Bulkley
Timber Supply Area

Vegetation Resources Inventory

Ground Sampling and NVAF
Project Implementation Plan

PREPARED BY:

BULKLEY TSA STAKEHOLDERS COMMITTEE

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Timberline
Forest Inventory Consultants

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1.0 INTRODUCTION

1.1 Background Information

1.1.1 Vegetation Resources Inventory

The Vegetation Resources Inventory (VRI) is the Ministry of Forests and Range (MoFR) standard for assessing the quantity and quality of BC's vegetation resources. The VRI process is designed to include a flexible set of sampling procedures for collecting vegetation resource information. The VRI is essentially a toolbox of procedures, which include:

- *Photo Interpretation*: the delineation of polygons from aerial photography or imagery and the estimation of a pre-determined set of resource attributes *.
- *Ground Sampling*: the establishment of plot clusters in selected polygons to measure timber, ecological, and/or range attributes.
- *Net Volume Adjustment Factor (NVAF) Sampling*: Stem analysis sampling of individual trees for net volume adjustment.
- *Within Polygon Variation (WPV) Sampling*: Intensive sampling of selected polygons to determine the error between the estimated attribute values and the "true" attribute values.
- *Statistical Adjustment*: the adjustment of the photo-interpreted estimates for all polygons in an inventory unit or management unit using the values measured during ground sampling.

*The pre-determined set of resource attributes gathered through photo interpretation is currently found on the Internet at:

http://ilmbwww.gov.bc.ca/risc/pubs/teveg/vri-photointerp2k2/photo_interp2k2.pdf

The VRI can be deployed over a management unit measuring selected resources in specific portions of the land base. The VRI sampling process produces spatial and non-spatial databases that can be used in multiple resource management applications including timber, ecosystem, and wildlife habitat management.

The next inventory in the Bulkley Timber Supply Area (TSA) will be a VRI. There will be three phases to this VRI; photo-interpretation, ground sampling, and net volume adjustment factor (NVAF) sampling. The VRI Phase II data collected will be compiled and the photo interpreted inventory will be adjusted to the new adjustment standards which will be made available before March 31st 2006. The adjusted inventory will facilitate the forthcoming Timber Supply Review (TSR) project, and the new Phase 1 VRI will be the foundation inventory for a Predictive Ecosystem Mapping (PEM) project under consideration, as well as numerous other applications.

1.1.2 State of the Current Inventory

The current Forest Cover re-inventory was completed between 1995 and 1997, and was delivered in 1997. The aerial photographs were 1993 and 1994 vintage, 1:15,000 black and white hardcopy photographs. This inventory, while not necessarily of poor quality, does not meet the needs of the licencee stakeholders.

The Bulkley TSA inventory was last audited in 1994 with the data reported in 1996. The audit was conducted using the previous Forest Cover inventory that was re-inventoried in 1988. As the latest inventory audit conducted does not relate to the current forest cover inventory, the

inventory audit results are not presented here. The inventory audit of the 1988 Bulkley TSA re-inventory can be reviewed at the following site:

http://www.for.gov.bc.ca/hts/vri/audits/reports&pub/

No significant forest management issues in the Bulkley TSA were highlighted in the last timber supply review determination (TSR 2 Rationale for AAC determination update, January 1, 2002). The issues that were brought forward by the Bulkley TSA stakeholder group are summarized below.

Emerging data needs were considered to be relevant to the Bulkley TSA and could be addressed with a completed VRI. While the VRI as a whole includes photo interpretation (phase 1), ground sampling (phase 2), and destructive sampling (NVAF), those data needs specifically addressed by the ground sampling and NVAF destructive sampling are highlighted in **bold** text below. Those data needs that are not highlighted in bold text do not however sit in isolation from ground sampling, they are simply addressed more prominently by the phase 1 VRI.

