KALUM TIMBER SUPPLY AREA

Vegetation Resources Inventory
Strategic Inventory Plan

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EXECUTIVE SUMMARY

This draft Vegetation Resource Inventory (VRI) Strategic Inventory Plan (VSIP) for the Kalum Timber Supply Area (TSA) was prepared in consultation with stakeholders in the TSA. The purpose of the plan is to outline the VRI activities and products needed to address forest management issues identified by the stakeholders. This document may be used by the District Land Base Investment Program (LBIP) steering committee to assist in long term inventory planning. It is recommended that this group review the VSIP prior to the development of a VRI Project Implementation Plan (VPIP) to ensure it meets their business needs.

VRI activities and products needed to address the priority forest management issues identified by stakeholders include:

- air photo acquisition for the TSA.
- timber emphasis ground plots (8 in mature stands and 34 in immature stands),
- 30 NVAF trees from within the immature stands,
- data analysis and database attribute adjustment.

The target population for ground sampling plots is the vegetated treed portion of the operable landbase. The sampling will supplement previously gathered ground samples and NVAF samples and help achieve low enough sampling errors to provide reliable inventory estimates needed for timber supply analysis and operational decisions. It is expected that implementation of this plan will improve the accuracy of inventory attributes for stands less than 120 years of age (age, height, volume, site index, taper, and decay estimates) as well as attributes in older stands, that are not hemlock leading, that are greater than 120 years of age (age, height, and volume). Costs for proposed VRI activities and products are summarized in section four of this VSIP.

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1. INTRODUCTION

1.1 SCOPE AND OBJECTIVES

This Vegetation Resources Inventory (VRI) Strategic Inventory Plan (VSIP) outlines VRI activities and products needed to address forest management and inventory issues in the Kalum Timber Supply Area (TSA), as identified by stakeholders at a meeting on November 8, 2006. A VSIP can provide strategies for photo interpretation, timber or ecological emphasis ground sampling, monitoring, and associated research projects in the TSA. Once the VSIP is approved, the next step is to prepare and implement a project implementation plan (VPIP).

LM Forest Resource Solutions prepared this report in consultation with the Kalum TSA stakeholders. These stakeholders included:

- BCTS representatives from the Skeena and Babine Business Units
- The MoFR Forest Analysis and Inventory Branch
- The Coast Tsimshian Resources L.P.
- Representatives from the Kalum Land Base Investment Program (LBIP) DFAM working group.
- Kalum TSA Steering Committee representativies.

This VSIP was reviewed by stakeholders and discussion and comments were incorporated into this document and, where appropriate, the Vegetation Strategic Program Implementation Plan (VPIP).

1.2 VEGETATION RESOURCES INVENTORY

The Chief Forester is responsible for determining allowable annual cut (AAC) for TSAs (and TFLs) in accordance with Section 8 of the Forest Act. Under the BC government's defined forest area management (DFAM) initiative, responsibility for preparing a data package, undertaking timber supply analysis, and providing key information that is considered by the chief forester in making an AAC determination was to be the collective responsibility of the BC Timber Sales (BCTS) manager and the holders of replaceable forest licenses (the DFAM group). The legislation supporting the DFAM initiative was never brought into force and as of Feb. 2007, the Chief Forester declared that the program would be discontinued. The Chief Forester is encouraging licensees to voluntarily complete scheduled TSR data packages and timber supply analysis using the Forest Investment Account's (FIA) Land Based Investment Funding. Fundamental to this task is ensuring that the quality of forest inventory supporting timber supply analysis and the AAC determination is sufficient to provide a useful level of accuracy. Forest licensees (and other forest resource users) also need land and resource information to undertake other forest management activities such as timber harvesting, forest protection, and wildlife, water, and range management.

In order to inform timber supply analysis and provide the information necessary to undertake forest management operations, a vegetation inventory needs to answer two questions:

1. Where is the resource located?

2. How much of a given vegetation resource (for example, timber or coarse woody debris) is there?

The process to answer these two questions is carried out in two phases. Phase I (Photo Acquisition and Interpretation) involves the mapping of forest cover polygons and the estimation of resource attributes from aerial photography and ground calls. Phase II (Ground Sampling) is the establishment of plot clusters in selected polygons to measure timber, ecological, and/or range attributes. This commonly includes measurement of tree and stand attributes from sample clusters established randomly within the target population and includes stem analysis of individual trees to assess decay and taper (net volume adjustment factor measurements - NVAF). A third, less common type of Phase II sampling is "within polygon variation" - intensive sampling of selected polygons to determine the error between the estimated attribute values and the "true" attribute values. The information from ground samples is used to adjust or correct the photo-interpreted estimates for all polygons in an inventory unit or management unit.

