

July 21, 2011

Chris Jenkins Manager, Air Emissions
British Columbia Ministry of Environment
PO Box 9341 Stn Prov Govt
Victoria, British Columbia, Canada V8W 9M1

Re: BC CLEAR 2010/11 Annual Report

Dear Mr. Jenkins,

Please find enclosed the 2010/11 Annual Report for the BC CLEAR Fund. Thank you for the tremendous opportunity to work on this exciting initiative with you. We welcome any feedback, suggestions or questions you may have.

Respectfully Submitted,

A handwritten signature in blue ink, consisting of several fluid, overlapping strokes that form a cursive-style name.

Terry Robert
Program Manager
Fraser Basin Council

ANNUAL REPORT

Funding Agency: BC Ministry of Environment
Proponent Name: Fraser Basin Council
Period: April 1, 2010 to March 31, 2011

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Fund Description

Purpose

The BC Clean Air Research (BC CLEAR) Fund promotes excellent research by funding transformative, internationally significant research of strategic importance for the management of air quality in British Columbia.

Management

The BC Clean Air Research Fund is sponsored by the BC Ministry of Environment and is jointly managed by three parties, namely the BC Ministry of Environment (MoE), Metro Vancouver and Environment Canada (EC). A representative from each of these parties makes up the Fund Steering Committee. The role of the Steering Committee is to:

- Review and make decisions on proposals;
- Obtain reviews of proposals from independent experts when certain expertise is required;
- Arrange coordination on proposed projects that overlap with existing or proposed work;
- Whenever possible, provide funding or in-kind contributions from their respective agencies in addition to the amount requested from the Fund.

The Fraser Basin Council provides administrative support to the Steering Committee by acting as the Fund secretariat. In this role the Council receives proposals, communicates with applicants, and prepares annual reports for the Fund.

Program Highlights in 2010/11

Activity	Successes
Project Management	<ul style="list-style-type: none"> ▪ 8 new projects awarded BC CLEAR grants of up to \$25,000 each (to be paid in 2011/12). ▪ 3 scholarships awarded through the Robert Caton Scholarship Committee. ▪ 6 previously approved BC CLEAR projects continued with 3 receiving additional grant instalments, and 4 completing their research in the 2010/11 year.
Application Management	<ul style="list-style-type: none"> ▪ 26 applications received from academic, government, private consultants and First Nations researchers.
Steering Committee Meetings	<ul style="list-style-type: none"> ▪ 5 meetings facilitated (July 28, 2010; November 10, 2010; December 8, 2010; January 19, 2011; February 3, 2011).
Document and Template Assessment	<ul style="list-style-type: none"> ▪ Application forms updated. ▪ Interim, annual and final report templates updated.
Website Management	<ul style="list-style-type: none"> ▪ Updated website with a new funding call in 2010/11.

Research Project Descriptions and Updates

Projects - Starting in 2008/09

Identification and Monitoring of Airborne Volatile Organic Compounds

Konrad Walus

Description

This project will develop novel sensor technology for characterizing and quantifying volatile organic compound (VOC) emissions. These devices will be integrated into the existing monitoring network, which covers a wide geographical range across the province. As a result, the data collected by the sensors will be used to locate the associated pollution sources. The information acquired with these sensors will help support the B.C. Air Action Plan, which has identified VOCs as a precursor to ozone (an ingredient in smog and one of the worst pollutants in B.C. in terms of its effects on human health and the environment).

Walus Revenue Schedule

Year	CLEAR	Other (cash)	Other (in-kind)	Total
2008/09	\$25,000	\$0	\$26,000	\$51,000
2009/10	\$25,000	\$119,156	\$58,505	\$202,661
2010/11	\$25,000	\$82,452	\$45,125	\$152,577
Total	\$75,000	\$201,608	\$129,630	\$406,238

Status

The project will be completed on schedule in 2011/12. Some of the milestones have taken longer than expected to complete. Additional time has been required for completing the process development for various components (piezoelectric substrates, printing process) of the sensors. However, significant progress has been made during 2010/11, and the project is still on track to demonstrate an initial prototype by October 1, 2011. The project has leveraged other sources of funding to pay additional students to work on the project completion.

Key Findings

The primary objectives of this project are to develop an all-polymer acoustic sensor platform and to use that platform to sense 10 target volatile organic compounds (VOCs). The sensor platform has been developed using piezoelectric polyvinylidene fluoride (PVDF) and conductive poly(3,4-ethylenedioxythiophene) poly(styrenesulfonate) (PEDOT). The conductive traces on the piezoelectric substrate form input and output transducers. An electric signal applied to the input transducer will generate an acoustic wave in the substrate that travels toward the output transducer where it is converted into an electric signal. Analytes interacting with a sensitive layer between input and output transducer will interfere with the propagating acoustic wave resulting in a delay. The

main challenges in the development of the sensor platform have included: achieving the necessary piezoelectricity of the PVDF, development of an inkjet printing process for the patterning of high resolution electrodes, overcoming damping of mechanical waves and conducting the complex mechanical and electrical characterization. However, each of these steps have been completed.