1. A more 'operational' level Phase I VRI to address the issues around the partition, specifically refined delineation and more accurate, structure, species composition, age, height, and derived volume estimates to better define those stands that actually fall within the marginal saw log and pulp log criteria as defined by the Harvest Method Mapping (HMM) parameters.
2. Refined delineation and calibration information collection in problem forest and low productivity types.
3. Forest health issues. Improve stand mapping and identification of lodgepole pine in the TSA in support of mountain pine beetle and pine needle blight hazard mapping and salvage opportunities.
4. VRI of the parks due to their contributions to TSA seral stage balances, habitat representation, and old growth management. A financial contribution from the Ministry of Environment, Parks Branch, to cover off a portion of the inventory costs has been discussed and agreed to in principle.
5. **Growth and yield linkages. If designed properly from the outset, a VRI (phase I and II) can provide valuable attributes and sample data that can be used to enhance follow-up growth and yield programs.**
6. A predictive ecosystem mapping (PEM) project is planned for once the bioterrain delineation based VRI is completed to spatially refine both productivity SI 50 and habitat supply.
7. **Market certification requirements can be met through the VRI Phase II by providing a statistically defensible inventory that is subsequently used in timber supply analysis.**
8. **Localized (to TSA level) decay factors (NVAF) for net volume determination, as well as providing sensitivities to the tools used to derive net volume (net factoring, loss factors, and taper equations).**

1.2 Document Objectives

The Vegetation Resources Inventory Project Implementation Plan (VPIP) is a working document that details the specific operational activities associated with implementation and documentation of the inventory project. It identifies the project geographic areas, priorities, the sample plan, sample size determination for phase 2 (TEP or full plots) and for NVAF sampling by species or

species groups to strengthen the sampling activities, project scheduling, plot location coordination, inventory costs by year, and roles and responsibilities for implementation.

1.3 Land Base

The Bulkley TSA is situated in northwestern British Columbia in the Northern Interior Forest Region. Covering approximately 762,540 hectares, the Bulkley TSA is part of the Skeena-Stikine Forest District and is administered from the district office in Smithers (see Figure 1)