1.3 VRI OVERRIDING PRINCIPLES

A vegetation resources inventory is guided by a number of fundamental principles:

- The inventory must satisfy the business needs of stakeholders.
- Inventory activities must be conducted to Provincial RISC standards.
- Inventory activities must be coordinated.
- There must be adequate statistical confidence in timber value estimates.

To help ensure these principles are followed standards and methods for VRI products have been produced (available at http://www.for.gov.bc.ca/hts/vri/standards/index.html). Periodic reviews of the standards are coordinated by a Resources Inventory Committee.

With respect to business needs, in the Kalum District, needs and priorities are identified by a Land Base Investment Program steering committee. This group met prior to the development of this VSIP to provide strategic direction. Within the context of funding available within each organization, and through the Forest Investment Accountant (FIA), the group identifies the type and quality of inventory information they will need to achieve their business goals. FIA inventory funding allocations, however, are also influenced by a different group – a provincial council of individuals known as the VRI Advisory Council (VIAC), that includes representatives from the Ministry of Forests and Range (MoFR) Forest Analysis and Inventory Branch (FAIB), MoFR Regional Offices, the MoFR's BCTS program, the Integrated Land Management Bureau (ILMB), the Ministry of Environment (MoE), and the forest industry. The role of VIAC is to rank and prioritize forest inventory activities for all units in the province. The level of funding for any particular project will be a function of the total funding available, and the relationship between the various projects (relative priority, time frame for completion, etc).

1.4 VRI PLANNING

The VRI planning process requires that a Strategic Inventory Plan and a Project Implementation Plan be developed for a defined forest management unit (e.g. Timber Supply Area). A VSIP outlines the VRI products required to address forest management issues and provides strategic direction for implementing the inventory activities. The VPIP more specifically identifies the needs for VRI management inventories, and provides the details for implementation of the VRI in terms of geographic areas, scheduling, priorities, plot location, coordination, estimated inventory costs by year, and roles and responsibilities. Guidelines for preparing a VSIP and a VPIP are available at http://www.for.gov.bc.ca/hts/vri/standards/index.html.

1.5 FUNDING

Funding for VRI activities under DFAM was a licensee responsibility that, in the Kalum TSA, was coordinated by the Kalum FIA Land Base Investment Program (LBIP) steering committee. The primary source of funding for inventory activities has been the Forest Investment Account's (FIA) land base investment program. While the FIA allocation for 2006/2007 is $59.84 million; VRI is only one component of the LBIP, and completion of Phase I and II VRI activities will take more than one year. The program is also in transition and it is expected that funding for future inventory work will likely come from a different source known as Focussed funding within the FIA program. The VRI Advisory Council is currently developing a set of criteria to rank TSA's in terms of their forest inventory priorities. It is expected that only VRI projects attaining the *highest priority* ranking will be eligible. At present no figures are available regarding magnitude of funding and there is no guarantee of surplus funds for lower priority TSA's.

The FIA Forest Science Program (FSP) (previously known as the Forestry Innovation Investment) is another potential funding source for the activities outlined in this VSIP. Innovative aspects of the inventory, particularly the aspects of research into existing stand volumes and decay, may be eligible for funding under the FSP timber growth and value program.

In the absence of outside agency funding, the DFAM groups are encouraged to enter into partnerships to minimize the costs associated with the implementation of the activities outlined in this plan. It is government's intention that businesses invest in the necessary information, infrastructure, and human capital to run their business effectively.

