Peace Project Water Use Plan

Physical Works Terms of Reference

- **GMSWORKS-21 WLL Dust Control Trials**

Addendum 6

February 27, 2014

A6 Addendum to GMSWORKS-21 WLL Dust Control Trials

A6.1 Addendum Rationale

The terms of reference (ToR) for GMSWORKS-21 WLL Dust Control Trials (Dust Trials), dated April 2, 2008 (with Addenda 1, 2, 3, 4 and 5 dated March 26, 2009, March 15, 2010, April 6, 2011, June 11 2012, and April 2 2013, respectively), revised the deliverable completion date for the dust mitigation trials. After six of years of trials we have a greater understanding of how trials need to be coordinated with forecast reservoir operations. In some years the reservoir will rise quickly and others slowly, sometimes it will reach full pool and in other years the maximum reservoir elevation will be metres below full pool. Each of these conditions provide different opportunities and barriers to dust mitigation methods. The Dust Trials completed its sixth year in 2013, having conducted assessments of several different dust mitigation methodologies including:

1. Tillage techniques, including analysis of appropriate tools (e.g., chisel, lister, disc trencher) and methods (e.g., spacing experiment completed in 2010),
2. Irrigation, using gravity-fed distribution,
3. Native vegetation, including grasses and *Equisetum* sp. with and without soil enhancement, and
4. Vegetation protection using protective debris berms.

The results of those trials indicate:

1. Tillage is an effective short-term (within season or shorter depending on weather conditions, reservoir elevation at the time of spring melt and reservoir rate of rise) dust control method where soil, beach access, archaeological site density, and topography are suitable. Given these limitations, tillage is not suitable for all locations in the Finlay Arm. We are proposing to test engineered roughness in 2014. We will place an array of woody debris (logs) on the beach perpendicular to the prevailing winds to provide roughness without tillage.
2. The conclusion in 2011 was that irrigation is impractical because of logistical requirements and this was valid at the time given the previous study methods. We are proposing that another method providing a much larger volume of water and more robust equipment be tested in 2014.
3. Native vegetation shows potential for effective and efficient dust control in suitable areas. However, more extensive longer term studies are needed to identify the best species, planting technique, maintenance requirements, and survivability. Soil enhancement is required in most areas due to nutrient depletion over the past 40 years of reservoir operation. Soil enhancement using debris to create compost is promising and longer term studies in conjunction with the native vegetation trial described above are needed. Our experience in 2012 and 2013 with a high minimum reservoir elevation and a rapid reservoir rise to full pool indicates we may need to wait until later in the Water Supply Forecast before making a decision to invest in vegetation trials. Based on the rate of rise and maximum reservoir elevation in the February 1 Williston forecast we will not be conducting any vegetation trials in 2014.
4. Due to low reservoir levels in 2009 and 2010, vegetation protection techniques remained untested. In 2011, reservoir elevations were higher and the early indications are that vegetation protection techniques will need to be far more

robust to protect against debris, wave action and winter weather conditions. Based on the rate of rise and maximum reservoir elevation in the February 1 Williston forecast we will not be installing any vegetation protection trials in 2014.

5. Adequate dust control in the region will likely not be achieved using only tillage. Therefore, additional dust control methods require identification and testing when the opportunity arises. Over the next few years we will use the February 1 Williston Reservoir forecast to guide decision-making on the most appropriate trials to implement in a given year.

To further address dust mitigation knowledge gaps and potential logistical constraints related to engineered roughness and irrigation, BC Hydro and Tsay Keh Dene jointly propose to conduct further work as described in this ToR Addendum. BC Hydro and Tsay Keh Dene have accepted two proposals from Chu Cho Industries LP and Chu Cho Environmental to complete this work.

This Addendum describes a one-year work scope and a one-year budget for:

An engineered roughness trial that will assess feasibility of using woody debris arrays on beaches as a method for dust mitigation, and

An irrigation trial using reservoir water sprayed onto Tsay Keh beach at a rate of ~2200 GPM.

A6.2 Revised Work Plan for GMSWORKS-21 WLL Dust Control Trials

A6.2.1 Management Questions

The management questions are identified as:

1. Can engineered roughness be established on the beaches of the Finlay Arm of Williston Reservoir at a sufficient density and over a sufficient area to be an effective and feasible dust mitigation technique?
2. Can irrigation be an effective and feasible mitigation technique for reducing dust emissions on the beaches of the Finlay Arm of Williston Reservoir?

These management questions will be addressed in 2014 through two sub-projects:

1. Engineered Roughness
2. Irrigation (mobile sprinkler and pump)

A6.2.2 Revised Objectives

The objectives of these trials are to address the management questions by establishing appropriate hypotheses, identifying scientific methods, collecting data and providing findings and conclusions that confirm either the alternative hypothesis (H1) or the null hypothesis (H0) (e.g. H1: engineered roughness in the form of a debris array reduces dust emissions from the beach containing the array; H0: engineered roughness in the form of a debris array does not reduce dust emissions from the beach containing the array).

Both trials will take an adaptive management approach emphasizing both effectiveness of dust mitigation and efficiency in terms of logistics, personnel, and timing. This may require alterations to scope, schedule, or budget of the project over time as lessons learned suggest or require alterations to the approach.

Design and implementation of the project should also anticipate the need to acquire sufficient data within the season (between minimum and maximum reservoir elevation) to, at minimum, provide as sound a scientific analysis as possible to allow a determination of the value of continuing, cancelling, expanding, or operationalizing the use of any or all of the aforementioned methods for dust control on Williston at the end of that one-year period (end of the 2014 Field Season).

A6.2.2.1 Engineered Roughness Trial

The objectives of the Engineered Roughness trial and build upon the results-to-date related to soil roughening (tillage) and include:

1. Evaluate the feasibility and costs associated with creating a large array of surface roughness using woody debris placed on the ice and snow on beaches that will be exposed after spring melt.
2. Determine if the project is scalable and effective in its current form.
3. Provide immediate early season dust mitigation.

A6.2.2.2 Irrigation Trial

The objective of this trial is to evaluate the use of high volume (2200 GPM) mobile sprinklers and pumps to reduce dust and to potentially support irrigation needs of any future vegetation trials.

Project coordination between both trials is necessary as well as with other projects involved in the Williston Dust Mitigation Program and other BCH projects; therefore design and implementation should be flexible.

A6.2.3 Methodology

A6.2.3.1 Engineered Roughness

See Appendix A6-1 GMSWORKS-21: Williston Dust Mitigation Trials – Debris Roughness

A6.2.3.2 Irrigation Trial Feasibility Assessment

Irrigation Trial Feasibility Assessment Methodology:

See Appendix A6-2 GMSWORKS-21: Williston Dust Mitigation Trials - Irrigation

A6.3 Revised Deliverables for GMSWORKS-21 WLL Dust Control Trials

This project includes the following deliverables:

- Any permits required to implement these trials.
- A comprehensive annual report that collates all of the data and includes:
  a) An executive summary of the project;
  b) The objectives and scope of the monitor;
  c) Methods of data collection (including map of sites and photodocumentation), assumptions, and analysis;
  d) A description of the compiled data set and results of all analyses,
  e) A discussion of gaps, delays and/or deferrals of proposed work in the implemented program, and

f) A discussion of the consequences of all results as they pertain to the management questions.

A report will be provided in hard-copy and electronically in Microsoft Word and Adobe Acrobat (*.pdf) format. The required maps and figures will be included as embedded objects in the report. All maps and figures will also be provided in their native format as separate files. Raw data will be submitted in an appropriate format (e.g., Microsoft Access database, Microsoft Excel). All photos will be submitted electronically.

