Visibility Science Initiatives in Canada

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IMPROVE Steering Committee Annual Meeting
October 27, 2011
Frostburg, MD

Policy Context

National

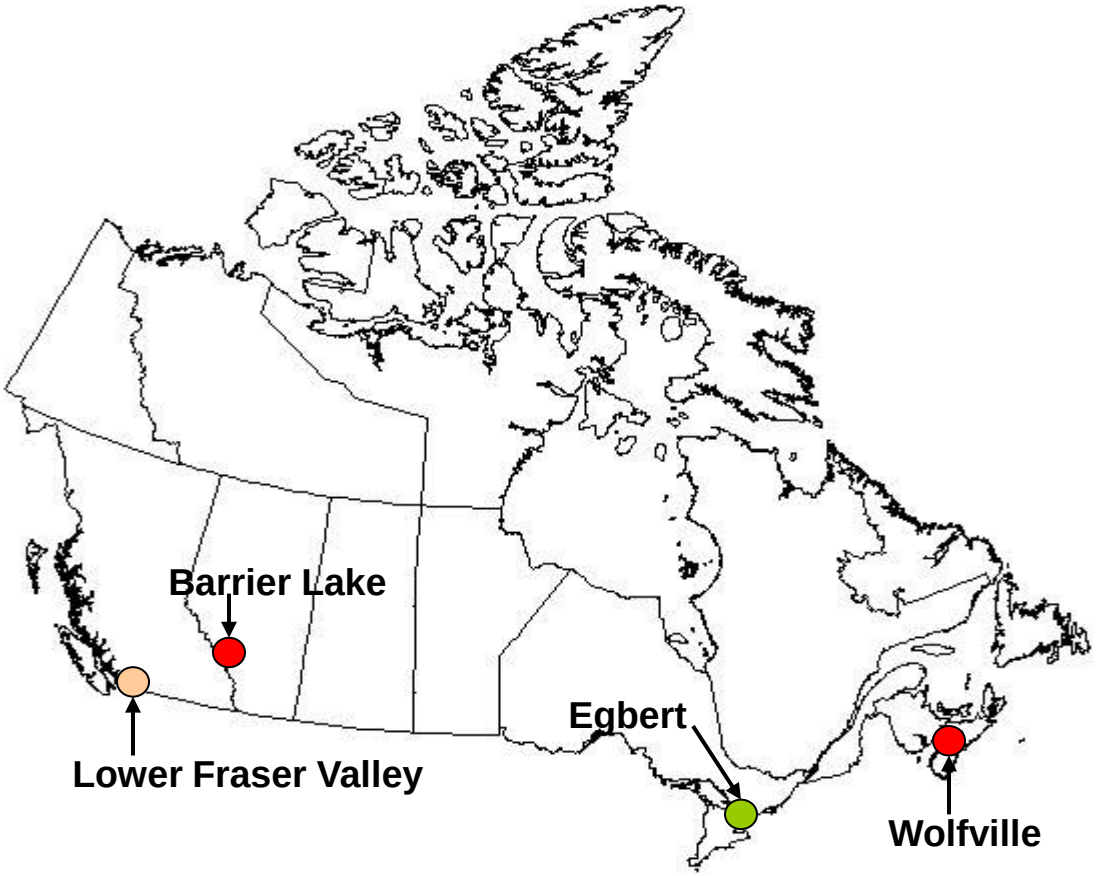
- Canada Wide Standard (CWS) for $PM_{2.5}$ (30 µg/m^3, 24 hr average)
  - In areas where ambient levels are lower than the CWS's for PM and Ozone, the Continuous Improvement and Keeping Clean Areas Clean provisions require jurisdictions to establish pollution prevention and best management programs to further improve or maintain good AQ.
    - Example: Metro Vancouver has "*improve visual air quality*" as one of three primary goals in its current Air Quality Management Plan.

Canada-US Air Quality Accord

- Annex 1 of the 1991 accord recognizes "the importance of preventing significant air quality deterioration and protecting visibility, particularly for international parks, national, state, and provincial parks, and designated wilderness areas".
- Visibility is part of the ongoing discussions; next meeting Fall 2011

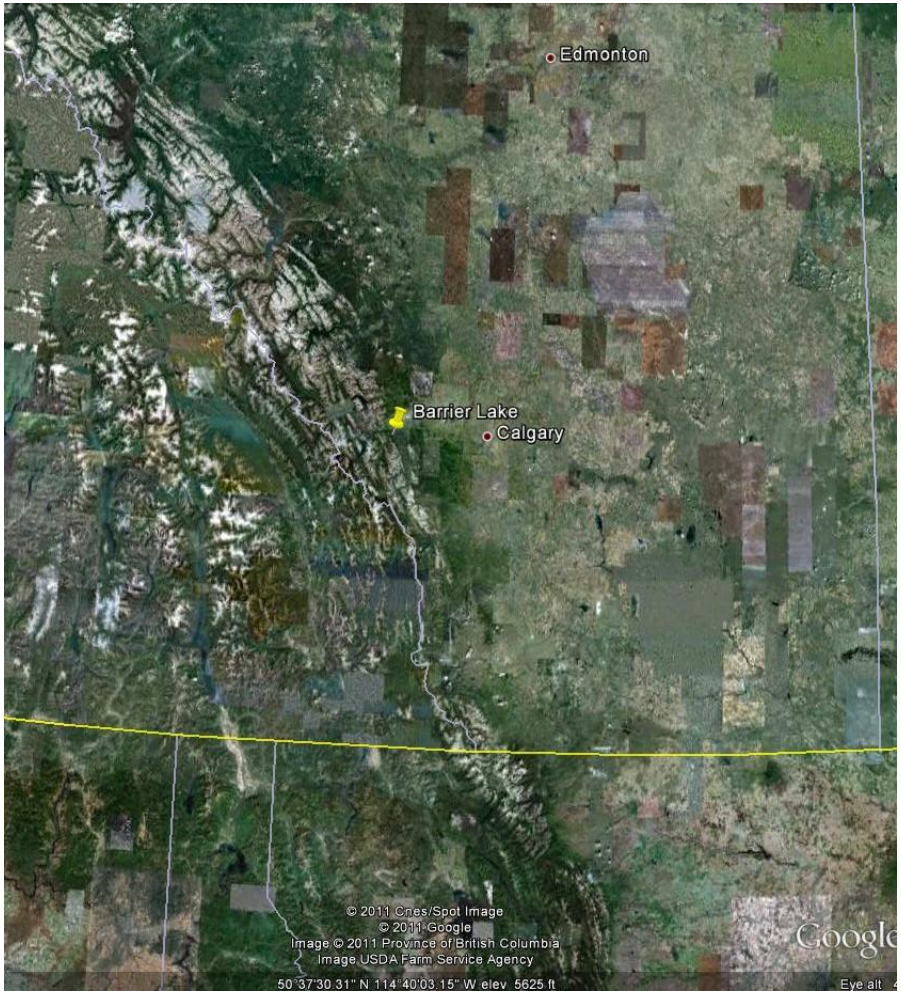
Visibility Activities

- Environment Canada pilot monitoring sites
  - Barrier Lake, AB
  - Wolfville, NS
- Environment Canada IMPROVE/CAPMoN comparison site
  - Egbert, ON
- Multi-agency visibility pilot management project
  - Lower Fraser Valley, BC



Pilot Monitoring Sites – Barrier Lake, AB

- Established Jan. 2011
  - To operate for a minimum of 2 years
- Located at Barrier Lake Station (University of Calgary)
  - 70km west of Calgary
    30km east of Banff NP
    220km north of USA
  - Maintained by Station staff and Environment Canada
- Monitors visibility in the vicinity of the Rocky Mtn. parks – a scenically important region of Canada



