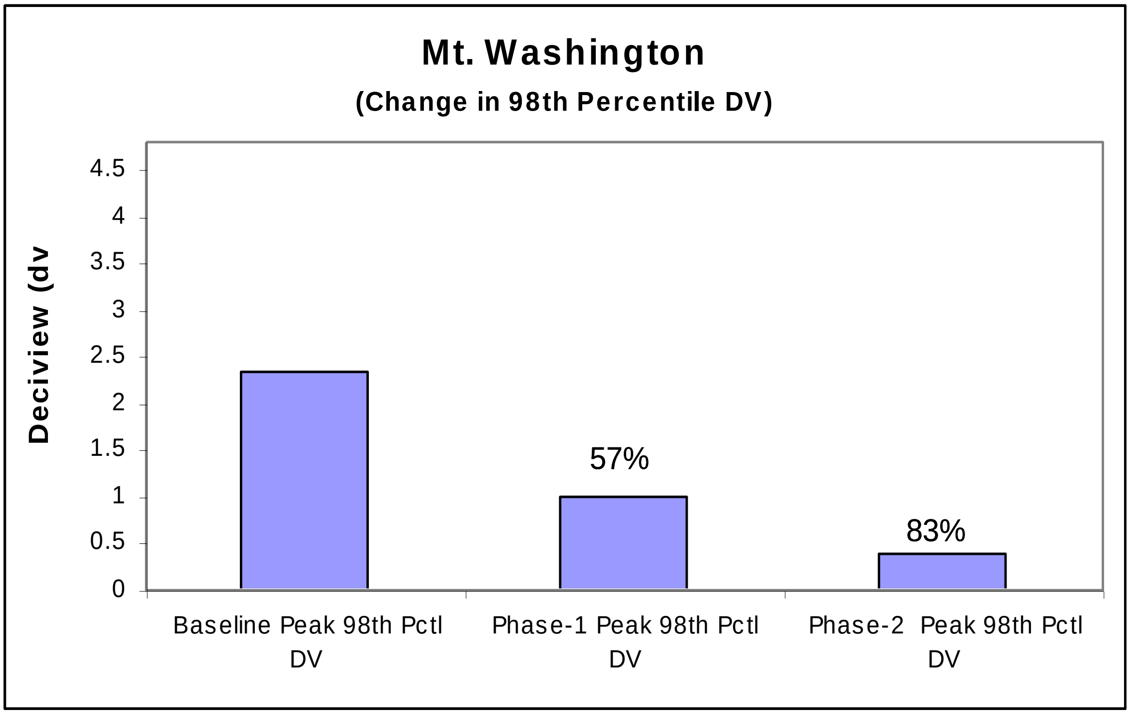


Figure 10. Three Sisters Wilderness reduction in peak visibility impact

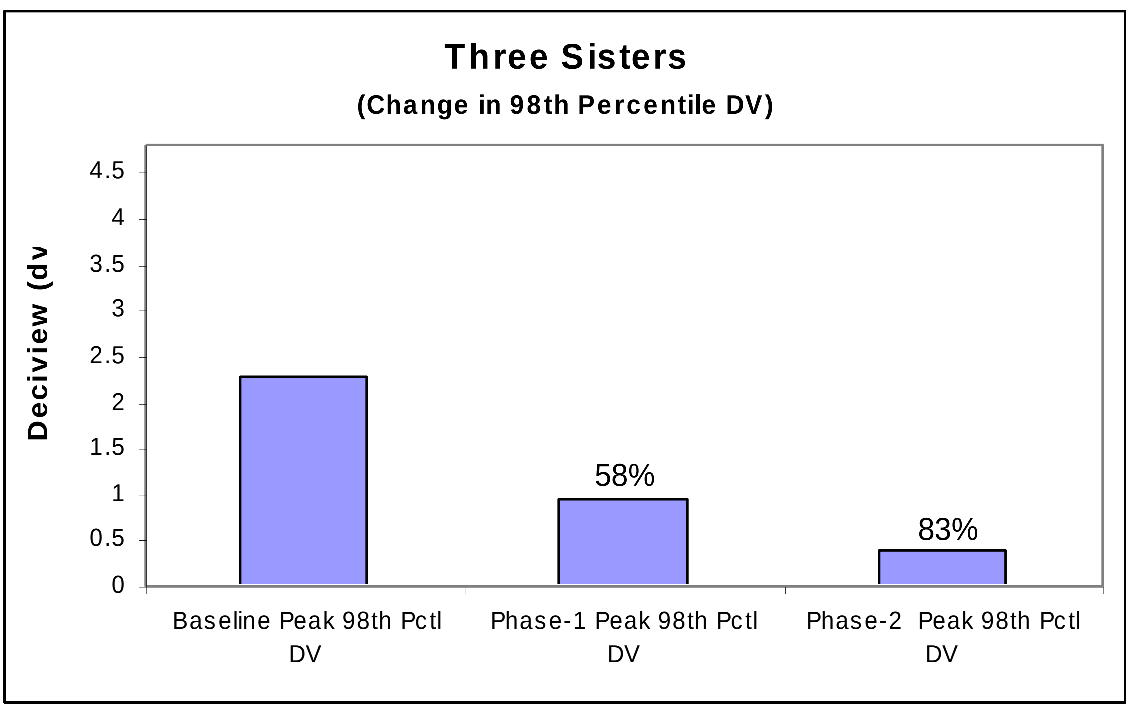


Figure 11. Eagle Cap Wilderness reduction in peak visibility impact

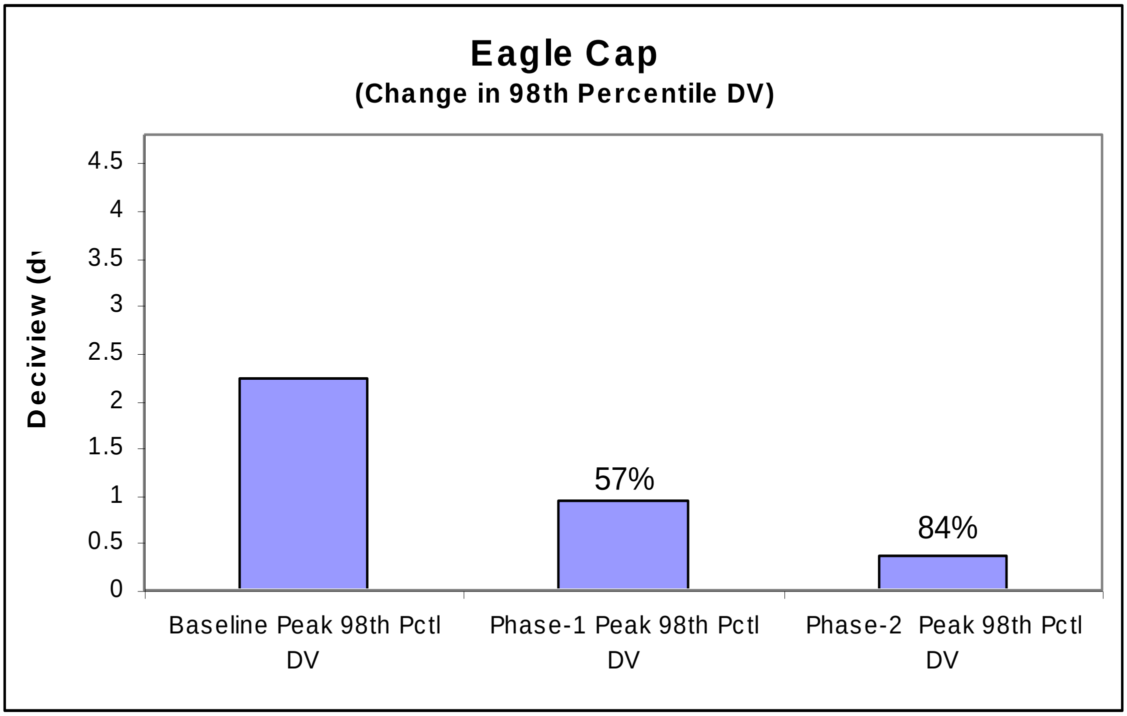


Figure 12. Alpine Lakes Wilderness reduction in peak visibility impact