- A final report submitted at the end of the trial period that collates the data from the entire trial period. It will include conclusions and recommendations for future dust mitigation measures in addition to the requirements described above for an annual report.

A6.4 Revised schedule for GMSWORKS-21 WLL Dust Control Trials

To understand the feasibility of this project it is important that the work start no later than March 15, 2014, therefore an early response to the Addendum would be very helpful.

Engineered Roughness trials:

Fieldwork -March to April 2014.

Draft report(s) - November 2014.

Final report(s) - January 2015.

Irrigation Trial Feasibility Assessment:

Fieldwork - May to July 2014.

Draft report(s) - November 2014.

Final report(s) - January 2015.

A6.5 Revised budget for GMSWORKS-21 WLL Dust Control Trials

Total Implementation: $3,221,352.00

Appendix A6-1 GMSWORKS-21: Williston Dust Mitigation Trials – Debris Roughness

GMSWORKS#21: Williston Dust Mitigation Trials – Debris Roughness

GMSWORKS#21 – Williston Dust Mitigation Trials:

Debris Roughness Trial

PREPARED FOR:

BC HYDRO
3333 22ND AVE
PRINCE GEORGE, BC, V2N 2K4

PREPARED BY:

CHU CHO INDUSTRIES LP AND CHU CHO ENVIRONMENTAL.
1877 QUEENSWAY ST.
PRINCE GEORGE, BC, V2L 1L9

Chu Cho Industries Contact:

DAN WIEBE
1-250-613-6566

This page is intentionally blank.

TABLE OF CONTENTS

1 BACKGROUND **1**

1.1 HOW IS THIS PROJECT UNIQUE 2

2 WORK PLAN **4**

2.1 ROUGHNESS ARRAY WORK PLAN 4

2.1.1 Equipment and Procedure *5*

2.1.2 Setup *5*

2.2 MONITORING WORK PLAN 6

2.2.1 Equipment and Monitoring Techniques *7*

2.2.2 Monitoring Schedule *8*

3 BUDGET **10**

4 SCHEDULE **11**

5 TEAM MEMBER RESUMES **12**

BIBLIOGRAPHY **15**

1 BACKGROUND

Surface roughness protects an erodible surface in three ways (Wolfe and Nickling, 1993):

1. It covers part of the surface,
2. It disrupts the shear stress at the surface by creating turbulence which in turn creates a protected zone in the lee of the object, and
3. It extracts momentum from the wind flow to some height above the surface.

Considerable research has been done to evaluate the effect of non-erodible roughness elements on controlling wind erosion, particularly within staggered arrays. A conceptualized image of a staggered roughness array is shown in Figure 1. Staggered arrays have an even distribution of roughness over the surface, and when viewed "head-on" or in plane, as the wind would see, the array creates an effective wall that displaces the force of the wind upward and around. The displacement of the wind creates near surface turbulence, which acts as a buffer between the shearing forces of the wind and the erodible surface thereby reducing sediment movement on the surface.

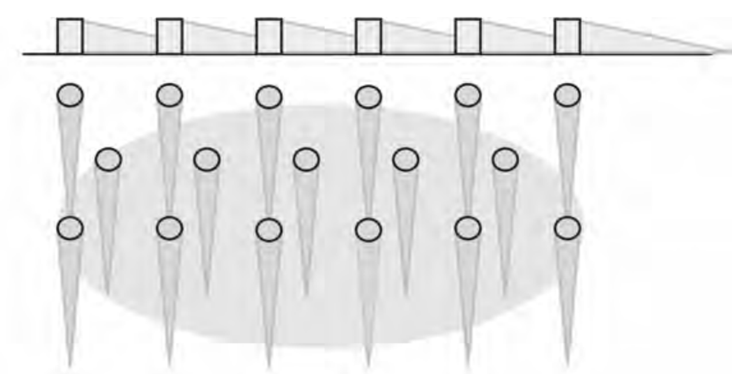

Figure 1: Staggered array of roughness elements showing protected zone of the surface.

There are three types of wind flow that will occur through an array of roughness elements (Wolfe and Nickling, 1993):

1. **Isolated Roughness Flow** occurs when wind flows around elements but there is not enough shelter created by each individual element to protect the entire surface. Each roughness element will protect a small piece of the surface leaving "streets" in between the elements where increased erosion may occur. This effect can be seen in and around the stump fields that are present on a number of reservoir beaches.
2. **Wake Interference Flow** occurs when the density of roughness elements on the surface is such that the protective shelter zone created by each element overlaps with the next downwind element, thus nearly the entire surface is protected. The shearing force of the wind may reach the surface in various locations within the array but it is largely protected. The roughness array shown in Figure 2

is achieving approximately wake interference flow. Wake interference flow is the most the cost effective roughness array configuration.

3. **Skimming Flow** occurs when the surface roughness array is so dense that the wind skims over the top of the entire array. While skimming flow provides protection for the surface it is not generally the most cost effective roughness array configuration.

Tractor tillage creates long furrows in the beach sediment, which will effectively achieve *skimming flow*; however, tillage is erodible and will breakdown over time. The tillage trials conducted in 2008, 2009 and 2010 demonstrated that tractor tillage could potentially achieve a 99% reduction in the movement of sediment on the surface (Fryrear at al. 2011). However, when there are erodible soils upwind the dust will be picked up by the wind flow and carried overtop of the tillage (*skimming flow*). When this occurs, tillage is ineffective at removing dust from the passing air parcels. These tillage trials showed that there will be essentially no erosion of the tilled area unless eroded material from upwind moves into the tillage or the tillage itself is broken down. This means that as near as possible the entire surface must be tilled in order to stop fugitive dust emissions. In 2013, a study was launched to investigate the durability of roughness for each tractor implement type in the various sediment types of the reservoir beaches. This study demonstrated that the differences in durability are explained primarily by silt content and moisture content of the sediment and that the implement type drives only minor but statistically significant differences in furrow durability between the various sediment types (Tilson, 2013). It was suggested that a tactical approach utilizing multiple alternating rows of treatment types on a given beach might increase productivity and provide useful surface roughness. The difficulty in managing the durability and overall effectiveness of erodible roughness on the reservoir beaches is the impetus for designing a study that will use non-erodible roughness.

Vegetation, debris, stumps, erosion control mats, gravel and berms are all examples of non-erodible roughness. To date the only form of non-erodible roughness that has been used by the Williston Dust Mitigation Program (WDMP) is vegetation. The vegetation trials have shown some success in growing the various plant species but to date have not demonstrated that the various species can proliferate to the point where they are achieving *wake interference flow* or *skimming flow*.

Our project team is proposing a new roughness trial using local woody debris to create a staggered array of non-erodible roughness elements over a 50 ha section of Omenica Beach. To date no trial has been conducted on the reservoir beaches that employs course woody debris to control sediment transport.

1.1 HOW IS THIS PROJECT UNIQUE

Our proposed roughness debris trial will transport woody debris from the foreshore zone of the reservoir to the beach where it will be placed into a staggered array that is designed to create wake interference flow. The staggered array will cover 30 ha of Omenica beach with enough woody debris to protect the surface in that area from wind erosion.

The proposed staggered array will be created in March while the beach is still covered with snow and ice. The woody debris will be placed on top of the snow and ice. As the snow and ice melts in April, the woody debris will fall in place to the surface. This means that immediately following the spring thaw, this section of Omenica Beach will be taken out of dust production. This is an important consideration since the current strategy of creating roughness by tillage suffers from a lag between spring thaw and access to the beaches. Many of the reservoir beaches receive un-shaded sunlight for most of the day whereas the access roads do not, resulting in early season beach exposure and erosion with no way to roughen the surface. Protecting the surface from early season erosion would be an enormous achievement.