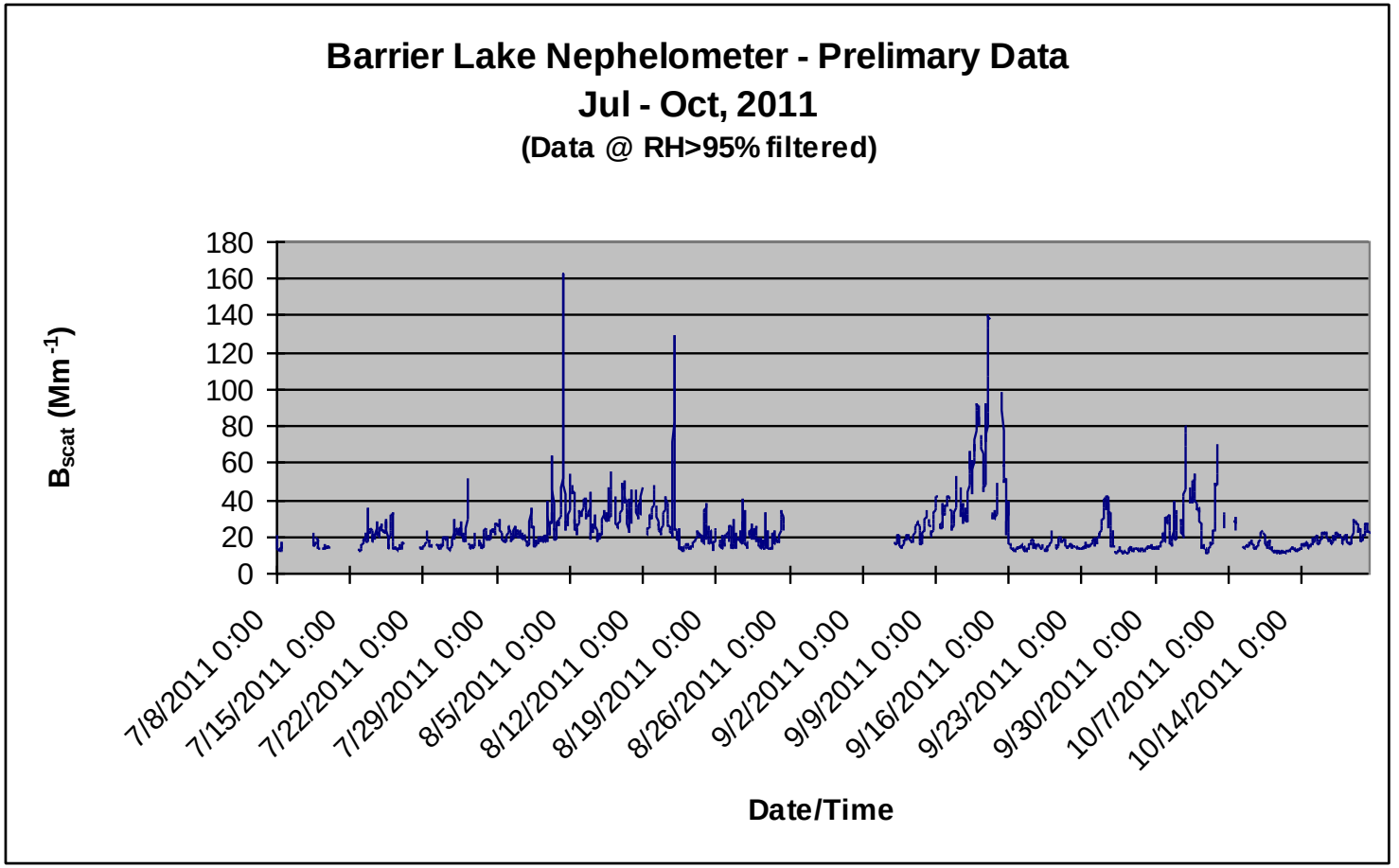
Pilot Monitoring Sites – Barrier Lake(2)

- IMPROVE Aerosol Sampler (BALA1)
  - 1 in 3 day
  - IMPROVE Sampling Protocol (Thursday change)
- Optec NGN-2A Nephelometer
- Meteorology (AT/RH, WS/WD)
- Webcam (U of Calgary)



Pilot Monitoring Sites – Barrier Lake(3)

- Preliminary nephelometer data: Jul. – Oct. 2011



Pilot Monitoring Sites – Wolfville, NS

- Established Sep. 2011
  - To operate for a minimum of 2 years
- Located at Acadia University
  - 80km northwest of Halifax 210km east of USA
  - Maintained by Acadia staff and Environment Canada



Pilot Monitoring Sites – Wolfville(2)

- Optec NGN-2A Nephelometer
- Meteorology (AT/RH, WS/WD)
- Digital camera





IMPROVE/CAPMoN Comparison site

- Egbert, ON
  - ~70km north of Toronto
- IMPROVE Aerosol Sampler (EGBE1) collocated with Canadian Air and Precipitation Monitoring Network (CAPMoN) speciation sampler
  - In operation from 2005 – current
  - Comparison data analysis is on-going
- Optec NGN2 Nephelometer
  - In operation from 2005 – 2010
  - Data analysis is complete



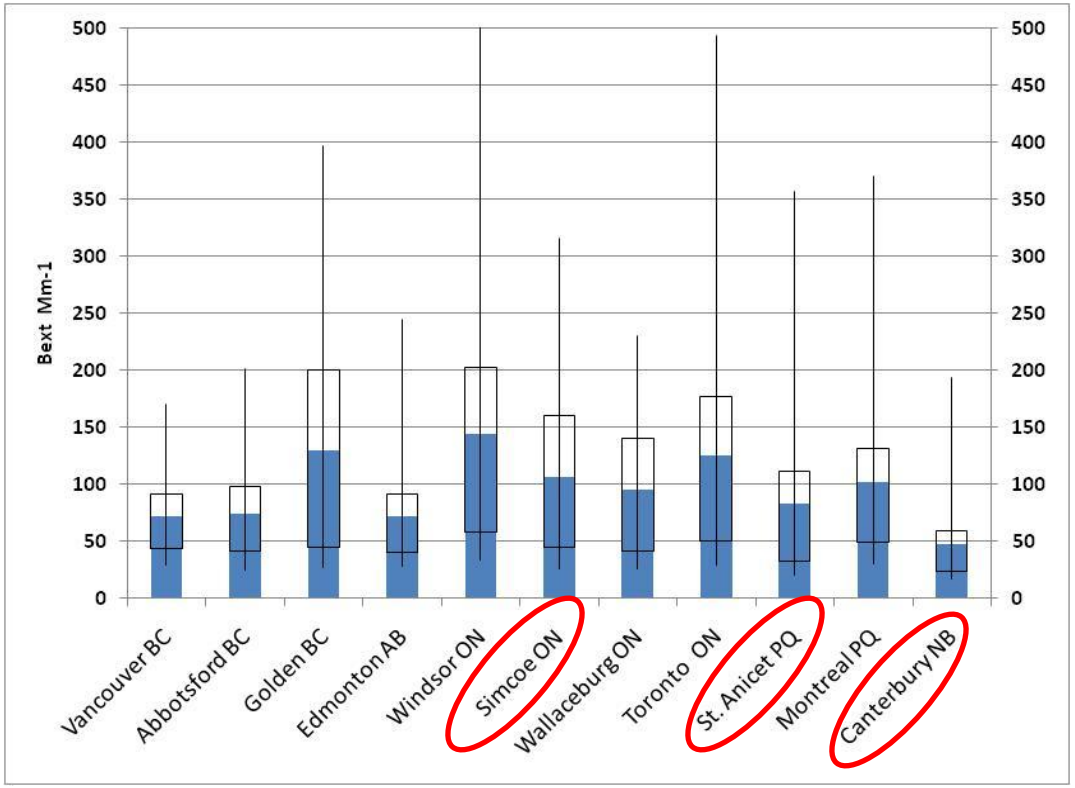
National Visibility Activities - other

- National Air Pollution Surveillance (NAPS) $PM_{2.5}$ speciation network
  - Data can be used to derived estimates of visibility
  - Primarily an urban network but there are a some “rural” sites

Extinction estimates (Mm^{-1})

2003 – 2007 (varying periods)

Revised IMPROVE Algorithm



Bar = mean
Box = 20th – 80th percentile
Whisker = 2nd – 98th percentile

Lower Fraser Valley Visibility Management Pilot Project



Why the Lower Fraser Valley?