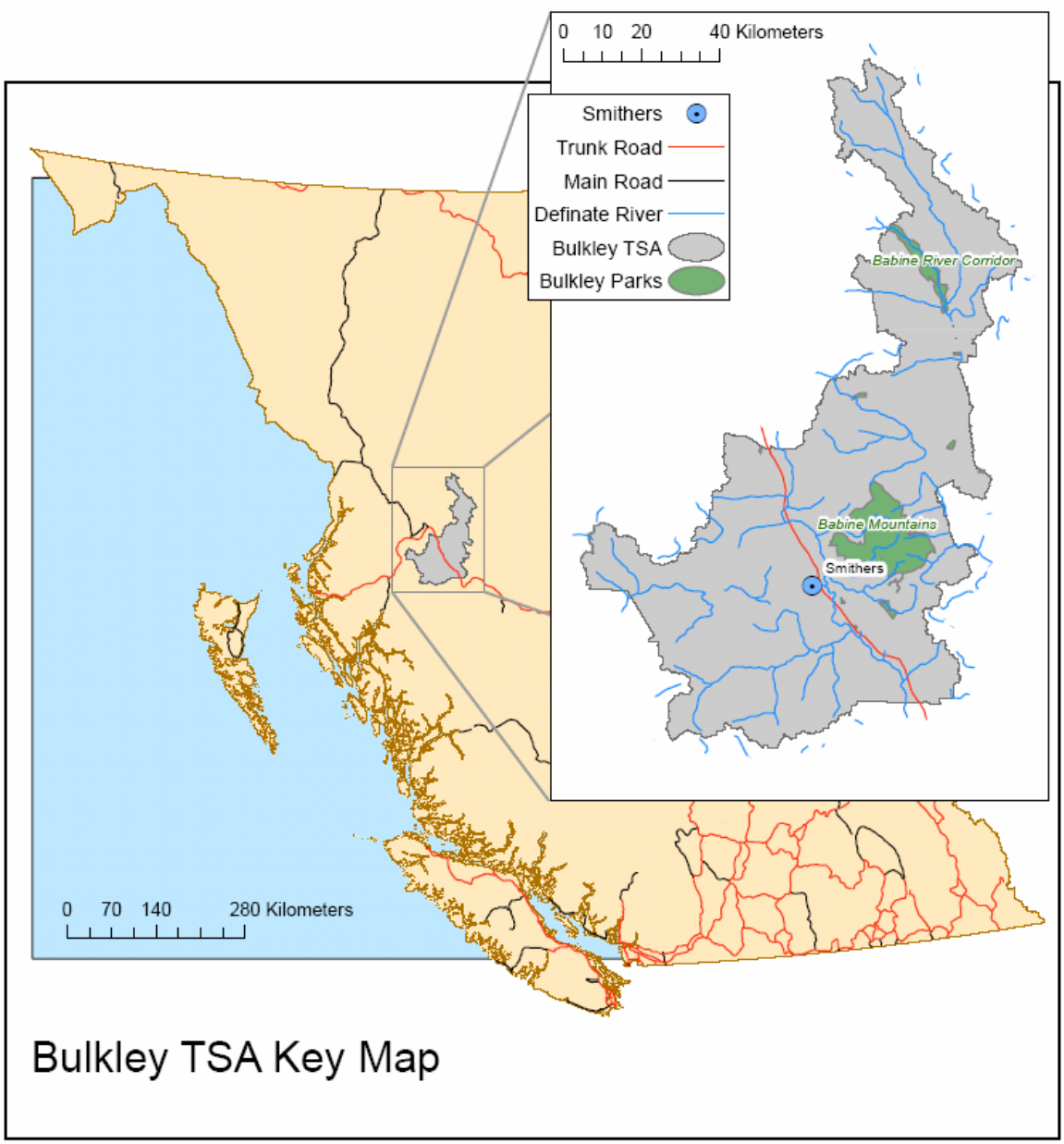

Figure 1 Bulkley TSA Overview Map

The Bulkley TSA is located on the eastern drainage of the Skeena River. It is bounded by the Hazelton Mountains to the west, the Telkwa River watershed to the south, and the Babine Mountains to the east, and extends north to the headwaters of the Nilkitkwa River. The Bulkley River runs through the center of the southern portion of the TSA. The terrain in the Bulkley TSA varies from wide river valley bottoms to steep sided v-shaped valleys and high mountains.

Due to its location between interior and coastal climates, the Bulkley TSA includes diverse ecological features. The dominant tree species in the TSA are sub-alpine fir (48%), spruce (23%), lodgepole pine (25%) and hemlock (4%). Minor deciduous areas are present but these are almost entirely restricted to the private land areas in the TSA. Mountainous terrain and high elevations limit the amount of land considered suitable for timber production in this TSA. In this 'plan', the assumption is made that the forested land base corresponds to the Vegetated Treed (VT) land base according to the BC Land Cover Classification Scheme, or BCLCS.

Table 1 Bulkley TSA Area Summary *

Landbase Classification	Area (ha)	Percent (%)
Total TSA area	**762, 540**	**100**
Not managed by the BCFS (not including parks and protected areas)	56,111	7.4
Parks and Protected Areas	39,121	5.1
Non-forest and non-productive	171,386	22.5
Total forested area managed by the BCFS	**495,922**	**65**
Reductions to Crown Forest		
-Non-commercial cover	6,312	0.8
-Inoperable	348	0.0
-Terrain stability in Copper LU	1,698	0.2
-Riparian areas	10,932	1.4
-Helicopter areas	7,388	1.0
-Cable areas	31,320	4.1
-Low productivity sites	44,551	5.8
-Problem forest types	19,020	2.5
-Existing road, trails, and landings	8,340	1.1
-Recreation areas	696	0.1
-Environmentally sensitive areas	7,836	1.0
-Newly created parks	9,499	1.2
-Special management zone 1	8,108	1.1
Total current reductions	**156,048**	**20.5**
Current timber harvesting land base (THLB)	**339,874**	**44.6**
Future reductions		
-Future roads	15,763	2.2
-Agricultural land reserves	4,841	0.6
Future timber harvesting land base	**319,270**	**41.9**

*Source: TSR II Analysis Report.