This surface roughness trial is not designed to test the effectiveness of surface roughness for controlling sediment erosion, this has been proven repeatedly over 70 years of wind erosion research. Instead, our trial is intended to evaluate the feasibility and costs associated with creating a large array of surface roughness using woody debris during the winter months and to determine if the project is scalable and effective in its current form.

There are several core management questions that we plan to address through this debris roughness trial:

1. If roughness is placed in March will it remain in place until late-April when the snow/ice melts?
2. Is woody debris an effective form of roughness for the reservoir beaches? If so, for how long does it provide surface protection?
3. Are there other forms of reusable roughness elements that could be put to the same purpose?
4. Is the system scalable?

2 WORK PLAN

There are two components of our proposed work plan:

1) The roughness array work plan, and
2) The monitoring work plan.

2.1 ROUGHNESS ARRAY WORK PLAN

In this work plan we will detail the equipment to be used and the procedures for creating the roughness array. Operations are slated to begin in March, we propose a 20-day work plan and estimate 30 hectares can be treated with a log array. The array will be placed near the center of Omenica Beach in a location with excellent wind exposure and a large supply of woody debris. The approximate location for the proposed array is shown in Figure 2.

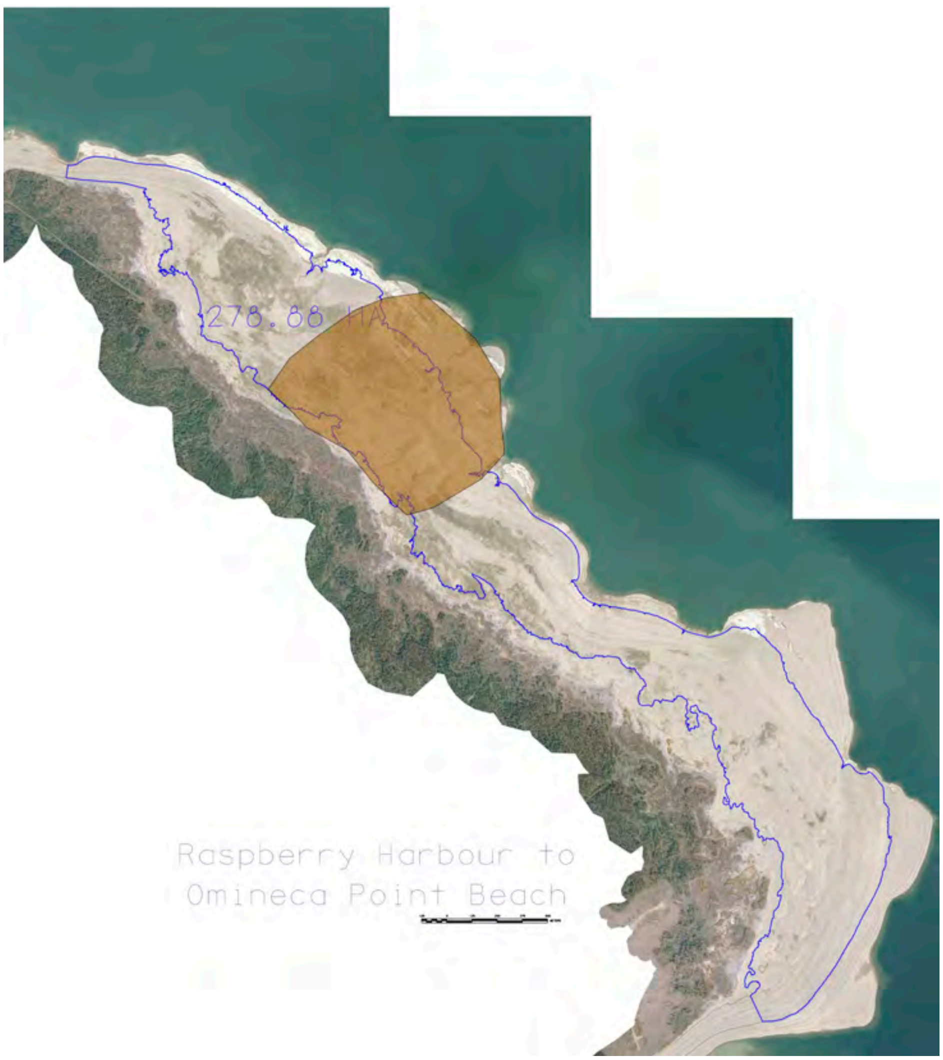

Figure 2: Approximate location of debris roughness trial on Omenica Beach.

2.1.1 Equipment and Procedure

There are two equipment components required to create to the surface roughness array:

1. 30 Ton Excavator:

    - Chu Cho LP will mobilize a 30 Ton Excavator to Omenica Beach.
    - The excavator will be fitted with a thumb and will be used to uncover woody debris along the foreshore zone of Omenica Beach.
    - In the foreshore zone of Omenica Beach there is a large supply of woody debris that consists of varying lengths and diameters. We will select a minimum log length and diameter of 3m and 0.2m (at the largest cross-section), respectively. Logs with large root wads will be used as well but will be strategically placed or modified so that the root wad does not hold the log above the surface when the ice melts.
    - The excavator will roughly sort the logs according to size, removing those that do not meet the minimum specifications. The operator will then place bundles of logs in sequence for the 525 Skidder operator.
    - The excavator will move along the foreshore as the roughness array grows in size, creating several small staging stations.
    - A light truck outfitted with a tidy-tank, maintenance supplies and tools will be used to service the excavator when required.

2. 525 Skidder:

    - Chu Cho LP will mobilize a 525 Skidder to Omenica Beach.
    - The skidder will be outfitted with a grappling attachment that will be used to transport the logs to the beach from the staging area where the excavator operator has prepared the bundles.
    - The skidder operator will selectively place the logs in sequence creating a staggered array of roughness elements.
    - A light truck outfitted with a tidy-tank, maintenance supplies and tool will be used to service the skidder when required.

2.1.2 Setup

The setup for the debris roughness program includes the following:

- Logs placed in a staggered array across the beach, perpendicular to the mean wind flow direction. Figure 3 shows a sample array of logs; the logs are placed so that successive rows are staggered to create no gaps when view in plane (from the wind's perspective).
- The distance between successive rows will be a function of the height of the upwind log but will generally be between 3 and 5 feet.
- The array will sit unmoved until the end of April when the snow melts and the system becomes active.
- As the reservoir rises and the logs begin to float away our monitoring team will observe any effects these log have on the array itself and in a broad sense where they go when they become mobile. If this initial small trial is shown to be effective, we will develop a formal debris control program that will be used to capture and reuse the logs in successive years.