- An abundance of scenic vistas in the valley, means that both visitors and residents place a high value on the protection of visibility
- Compared to other regions in Canada, there is an abundance of knowledge on visibility impairment in the LFV from both past and on-going monitoring activities
- Local and regional government support for the development of a visibility management plan
  - Metro Vancouver has "*improve visual air quality*" as one of three primary goals in its current Air Quality Management Plan



British Columbia Visibility Coordinating Committee (BCVCC)

- Inter-agency committee formed in 2006, comprised of Regional, Provincial and Federal agencies.

Metro Vancouver Fraser Valley Regional District

- Purpose
  - Provide on-going direction to government agencies on efforts to reduce the impact of air pollution on visibility in BC

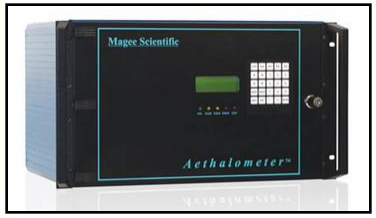
- BCVCC currently leading a “pilot” visibility management project in the LFV
  - Aims to demonstrate, test and implement policy mechanisms and technical tools to achieve visibility protection or improvement in the LFV
  - Could be used to spawn similar programs in other regions of B.C. or Canada

- Five BCVCC workgroups currently undertaking various projects
  - **Science –** monitoring and data analysis
  - **Emissions/Modelling** – visibility scenario modelling
  - **Goal and Index** – development of
  - **Business Case** – development of
  - **Strategic Outreach** – communications, website development

Visibility Monitoring

$$b_{ext} = \Sigma (\text{part.+ gas scat.}) + \Sigma (\text{part. + gas abs.})$$

- Hourly/Real time → Nephelometer Aethalometer NO_2 analyzer
- 1 in 3 day → Speciation sampler (NAPS $PM_{2.5}$ Speciation Network) (Source apportionment)
- Digital images – 2x hourly

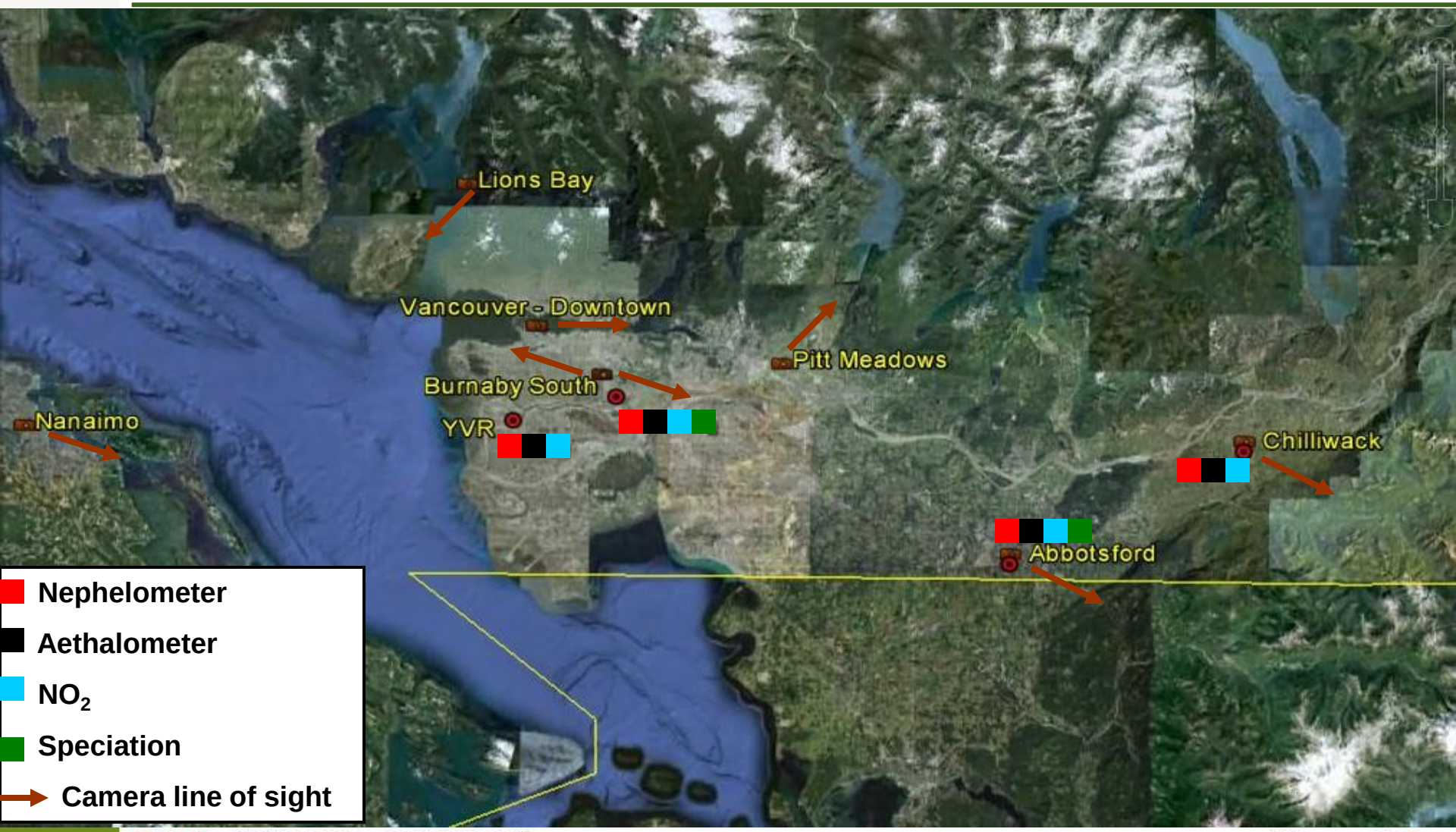








Visibility Monitoring Network - 2011



Visibility Data - Images

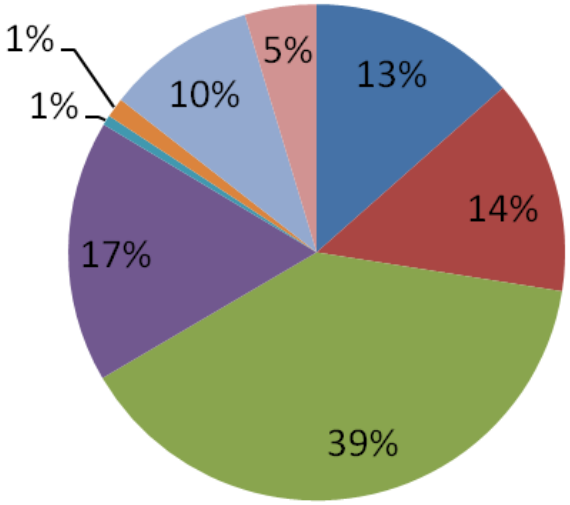
Images from Chilliwack
Summer 2010

Aug 24	Jul 28	Aug 5
		
$B_{ext} \approx 36\ Mm^{-1}$ (12.8 DV) $PM_{2.5} = 2.9\ \mu g/m^3$ RH = 34%	$B_{ext} \approx 112\ Mm^{-1}$ (24.2 DV) $PM_{2.5} = 11.9\ \mu g/m^3$ RH = 57%	$B_{ext} \approx 169\ Mm^{-1}$ (28.3 DV) $PM_{2.5} = 24.6\ \mu g/m^3$ RH = 50% *Impacted by forest fire smoke