In summary the study has:

- A) Developed the fabrication process for acoustic wave devices including:
 - Preparation of the piezoelectric substrates
 - Mounting of these substrates under pretension in custom frames
 - A process for printing of the electrical conductors onto these substrates
- B) Demonstrated the generation of acoustic waves by:
 - Measuring the mechanical waves across the substrates
 - Measuring the electrical response generated by the mechanical waves
- C) Developed appropriate instrumentation for the sensor device.
- D) Completed the initial design of the preconcentrator/sensing chamber system.

Next Steps

Several tasks remain for the demonstration of VOC sensing. A process for depositing polymer sensing layers remains to be developed. Several different polymer layers, potentially more than ten, will be needed in order to selectively sense the ten target VOCs. The measurement electronics must be improved to provide a real-time digital reading of the resonant frequency and phase delay of the sensing platform. A gas test system has been acquired and is being installed to controllably expose the sensors to sample air with precise concentrations of VOCs. This system will be used to characterize and calibrate the sensors with different sensing layers in response to the ten target VOCs.

Understanding the Spatial Distribution of Ambient Fine Particulate Matter in Prince George

William Osei

Description

This project will measure ambient air pollution, specifically fine particulate matter (PM_{2.5}), at a fine spatial resolution using mobile monitoring, which will complement the existing fixed air quality monitoring done by the Ministry of Environment. The mobile monitoring will provide the resolution necessary to identify pollution ‘hotspots’ within the airshed, which will, in turn, support airshed management planning and air pollution control strategies. In addition, it will provide a more detailed ‘exposure’ assessment for

studying air pollution-related health effects, and inform the greater public understanding on air pollution in Prince George.

Osei Revenue Schedule

Year	CLEAR	Other (cash)	Other (in-kind)	Total
2008/09	\$15,000	\$0	\$5,000	\$20,000
2009/10	\$10,000	\$5,000	\$17,500	\$32,500
2010/11	\$0	\$16,000	\$12,500	\$28,500
Total	\$25,000	\$21,000	\$35,000	\$81,000

Status

The project has been completed. See <http://www.digitalbucket.net/browse/e15dffda9ae41144/Osei> for the final research report, including maps of hotspots.

Key Findings

Research Goal 1: To assess neighbourhood exposure of PM_{2.5} from residential wood burning, to identify whether and to what extent there are significant, localized wood smoke ‘hotspots’ (i.e. persistent elevated wood smoke concentrations) in neighbourhoods.

Findings: Researchers were somewhat successful in finding localized wood smoke hotspots in Prince George neighbourhoods. The divisions sampled the most often: College Heights, Hart East and Hart West, all seemed to show some consistent hotspots. However, more sampling may be necessary to confirm the hotspots.

In neighbourhood areas, monitored once, it was impossible to determine whether elevated areas were indeed hotspots or whether these divisions did display a consistent ambient pattern. Divisions with one set of monitoring results included: Cranbrook Hill and Prince George East.

Research Goal 2: To assess neighborhood exposure of PM_{2.5} from residential wood burning, to determine whether and to what extent wood smoke is a significant contributor to PM_{2.5} levels in Prince George.

Findings: Unfortunately, the results from this study did not provide conclusions on neighborhood exposure of PM_{2.5} from residential wood burning because the relationship between the nephelometers and Tapered Element Oscillating Microbalance sensors (TEOMs) were not constant.

It was difficult to determine whether and to what extent wood smoke was a significant contributor to PM_{2.5} levels in Prince George because researchers were not able to convert scattering values to PM_{2.5}.

Research Goal 3: To assess exposure of PM_{2.5} from traffic-related sources (as apportioned by light duty gasoline, heavy duty diesel, and locomotives), to determine whether and to what extent such mobile emissions are a significant contributor to PM_{2.5} levels in Prince George.

Findings: This research goal was not explored due to technical problems; specifically the frequencies on the nephelometers were found to be unsuitable for these types of measurements.

Research Goal 4: To assess population exposure in wood smoke hotspots so to determine vulnerability and highlight priority neighborhoods.

Findings: This goal will be the focus of a follow up study. Health outcome data for Prince George will be assessed with the wood smoke data to determine whether a correlation exists. Research findings will be compiled in an additional research report.

Next Steps

Further monitoring of Prince George's wood smoke "hotspots" are needed to confirm "hotspots" identified by the study. The project is securing additional funding and a GIS expert to assess population exposure in wood smoke hotspots areas.