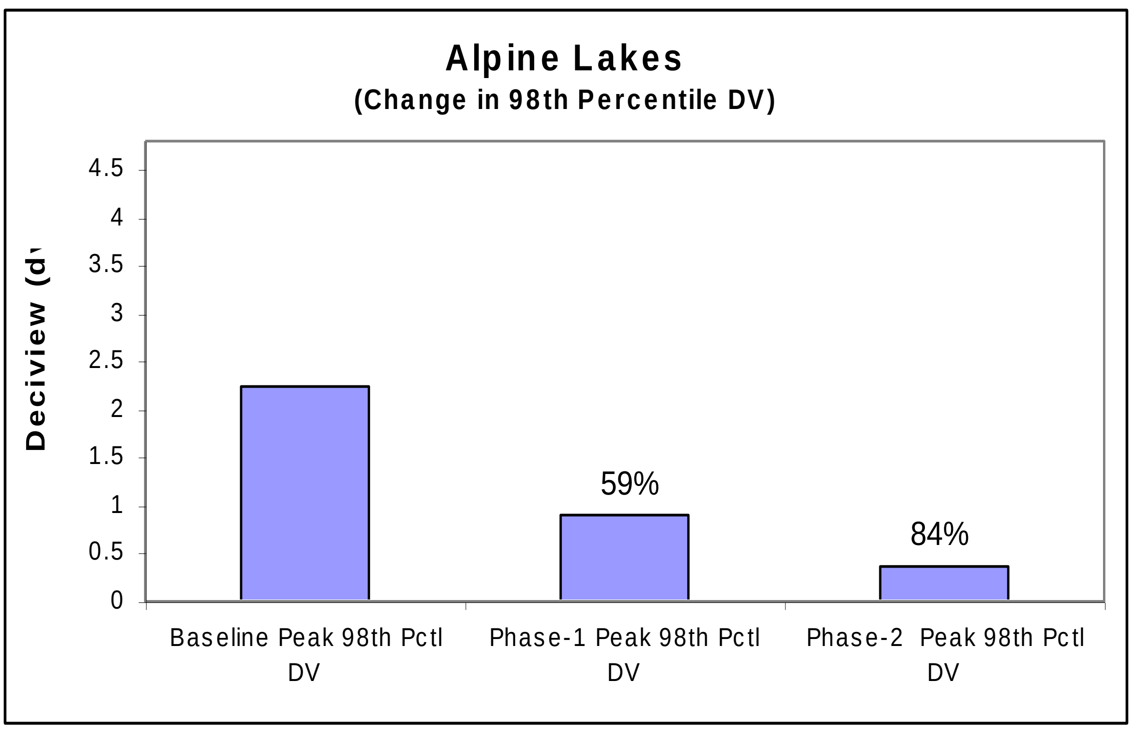


Figure 13. Mt. Rainier National Park reduction in peak visibility impact

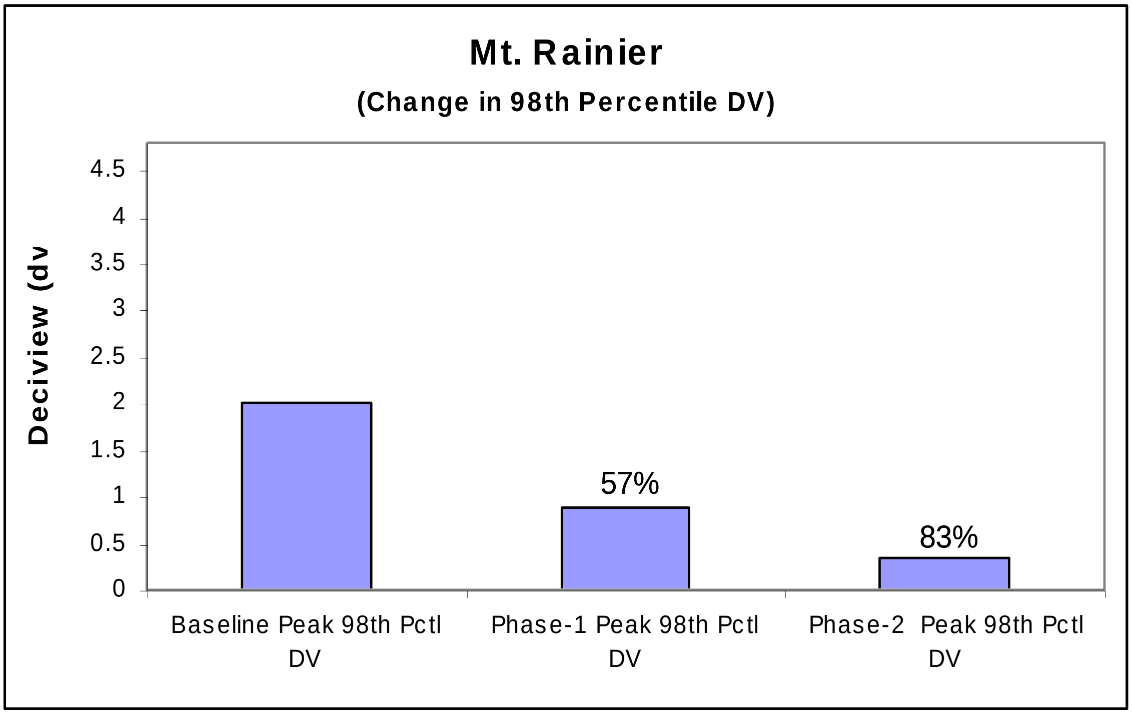


Figure 14. Strawberry Wilderness reduction in peak visibility impact

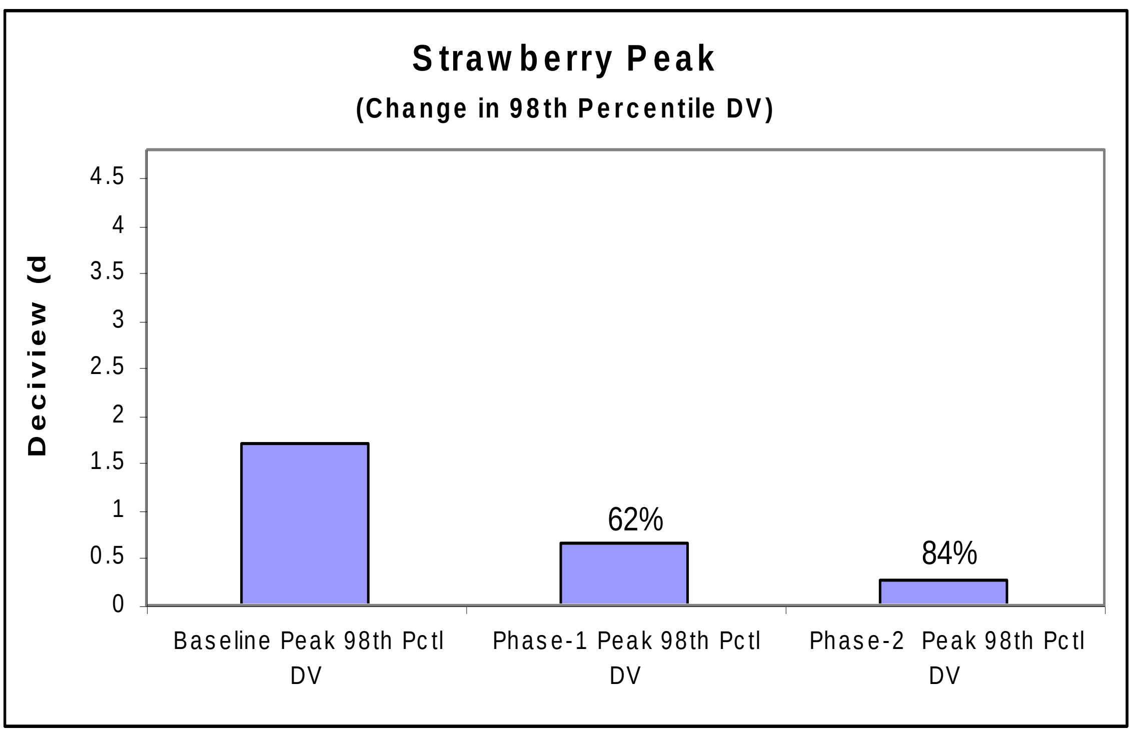