2.0 GROUND SAMPLING PLAN

2.1 Sampling Objectives

Generally speaking, the ground-sampling phase of the VRI is designed to improve TSA polygon volume information through field work and statistical adjustment, eliminating or reducing the bias associated with the photo interpretation process. The main purpose is to attain a statistically reliable and unbiased estimate of the total volume for the TSA.

In addition to a more operational inventory achieved through the proposed VRI Phase I and general improvement in TSA data, the data adjusted through sampling will be available to better define:

1. The hemlock-balsam height and volume defined problem forest type (PFT) currently subject to a 367,000 m3 partition for the harvest of marginal saw logs and pulp logs; and
2. The volume of lodgepole pine, as first and second leading species, available to mountain pine beetle.

The objective would be to install an adequate number of Phase II VRI sample clusters (enhanced timber emphasis including the collection of site series information) to statistically adjust the photo interpreted timber inventory attributes in the Vegetated Treed (VT) portion of the Bulkley TSA. Enough samples need to be installed initially to achieve a sampling error of between 10 and 15% (95% probability) for overall net timber volume in the VT area, and accurate individual polygon adjusted estimates. Further samples may have to be installed in subsequent sampling programs to achieve an anticipated sampling error of ±10% (95% probability) for net timber volume. This is explained in further detail in section 2.3 below.

2.2 Target Population and Sample Size

The TSA is transitional, in that both the interior and coastal biogeoclimatic sub-zones are represented in this unit. However, only 5.5 % of the TSA is found in coastal sub-zones. As tree species are closely correlated to the sub-zones in the Bulkley TSA, using the three broad-level productivity zones, as defined by the following grouping of BEC sub-zones in the TSA, would provide a reasonable first split for sampling strata. The first split would be:

- ICH and CWH
- SBSdk and SBSmc
- ESSF

The second split would be by age. For each of the BEC sub-zones groups identified above, the following age breaks set out in Table 1 would be considered. These age breaks are consistent with the Landscape Unit Plan (LUP) biodiversity objectives regarding seral stage targets for each BEC sub-zone, making it easier to analyze the inventory. Stands less than 40 years would not be sampled, as TASS/TIPSY yield curves will be used. Strata without significant representation by area would be coalesced in other strata to ensure an adequate sample size.

Table 2 Suggested Phase 2 Sample Stratum Age Breaks

BEC Sub-Zone	Managed Stand Yield Tables	Natural Stand Yield Tables	Natural Stand Yield Tables	Natural Stand Yield Tables
	Early	Immature	Mature	Old
SBSdk and SMSmc2	0 - 40	41 - 100	101 - 140	> 140
All CWH and ICH	0 - 40	41 - 100	101 - 250	> 250
All ESSF	0 - 40	41 - 120	121 - 250	> 250

The target population for the ground sampling program will be all BCLCS-defined Vegetated Treed (VT) polygons with a leading species age greater than 40 years, excluding private land, parks, and protected areas.

2.3 Sample Size

This breakdown provides nine strata. The recommendation is to **initially** install **approximately** 60 plots with equal probability across the target population. Any individual strata within the matrix that by area is too small would be combined with its most closely associated strata (BEC zone or age range). On completion of sampling, a preliminary analysis will be conducted and based on the results of this analysis to determine if more samples are required based on refined sampling objectives. The most substantial reason for this approach is the unknown effect that the coastal / interior complex will add to the adjustment. After the ~60 plots are installed and compiled there will be a clearer picture available. This total sample size was estimated using a CV of 90% (these stand types tend to be relatively heterogeneous) and an anticipated sampling error of ±10% (95% probability) for net timber volume.

The initial 60 samples will be distributed proportionally between each of the nine strata based on the total hectares occupied by each of the nine strata. Any strata containing too small a sample size will be coalesced with the closest associated strata.