2. BUSINESS CONSIDERATIONS

2.1 LANDBASE

The Kalum TSA lies within the Northern Interior Forest Region and is administered from the Kalum Forest District office in Terrace. The Kalum TSA comprises a total of 539,319 hectares centred on the community of Terrace. The TSA is bordered by the Nass, Kispiox, North Coast and Bulkley TSAs, as well as two Tree Farm Licenses (TFL 1 and TFL 41). Adjacent to the TSA are several parks, including the Nisga'a Memorial Lava Bed Provincial Park, the Lakelse Lake Provincial Park, the Exchamsiks River Provincial Park, and the Gitnadoix River Recreation Area (See Figure 1). It is expected that some of the area in TFL1 will be removed from the TFL and incorporated in the Kalum TSA. Hectares and dates for this transfer have not yet been determined.

According to the Chief Forester's Rationale for Allowable Annual Cut Determination for the Kalum TSA produced in 2000, there are 539,319 hectares in the TSA of which 36,213 hectares, or approximately 6.7 percent, are not managed directly by the British Columbia Forest Service (BCFS), including parks, ecological reserves, private land and various special use permit areas. An additional 305,698 hectares, or approximately 57 percent, are non-productive areas which include rock, swamp, alpine areas and water bodies. Productive forest land managed by BCFS totals 197,408 hectares and comprises roughly 37 percent of the total area. Other reductions to the productive forest land base mean that only 98,256 hectares or approximately 50 percent of the productive forest land, is considered to be available for timber harvesting (Table 1). Hemlock species dominate in stands on about 76 percent of the area, balsam dominates on 8 percent, spruce on 6 percent, and lodgepole pine on 5 percent (Table 2).