Figure 15. North Cascades National Park reduction in peak visibility impact

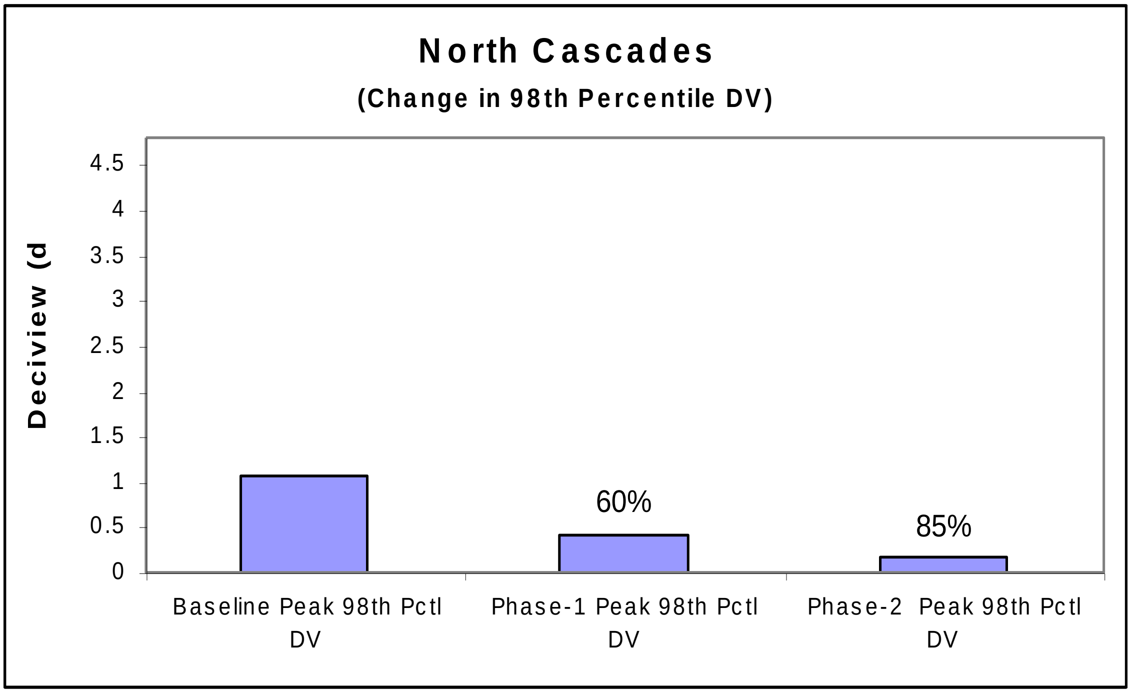


Figure 16. Hells Canyon Wilderness reduction in peak visibility impact

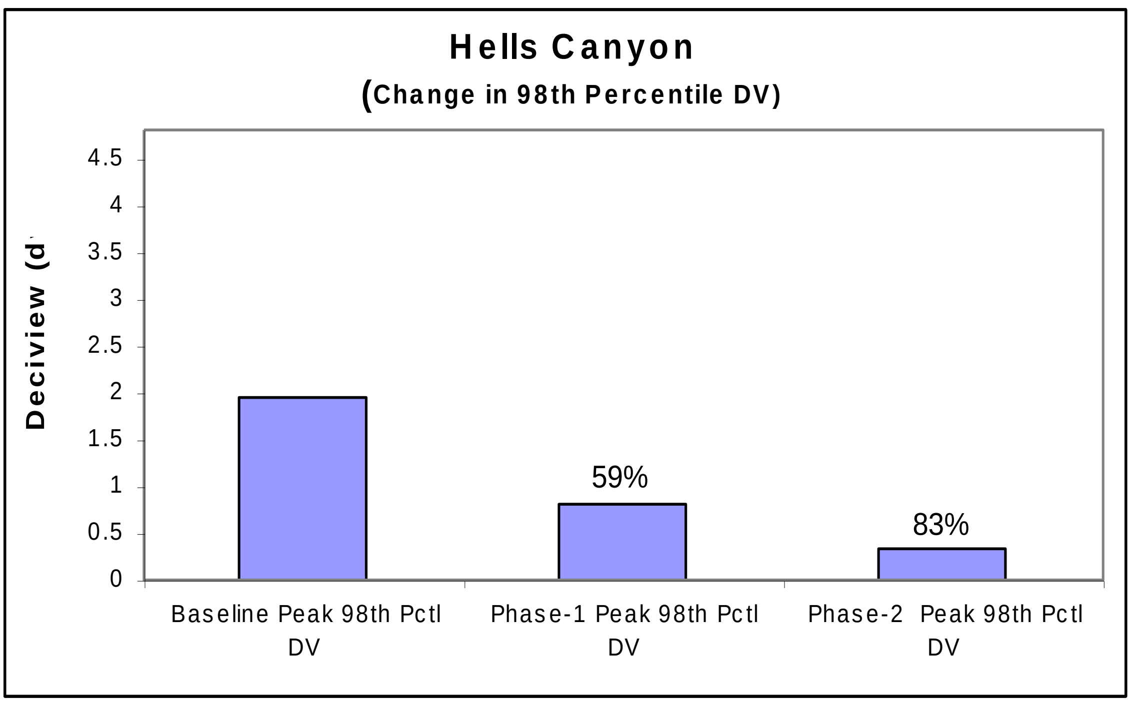


Figure 17. Goat Rocks Wilderness reduction in peak visibility impact