Development of a Nanoparticulate Matter Monitor **Winnie Chu**

Description

Airborne particulate matter and ground-level ozone are the two main components of smog. Most environmental agencies (including Metro Vancouver and the BC Ministry of the Environment) routinely monitor these two air pollution indicators to assess overall ambient air quality. Exposure to airborne particles smaller than 2.5 µm increases the risk of human mortality and morbidity from respiratory and cardiopulmonary diseases. While particles as small as 2.5 µm are now monitored in many BC locations, currently no portable system is in place to quantify much smaller particulates (nanoparticles). There is evidence to indicate that nanoparticles exhibit higher toxicity than micron size particles of identical substances due to their very small size. The proposed nanosensor is designed to fill the current gap in existing air monitoring systems.

Chu Revenue Schedule

Year	CLEAR	Other (cash)	Other (in-kind)	Total
2008/09	\$12,500	\$0	\$10,500	\$23,000
2009/10	\$25,000	\$0	\$48,000	\$73,000
2010/11	\$25,000	\$20,000	\$48,000	\$93,000
2011/12	\$12,500	\$0	\$25,000	\$37,500
Total	\$75,000	\$20,000	\$131,500	\$226,500

Status

The project is on target to be completed in January 2012. The remaining \$12,500 of the BC CLEAR grant will be paid in the 2011/12 year. The research project: a) patented the nanosensor in November 2010; b) obtained an NSERC Idea-To-Innovation (I2I) grant for commercialization related work for the aerosol sensing technology; and c) received UBC's UILO support to conduct market research.

Key Findings

A working particle detection method based on light scattering techniques has been demonstrated. A miniature fiber coupled laser light source illuminates 1 μ m diameter polystyrene microspheres in a flowing stream of air. The light scattered by the particles registers a pulse in an avalanche photodetector. The output of the photodetector is recorded using a DAQ and the data is processed with Matlab software. The number of pulses caused by light scattered from the particles over 20 second intervals are counted.

Over a four minutes period, the ratio of the number of particles counted corresponds to the particle concentration ratio measured by the reference measurement. The time and amplitude characteristics of the signal output also matches the particle speed calculations and the light intensity calculation described by the MIE scattering theory.

With a known volumetric flow rate and a known particle density, a mass concentration of particles can be estimated by counting the number of particles over a time interval. The flow rate is controlled by the channel size and the pressure source. Particles of a certain size range can be directed into the same channel with the separator. The limitation of this technique is the number of particles over each time interval is not consistently the same. This introduces a large change in the computed concentration when the sampling time interval is small. Furthermore, as with all optical detection techniques, the expected output is highly dependent on the optical properties of the particle. The performance for particles of different refractive index may vary. Nonetheless, the results shows that light scattering method is a promising particle detection option which can be integrated with the separator for an inexpensive portable particle monitoring solution.

Next Steps

The research team will refine the instrumentation of the PM monitor and integrate the PM monitor units in preparation for field-testing. Dr. Chu and her research team are also writing a manuscript for a special issue of the IEEE Sensors Journal.

Projects - Starting in 2009/10

Understanding Strategies for Exercise in Urban Pollution

Michael Koehle

Description

Exercise is an important parameter in the prevention of disease, for access to work and

quality of life for many individuals. Exercise in the outdoors is the most accessible form of activity for many individuals, however the effects of air pollution on urban exercisers remain unclear. There are pre-existing guidelines for individuals, particularly those with disease to limit exercise during times of high air pollution. However, there is little reliable evidence for this, and due to the positive implications of exercise on health, it would be beneficial to better understand this relationship. Inflammatory and oxidative stress markers will be studied in individuals at a variety of exercise intensities. Specifically the study will determine the effect of pre-exercise exposure to dilute diesel exhaust containing 300 µg/m³ of particulate matter 2.5 microns or less (PM_{2.5}) on 20km time trial performance, cardio-respiratory responses during exercise, and lung function after exposure and exercise. It was hypothesized that pre-exposure to 300 µg/m³ of PM_{2.5} from diesel exhaust would significantly impair performance on a 20km cycling time trial, pulmonary function, and alter breathing pattern during exercise.

Koehle Revenue Schedule

Year	CLEAR	Other (cash)	Other (in-kind)	Total
2009/10	\$25,000	\$7,500	\$50,000	\$82,500
2010/11	\$0	\$85,894	\$0	\$85,894
Total	\$25,000	\$93,394	\$50,000	\$168,394

Status

Last year the research project was delayed due to an injury acquired by the project's lead graduate student; however, the research is now complete and a manuscript has been drafted and will be submitted for publication. Luisa Giles, MSc. Candidate, presented the research findings at two conferences (Allergen Research Symposium 2011 and Vancouver Heart and Lung Festival 2011) and received awards for her research contributions. The project team has secured additional funding from Health Canada (\$85,894) to further investigate their initial findings. The second round of research will be conducted between June 2011 and December 2012.