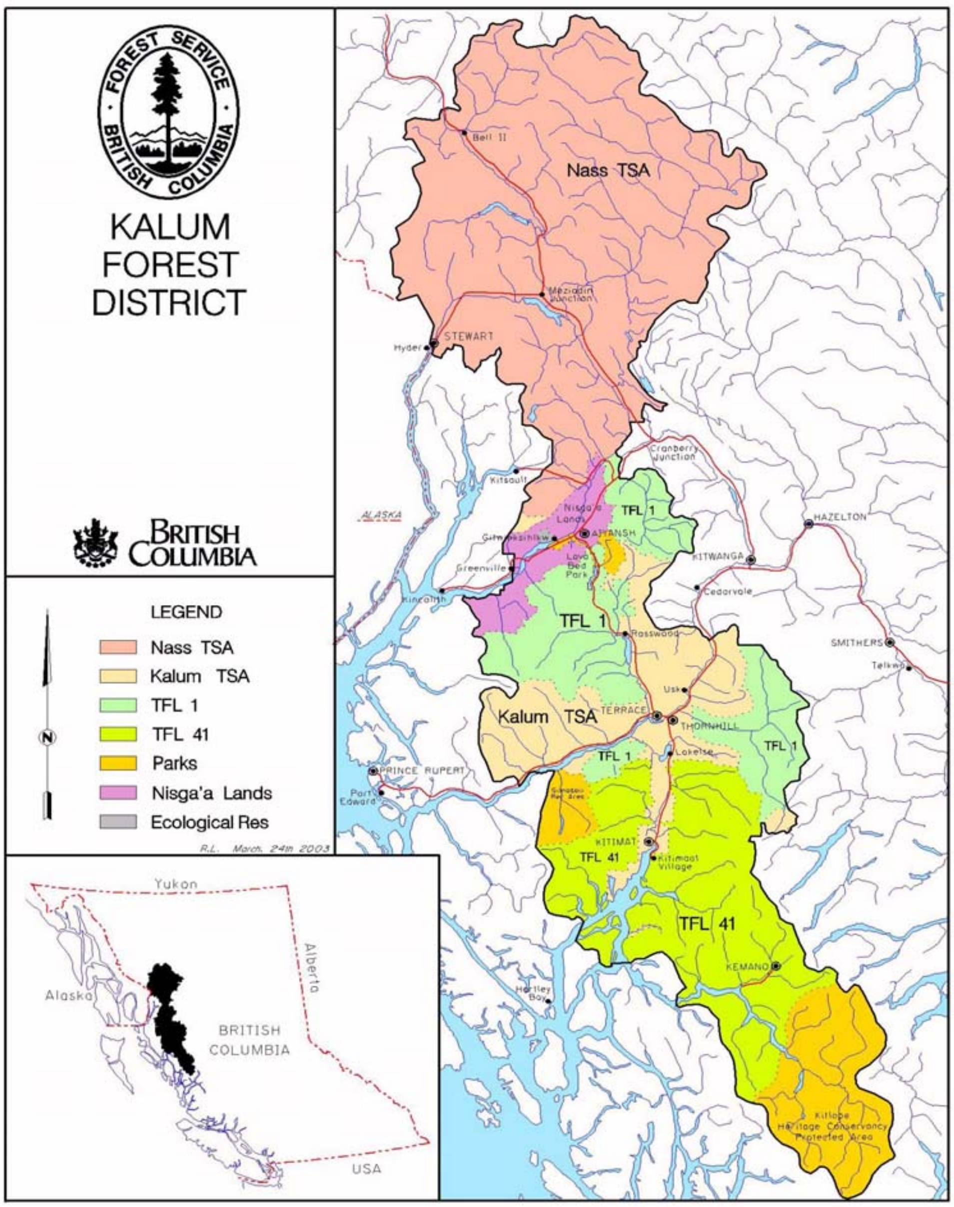

Figure 1. The Kalum Forest District

Table 1. Kalum TSA landbase[1]

Landbase Classification	Area (ha)	Total area (%)	Productive forest area (%)
Total Kalum TSA area	539,319	100.0	
Not managed by BC Forest Service	36,213	6.7	
Non-productive	305,698	56.7	
Total productive forest managed by Forest Service (Crown Forest)	**197,408**	**36.6**	**100**
Reductions to Crown Forest:			
Non-commercial cover (brush)	503	0.1	0.3
Inoperable	70,897	13.1	35.9
Humphreys reversion (to TFL)	906	0.2	0.5
Aspen, birch alder	4,041	0.7	2.0
Problem forest types	7,090	1.3	3.6
Low timber productivity	808	0.1	0.4
Existing roads	3,815	0.7	1.9
Environmentally sensitive	4,836	0.9	2.5
Riparian management area	4,625	0.9	2.3
Wildlife tree area	1,359	0.3	0.7
Exchamsiks	272	0.1	0.1
Total current reductions	**99,152**	**18.4**	**50.2**
Timber Harvesting Landbase	**98,256**	**18.2**	**49.8**

Based on TSA boundary and timber harvest landbase adjustments made in 2007, the area that is considered operable and within the vegetated treed landbase is very similar to the THLB at 97,622 ha. The target population for the inventory work proposed in this VSIP is stands greater than 30 years of age within the vegetated treed portion of the operable landbase.

Table 2. Kalum TSA area breakdown (ha) for the operational portion of the vegetated treed landbase.[2]

Dominant Species	Area of Mature	%	Area of Immature	%	Total Area	%
Hemlock	43592	86.4	29079	61.6	72671	74.4
Abies	3157	6.3	5968	12.7	9125	9.3
Spruce	1058	2.1	1667	3.5	2725	2.8
Pine	654	1.3	4375	9.3	5028	5.2
Cedar	961	1.9	819	1.7	1780	1.8
Deciduous	1021	2.0	5271	11.2	6292	6.4
Total	**50,443**	**100**	**47179**		**97,622**	**100**

[1] This landbase information is summarized from the 2000 Kalum Timber Supply Area Rationale for Allowable Annual Cut Determination.

[2] Area based on TSA boundary and timber harvest landbase adjustments made in 2007.

2.2 INVENTORY HISTORY

The vintage of information in the Kalum TSA inventory database is quite varied dating back from as early as 1961 (figure 2). The oldest interpretation dates are typically for areas of non-forest. In the vegetated treed portion of the TSA, there were four main inventory dates: 1976, 1988/89, 1992, and 1999 with corresponding photography from 1976, 1988, 1992, and 1997. A complete set of VRI attributes is only available for the areas updated in 1999 (primarily the Kitimat Valley) while for the rest of the TSA, the database and map files are typical of pre-VRI FC1 and FIP files. The database has been projected to 2004. Data base files were updated for depletions such as timber harvesting, fire, and silviculture treatments prior to the last timber supply analysis in 1999.