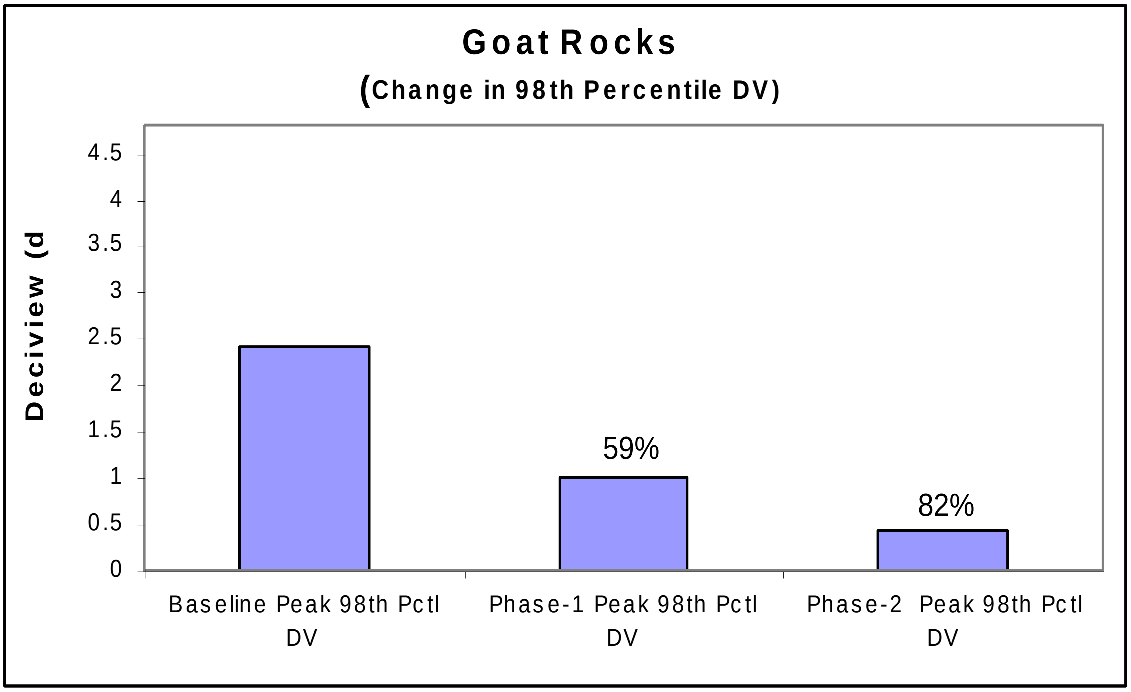


Figure 18. Glacier Peak Wilderness reduction in peak visibility impact

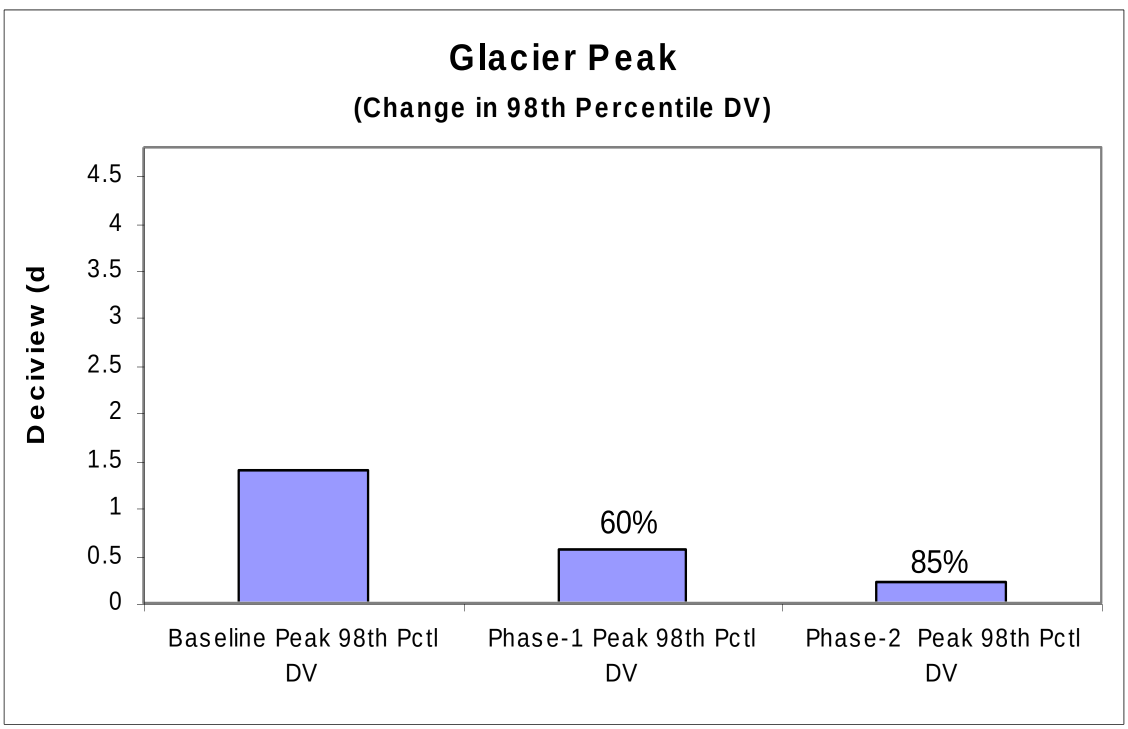


Figure 19. Diamond Peak Wilderness reduction in peak visibility impact

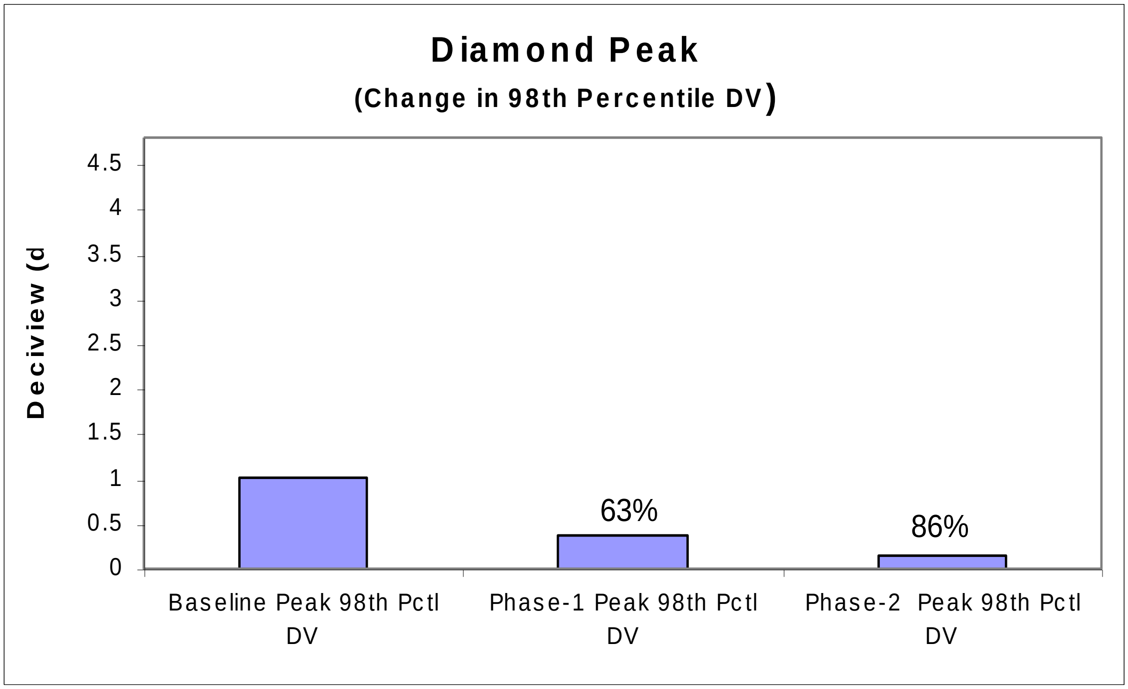
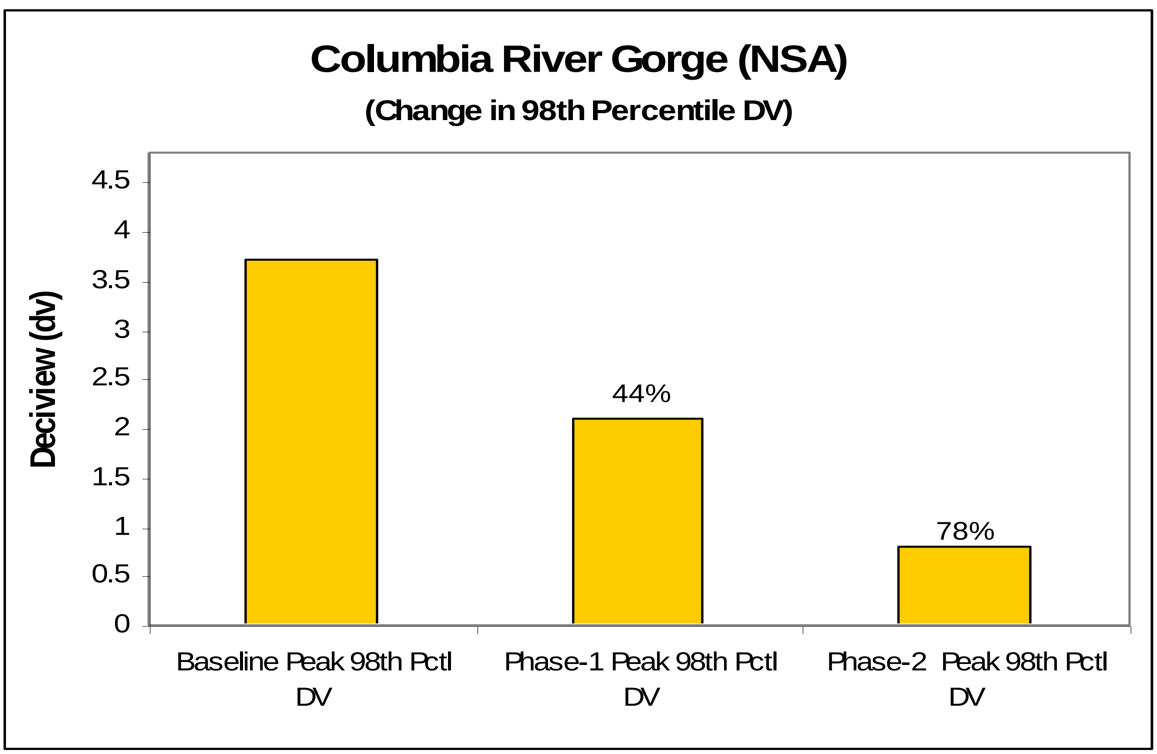