Visibility Data – Extinction Attribution

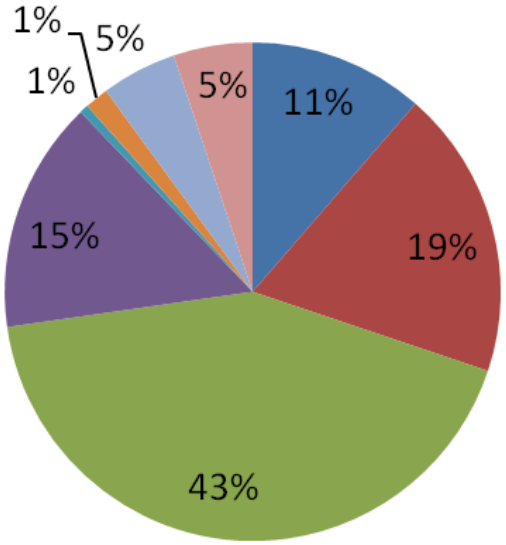
2003 - 2008

Burnaby South

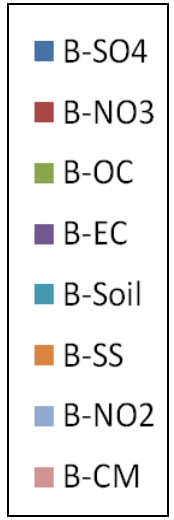


69.9 Mm^{-1}

Abbotsford

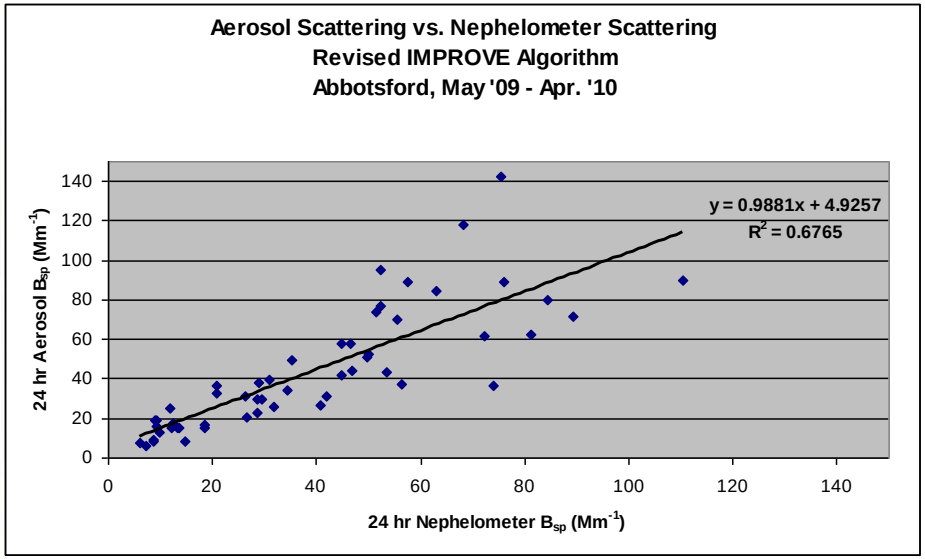


71.6 Mm^{-1}



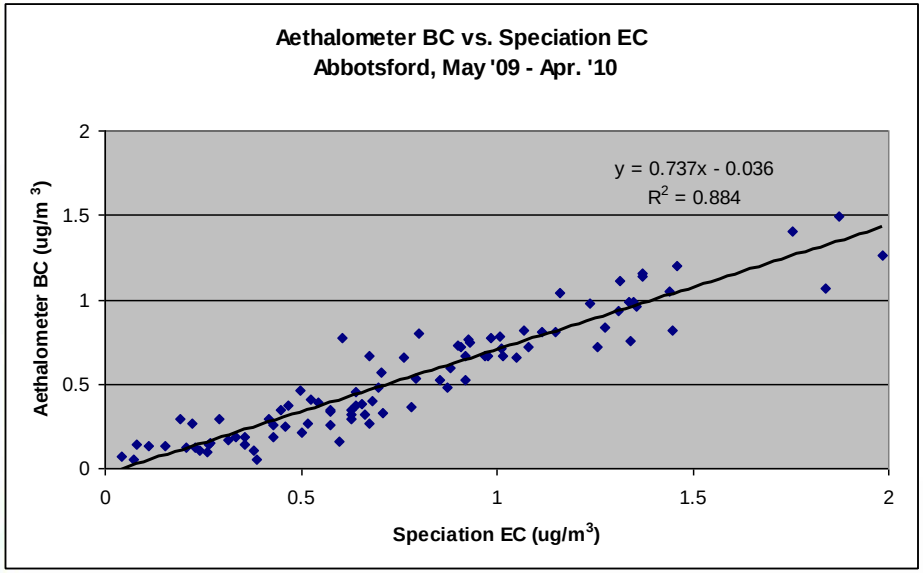
Order of importance: OC>NO3≈ EC> SO4> NO2> coarse mass

Visibility Data – Instrument Comparison



Why poor correlation?

- Urban/suburban site vs. wilderness (IMPROVE)?
- Meteorological effects?



Why low slope?

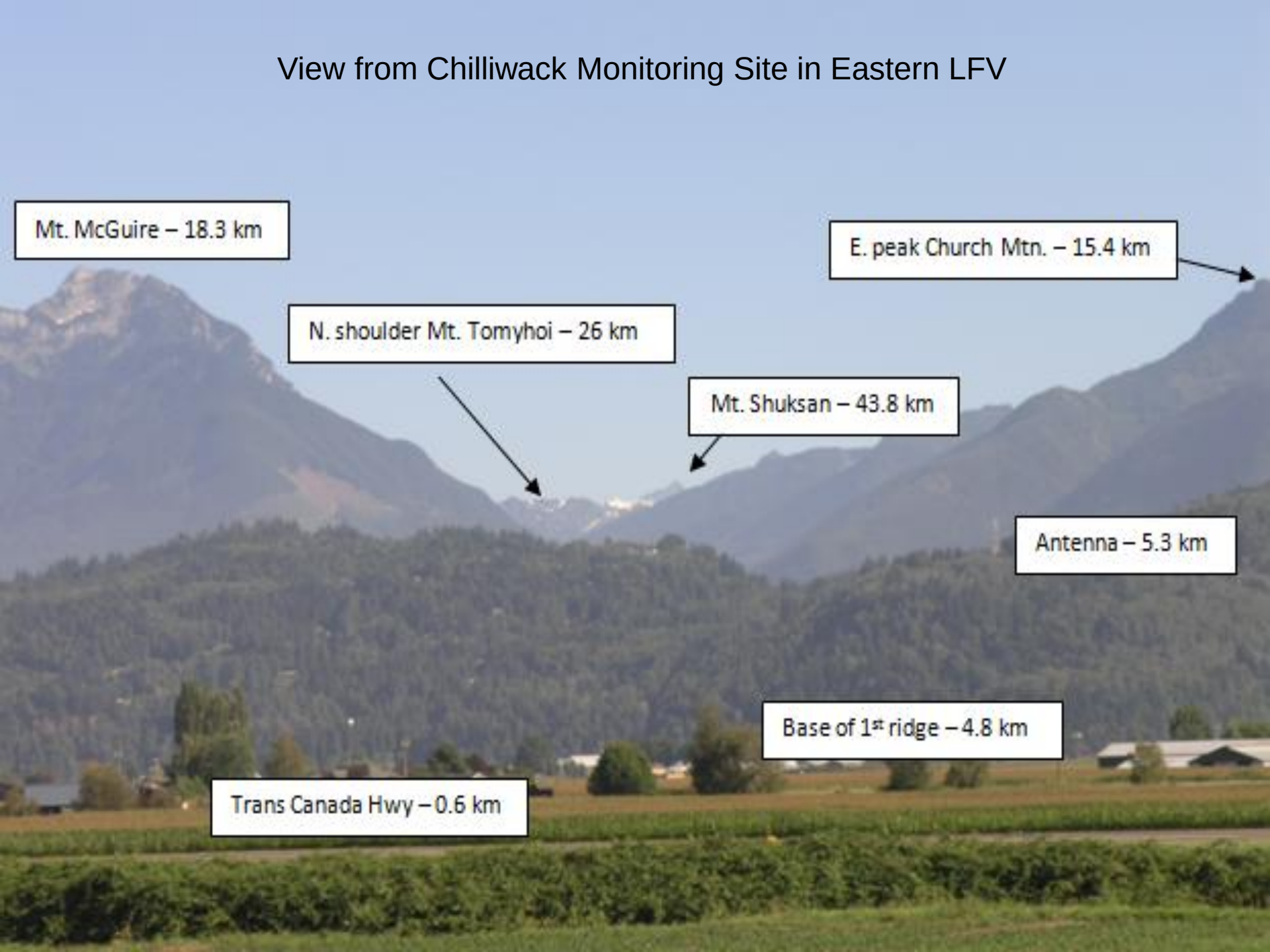
- Inherent bias?
- Particle composition?