Key Findings

- Pre-exercise exposure to particulate matter pollution does not directly affect exercise performance, but there is an increase in heart rate during exercise, and the normal dilation of the airways during exercise is significantly inhibited by the pollution.
- There is no difference in blood vessel responsiveness following diesel exposure as compared to filtered air, using the EndoPAT technique of measurement.

In other words, exercise caused modest bronchodilation. However, a 60-minute exposure to dilute diesel exhaust (300ug/m³ of PM_{2.5}) prior to exercise significantly attenuated exercise induced bronchodilation and significantly increased heart rate during exercise.

Pre-exercise exposure to diesel exhaust did not significantly impair 20km cycling time trial performance or alter breathing pattern during exercise.

Next Steps

The research team's findings were unexpected. They found that there was no measurable effect on blood vessel function with diesel exposure using the EndoPAT technique. In a follow up study, funded by Health Canada, the research team will use a different method of measuring blood vessel function called Flow-Mediated Dilatation. They hypothesize that there is a difference between PM exposure and filtered air in terms of blood vessel response (i.e. healthy blood vessels are highly responsive; they expect a decreased responsiveness following pollution exposure). Once the Health Canada funding is released, they will commence data collection on the second phase of their research.

Modeling Photochemical Pollution in the Lower Fraser Valley

Douw Steyn

Description

The objective of this project is to provide a policy relevant understanding of the relationship between ambient ozone and emissions of ozone precursors in the Lower Fraser Valley through modeling. The models will be evaluated on the demonstration of responsiveness to emissions changes (gross reductions in NO_x and VOC), changes in chemical speciation and spatial and temporal shifts in emissions) that have occurred in the past, and are likely to occur in future scenarios. Models will also be evaluated by demonstrating that they can successfully capture the decadal evolution of photochemical pollution in the LFV in relation to changes in emissions and meteorology.

Steyn Revenue Schedule

Year	CLEAR	Other (cash)	Other (in-kind)	Total
2009/10	\$25,000	\$41,000	\$35,600	\$101,600
2010/11	\$25,000	\$36,800	\$35,600	\$97,400
Total	\$50,000	\$77,800	\$71,200	\$199,000

Status

The project has been completed. See

<http://www.digitalbucket.net/browse/92f6133f1aa62a99/Douw%2520Steyn> for the final research report.

Key Findings

- The WRF-SMOKE-CMAQ modeling system produces ozone fields over the 20-year retrospective period which are responsive to the estimated changes in local precursor emissions and are in general agreement with observations. Some of the modeled episodes show better comparisons with observations than others, and this, in part, can be traced back to past weaknesses in the meteorological

modeling.

- Many of the simulations show highest ozone concentrations occur outside of the area sampled by the fixed monitoring network and within the LFV's numerous tributary valleys.
- Precursor emission reduction within the LFV have generally moved the ozone ridgeline boundary westward from the Agassiz-Chilliwack area to the Abbotsford-Langley area and southward from the ridges of the North Shore Mountains to the valley floor near Port Moody, Coquitlam and Pitt Meadows. However, the ozone ridgeline is sensitive to meteorology (mainly wind direction and wind speed) and shows a great deal of variability within and between ozone episodes.
- Based on the current modeling and consistent with previous studies, it was found that the Port Moody (T09) station has been and remains a VOC-sensitive location. Based on the current modeling and observational data, the project team infers that the large VOC emission reductions that have occurred within the LFV over the 1985-2005 period, stemming largely from the LDV and petroleum refining sectors, have been effective in reducing ozone concentrations at T09. Some of the benefits of the VOC emissions reductions have likely been offset by the concomitant NO_x emissions within the LFV. Nonetheless, the local NO_x and VOC emissions reductions have been responsible for the decreasing 1-hr and 8-hr episodic ozone concentrations seen at this station. Although there is not the observation data to confirm this, the modeling suggests the western areas of the LFV surrounding Port Moody (Coquitlam, Port Coquitlam and Pitt Meadows) have likely responded to these same precursor emissions changes in a similar fashion.
- Based on the modeling, it was found that the eastern part of the LFV around Chilliwack has generally gone from being VOC-limited to NO_x-limited over the last 20 years, although the ozone ridgeline shows a lot of variability with meteorological conditions. It is possible that presently this region has a mixed-sensitivity. Additionally, the researchers suspect that VOC reductions (largely from the LDV VOC emission controls with the petroleum refining emissions not being as greatly influential here as at Port Moody) and NO_x emission reductions, appear to have offset one another in terms of ozone production in this part of the LFV. Furthermore, based on the observational data, ozone production efficiency as a function of NO has increased noticeably at Chilliwack (T12) and likely in the other eastern parts of the valley. This efficiency increase has likely offset some of the benefits resulting from NO_x emission reductions. The change in ozone sensitivity, along with the increased ozone production efficiency have changed the shape of the diurnal ozone profile to one that is less peaked around the daily maximum. As a result of this broadening, for a fixed peak ozone level, 8-hour averaged concentrations calculated around the peak concentration are increased. Finally, changes in population and economic activity over the 1985-2005 period

have likely had a greater impact at T12 than T09. However, compared to the absolute changes in precursor emissions seen over the LFV during this period, the effects of this differential growth are likely small.