Figure 20. Columbia River Gorge (NSA) reduction in peak visibility impacts



Daily Visibility Estimates

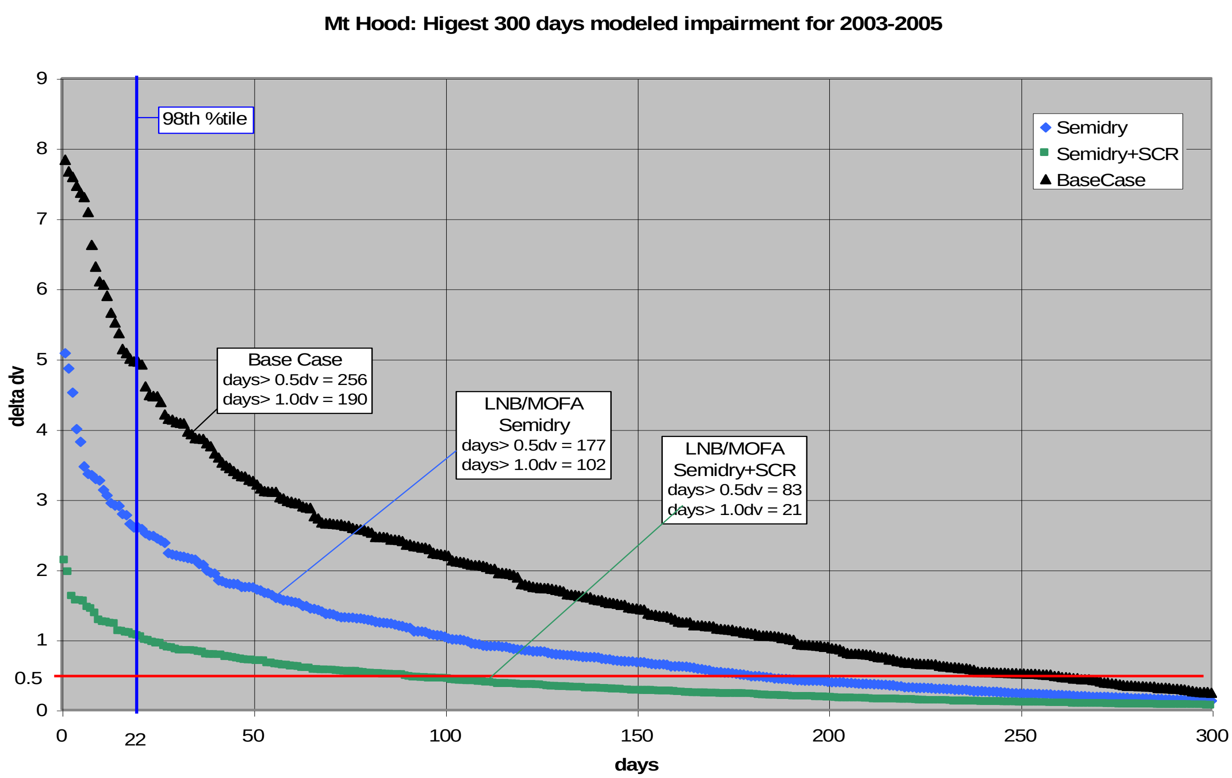
While the 98th percentile visibility impact level is used by state and federal agencies to make decisions about the applicability of BART requirements, varying levels of visibility impact occur throughout the year, and these daily impacts were also evaluated by DEQ. One example of this analysis is shown below in Figure 21 for Mt. Hood.

Figure 21 shows the range of daily visibility impacts estimated for the highest 300 days in the three year period (2003-2005) evaluated in DEQ's visibility modeling analysis. These daily values are ranked from highest to lowest. The 98th percentile, shown as the 22nd highest day, is used for comparison against the 0.5 dv BART visibility threshold and for evaluating the relative visibility benefit of different control scenarios.

Figure 21 also shows the expected reduction in haze from DEQ's proposal for Phase 1 and Phase 2 emission controls. Again, Phase 1 controls include Low NOx Burners with Modified Overfire Air + a Semi dry SO_2 scrubber (LNB/MOFA, Semidry). Phase 2 controls include the Phase 1 controls, plus selective catalytic reduction (SCR) for additional NOx control.

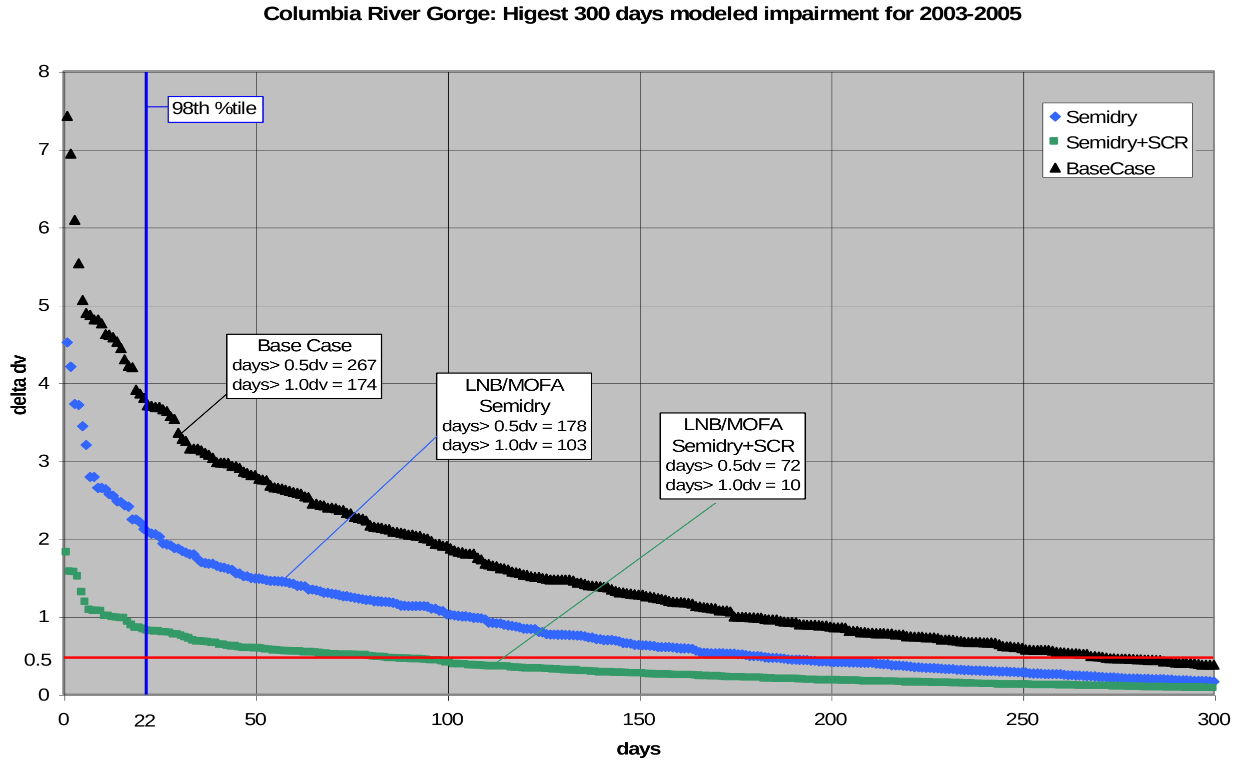
The lower the delta deciview (dv), the lower the haze, and the better the visibility. The "base-case" line reflects visibility impacts during 2003-2005 using PGE Boardman's actual emissions.

Figure 21. Mt. Hood - Estimated Daily Visibility Impacts (highest 300 days)



Similar to Figure 21, **Figure 22** shows the range of daily visibility impacts for the Columbia River Gorge (highest 300 days in the 2003-2005 modeling study period).

Figure 22. Columbia Gorge - Estimated Daily Visibility Impacts (highest 300 days)



Reduction in Impact Days and Class I Areas impacted under Phase 1 and Phase 2

DEQ's proposed NOx and SO_2 controls would reduce both the **number of days** of visibility impact (over 1 and over 0.5 deciview) and **the magnitude of** the impacts. The two figures below summarize these reductions. It is important to note, that even with very stringent controls, the PGE Boardman plant will continue to have some visibility impact in Class I areas, as well as the Columbia River Gorge, although these impacts will be significantly reduced from current levels.