Based on the statistics generated at the end of the first sampling season, the installation of additional samples (perhaps as many as 20 more +) may be required later in the sampling field season. The total number of samples is subject to change, following the selection of samples, and completion of the ground sampling. The final analysis documentation will contain the actual areas and numbers of samples completed by strata.

2.4 Sampling Selection

All the vegetated treed polygons within the TSA will be identified in the VRI photo-interpretation generated database and assembled into a list using the Probability Proportional to Size With Replacement (PPSWR) sample selection standard. This is a method of randomly sampling within an identified stratum of the inventory, in which every point in the stratum must have an equal chance of being sampled, even though variable sized polygons are treated as the basic sampling units. A polygon that is twice as large as another has twice the chance of being chosen, once chosen it is still eligible to be chosen again.

The spatial and attribute files used for the sample selection will be submitted to the MoFR in an acceptable format.

2.5 Sampling Approach

This inventory will be achieved in two steps. The first step is to complete a statistically valid sample of the area that will include ~60 samples in the spring to early summer of the 2008 field season. The second step will be to complete any remaining samples required (based on the results of the preliminary analysis) in the late summer to early autumn of the 2008 field season.

2.6 Sample Type

Timber Emphasis Plot (TEP) ground sampling will be used for this inventory. This sampling will include call grading and net factoring. The sub-sampling of trees for stem analysis to address

decay and waste issues (not breakage) will be undertaken during the NVAF (net factor/call grading and destructive sampling) phase.

2.7 Measurements

All ground sampling measurements should conform to existing minimum standards. These measurements will be recorded using the following VRI field cards:

FS 505I	Header Card (CH) 1
FS 505N	Compass Card (CP) 2
FS 505O	Cluster Layout (CL) 3
FS 505K	Tree Details (TD) 8
FS 505J	Tree Loss Indicators (TL) 9
FS 505L	Small Tree, Stump and Site Tree Data (TS) 10
FS 505M	Auxiliary Plot Card (TA) 11

Note that FS 505L is on the reverse of FS 505J. Note also that all call grade and net factor enhancement data of tree selected for NVAF sampling will be recorded on the FS 505M Auxiliary Plot Card (TA) 11.

All ground sampling field data will be digitally captured using Timber Vegetation (TIMVEG) software, and submitted to the MoFR in that format.

All NVAF sampling field data will be digitally captured using DVHAND / DVHOST software, and submitted to the MoFR in that format.

2.8 Net Volume Adjustment Factor Sampling

Net Volume Adjustment Factor destructive sampling will provide net factors to adjust net tree volume calculated from the ground sampling data, where net tree volume is estimated from the VRI ground sample net factoring process and various taper equations. The net factors will account for hidden decay and possible taper equation bias. Sampling will involve detailed stem analysis of sample trees to calculate actual net volume. The actual net volume is compared to the estimated net volume from ground sampling, which in turn is compared to the estimate net volume from photo-interpretation.

This volume adjustment will facilitate the forthcoming TSR project.

There are increased efficiencies to be gained through the enhancement of selected auxiliary plots for the NVAF program at the time of the initial sample establishment (during Phase II ground sampling), rather than at the time of the NVAF destructive sampling. This should be considered by the stakeholders and be incorporated into the Phase II / NVAF Sample Plan. Phase 2 certified timber samplers will provide detailed enhanced cruising (net factoring and call grading) of all trees in the pre-selected auxiliary plots during initial ground sampling.

Net Volume Adjustment Factor sampling can only occur after VRI ground sampling. It is strongly recommended that both projects occur in the same field season in order to garner the best results from the data of both programs. The NVAF sampling will **at a minimum** require the destructive sampling of 30 mature, 20 immature and 10 dead trees selected from the complete tree list compiled during ground sampling. However, there are known concerns over sub-alpine fir

taper and loss factors particularly in terms of live trees differing by BEC zonation (elevation and coast vs. interior locations) and for dead trees due to the balsam bark beetle infestation. The recommendation has been made by MoFR Forest Analysis and Inventory Branch staff to increase the sample size, specifically for sub-alpine fir, such that at least 20 trees are sampled per sub-alpine fir stratum.