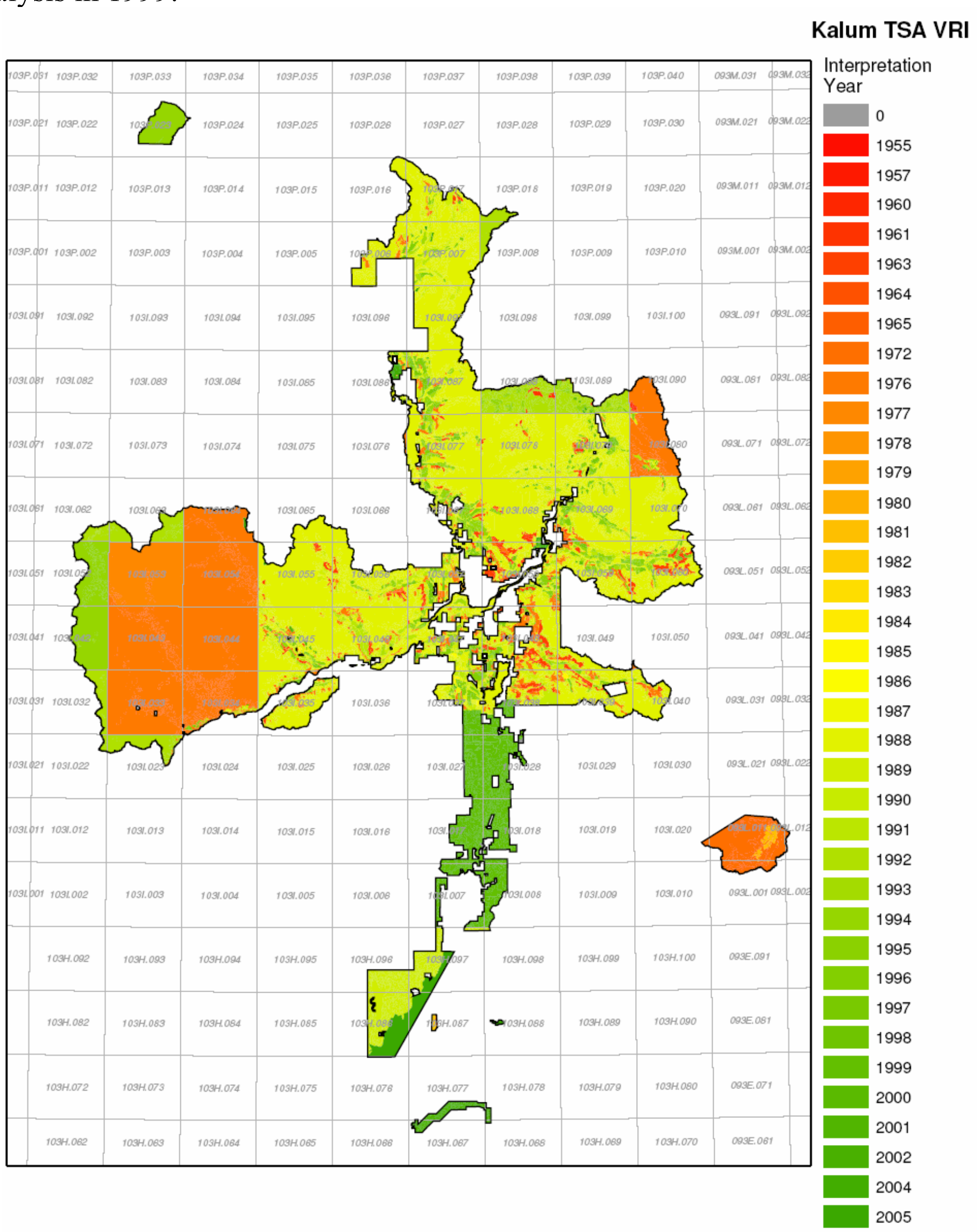

Figure 2. Interpretation dates for the Kalum TSA inventory database.

Since the last timber supply analysis, all mapsheets in the TSA were also shifted from NAD 27 to NAD 83 and 1:30,000 scale black and white air photos were acquired in 2001 (for the whole TSA) and, in 2003, for a relatively small area (a few flight lines on the western part of the TSA). These have been scanned and are available digitally as orthophotos. The rubber sheeting exercise used to shift from NAD 27 to NAD 83 has left a lot of slivers in the map files. The photos, which were not obtained strictly for vegetation inventory, are problematic, even with softcopy technology, because:

- scale is small,
- the 2001 photos are old
- they are not colour.