Canada

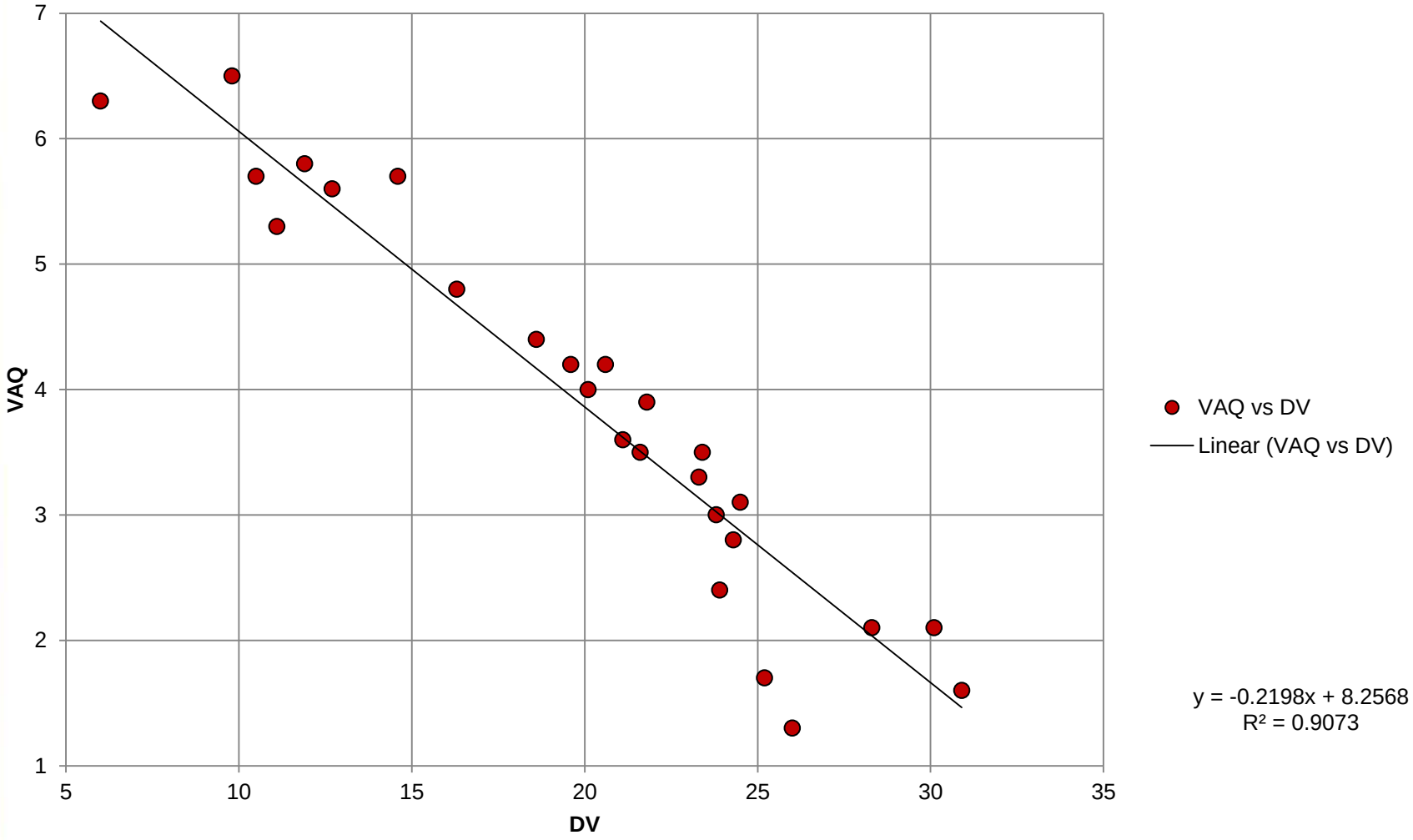
Visibility Goal and Index Development - Rationale

- Need to develop a public perception based goal/standard for visual air quality in the LFV
- Previous perception studies were carried out in the mid-90's in the LFV as part of REVEAL and REVEAL II
- There was a desire to:
  - Obtain a larger set of data relating public perception of visibility to measured atmospheric parameters
  - Investigate whether visibility perception has changed over time as air quality in the LFV has changed
  - Investigate whether previous techniques, will work in a broader range of atmospheric conditions (humidity, partial cloud cover)
- New perception study carried out in 2011
  - Nearly same methodology as previous studies (Pryor, *Atmos. Env.,* 30(15), 1996)
  - New photos, larger data set