- In the easternmost part of the LFV, around Hope, the CMAQ modeling has difficulties capturing ozone formation. It is believed that this difficulty is due to the narrow valley and steep topography near the station; deficient modeled NO_x sources upwind of T29 and deficient modeled NO_x sources around the station. Nonetheless, based on the modeling, it is fairly evident that Hope has been and remains a NO_x-limited region and based on the observational data at Chilliwack, that ozone production efficiency with respect to NO has likely increased here as well. Such an increase would have offset some, and perhaps all of the NO_x emissions reductions achieved in the LFV. Due to its NO_x-sensitive conditions, VOC emission reductions within the LFV have likely had negligible impact on ozone concentrations at T29.
- The modeling suggests that for every 10 ppb increase in background ozone concentration a roughly 3.0 ppb increase in 8-hour ozone concentrations would be observed in the LFV, with slightly higher increases expected in the western parts (3.7 ppb) of the LFV than the eastern parts (2.3 ppb). Based on recent studies showing increasing background ozone concentrations over Western North America (Vingarzan (2004), Jaffe and Ray (2007), Chan and Vet (2010)), over the next 20 years and within the LFV, a 3.0 ppb increase in episodic 8-hour averaged ozone concentrations could be expected, independent of local air quality management planning.
- The model consistently over-predicts ozone at a number of stations within the city of Vancouver (T04, T06) and under-predicts daytime NO_x concentrations there. Both results are consistent with a deficiency in NO_x emissions. Given the dominant role that marine, off-road and LDV emissions play as a local NO_x sources, episodic emission rates from these sources need to be investigated further. Additionally, the model tends to under-predict ozone concentrations at Hope, also suggesting deficient modeled NO_x sources within the LFV. The model shows a changing bias over time, which implies uncertainties in the emissions backcasting.
- Trajectory modeling suggests that emissions and ozone from the Puget Sound region do not directly impact LFV air quality during summertime ozone episodes.

Next Steps

The research team will present their findings to a project advisory committee on July 12, 2011. See <http://www.digitalbucket.net/browse/92f6133f1aa62a99/Douw%2520Steyn> for a list of future recommendations (page 96 of the final report).

Collection of PM Emission Data from In-Use Light-Duty Diesel and Gasoline Vehicles

Stephen Stewart

Description

There is very little available data relating to the PM emissions from in-use light-duty vehicles. The goal of this project is to collect PM emissions data from light-duty diesel and gasoline vehicles, for the purposes of characterizing the PM emissions of the in-use fleet. The resulting data will be used for emission factor development; to aid in developing mitigation strategies; and to support effectiveness evaluation of mitigation strategies. In addition, the PM emission data will contribute to inventory work, development of emission reduction strategies, and evaluation of reduction strategies.

Stewart Revenue Schedule

Year	CLEAR	Other (cash)	Other (in-kind)	Total
2009/10	\$22,000	\$1,665	\$12,400	\$36,065
Total	\$22,000	\$1,665	\$12,400	\$36,065

Status

The project has been completed. See <http://www.digitalbucket.net/browse/cafab997b56826d8/Stephen%2520Stewart> for the final research report.

Key Findings

- The MAHA MPM4 PM analyser appears to be adequately robust, usable and reliable for incorporation into real non-laboratory inspection environments.
- The MAHA analyser can be used to objectively measure the amount of blue/grey smoke produced by oil-burning gasoline vehicles. This type of smoke does not register on smoke opacimeters because they are designed to detect black diesel smoke. Until now, assessments of the smoke from oil-burning gasoline vehicles have been entirely visual, and therefore subjective.
- Comparison of the MAHA results to results of gravimetric analyses indicates a correlation that confirms that the MAHA unit could be used in inspection situations to characterise low, medium and high emitters.
- The assessments of PM mg/km from this project are consistent with those obtained by Environment Canada using gravimetric methods in 1999

- The methodology of combining continuous PM concentration measurements with CVS modal data and then aggregating to derive overall mg/km has been confirmed as a usable approach.