A feasible option as presented by MoFR Forest Analysis and Inventory Branch staff is to set a NVAF sample size greater than the minimum standard by ensuring that there are adequate numbers of live and dead sub-alpine fir to assess the accuracy of the taper, loss factors, and VRI net factors as per the following:

- 45 to 50 live mature sub-alpine fir
- 15 dead sub-alpine fir
- Five dead trees of all other species combined
- 20 mature trees of all other species combined
- 10 to 15 immature species of all species combined

*(Totaling 95 to 105 trees)

- Select 20 mature ground samples and three immature ground samples for NVAF
- Sampling.
- Enhance either two or three auxiliary plots from these ground samples at the time of sample establishment. This is a far more efficient process than enhancement at the time of the destructive sample.

What has not been addressed above is the possibility that there is a separate sub-alpine fir stratum in the coastal/interior transition. If this is a concern, then an additional live mature sub-alpine fir stratum of 20 trees can also be considered.

Another issue is log grades, as this is an issue within the Bulkley TSA around the proportion of sawlog vs. pulplog. VRI log grades should be able to be directly translated into the interior log grades and this conversion is probably best done as a post VRI compilation exercise. VRI log grades are letter grades based on the coastal log grades, but with different parameters in some grades to reflect conditions in the Interior and the Peace.

The continued use of the current system used to valuate decadent balsam is contingent upon a detailed Destructive Stem Analysis Plan. This plan should investigate adding interior log grading element to the VRI program. The proposal suggests that the Bulkley TSA, be used as a trial VRI to test the addition of interior log grading to NVAF sampling procedures, and assess the viability of using pathological indicators to predict log grades in Balsam (i.e. a tree-level cruise grade algorithm).

The standing log grade assessment can be verified by having the NVAF sample trees ‘bush scaled’ at the time of the destructive sample. A grade adjustment can then be calculated and used to adjust the estimates of VRI ground sample volumes by grade. However, log grade assessment work is not standard in the VRI so should be considered as an addendum to the project. Additionally, log grades should be called directly in the field, and eliminate the need for grade conversion. For the test exercise, perhaps both Interior and Coastal grades could be recorded in the field.

Sampling will be conducted according to the NVAF and ground sampling procedures manuals, with enhancements (as indicated above) as required to address the special situation that exists in the Bulkley TSA. The digital data will be submitted to MoFR in an acceptable format.

3.0 GROUND SAMPLING PROJECT IMPLEMENTATION

3.1 Sample Packages

Field sample packages will be prepared following VRI methodology. Maps will be plotted at 1:10,000 scale showing the VRI grid overlays and selected sample locations.

3.2 Roles and Responsibilities

3.2.1 Project Coordinator

The project coordinator will be an employee of the company that is the winning proponent, and will be subordinate to the Pacific Inland Resources (PIR) contract coordinator for the purposes of this project.

The project coordinator's responsibilities will include, but will not be limited to:

1. Coordinating the project;
2. Monitoring and communicating project progress;
3. Ensuring all contractors are qualified and certified;
4. Ensuring quality assurance is complete; and
5. Assisting in coordinating technical expertise where required.

3.2.2 Project Support

The contractor will be responsible for the provision of field supplies such as aluminum stakes, cards, etc., and technical support for GPS, TIMVEG, and DVHAND / DVHOST software.

The contractor will be responsible for the sample list; sample packages (including compiling field maps, photos, and grids); coordinating the fieldwork, data compilation, and data analysis.

3.2.3 Standards

1. VRI Ground Sampling Procedures Version 4.5 Errata No. 1 (February 2005).
2. Vegetation Resources Inventory Ground Sampling Procedures Version 4.5 (March 2004).
3. Vegetation Resources Inventory Ground Sampling Procedures Appendices Version 4.5 (March 2004).
4. VRI Ground Sampling Data Collection Procedures for Inaccessible Sample Version 1.0 (March 2003).
5. Vegetation Resources Inventory Ground Sampling Quality Assurance Procedures Version 3.0 (March 2004).
6. Net Volume Adjustment Factor Sampling Standards and Procedures, Version 4.0 Errata 1.0 (January 2005).
7. Net Volume Adjustment Factor Sampling Standards and Procedures, Version 4.0 (March 2004).