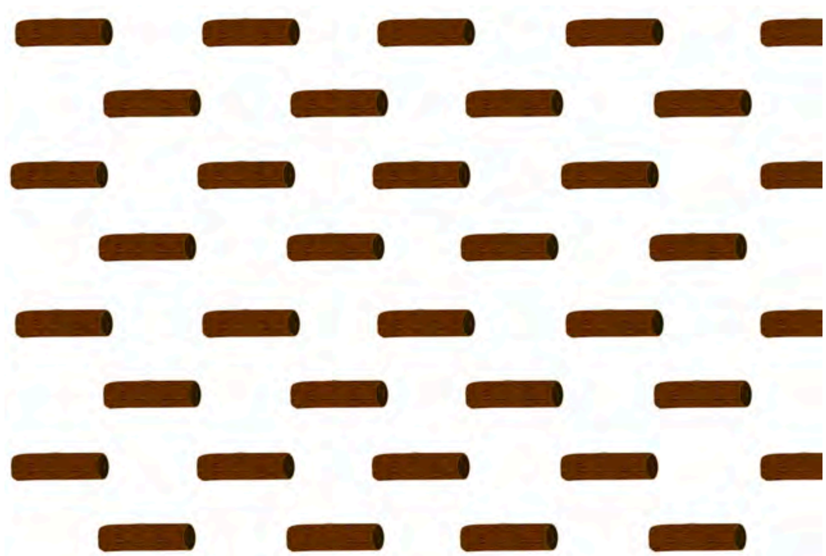

Figure 3: Staggered array using woody debris logs placed perpendicular to mean wind direction.

2.2 MONITORING WORK PLAN

Chu Cho Environmental will operationalize a monitoring work plan for addressing the core management questions identified in Section 1.1. Chu Cho Environmental operates as a division of Chu Cho Industries LP with expertise in wind erosion, fugitive dust emissions and air quality. Chu Cho Environmental provides the WDMP with general monitoring services for a number of the trials and mitigation techniques that are ongoing.

2.2.1 Equipment and Monitoring Techniques

The monitoring team will use existing instrumentation and equipment that is owned by the WDMP so that no new equipment will be purchased for monitoring this trial. Our monitoring team will use similar techniques to those used during the 2008 – 2010 tillage trails on Omenica and Davis Beach for monitoring sediment transport and addressing the core management questions. The list of equipment and techniques includes:

- Basic Surveying:
  - The aerodynamic drag created by the staggered array is a function of the roughness type, size and spacing of the elements within the array. Most often this is described by the roughness density, λ, defined as:
  - $\lambda = \frac{nbh}{S}$
  - Where *n* is the number of roughness elements of width *b* and height *h* per unit surface area *S*. Calculating the roughness density of the array will allow us to estimate the overall effectiveness of woody debris within the context of shear stress and drag partition.
  - Our monitoring team will count and measure the debris in order to ascertain the roughness density of the proposed staggered array. The roughness density will be used to estimate drag coefficient of the array thereby allowing us to estimate sediment transport rates and overall, the protective role of the staggered array for the given wind conditions.
  - The estimated sediment transport rates will be compared to the calculated sediment transport rates obtained from the BSNEs.
- BSNE Sediment samplers:
  - BSNEs were used to monitor sediment transport during the tillage trials on Davis Beach.
  - We will use a total of 9 BSNEs to monitor the sediment moving into and out of the staggered array. This includes: 3 upwind of the array, 3 within the center of the array and 3 downwind of the array.
  - Samples will be collected after a 2+ hour sustained wind event of greater than 5 m/s as measured at the regional air monitoring station in Tsay Keh Dene. Using the Tsay Keh Dene station as the measuring reference is not ideal as wind events can be highly localized but since this station provides remote access to data this is the most cost effective method. If our project team receives anecdotal evidence of a wind event at Omenica Beach from people working in the area we will visit the beach to collect the samples.
  - The BSNE samples will be collected, dried and weighed using the Mettler-Toledo scales owned by the WDMP.

  - The size fraction of the sediment collected in the BSNEs will not be evaluated since we are evaluating only the total sediment moving through the array.
  - The data from the BSNEs will be used to estimate the efficiency of the staggered array at stopping sediment movement for a given storm event. Overall the BSNEs will allow us to infer the amount of sediment moving into, through and leaving the roughness array.
- Trimble GPS units:
  - Trimble GPS units will be used to map the extent of the staggered array.
  - Mapping will occur before and after the melting of the ice and snow to determine if there is any significant movement of the array elements during the melting process.
- Air quality monitoring network:
  - Our project team will communicate with the GMSMON#18 Air Quality monitoring team to request that we be granted access to data from the nearest monitoring station.
  - It is suggested that a single E-Sampler installed on this beach could be used to infer the relative impact of the debris roughness trial on fugitive dust emissions from the beach. Our project team will work with the Air Quality monitoring team to evaluate the feasibility of installing an E-Sampler on this beach.
  - Wind speed and direction data from the nearby weather station can be used to infer the magnitude, intensity and direction of erosion events at Omenica Beach. These data will be collated with the BSNE data to provide an estimate of overall effectiveness of the debris roughness array.

2.2.2 Monitoring Schedule

The monitoring team will visit the staggered array several times throughout the dust season, these include:

- Once in March when the array is initially created to gather photographs, observations and GPS data.
- Again at the start of April to take images of the likely now buried array.
- Again at the start of May to take photographs, observations, GPS data and to measure the roughness density of the staggered array once it has melted to the surface. At this time the BSNEs will be deployed.
- The team will visit the site once per week during the dust season to collect and weigh sediment collected by the BSNEs. Photographs documenting the progression of sand into the array will be documented during these visits.

At the end of the dust season, the monitoring team will interface with the air quality monitoring team to gather the required data for the time period. These data will be collated with the BSNE data collected on the beach and a report addressing the core management questions will be prepared for Tsay Keh Dene, Chu Cho Industries LP and BC Hydro by July 30th, 2014. This report will provide recommendations for future actions regarding the use of woody debris to control sediment transport on the Williston Reservoir beaches.

3 BUDGET

4 SCHEDULE

Schedule for the Engineered Roughness Program starts March 1st, 2014.

Task	Mar 5th – 14th	Apr 9th	May 1st	May 7th – 31st	June 5th	July 15th
Create Engineered Roughness	X					
Examine Roughness Distribution	X					
Re-evaluate roughness distribution – snow cover, etc.		X				
Re-evaluate roughness – Calculate Aerodynamic Properties			X			
Re-evaluate roughness – Weekly monitoring routine.				X		
Re-evaluate roughness – drifting sand, overall effectiveness at capturing sand					X	
Final Report						X

Chu Cho Industries LP has six years experience working on the beaches of the reservoir dealing with debris and dust mitigation. There are no permits required for this work, as the beaches will be covered with snow and ice when the works are occurring.

5 TEAM MEMBER RESUMES

Dan Wiebe, General Manager, Chu Cho Industries LP, 2012 – 2014

Earthworks Construction foreman, Chu Cho Enterprises Ltd. 2011 – 2012

Foreman, Lead Hand, Owner Operator, Heavy Equipment. 1988 – 2011

Jon Kostyshyn, Operations Superintendent, Chu Cho Industries LP. 2012 – 2014

Earthworks, Bridge installation, Debris and Dust Mitigation, Safety Management

Operations Supervisor, TDB Consultants, 2008 – 2012

Logging Operations Supervisor, Nacausely, 2002 – 2008

Field Technician, Canfor, 1998 – 2002

Johnny Pierre, Field Superintendant, Chu Cho Industries LP, 2012 – 2014

Supervisor, Chu Cho Enterprises Ltd. 2008 – 2014

TKDB, Chief

1998 – 2008, Dust and Debris Mitigation

Kenny Warren, Lead Hand, Equipment Operator, 1988, 2014

Aaron Poole, Equipment Operator, 1988 – 2014

MICHAEL TILSON, M.SC

ROLE:

Michael Tilson will manage the monitoring program for the debris roughness trial.