Next Steps

This initial research has shown that the MAHA unit appears suitable for use in an ordinary inspection lane situation. Therefore, the next step would be to install the unit in one of the regular AirCare inspection lanes. The best candidate is Lane #1 at Abbotsford. This lane has a 4WD dynamometer and can test both diesel and gasoline vehicles. In addition to the usual inspection equipment in this lane, the project has also installed a diesel NOx analyser and a diesel AFR/Lambda sensor. These are for the purpose of collecting light-duty diesel fleet characterization data for NOx emissions, as well as possibly developing pass/fail standards for diesel NOx that might be used as a future AirCare inspection requirement. These purposes are equivalent to the plan for the MAHA PM analyser, except that the PM data collection would also apply to gasoline vehicles.

Using the MAHA analyser in an inspection lane requires it to be integrated with the other lane equipment and software. It is expected that this task will be similar to that already achieved for the diesel NOx and AFR analysers. Software integration will include automated time alignment with the other data, and this means that future analyses of the data can also be much more automated than was possible in the present project.

In the first six months of 2010, Lane #1 at Abbotsford tested 11,368 vehicles, including 685 diesel and 10,647 gasoline. Therefore, after a year of data collection the total will be about 150 times the number tested in this project. Having more data will improve the reliability of analyses and may allow identification of patterns or relationships that are not discernable from the present limited data.

The reliability of the measurements themselves needs to be improved. The correlations found in the study do not adequately establish the absolute validity of the MAHA analysers readings. To perform the necessary work the project requires its own gravimetric, filter-based system, installed at the AirCare Research Centre. This issue is being considered as a desirable part of the AirCare Program contract renewal process. The present inspection contract expires at the end of 2011, and it is not prudent to expend the cost of this new capability until there is more certainty regarding 2012 and beyond.

New Projects - Starting in 2011/12

An unprecedented number of researchers applied to the BC CLEAR Fund in the 2010/11 year. The Steering Committee reviewed 26 applications and approved 8 new projects to receive funding in the 2011/12 year. The following describes the projects that will receive funding:

The Effect of Pollution from Asia on Background Levels of Black Carbon in British Columbia

Dr. Allan Bertram, UBC: \$25,000

It is well known that there is a strong correlation between atmospheric concentrations of particles less than 2.5 microns in size (PM_{2.5}) and negative health effects. A key component of PM_{2.5} is black carbon, which is produced from incomplete combustion. This project will assess the importance of long-range transport of black carbon from Asia to British Columbia.

Fuel Cell Airport Ground Support Equipment Feasibility Study

Jeff Grant, Ballard Power Systems: \$25,000

The Vancouver International Airport (YVR) could be a worldwide centre of excellence in deployment of zero emission fuel cell ground support equipment (GSE), with hydrogen supplied from a waste hydrogen source in North Vancouver. Currently, there are a variety of unknowns preventing the development of this infrastructure. Ballard Power Systems and BAE Systems will collaborate to complete a commercial feasibility study for hybrid fuel cell-battery powered ground support equipment (GSE) at YVR.

Multi-Attribute Valuation of Air Quality Effects: An Application to Local Energy Options

Lee Failing, Compass Resource Management: \$25,000

Many communities in BC are currently exploring options to develop local energy systems to meet sustainability goals. Some of these options, such as biomass, consistently emerge as top ranked options on the basis of costs and greenhouse gas emissions, but are subsequently opposed by stakeholders based on perceived air quality issues. Most often this occurs without any rigorous examination of the magnitude and significance of trade-offs among competing objectives. Municipal planners and decision makers are keenly interested in understanding stakeholder values with respect to air quality and enabling them to appropriately consider and address their concerns. Outcomes from the project will be useful both for communities evaluating specific local energy systems and, more broadly it will demonstrate the use of a multi-attribute approach, which will have applicability across a range of air quality management problems.

BlueSky Forest-Fire Smoke-Forecast Enhancements

Dr. Roland Stull, UBC: \$25,000

BlueSky predicts the spread of smoke from wild fires in Western Canada. The BlueSky

system does this by coupling information on actual forest-fire hot spots observed by satellite, forest fuel loads compiled by the Northern Forestry Research Center, algorithms to predict smoke and heat release, high-resolution numerical weather forecasts provided by UBC, and pollutant-dispersion modeling. After three years of development, the BlueSky system became operational in Western Canada for the 2010 forest-fire season.

This year researchers will work on the following BlueSky Enhancements:

- 1) Install and test the new BlueSky server (loaned from MoE) at UBC.
- 2) Test a way to incorporate carryover "old" smoke from previous days.
- 3) Test burn persistence algorithms to determine optimum persistence that would balance realism with the corresponding extra processing requirements.
 - 4a) For the trans-border effects: Modify the MM5 numerical weather prediction model domains so that the fine-resolution (4 km horizontal grid spacing) primary grid over BC and AB is imbedded in a larger domain coarser resolution grid (12 km spacing) so that the weather outside the primary domain can be able to blow in emissions from US, Yukon, NWT, and Saskatchewan fires.
 - 4b) *Enhancements*: Incorporate and test the new nested grid codes (provided by STI) to allow for a larger domain for the smoke forecasts, and the inclusion of trans-border smoke into the operational BlueSky system run on the loaned server at UBC.
- 5) Make daily BlueSky test runs during the 2011 fire season (April - September), and provide the output to the sponsoring government agencies, and to Dr. Michael Brauer at UBC. Document the final state of the enhanced BlueSky code in an online or paper users manual.
- 6) Start implementing improvements based on suggestions from MoE and other stakeholders.