8. British Columbia Standards, Specifications and Guidelines for Resource Surveys Using Global Positioning System (GPS) Technology, Release 3.0 (March 2001).
9. VRI Procedures and Standards for Data Analysis Attribute Adjustment, and Implementation of Adjustment in a Corporate Database, Version 2.0 (March 2004).

3.2.4 Quality Assurance

Internal quality control of field work and data entry will be undertaken by the contractor in accordance with the appropriate standards.

External third-party quality assurance will be undertaken by a consultancy which is not involved in the undertaking, and who is chosen by PIR through an open bidding process. Files will be submitted for third-party quality assurance in batches of at least five or as agreed to by the contractor and quality assurance contractor.

3.2.5 Data Compilation, Analysis and Adjustment

Data compilation will be completed based on the VRI compilation standard. Data entry and analysis will be completed after the installation of the preliminary 60 samples. New CVs will be calculated from the first 60 samples and used to determine the need for and number of additional samples. All tree level information will be supplied to the MoFR.

The database (individual-polygon) adjustment will be done by December 15, 2008 after all sampling is completed. The analysis will follow the minimum MoFR standards.

Ground sample and adjusted inventory digital data will be submitted to the MoFR in an acceptable format.

3.3 Sample List

A complete sample list and plan, and a comparison of the sample and population, as per the sample selection standards, will be provided upon completion of the VRI photo-interpretation phase (see table 3).

4.0 SCHEDULE

The schedule for this VRI is presented in Table 3. The gray shaded cells are those specifically pertinent to this ground sampling and NVAF VPIP.

Table 3 Bulkley TSA VRI Project Schedule

Item	End Date
VSIP	21 November 2005
VPIP	31 January 2006
Aerial Photo Contract established with BMGS	31 January 2006
Aerial Photos Acquired	31 August 2006
Aerial Photo Scanning, A/T, viewer sets	15 January 2007
Request for Proposals Issued	3 January 2007
Contract Award	15 January 2007

VRI Phase I Photo Interpretation	15 June 2008
VRI Phase II Ground Sampling & Adjustment	15 October 2008 (or earlier)
NVAF Destructive Sampling	15 October 2008 (or earlier)
VRI Updated and Approved	15 December 2008

5.0 COSTS

The approximate costs for this VRI are presented in Table 4.

Table 4 Costs

VRI Project Component	Unit Cost (est.)	Total (est.)
1:20,000 Aerial Photo Acquisition	~$0.08 - $0.09 / ha.	$68,500
Scanning, A/T, DiAP viewer sets	~$0.045 / ha.	$35,000
VRI Phase 1	$0.90 - $1.10 / ha.	$762,500
VRI Phase 1 QA Audit (Third Party)	~$0.03 / ha.	$23,000
VRI Phase 2 Sample Plan	~$8,000	$8,000
VRI Phase 2 *	$1400 - $1800 / sample	$108,500
VRI Phase 2 QA Audit (Third Party)	$1000 / sample	$6,000
VRI Phase 2 Compilation & Adjustment	~$10,000	$10,000
NVAF	$450 / tree	$45,000
NVAF QA Audit (Third Party)	$500 / tree	$5000
All VRI Projects	**-**	**$1,071,500**

* First 60 samples, exclusive of helicopter costs

6.0 APPROVAL AND SIGN-OFF OF THE VPIP: GROUND SAMPLING AND NVAF SAMPLING

I have read and agree that the procedures outlined in this proposal meet current MoFR minimum standards.

_____ per Pacific Inland Resources Inc.

_____ per Canadian Forest Products Ltd.

_____ per Skeena-Stikine Forest District (MoFR)

_____ per Northern Interior Forest Region (MoFR)