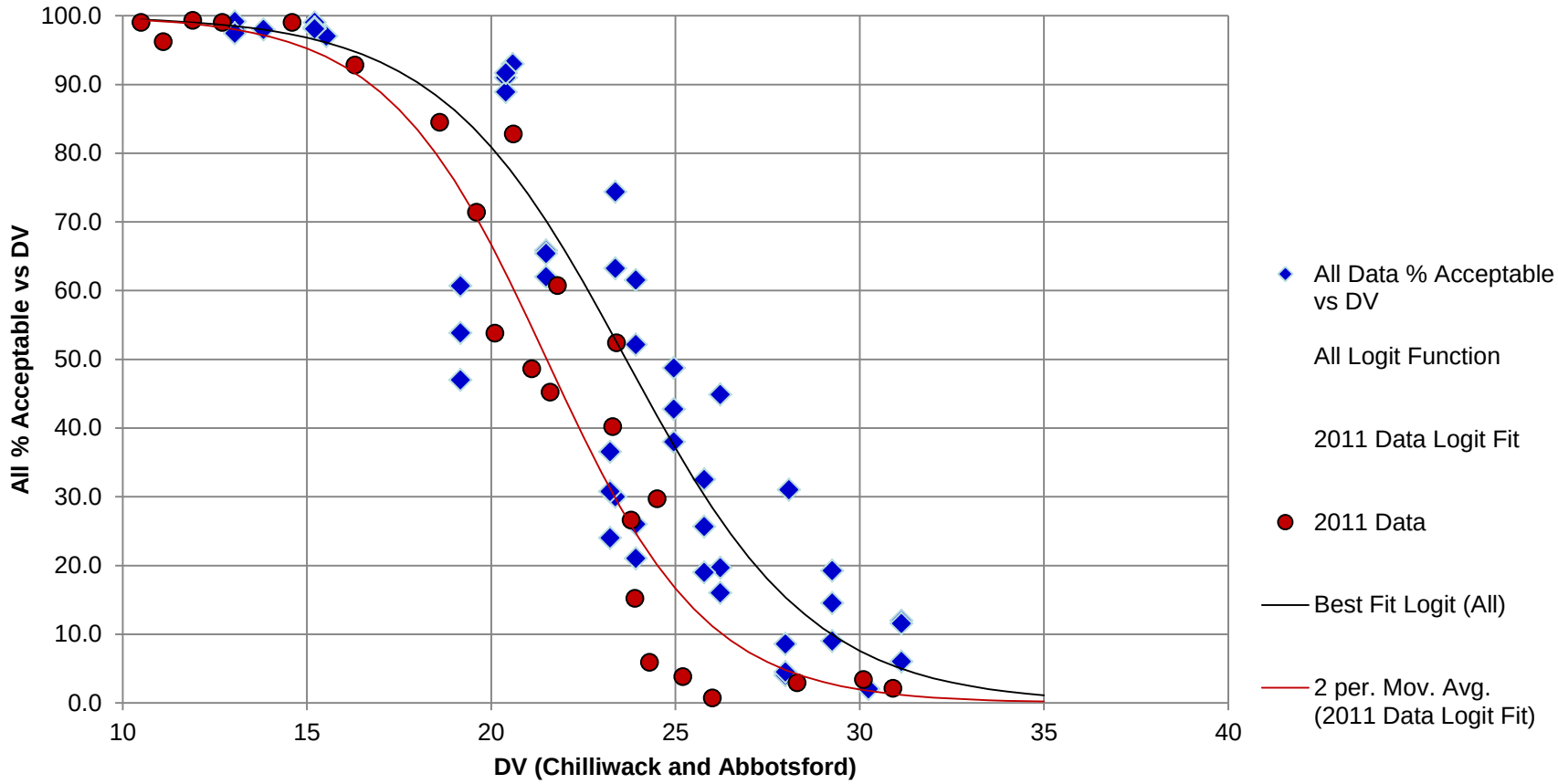
View from Chilliwack Monitoring Site in Eastern LFV



Visibility Index - Updated Perception Study



Visibility Index – Perception Results – Then and Now



Perception Study: Conclusions/Next Steps

Conclusions

- Similar relationship between public perception and measured VAQ in the LFV between the early 1990s and 2011
- Slight shift in curve - less tolerant of impaired visibility vs. early survey results
  - Change in public values and expectations (a greater desire for clear views)?
  - Differences in the way b_{ext} was calculated
    - Earlier studies: b_{ext} directly measured via a transmissometer at Chilliwack and estimated with nephelometer + scaling factor at Abbotsford
    - 2011 study: b_{ext} reconstructed from nephelometer, aethalometer and NO_2 at Chilliwack
  - Difference in viewscape (rural foreground in 2011 study versus urban foreground in earlier studies)

Next Steps

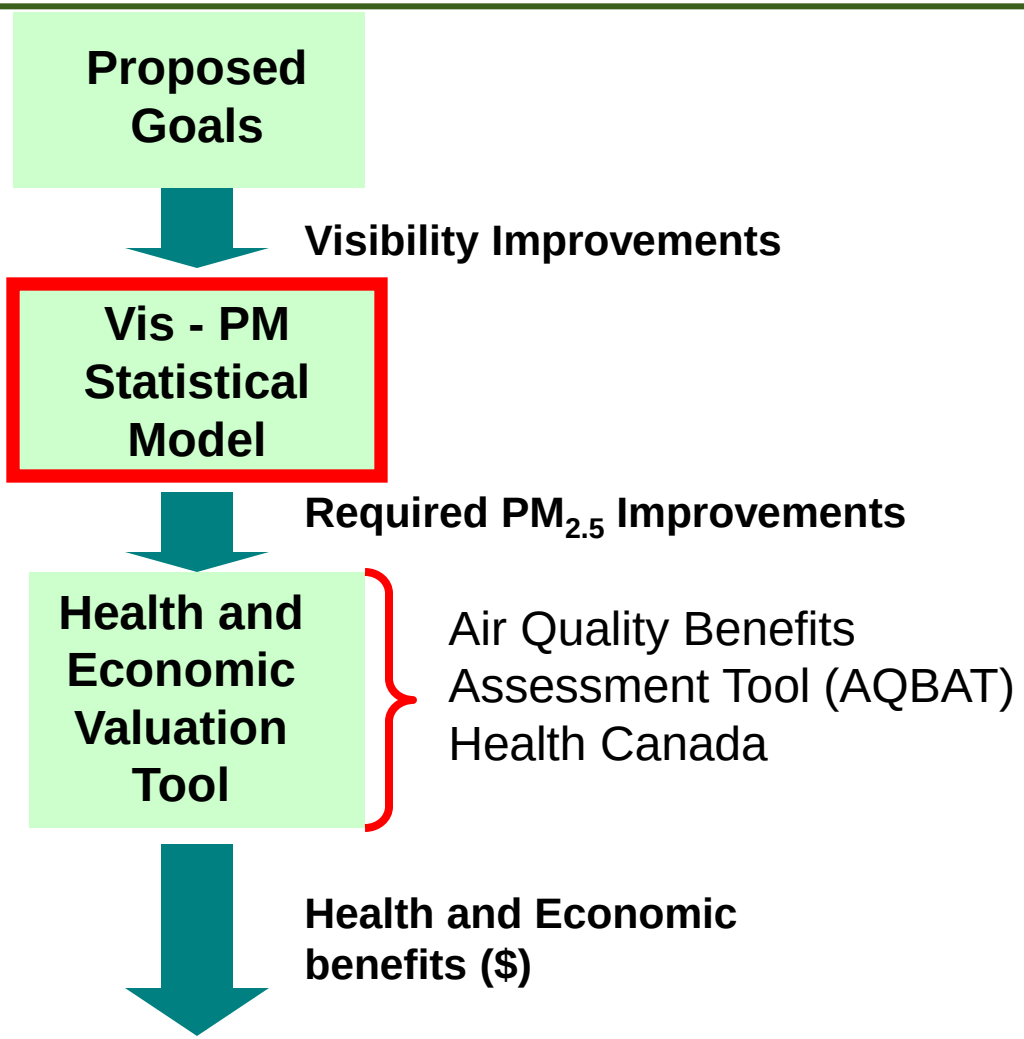
- Small extension of the study to include more eastern LFV residents
- Use results of perception studies to finalize a Visual Air Quality Index and Goal for the LFV