BIOGRAPHY:

Michael Tilson is an air quality scientist and project manager with Chu Cho Environmental. Michael's background includes study in earth processes, physics and environmental science. For the last 6 years Michael has been involved in planning, implementing and managing a number of projects for the Williston Dust Mitigation Program relating to wind erosion and air quality. Prior to this, Michael worked as a research assistant for the University of Guelph on various wind erosion, sediment transport and air quality projects. Michael is an avid programmer/scripter utilizing several different and high-level languages for dataloggers/prototyping boards and for data processing, analysis, modeling and display.

EDUCATION, TRAINING, MEMBERSHIP ASSOCIATION

	Degree, Diploma, Certificate or Designation	Issuing Institution or Association	Date Conferred or Awarded
Consultant's Degrees, Certificates, Diplomas	M.Sc Geography	University of Guelph	April 2010
	B.Sc Earth Surface Science, Minor: Physics	University of Guelph	February 2008
Professional Development/ Training	Erosion Sediment Control	Vancouver Island University	October 2013

RELEVANT PROJECT EXPERIENCE

Projects, Roles and Responsibilities	Areas of Expertise
Timeframe – Spring 2008 – On-going **Project Details –** The annual operation of the Williston Reservoir in northern British Columbia results in the exposure of over 10,000 Ha of erodible beach sediments during the spring recharge months. Wind Storms funnelling through the valley pick up loose sediment and eventually create massive dust storms that last for several hours to several days. The air quality monitoring program is designed to assess human exposure patterns and to provide data that is used as input for modelling the development and dispersion of dust events. **Role and Responsibilities** – Project manager for the Williston Reservoir air quality monitoring network. Directly involved in reviewing the airshed monitoring plan and network design to recommend improvements in monitoring and maintenance routines. Responsible for coordinating all annual and daily operations related to maintaining the network. (2008 – 2012) • Developed Data Quality Objectives, monitoring objectives, QA/QC	Air Quality Monitoring Dispersion Modelling Wind Erosion and Sediment Transport Data Management and Analysis **Project Value:** **$4,599,560.00 (over 10 years)** **Funding: BC Hydro**

procedures and data analysis procedures.	
Timeframe – Winter 2008 and 2009 **Project Details –** The Dry Valleys of Eastern Antarctica provide a unique environment in which to study wind erosion, sediment transport and the development of aeolian landforms. Cold air temperatures coupled with intense katabatic winds create erosive forces that are among the strongest on earth, giving rise to numerous strange and unique landforms. Our project team implemented a monitoring program that would observe the atmospheric and erosive conditions during the dark winter months in order to provide substantiated evidence to explain the development of many of the strange landforms. **Role and Responsibilities –** Field/laboratory technician responsible for developing instrumentation and the programming required to implement a complicated data capture routine. Accountable for field logistics and ensuring that all equipment was on-site and fully operational.	Wind Erosion and Sediment Transport Geomorphology Data Management and Analysis **Project Value: $350,000.00** **Funding: National Science Foundation (NSF)**
Timeframe – Summer 2007, 2008 and 2011 **Project Details –** Our project team implemented a monitoring program for assessing the role of vegetative roughness in protecting the desert surface from wind erosion and inducing sediment deposition. This project was implemented in the Chihuahuan Desert of New Mexico at the Jornada Experimental Range. We utilized a network of anemometers, wind vanes, sediment flux counters and shear stress monitors to model the movement of sediment as it relates to wind flow and shear stresses on the surface. **Role and Responsibilities –** Field technician responsible for helping to develop the infrastructure required to host the instrumentation and the programming required to capture all of the data.	Wind Erosion and Sediment Transport Data Analysis **Project Value: $180,000.00** **Funding: Natural Sciences and Engineering Research Council (NSERC)**

BIBLIOGRAPHY

Fryrear, D.W., Nickling, W.G., and Schillinger, W.F. (2011), BC Hydro Williston Reservoir Tillage Experiments and Regional Air Monitoring 2010 Annual Report Study Period: January 1, 2010– February 1, 2011, Peace River Project Water Use Plan, GMSWORKS-21/GMSMON-18

Tilson, M., Ord, J.(2013), Roughness Monitoring Program 2013 Report, Study Period: May – June 2013, Peace River Water Use Plan, GMSWORKS-21

Wolfe, S., Nickling, W., 1993. The protective role of sparse vegetation in wind erosion. Progress in Physical Geography 17(1), 50{68}.

Appendix A6-2 GMSWORKS-21: Williston Dust Mitigation Trials - Irrigation

GMSWORKS#21: Williston Dust Mitigation Trials - Irrigation

GMSWORKS#21 – Williston Dust Mitigation Trials:

Irrigation Trial

PREPARED FOR:

BC HYDRO
3333 22ND AVE
PRINCE GEORGE, BC, V2N 2K4

PREPARED BY:

CHU CHO INDUSTRIES LP AND CHU CHO ENVIRONMENTAL.
1877 QUEENSWAY ST.
PRINCE GEORGE, BC, V2L 1L9

Chu Cho Industries Contact:

DAN WIEBE
1-250-613-6566

This page is intentionally blank.

TABLE OF CONTENTS

1 BACKGROUND 1

1.1 HOW THIS PROJECT IS DIFFERENT 2

2 WORK PLAN 4

2.1 IRRIGATION WORK PLAN 4

2.1.1 Equipment 4

2.1.2 Setup 5

2.1.3 Procedure 7

2.1.4 Wetting Schedule 9

2.2 MONITORING WORK PLAN 9

2.2.1 Equipment 9

2.2.2 Monitoring Design and Schedule 11

3 BUDGET 13

4 SCHEDULE 14

5 TEAM MEMBER RESUMES 15

This page is intentionally blank.

1 BACKGROUND

BC Hydro and Dr. Sietan Chieng initiated reconnaissance for future irrigation studies in 2008. The purpose of this reconnaissance was to collect information on potential water sources, hydrologic data and sites where irrigation may be possible. The first irrigation field trials were initiated for the 2009 dust season on Tsay Keh Beach. Two methods were to be used for supplying water to the surface; pump based irrigation and gravity feed irrigation.

1. Gravity feed irrigation system:

   - The gravity feed irrigation system was not carried out in 2009 because approval to use Hydro Creek as the water source was not obtained from the B.C. Ministry of Environment.
   - A gravity feed system was implemented in 2010 with limited success due to materials failure.
   - Overall, the system was well designed but was unsuccessful due to materials failure and inadequate supplies for repairing the numerous leaks that developed in the drainage pipe.
   - It was generally reported that the system would have been far more successful if the tubes did not leak and the proper fittings where obtained for the T-junctions where the spur lines attached to the main line.

2. Pump based irrigation system:

   - Water was supposed to be pumped from a 2 meter deep well. No water was found at 2 meters so this idea had to be abandoned.
   - Instead, the water pump was installed near the mouth of the Finlay River and water was drawn from the reservoir.
   - The pump was capable of delivering 350 Gpm of water to the beach surface through one 4" hose. The hose was connected to 3" PVC tube with a single 5/8" hole that sprinkled water on the beach surface.
   - The purpose of this trial was to observe the wetting pattern that developed as the water moved across the beach.
   - The study showed that even a modest application of water to the surface will result in a wetted zone that continues to grow to some maximum that is determined by the sedimentological characteristics of the surface and the application rate.

- The maximum wetted zone represents the equilibrium where the rate of application is balanced by the rate of infiltration to the soil and evapotranspiration to the atmosphere.

It is the understanding of our project team that another trial was attempted in 2012 using an industrial lawn-sprinkler type setup. There is limited work documenting the successes/failures of this trial. It is likely that the equipment was purchased but was not setup on the beach because it arrived late and the water level rose very quickly in 2012.