Figure 23 shows that with no controls (i.e., baseline), visibility impacts from PGE Boardman's emissions result in a maximum of 108 days per year over 0.5 dv.[4] If days over 1 deciview are considered, this would be a maximum of 63 days per year.[5] With Phase 1 controls, 59 days are over 0.5 dv (a 45% reduction) and 34 days are over 1 dv (a 46% reduction). With Phase 2 controls, 28 days are over 0.5 dv (a 74% reduction from baseline) and 7 days over 1 dv (a 89% reduction from baseline).

[4] Using the maximum days rather than the average days provides a better indication of the visibility improvements expected under the DEQ's proposal. It is not intended to portray a "worst-case" scenario, but rather to avoid minimizing the visibility impact in those Class I areas with higher impacts, and to show the full benefit of the visibility improvements from the proposed controls.

[5] The maximum of 108 days per year over 0.5 dv represents the highest of the 14 Class I areas modeled during the 2003-2005 (baseline). In this case, it was the Hells Canyon Wilderness Area (324 days/3 = 108). This means that about 30 percent of the year visibility conditions were over 0.5 dv. The maximum of 63 days per year over 1.0 dv was modeled at the Mt. Hood Wilderness Area, which was equal to 17 percent of the year. For the other maximum day impacts under Phase 1 and Phase 2, as indicated in Figure 23, these were all modeled at the Mt. Hood Wilderness Area.

Figure 23. Reduction in the maximum number of days in 14 Class I areas with visibility impacts over 1.0 deciview and over 0.5 deciview under Phase 1 and Phase 2.

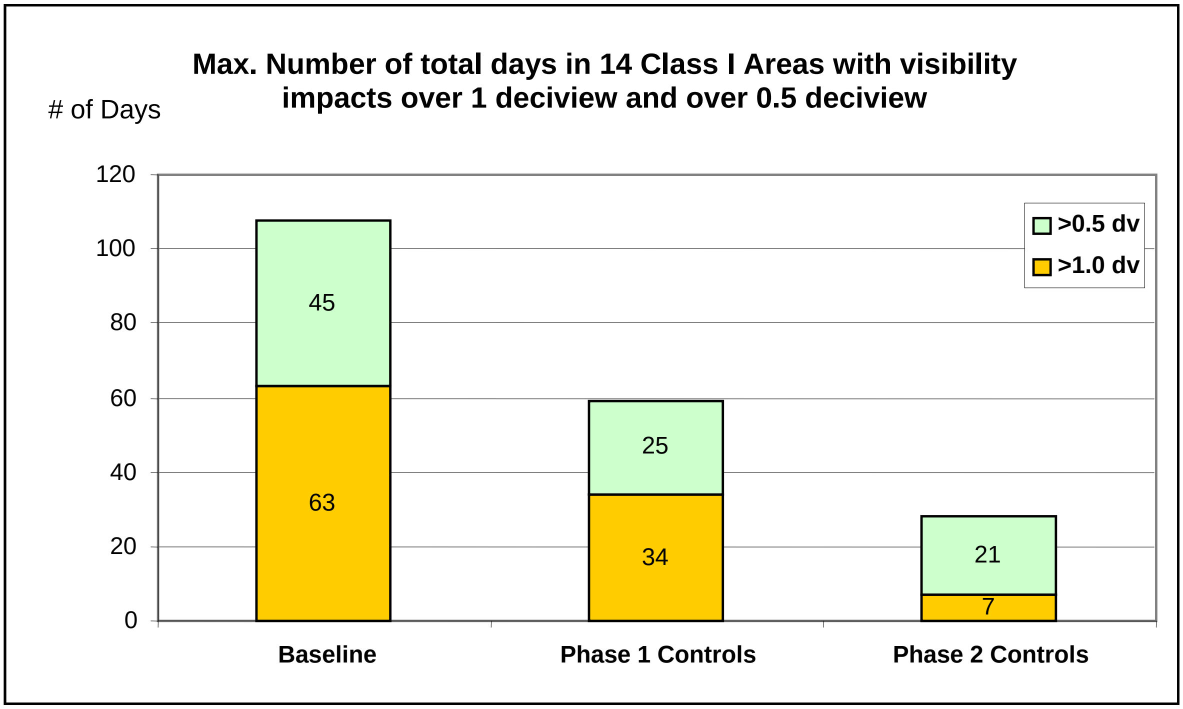
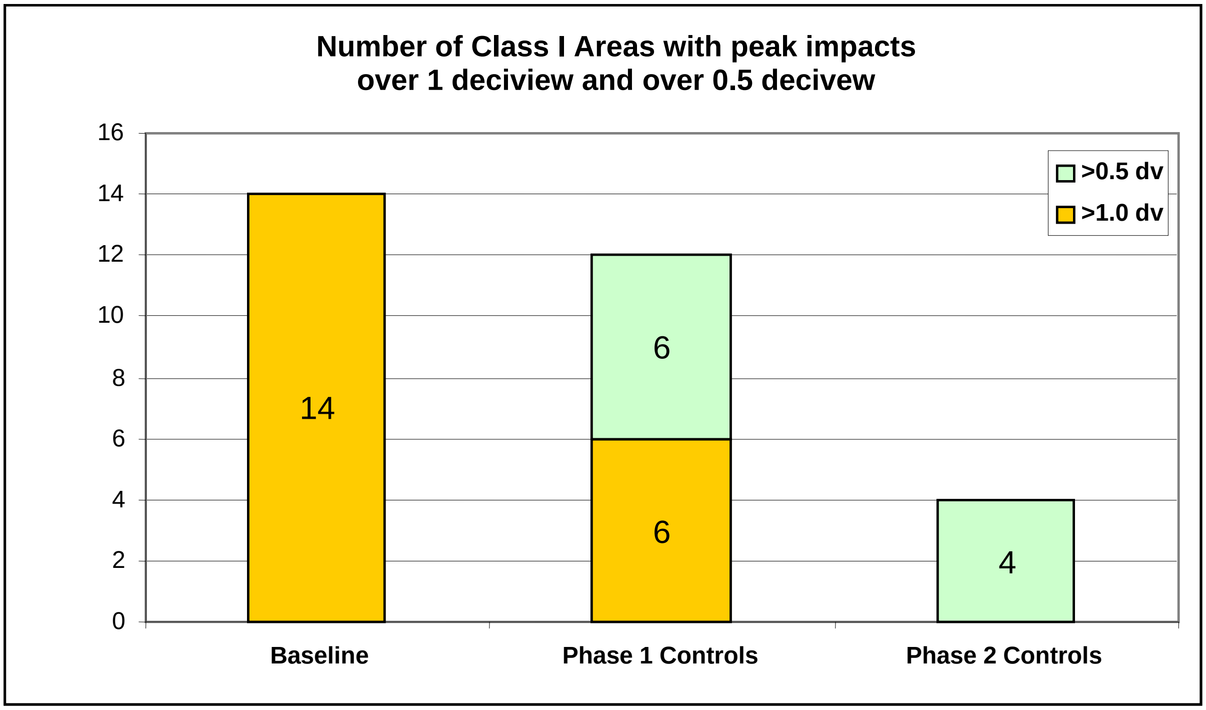


Figure 24 shows that without DEQ's proposal, Boardman's emissions would significantly affect visibility in all 14 Class I areas studied, with all peak impacts over 1.0 dv. With Phase 1 controls, the number of affected Class I areas drops to 12, with 6 areas affected by impacts of 1.0 dv or greater, and 6 areas affected by levels between 0.5 dv and 1.0 dv. With Phase 2 controls, the number are Class I areas affected drops to 4, with zero areas affected by levels of 1.0 dv, and 4 areas affected by levels between 0.5 dv to 0.9 dv. This reflects a 100 percent reduction in the number Class I areas affected at levels 1.0dv or higher, and a 71 percent reduction in Class I areas affected at levels between 0.5 dv and 0.9 dv.