Evaluation of the BlueSky Smoke Forecasting System and its utility for Public Health Protection in British Columbia

Dr. Michael Brauer, UBC: \$25,000

The project will evaluate the day-by-day performance of BlueSky around smoke-impacted communities in BC during the 2010 and 2011 wildfire seasons. For this evaluation researchers will compare BlueSky forecasts to: (1) Particulate matter (PM) measurements from air quality monitoring stations across the province; (2) Smoke plume tracings from the Hazard Mapping System maintained by the US National Oceanic and Atmospheric Administration (NOAA); and (3) Estimates of atmospheric aerosol levels

from multiple remote sensing platforms. These data will be used to assess the accuracy of PM concentration estimates from BlueSky in both space and time.

The project will also evaluate the association between PM concentration estimates from BlueSky and several measures of public health across BC. This work will build upon a project (funded by Health Canada) currently underway at the British Columbia Centre for Disease Control in which multiple health databases (pharmaceutical, physician, hospital, etc.) are being tested for their sensitivity to smoke-related elevations in PM concentrations measured at a few provincial monitoring stations. This is intended to support the development of a surveillance system for health effects related to smoke exposure. Co-variation between BlueSky output and health metrics would suggest that BlueSky forecasts (1) can be a valuable tool for public health messaging and (2) used to expand surveillance efforts into unmonitored parts of the province.

Biomonitoring Air Quality with Lichen in the Prince George Area

Asha MacDonald, MSc. Candidate: \$16,716

The research project will develop a biomonitoring protocol using lichens to monitor air quality in the Prince George area. Specifically, the goals of the research project are: 1) to synthesize the body of knowledge on lichens as biomonitors for air pollution (particularly sulphur dioxide) and adapt monitoring protocols for application in BC; 2) to set up a program that will monitor changes in air quality over time in Prince George and surrounding area, assessing the effects of emission reductions from the Canfor Northwood Pulp Mill; and 3) to develop a plan for engaging a public audience (high-school students) in this process and facilitate public understanding of: a) the effectiveness of technology for improving air quality, b) the effectiveness of using bioindicators to track environmental changes, and c) the quality of urban habitats for people as well as other organisms.

A Dispersion Model Analysis and Visualization Tool for Air Quality Managers

Dr. Peter Jackson, UNBC: \$15,000

The project will develop a visualization tool specifically for air quality management. It will allow non-modelers to interactively visualize and manipulate dispersion model outputs, and produce scenarios that lead to better air quality management plans. While the prototype will be developed for Prince George dispersion model outputs, it could be adaptable to other locations.

Use of FORECAST Model to Simulate Atmospheric Nitrogen Deposition Impacts on Sensitive Terrestrial Ecosystems in the Georgia Basin of British Columbia

Dr. Tony Zhong, A&M Greenland Co.: \$24,800

This project will use the ecosystem model FORECAST to examine the impacts of atmospheric Nitrogen (N) deposition on soil N status and biomass productivity, in the forest ecosystems sensitive to the N deposition, and to predict the consequences of increases in the N deposition in the ecosystems. To mitigate the adverse impacts of atmospheric N deposition appropriate forest management strategies will be discussed and developed based on the modeling results.

Scholarships – Awarded in 2010/11

The Steering Committee approved a \$5,000 contribution to the Robert Caton Scholarships Committee for three air quality research scholarships in 2010/11. At the *Air Quality and Health Workshop*, hosted by the BC Lung Association on March 10, 2011, the Robert Caton, David Bates and BC CLEAR scholarships were awarded to three outstanding graduate students studying air quality solutions. The following scholarship were awarded:

Recipient	Scholarship	Amount
Hind Sbihi	David Bates	\$2,000
Perry W. Hystad	Robert Caton	\$2,000
Mandy Pui	BC CLEAR	\$1,000

Financial Summary

BC CLEAR Fund Revenue and Expenses April 1, 2010 to March 31, 2011

Description	Amount
Revenue	
Carry forward from 2009/10	\$98,625.00
Ministry of Environment 2010/11 funds from BC Lung Association	\$237,500.00
Total Revenue	\$336,125.00
Expenses	
Research Projects *	\$75,000.00
Scholarships *	\$5,000.00
Fund Management and Administration	\$19,921.75
Communications	\$7,469.02
Total Expenses	\$107,390.77
Balance (to carry forward to 2011/12)	\$228,734.23
Leveraged Project Funds	
Cash	\$241,146.00
In-kind	\$141,225.00
Total Leveraged Funds	\$382,371.00

*Please refer to Appendix 1 for a detailed list of grant payments.