Our project team is proposing a new irrigation trial that is built on the successes and recommendations of the past trials as reported in the GMSWORKS#21 documentation. We will take special care to avoid the missteps that ultimately lead to the failure of the previous systems.

1.1 HOW THIS PROJECT IS DIFFERENT

The proposed irrigation trial will use a high-pressure diesel powered pump to deliver 2200 Gpm to four Nelson Irrigation 150 Series Big Gun sprinklers. The Big Gun sprinklers will be mounted on a stable skid that can be slid across beach sediments using a small tractor. This will allow our team to transport a great deal of water to the beach and to slide the sprinklers around once an area becomes saturated.

The Nelson Irrigation 150 Series Big Gun Sprinklers are designed to deliver between 200 and 550 Gpm at 60 – 120 psi. The 150 Series Big Gun allows the user to select a range of operating trajectories and spray nozzles that control the distance and dispersion of the water. The Big Gun can be made to rotate through a complete circle or fractional pieces of a circle. This series of Nelson Irrigation sprinklers are specially designed to withstand dirty water applications, as will be the case during the spring freshet into the Williston Reservoir.

Using the 150 Taper Bore nozzle with a bore of 1.0" the 200 Series Big Gun can reach a maximum diameter of 350' at 550 Gpm. Using four Big Guns and a 2200 Gpm pump, we can expect to reach a diameter between 300 and 400' at 550 Gpm per gun. This number will vary in response to wind conditions at the time of pumping. The 150 Taper Bore Nozzle is designed to throw the water as far as possible with the least amount of diffusion. Our project team believes that achieving the greatest distance will provide the most surface moisture since external environmental conditions like wind will likely increase the diffusion anyways.

An alternative to the 150 Taper Bore Nozzle is the Ring Nozzle, which is designed to create more diffusion of the spray. Using a Ring Nozzle with a 1.0" bore the 150 Series Big Gun can reach a maximum diameter of 350' at 550 Gpm. Using four Big Guns and a 2200 Gpm pump, we can expect to reach 350' at 550 Gpm per gun. The Ring Nozzle will create a more diffuse spray resulting in more wetness closer to the gun while the Taper Bore Nozzle send more water further away from the gun. Since the Ring Nozzle's spray is more diffuse we suspect that it will be more affected by wind conditions at the time of application.

This proposed irrigation project is different because it will use an industrial grade sprinkler system that is both scalable and mobile. Generally, irrigation systems provide dust control in two ways: 1) The wetted surface is taken out of dust production since the sand/silt particles are no longer able to move, and 2) The wetted surface acts like a "trap", capturing sediment that is blown across it. Therefore, this irrigation trial is not designed to test the effectiveness of water for controlling sediment movement but rather the feasibility of using an irrigation system. Specifically, we will examine the logistics associated with building, scaling and operating the irrigation system as it relates to managing fugitive dust.

There are several core management questions that we plan to address through this irrigation trial:

1. How long does the sprinkler need to be in each location? Conversely, how quickly does an area dry out once the sprinkler is moved?
2. Which nozzle type results in the greatest wetted area?
3. What is the effective control area created by each sprinkler?
4. Is it possible to modify our application procedures in response to beach sediment conditions and elevation contours? i.e. Strategic placement of the four sprinkler units.
5. Can we respond quickly to changing environmental conditions? i.e. rainfall
6. Is the system scalable?

2 WORK PLAN

There are two components of our proposed work plan:

1) The irrigation work plan, and

2) The monitoring work plan.

The irrigation work plan will describe the equipment, design, procedures and schedule required to implement the irrigation feasibility study. The monitoring work plan will describe the procedures used to evaluate the core management questions.

2.1 IRRIGATION WORK PLAN

In this work plan we will detail the equipment to be used, how it will be setup, the procedures for operating the system and the proposed duration of operation.

2.1.1 Equipment

There are four equipment components required for our proposed irrigation trial:

1. Diesel pump and water intake system:

    - Diesel pump and water intake system capable of delivering 2200 Gpm at 120 psi.
    - Diesel pump has four output channels with a standard fire hose attachment.

2. Fire hose:

    - Four lengths of durable 4" fire hose.
    - Each hose will be approximately 1000' long

3. Water tank skid:

    - Four heavy weight water tanks and mounting stands built on skid plates designed to withstand the considerable thrust generated by the Big Gun and to allow for easy transport across the reservoir beaches.
    - Nelson Irrigation recommends a 4" minimum tubing size for the valve/tube system that will deliver the water to the nozzle.
    - Figure 1 shows a sample design template that we will use for constructing the water tank skid.

4. Nelson Irrigation 150 Series Big Gun:

    - Four Nelson Irrigation 150 Series Big Guns, model number F150 capable of irrigating a full circle.
    - Four Ring Nozzles and Four Taper Bore Nozzles designed for the largest bore size at 1.0”
    - Specifications, applications and a sample video of the 150 Series Big Gun in operation can be found at: http://www.nelsonirrigation.com/products/family/big-gun-sprinklers/

Figure 1: Water tank skid for mounting and transporting the Big Gun

2.1.2 Setup

The experimental setup for the proposed irrigation trial includes the following:

- The diesel pump will placed adjacent to the reservoir near the mouth of the Finlay River and will sit in a protective spill berm to prevent fuel spills. The pump will be moved to higher ground as the reservoir level changes.

- The water intake for the pump will be attached to an anchored floating dock that is placed in the reservoir. The intake will be moved as the reservoir level increases. The intake will be regularly inspected for debris/sediment build up as the season proceeds. The red "X" in Figure 2 indicates the proposed water intake location.

- The diesel pump discharge of 10" will be connected to a header that has four 4" output channels that will be attached to 4" high pressure flexible rubber hoses, similar to that of a high pressure industrial air hose.

- The rubber hoses will be approximately 1000' long and will be attached to the water tank skids built by Chu Cho Industries LP. There will be four total units.

- The water tank skids will have chain rings welded to them so that a tractor can slide the skids back and forth across the beach.

- A Nelson Irrigation 150 Series Big Gun will be mounted to the top of each water tank skid.

- The 150 Series Big Gun will be setup to spray at a trajectory of 24^0 or 27^0 and will be setup to complete full rotations.

- Two of the Big Guns will be fitted with a Taper Bore Nozzle 1.0" and 1.1" and the remaining two will be fitted with a Ring Nozzle. We will change the nozzle as we discover which type functions best for our needs.