Figure 24. Reduction in number of Class I areas with peak visibility impacts over 1.0 deciview and over 0.5 deciview under Phase 1 and Phase 2



V. Acid Deposition: Case Study

Several U.S. Forest Service studies in and near the Columbia River Gorge have found elevated levels of acid deposition that raise some concern about the potential for damage to sensitive ecosystems and Native American rock images. Sulfur and nitrogen compounds can cause acid deposition and can contribute to acid rain. SO_2 and NOx emissions come from many different sources, including PGE's Boardman power plant.

DEQ's rule proposal would reduce the Boardman power plant's contribution to acid deposition across Oregon, Washington, and Idaho. DEQ conducted a case-study using a computer model to estimate the likely reduction in acid deposition that would occur in the Mt. Hood, the Columbia Gorge, and Mt. Adams areas as a result of DEQ's draft proposal for the Boardman power plant. This analysis shows that DEQ's proposed SO_2 and NOx controls for the power plant would reduce acid deposition in these areas by about 80 percent.

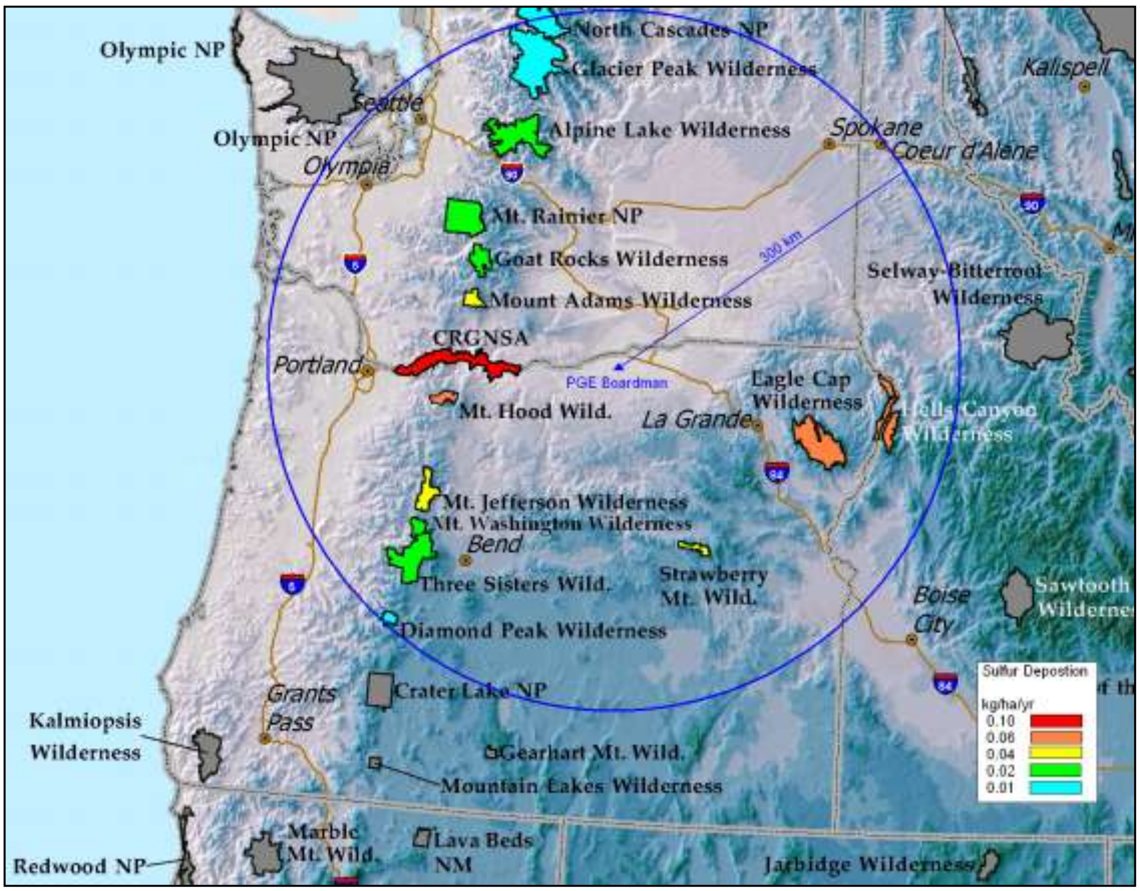
While is no study that looks at the cause and effect relationships between the power plant's emissions and potential affects on ecosystems or rock images, DEQ scientists agree that draft proposal would significantly reduce the Boardman power plant's contribution to acid deposition and thus help reduce the overall risk to ecosystems and culture resources in wilderness areas and well as the Columbia River Gorge National Scenic Area.

Figure 25 (map) illustrates the different levels of acidic deposition DEQ found in its case study. DEQ's computer modeling looked at an area 300 kilometers in radius (roughly 190 miles) centered at the Boardman plant. Different levels of average deposition were seen in each

Class I area, as well as the Columbia River Gorge. Figures 25 is color coded to correspond to acid deposition ranges from 0.01 to 0.10 kilograms (kg) of sulfur deposited per square "hectare" (ha)[6] per year. The National Park Service and U.S. Forest Service typically use a deposition analysis threshold (DAT) of 0.005 kg/ha/yr as a general guide for identifying a significant deposition impact when a new industrial plant is proposed. Using that metric, sulfur emissions from Boardman have a significant deposition impact on all Class I areas within the study areas as well as the Columbia River Gorge National Scenic Area.

Figure 26 (map) shows the same case-study analysis for nitrogen deposition. As with sulfur, nitrogen deposition from Boardman's emissions have a significant deposition impact on all Class I areas within the study areas as well as the Columbia River Gorge National Scenic Area.

Figure 25. Map of Class I Areas Affected by Boardman sulfur deposition



[6] One Hectare is equal to about 2.5 acres.