Business Case

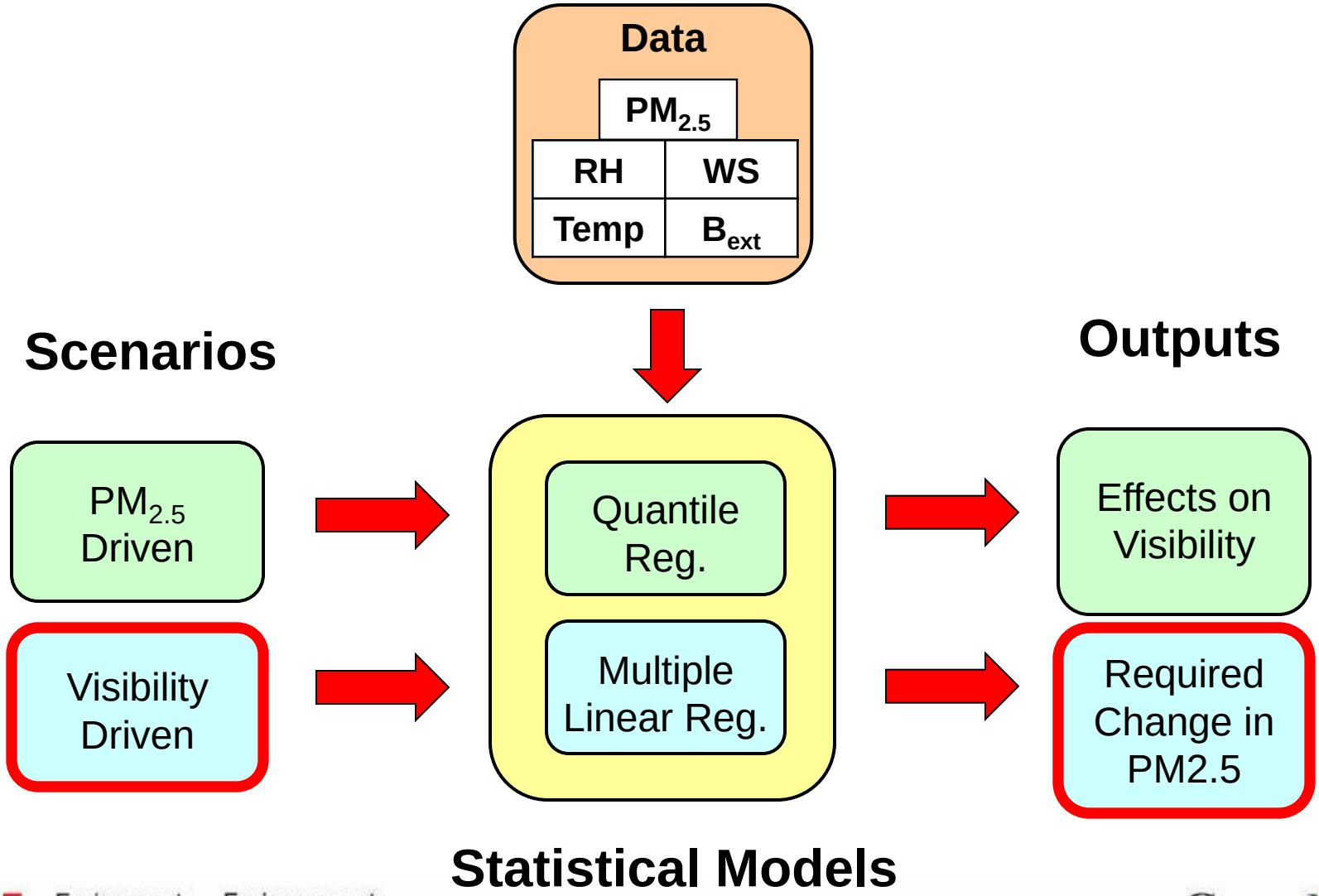
- Developing a case for improving visibility in the LFV
  - Beyond the environmental benefits

- Compilation of visibility improvement benefits stated in terms of
  - Economic
    - e.g. McNeil and Roberge (2000). *The Impact of Visual Air Quality on Tourism Revenues in Greater Vancouver and the Lower Fraser Valley*
  - Cultural/Spiritual
    - e.g. Carlson (2009). *Aboriginal Perspectives on Degraded Visibility Associated with Air Pollution in the BC Lower Mainland and Fraser Valley*
  - Health
    - e.g. Parker et al. (2011) (In preparation). *Health Benefits Estimates Associated with Improvements in (PM2.5) Air Quality*

Business Case for Visibility Management



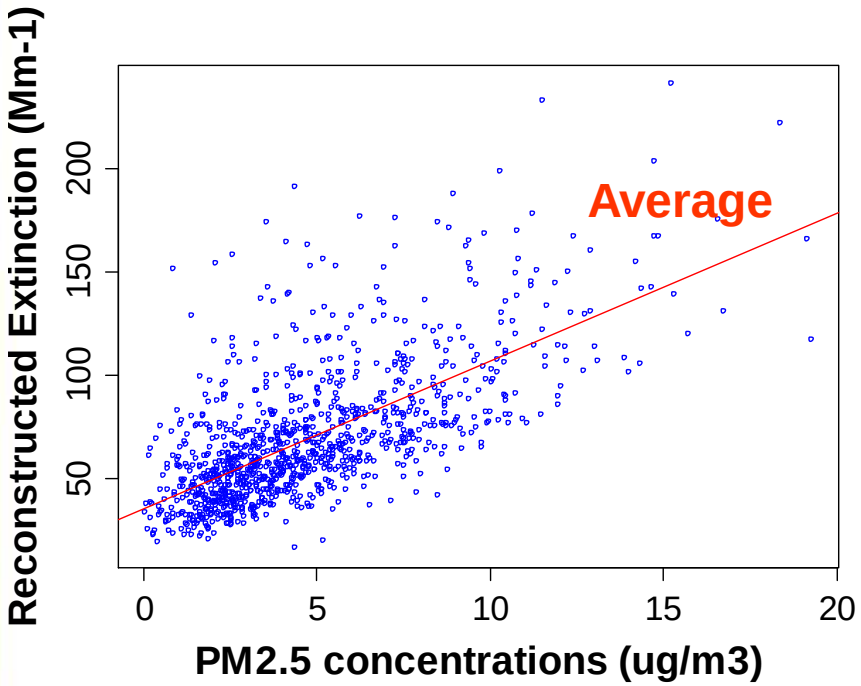
$PM_{2.5}$ – Visibility Statistical Model



$PM_{2.5}$ – Visibility Statistical Model(2)

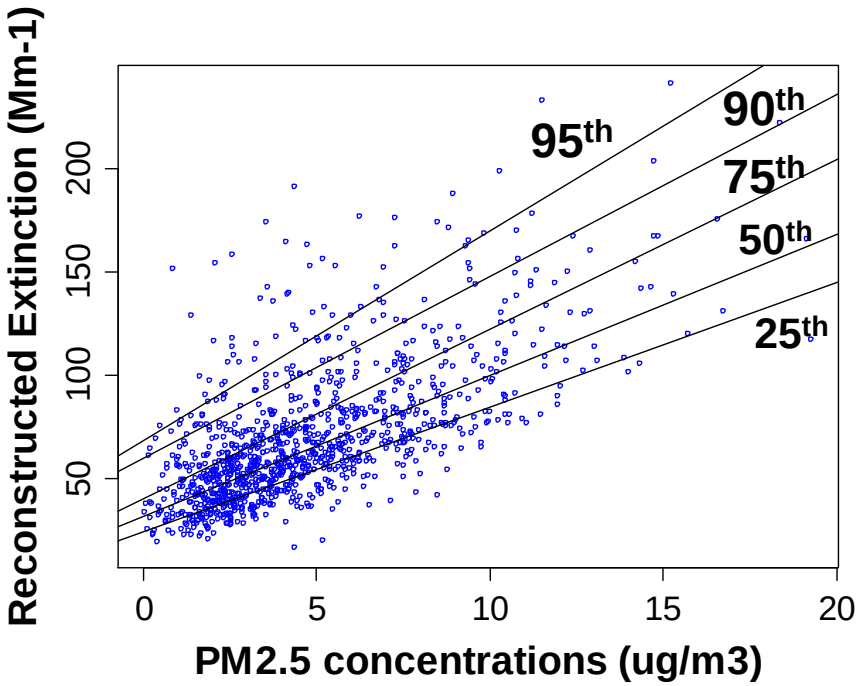
Multiple Linear Reg.