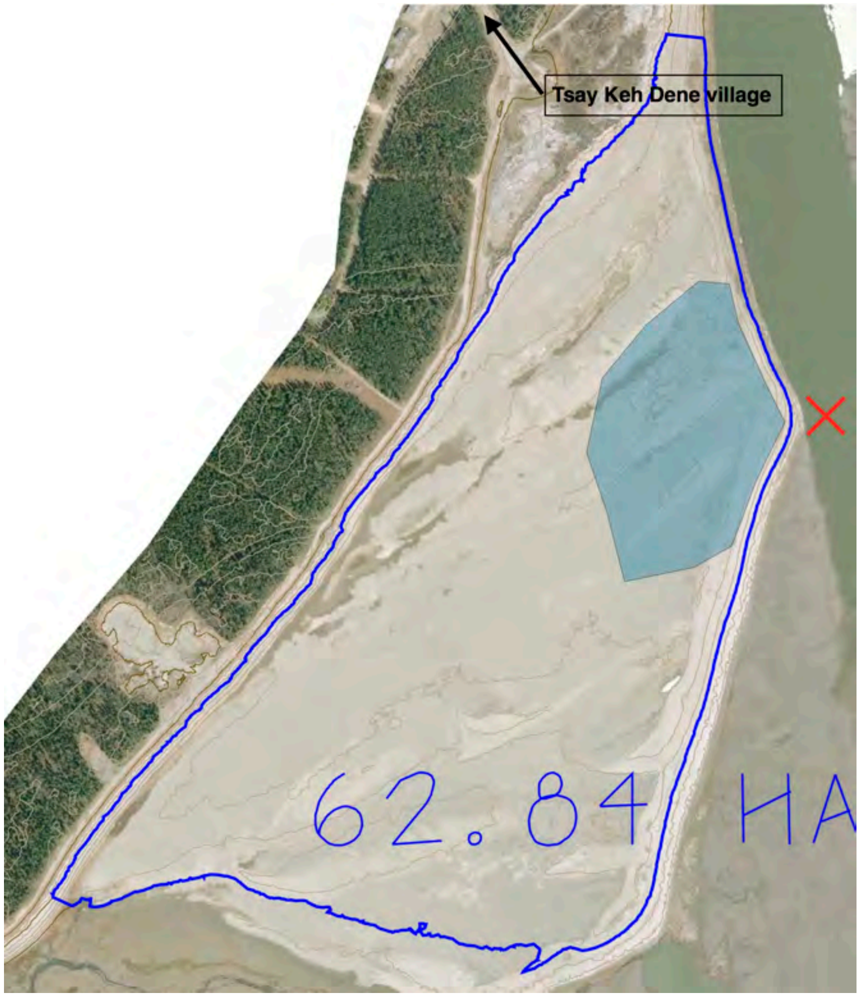

Figure 2: Proposed location of water intake and the presumed wetted zone. We will move the pumps and sprinklers in response to rising reservoir levels to ensure we are always maximizing our wetted area.

2.1.3 Procedure

The experimental procedure for the proposed irrigation trial is as follows:

- The diesel pump is inspected and serviced as necessary each morning. Fuel is delivered to the pump via pickup and tidy tank.
- The water intake system is inspected for debris and sediment and is re-anchored to the appropriate location in the reservoir.
- The water tank skids are placed in their starting locations and the fire hoses are attached to the base.

- The 150 Series Big Guns are mounted to the water tank skid and are fitted with either a Taped Bore Nozzle or a Ring Nozzle ranging in size from 1.0" to 1.3".

- The diesel pump is switched on and primed, then the fire hoses are attached to the output channels on the pump.

- The flow of water is switched on and the irrigation system is allowed to wet the surface for a set amount of time.

- The flow of water will be shut of to one sprinkler at a time, the hose will be un-attached from the sprinkler and it will be moved a distance outward away from the pump that is equivalent to one diameter of the wetted perimeter. This will ensure that the radii of the spray from the pump will just overlap with that of the previous location.

- The hose will be moved to the new sprinkler location and re-attached to the water tank skid. The hose is moved separately to minimize the potential damage caused by dragging the hose across the beach.

- Again the flow of water is switched on and the system is allowed to wet the surface of a set period of time.

- Each sprinkler will be moved sequentially for 12 hours per day. The amount of time that an individual sprinkler is at each location will change over the course of the field season as team members gain skill in moving the system and as underlying sedimentological characteristics are identified and used to our advantage.

- The system will continue to operate during the overnight hours but the sprinklers will not be moved until team members arrive in the morning.

- The project team members will record the daily weather conditions, dust conditions, nozzle used, general observations, photographs and any other relevant information.

- The team members will also track the movement schedule of the individual sprinklers and the time spent at each location.

- The nearby weather and dust sampling station in Tsay Keh Dene will serve as a data source for collating the weather/dust data to the observations of the project team members.

- The opaque blue shaded area in Figure 2 indicates the approximate work zone where we will focus our efforts. This zone will be expanded if possible during the field season as we discover the physical limitations of the irrigation system.

2.1.4 Wetting Schedule

The proposed irrigation system is designed to operate 24 hours per day for 30 days. Under periods of forecast intense rain in excess of 12 hours, the irrigation system will be shut off to conserve fuel. The sprinklers will be moved across the beach during the daylight hours to cover the most area possible. The sprinklers will remain stationary through the overnight hours but will continue to wet the surface. At 2000 Gpm the system will deliver 120,000 gallons of water to the beach each hour and 2,750,000 gallons each day. This totals 82,500,000 gallons of water over the 30-day program period.

Given the low evapotranspiration rates in northern BC, particularly during the spring months, our project team suspects that much of this water will infiltrate the sediment and will pool as runoff when the sediment becomes saturated. We suspect that runoff effects will increase our effective wetted area drastically and that we will be able to modify our tactics to create more runoff wherever possible.

2.2 MONITORING WORK PLAN

Chu Cho Environmental will operationalize a monitoring work plan for addressing the core management questions identified in Section 1.1. Chu Cho Environmental operates as a division of Chu Cho Industries LP with expertise in wind erosion, fugitive dust emissions and air quality (See Section 5 for a Resume). Chu Cho Environmental provides the Williston Dust Mitigation Program (WDMP) with general monitoring services for a number of the trials and mitigation techniques that are ongoing.

2.2.1 Equipment

The monitoring team will use existing instrumentation and equipment that is owned by the WDMP. No new equipment will be purchased for this trial. Our monitoring team will use well-established techniques for monitoring sediment transport and evaluating the effectiveness of the irrigation trial. The list of equipment includes:

- BSNE sediment samplers:
  - BSNEs were used to monitor sediment movement during the tillage trials from 2008 – 2010.
  - We will use 12 BSNEs to monitor the sediment transport at near ground-level in the vicinity of the irrigation trial and at a control site far away from the irrigation trial.
  - 3 BSNEs will be placed upwind and downwind of the wetted area and the control area.
  - The BSNE samples will be collected after a 2+ hour sustained wind event of greater than 5 m/s as measured at the Tsay Keh Dene air quality monitoring station.
  - The samples will be collected, dried and weighed using the Mettler-Toledo scales owned by the WDMP. The size fraction of the sediment collected in the BSNEs will not be evaluated since we are evaluating only the total sediment moving through the wetted area.

    - The data collected by the BSNEs will be used to estimate how shifting the sprinklers relates to the amount of sediment that is stopped by the irrigation system over long periods of time.
    - It is important to note that a wetted surface will not erode in response to wind forces and it is not our intention to evaluate this fact. We are using the BSNEs to evaluate the overall effectiveness of the sprinkler system and the extent of the wetted area that it is possible to create.
- Trimble GPS Units:
    - In 2009 and 2010 Trimble GPS units were used to map the advancement of sediment into the furrows on Davis Beach during the tillage trials.
    - Every three to four days the monitoring team will use these GPS units to track the extent of the wetted perimeter that is created by each sprinkler. We are not using the GPS to measure the wetted areas created by a single sprinkler over a short period of time but rather the combined effect of four sprinklers being moved sequentially.
    - The GPS unit will be mounted on an ATV, set to auto-collect mode and the ATV operator travel around the extent of the wetted margin. The GPS units allow the user to note areas of interest during the collection procedure. We will use this feature to delineate between wetted area and runoff effects.
    - These data will represent a snapshot of the control area on a given day and so over time we will be able to observe trends in the movement of the wetted perimeter, namely how it changes in response to weather and sediment conditions and the movement of the sprinkler system.
    - These data will also be used to establish the total area of beach taken out of dust production and thus a cost per hectare value can be applied to this irrigation system.
- HydroSenseII – HS2 Soil Moisture Probe:
    - The HS2 soil moisture probe will be fitted with standard 12cm sample tines and measurements will be taken at 25m intervals along the radius of a wetted perimeter.
    - The HS2 records GPS location with each sample and so can be mapped along with the Trimble GPS data.
    - HS2 measurements will be taken every three days at each sprinkler. The nozzle type and approximate sediment type will be recorded for each visit.
    - These measurements will be used to evaluate the "real" wetness of the near surface zone as a soil moisture percentage created by each sprinkler.