Figure 26. Map of Class I Areas Affected by Boardman nitrogen deposition

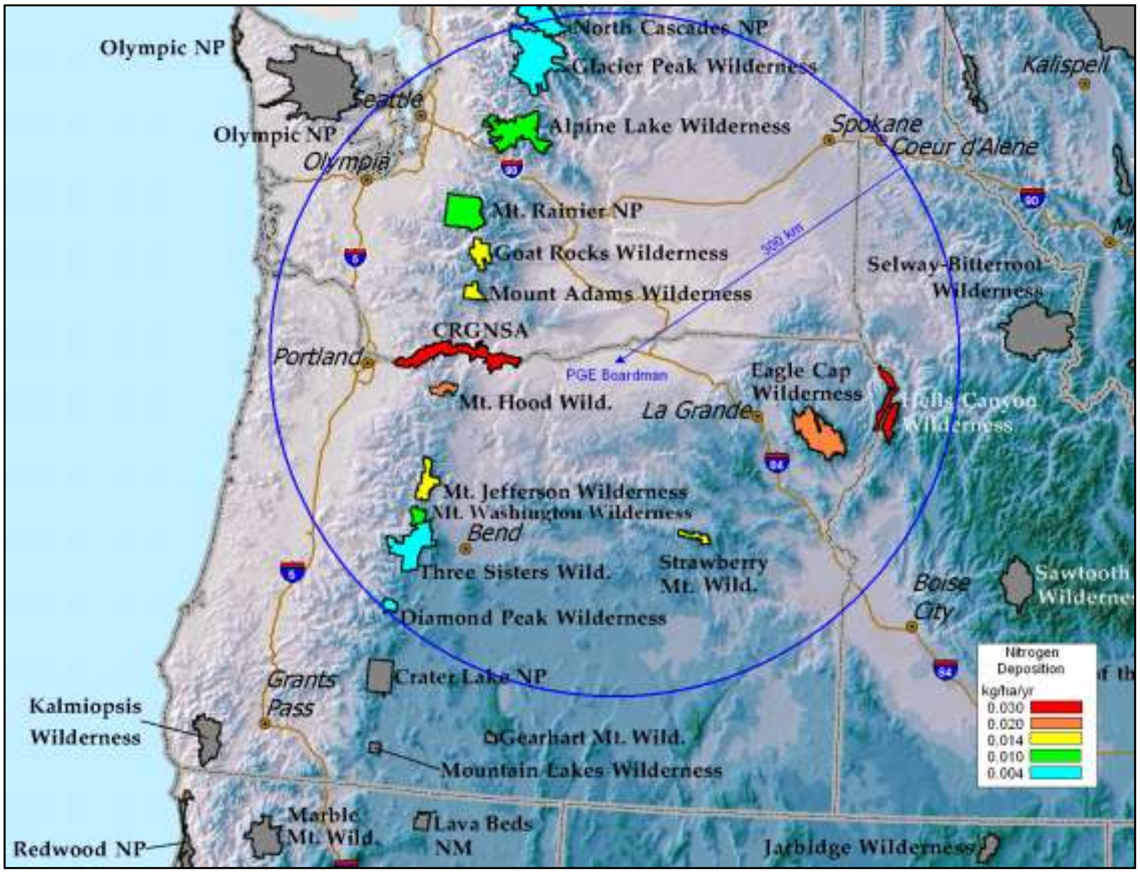


Figure 27 below illustrates the reduction in sulfur deposition in the study area under DEQ's draft rule proposal. **Figure 28** illustrates the corresponding reduction in nitrogen deposition. Three scenarios were evaluated: a) the maximum deposition occurring in the Mt. Hood, Columbia Gorge, Mt. Adams study area, b) the average deposition occurring in the Columbia River Gorge, and c) a weighted average deposition over the entire study area.

Figure 27. Reduction in Sulfur Deposition under DEQ's draft proposal

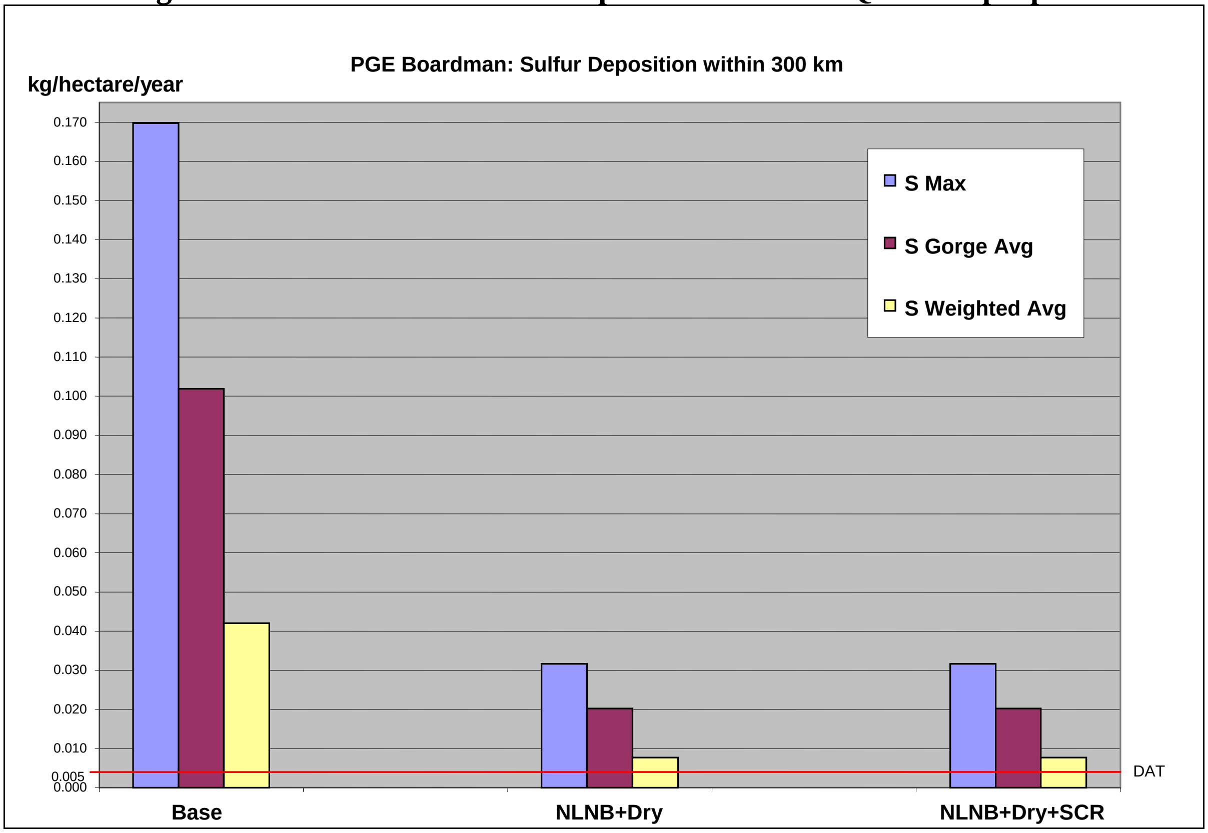
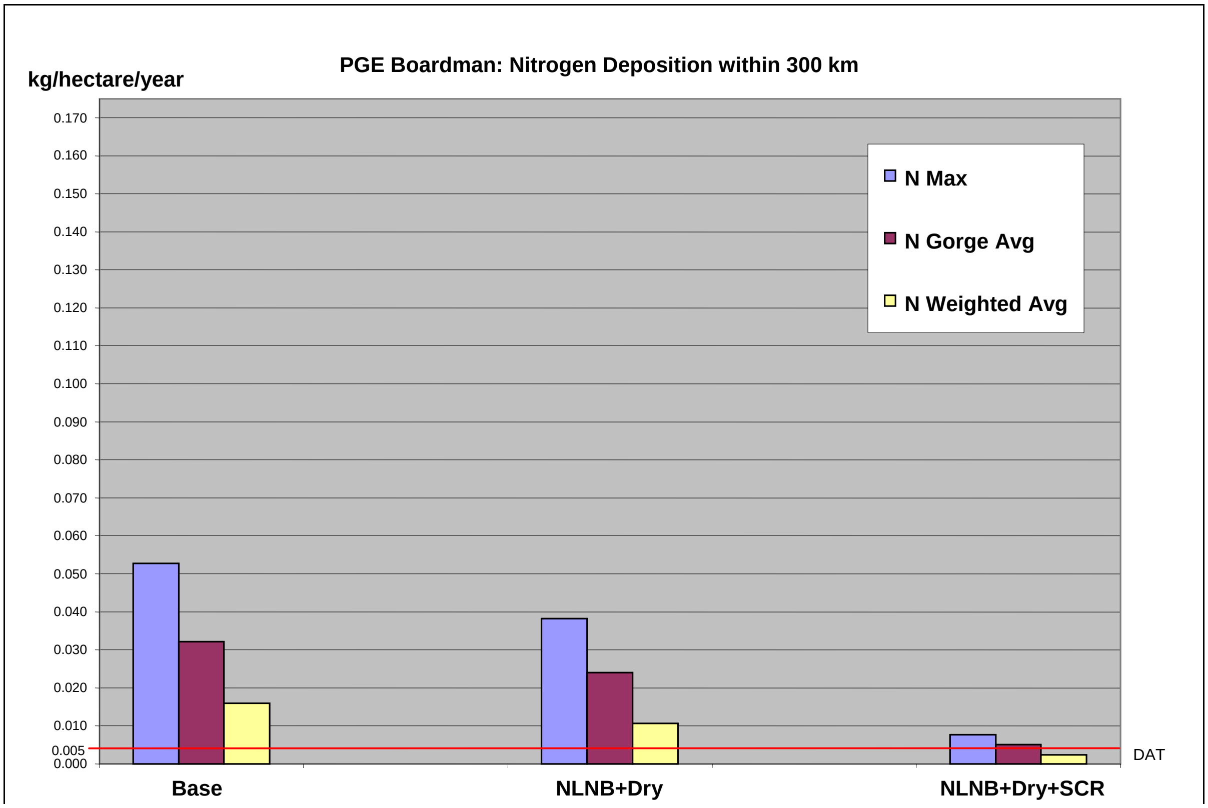


Figure 28. Reduction in Nitrogen Deposition under DEQ's draft proposal



Conclusion:

This report provides an overview summary of the results of DEQ's visibility and deposition modeling analysis for the PGE Boardman plant. DEQ's analysis shows that its proposal for stringent emission controls on the Boardman power plant will significantly reduce that plant's visibility and acidic deposition impacts in numerous Class I areas, and scenic areas like the Columbia Gorge.