Financial Description

The financial table includes a summary of the Ministry of Environment BC CLEAR funds (\$98,625), which were carried forward from 2009/10, and new funds (\$237,500), which were received through the BC Lung Association in 2010/11. FBC managed a total of \$336,125 funds on behalf of BC CLEAR in 2010/11. A total of \$107,390.77 expenses were incurred, and \$228,734.23 funds will be carried forward to the 2011/12 year.

Three researchers (Drs. Steyn, Chu and Walus) had previously been awarded multi-year BC CLEAR research grants and were each paid a \$25,000 grant installment in the 2010/11 year. Please refer to Appendix 1 for a detailed list of the research grant payments. In addition three new BC CLEAR scholarships were awarded through the Robert Caton Scholarship Committee (see Appendix 1). A total of \$80,000 of BC CLEAR funding was awarded to research projects, which was matched by \$241,146 cash funding and \$141,225 in-kind funding from other project funders.

FBC charged a 6% administration fee of \$19,921.75 to manage \$336,125 BC CLEAR funds in the 2010/11 year. The \$7,469.02 communications expenses covered outreach

and promotions work for a call for new BC CLEAR research proposals in October 2010. Communications expenses also included teleconference meetings; and hosting, maintaining, and updating the BC CLEAR website.

A total of \$228,734.23 BC CLEAR Funds will be carried forward to the 2011/12 year. These funds will be used to award eight new BC CLEAR research grants, which are described on pages 13-16 of this report, and to cover the last grant payment to Dr. Winnie Chu's project (see page 5). The carry forward funds will also cover FBC's administration and management of the BC CLEAR Fund in 2011/12.

Workplan 2011/12

Overall Function

The Fraser Basin Council acts as the Secretariat to administer the Fund and provide support services to the BC-CLEAR Steering Committee.

Activities

1. *Steering Committee Coordination*

- Organize and facilitate 3 quarterly BC-CLEAR Steering Committee meetings.
- Draft meeting agendas and minutes for approval.

2. *Annual Documentation and Template Assessment*

- Complete an update of fund documents and templates in collaboration with the BC-CLEAR Steering Committee.
- Update interim, annual and final report templates for 2011/12 projects.

3. *Website Updates*

- Provide and maintain a website where BC-CLEAR Fund information can be posted for public access.
- Add 8 new project summaries for 2011/12 projects.
- Add 4 final reports from previous projects completed in 2010/11 (including Drs. Stewart, Osei, Steyn, Koehle).

4. *Project Management*

- Prepare 5 new grant agreements, 3 new contracts, and renew 2 grant agreements for the 2011/12 year.
- Monitor the progress of the 8 new and 2 existing projects.
- Ensure the project leaders are aware of their responsibilities to submit their project status reports and financial reports as per the BC-CLEAR Steering Committee approved template and timeline.
- Collect and prepare BC CLEAR grantee's interim, annual and final reports for Steering Committee review.
- Administer and track grant payments to 1 exiting project (Dr. Chu) and 8 new projects.

5. *Fund Development*

- Explore opportunities for additional and renewed funding for a 2011/12 BC-CLEAR funding call.
- Explore opportunities for funding of First Nations research projects.
- If funding is secured, prepare funding call and manage application in-take

6. *Annual Reporting*

- Complete a BC-CLEAR Steering Committee approved annual report. The annual report will be approximately 10 pages, and it will describe the BC-CLEAR Fund,

the projects that have been proposed, the approved projects, the work that has been done and the financial status of the BC-CLEAR Fund.

Appendix 1 – Detailed List of Grant Payments (BC CLEAR)

07/16/10	University of British Columbia - Steyn	Grant	BC Clean Air Research Fund	\$25,000.00
07/09/10	University of British Columbia - Walus	Grant	BC Clean Air Research Fund	\$25,000.00
08/09/10	University of British Columbia - Chu	Grant	BC Clean Air Research Fund	\$12,500.00
12/08/10	University of British Columbia - Chu	Grant	BC Clean Air Research Fund	\$12,500.00
02/23/11	David Bates Scholarship Award - Hind Sbihi	Scholarship	BC Clean Air Research Fund	\$2,000.00
02/23/11	BC CLEAR Fund Scholarship Award - Mandy Pui	Scholarship	BC Clean Air Research Fund	\$1,000.00
02/23/11	Robert Caton Scholarship Award - Perry W. Hystad	Scholarship	BC Clean Air Research Fund	\$2,000.00

Total	\$80,000
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