- Air Quality Monitoring Network:
    - The baseline air quality monitoring equipment in Tsay Keh Dene and the remote monitoring equipment setup on Tsay Keh beach will monitor the regional and local dust concentrations.
    - The data collected by the air quality network can be used to infer the relative impact of the irrigation system on fugitive dust emissions from Tsay Keh Beach.
- Sediment Samples:
    - The monitoring team will collect 7 – 10 surface sediment samples during each visit to the irrigation site.
    - These samples will be analyzed for their sand, silt and clay content in order to classify the underlying sediment type in the irrigation zone.
    - The location of samples will be coordinated with the surface samples taken previously during GMSWORKS#21 and GMSWORKS#20 studies. Samples will be taken from other locations as well to continue to increase our database and knowledge of surface sediment types.
    - Sediment classification samples will used to explain the infiltration, pooling and runoff effects.

2.2.2 Monitoring Design and Schedule

The monitoring team will visit the irrigation trial site every three days for a total of ten visits and will perform the following tasks:

1. Interface with the irrigation team to discuss issues and observations and to gather any relevant data.
2. Perform all required data capture tasks:
    a. BSNE sample collection
    b. GPS mapping
    c. Soil moisture probing
    d. Sediment texture sampling
3. Take a number of photographic observations to backup the physical data captured.
4. Begin drying the current BSNE samples and weigh the previous samples.

At the end of the 30-day season, the monitoring team will interface with the air quality monitoring team to gather the required data for the time period. These data will be collated with the data collected on the beach and a report addressing the core management questions will be prepared for Tsay Keh Dene, Chu Cho Industries LP and BC Hydro will completed for July, 1st, 2014.

3 BUDGET

4 SCHEDULE

The following proposed schedule for the irrigation trial is subject to change depending on weather conditions, ice-pack and access to Tsay Keh Beach.

Table 2: Timeline for 2014 Irrigation Trial

Task	May 5th – 9th	May 10th – 31st	June 1st - 3rd	July 15th
Irrigation setup phase	X			
Monitoring setup	X			
Routine irrigation		X		
Routine monitoring		X		
Demobilize irrigation setup			X	
Demobilize monitoring equipment			X	
Final Report				X

5 TEAM MEMBER RESUMES

Dan Wiebe, General Manager, Chu Cho Industries LP, 2012 – 2014

Earthworks Construction foreman, Chu Cho Enterprises Ltd. 2011 – 2012

Foreman, Lead Hand, Owner Operator, Heavy Equipment. 1988 – 2011

Jon Kostyshyn, Operations Superintendant, Chu Cho Industries LP. 2012 – 2014

Earthworks, Bridge installation, Debris and Dust Mitigation, Safety Management

Operations Supervisor, TDB Consultants, 2008 – 2012

Logging Operations Supervisor, Nacausely, 2002 – 2008

Field Technician, Canfor, 1998 – 2002

Johnny Pierre, Field Superintendant, Chu Cho Industries LP, 2012 – 2014

Supervisor, Chu Cho Enterprises Ltd. 2008 – 2014

TKDB, Chief

1998 – 2008, Dust and Debris Mitigation

Kenny Warren, Lead Hand, Equipment Operator, 1988, 2014

Aaron Poole, Equipment Operator, 1988 – 2014

MICHAEL TILSON, M.SC

ROLE:

Michael Tilson will manage the monitoring plan and the crews responsible for collecting the data for the irrigation trial.

BIOGRAPHY:

Michael Tilson is an air quality scientist and project manager with Chu Cho Environmental. Michael's background includes study in earth processes, physics and environmental science. For the last 6 years Michael has been involved in planning, implementing and managing a number of projects for the Williston Dust Mitigation Program relating to wind erosion and air quality. Prior to this, Michael worked as a research assistant for the University of Guelph on various wind erosion, sediment transport and air quality projects. Michael is an avid programmer/scripter utilizing several different and high-level languages for dataloggers/prototyping boards and for data processing, analysis, modeling and display.

EDUCATION, TRAINING, MEMBERSHIP ASSOCIATION

	Degree, Diploma, Certificate or Designation	Issuing Institution or Association	Date Conferred or Awarded
Consultant's Degrees, Certificates, Diplomas	M.Sc Geography	University of Guelph	April 2010
	B.Sc Earth Surface Science, Minor: Physics	University of Guelph	February 2008
Professional Development/ Training	Erosion Sediment Control	Vancouver Island University	October 2013

RELEVANT PROJECT EXPERIENCE

Projects, Roles and Responsibilities	**Areas of Expertise**
Timeframe – Spring 2008 – On-going **Project Details –** The annual operation of the Williston Reservoir in northern British Columbia results in the exposure of over 10,000 Ha of erodible beach sediments during the spring recharge months. Wind Storms funnelling through the valley pick up loose sediment and eventually create massive dust storms that last for several hours to several days. The air quality monitoring program is designed to assess human exposure patterns and to provide data that is used as input for modelling the development and dispersion of dust events. **Role and Responsibilities** – Project manager for the Williston Reservoir air quality monitoring network. Directly involved in reviewing the airshed monitoring plan and network design to recommend improvements in monitoring and maintenance routines. Responsible for coordinating all annual and daily operations related to	Air Quality Monitoring Dispersion Modelling Wind Erosion and Sediment Transport Data Management and Analysis **Project Value:** **$4,599,560.00 (over 10 years)** **Funding: BC Hydro**

maintaining the network. (2008 – 2012) • Developed Data Quality Objectives, monitoring objectives, QA/QC procedures and data analysis procedures.	
Timeframe – Winter 2008 and 2009 **Project Details –** The Dry Valleys of Eastern Antarctica provide a unique environment in which to study wind erosion, sediment transport and the development of aeolian landforms. Cold air temperatures coupled with intense katabatic winds create erosive forces that are among the strongest on earth, giving rise to numerous strange and unique landforms. Our project team implemented a monitoring program that would observe the atmospheric and erosive conditions during the dark winter months in order to provide substantiated evidence to explain the development of many of the strange landforms. **Role and Responsibilities –** Field/laboratory technician responsible for developing instrumentation and the programming required to implement a complicated data capture routine. Accountable for field logistics and ensuring that all equipment was on-site and fully operational.	Wind Erosion and Sediment Transport Geomorphology Data Management and Analysis **Project Value: $350,000.00** **Funding: National Science Foundation (NSF)**
Timeframe – Summer 2007, 2008 and 2011 **Project Details –** Our project team implemented a monitoring program for assessing the role of vegetative roughness in protecting the desert surface from wind erosion and inducing sediment deposition. This project was implemented in the Chihuahuan Desert of New Mexico at the Jornada Experimental Range. We utilized a network of anemometers, wind vanes, sediment flux counters and shear stress monitors to model the movement of sediment as it relates to wind flow and shear stresses on the surface. **Role and Responsibilities –** Field technician responsible for helping to develop the infrastructure required to host the instrumentation and the programming required to capture all of the data.	Wind Erosion and Sediment Transport Data Analysis **Project Value: $180,000.00** **Funding: Natural Sciences and Engineering Research Council (NSERC)**