- Unbiased estimator for average of the distribution

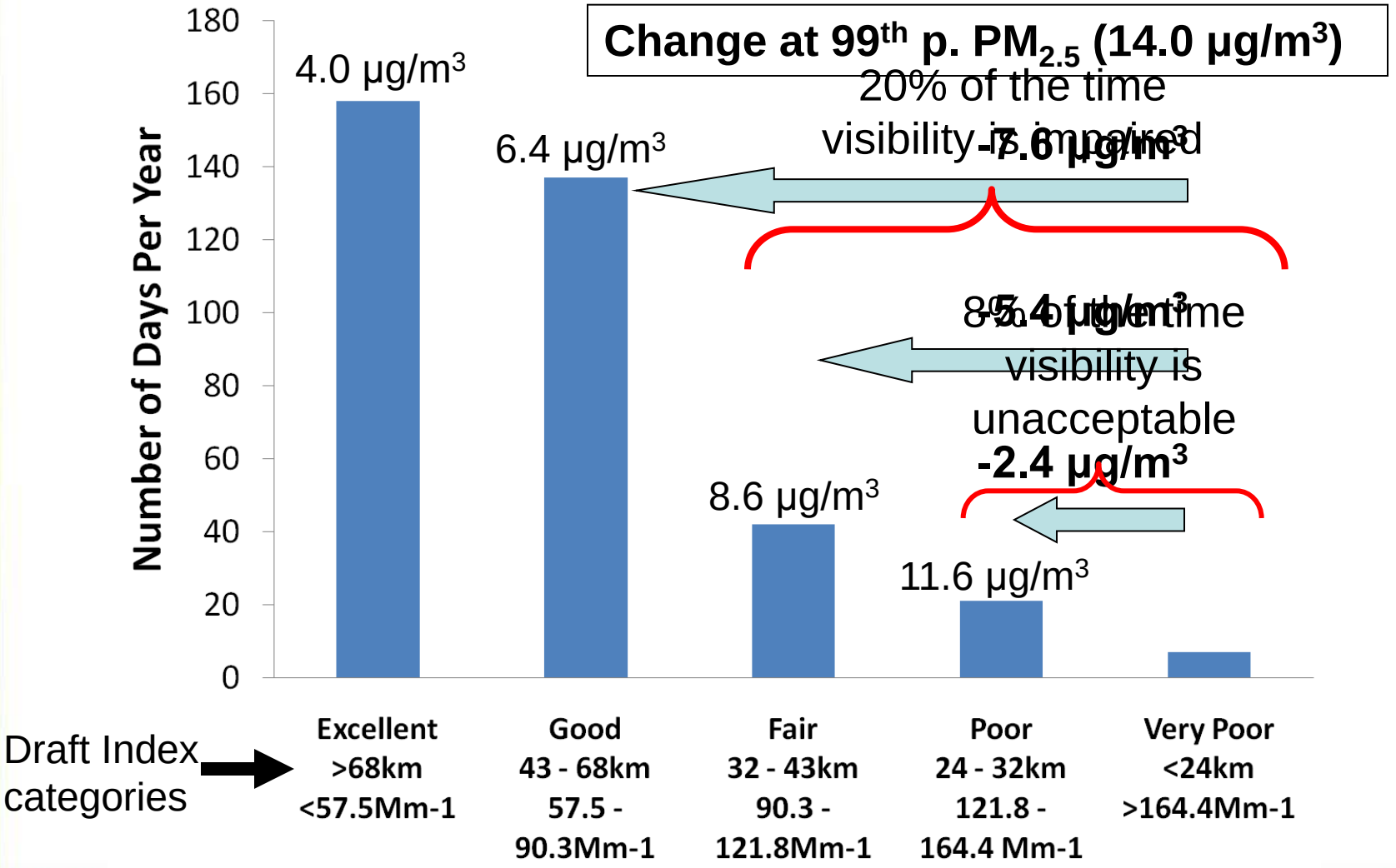


Quantile Reg.

- Can build regression specific to each percentile

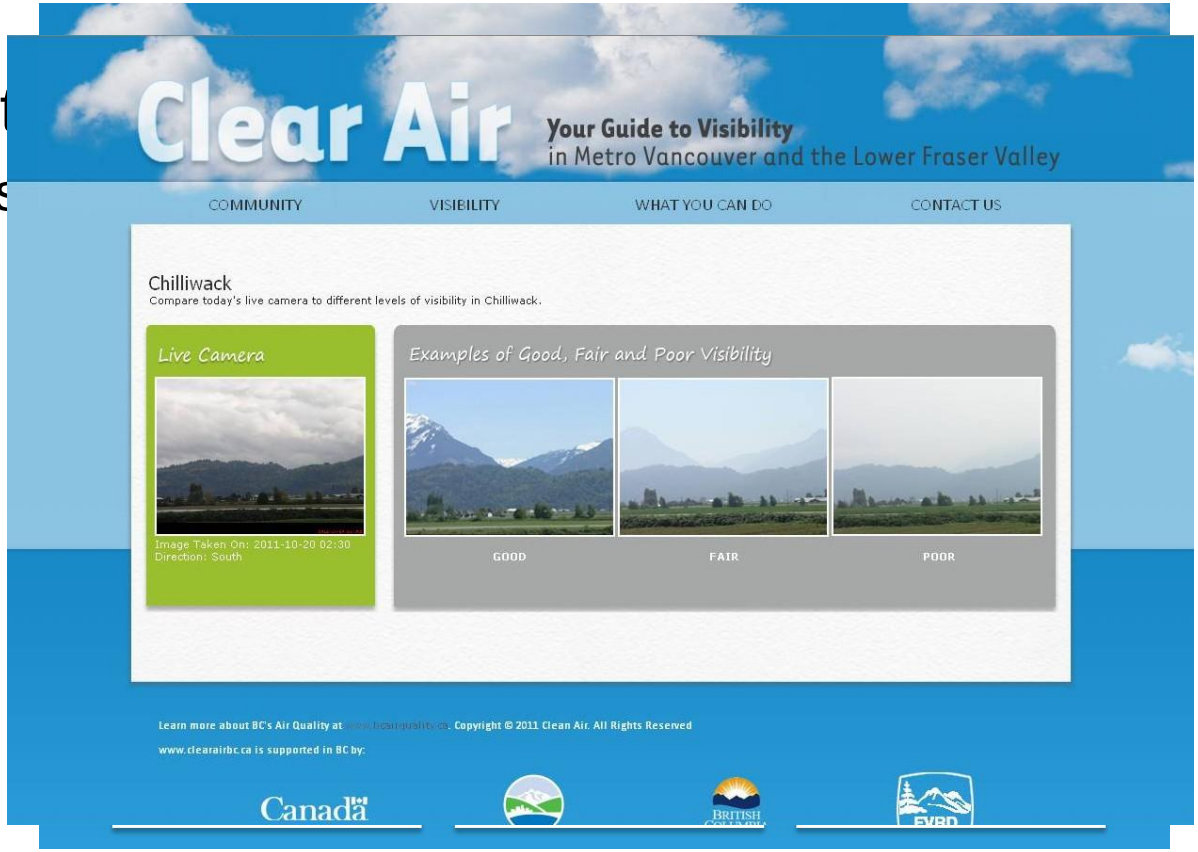


Visibility Driven Scenarios: $PM_{2.5}$ concentrations required to achieve perception-based visibility improvements



Outreach – Website Development

- Website launched in 2010 (www.clearairbc.ca)
- Updat
  - Vis ages



Thank you