In early 2004 a VSIP was prepared for the TSA and, based on recommendations in it, a Phase II VRI was undertaken including 50 ground samples, Net Volume Adjustment Factor (NVAF) destructive sampling, an analysis of inventory adjustment factors, and application of these adjustment factors to the inventory database. The 50 VRI Phase II ground samples were established among two strata and three sub-strata (high, medium, and low volume stands where western hemlock was leading, and high, medium, and low volume stands where other species were leading). The target population was confined to the vegetated treed (VT) stands greater than 120 years of age within the operable landbase. Based on these criteria, the target population encompassed 77,068 hectares.

During the establishment of 25 of the ground samples noted above, 85 trees were destructively sampled (45 hemlock, 30 other species, and 10 dead) to determine if there were issues with hidden decay or taper equation bias (figure 2). A sampling error of ± 10% at the 95% level of probability was targeted. Actual net volume measured in the sample trees was compared to estimates of net tree volume based on taper equations and net factoring currently in use in VRI[3] The results of this study were used to produce four net volume adjustment factors:

- balsam/pine/spruce: 0.928,
- cedar/cypress: 1.013,
- hemlock: 0.951 and
- dead: 0.875.

The NVAF work was also used to assess the Forest Inventory Zone (FIZ) 1976 loss factors used in appraisal analysis and the old inventory. It was found that FIZ loss factors predicted lower volumes than what would be expected using the results of the NVAF study, however, this was not consistent across all risk groups and FIZ zones. It should also be noted that, in the Kalum area, local loss factors (other than the FIZ 1976 Loss Factors), based on intensive local sampling (over 1100 trees) conducted in 1988/89 exist for hemlock and balsam (other species use broad based zonal factors). The results of that study were never used in appraisal analysis or the old inventory.

[3] The old inventory for the Kalum used FIZ 1976 Loss Factors to predict volume reductions due to decay. These are still used today in appraisal analysis. They assign losses by class of trees (risk groups) that represent average levels of decay determined from historic destructive sampling. A new VRI uses net factoring (a cruiser's estimates of decay and waste) to assign decay loss by log based on the direct evidence of decay such as conks and scars. It also uses new taper equations that are different than those used in the old inventory.

Upon completion of the 2004 Phase II ground sampling noted above, the inventory database was adjusted for age and height. These changes led to new volume predictions (using VDYP). The new volume predictions were then additionally adjusted; based on the NVAF sampling, to produce adjusted volumes for the inventory database. Adjustment factors used in this process are summarized in table 3:

Table 3. Adjustment factors developed in the 2004 Phase II ground sampling and NVAF project.

	Hemlock Stratum	Other Stratum
Age	0.724	0.719
Height	0.931	0.832
Volume	1.005	1.013

Figure 3. 2004 NVAF sampling.

To date this data has not been uploaded to the BC government's Land and Resource Data Warehouse (LRDW), because Forest Analysis and Inventory Branch is currently migrating to a new data model (ARC GIS and new file formats) and will also be introducing an updated version of VDYP and new adjustment procedures (for 11 attributes instead of 3). It is expected that the analyses discussed above will be rerun using the new procedures and new model and, once the database is adjusted, it will be posted to the warehouse.

Other inventory information obtained in recent years includes:

- Predictive ecosystem mapping (PEM) (2004) and validation (2006/07) for the whole District, and
- Terrestrial ecosystem mapping on the Skeena Islands (2005)

The validation process for the PEM mapping was recently completed indicating but it did not meet RIC standards owing in part to the lack of accuracy in the database. The TEM mapping on the Skeena Islands was part of a larger study whose objectives were to examine the structure and dynamics of the Skeena floodplain ecosystems at the landscape and stand levels, and to rank forested ecosystems for their conservation value. The landscape level TEM used 1947, 1994 and the 2003 aerial photography noted above to determine floodplain dynamics and historical and present extent of red and blue-listed ecological communities.

2.3 INVENTORY AUDIT

An inventory audit was performed in the Kalum TSA in 1997. The inventory audit tested three components of the current inventory:

- the accuracy of timber volumes in mature forested areas (forest stands older than 60 years),
- the accuracy of the site growth potential (site index) of immature stands (younger than 60 years of age but older than free growing age),

- the accuracy of the photo-interpreted classification of non-forest types in the inventory (areas such as lakes, gravel pits, and alpine meadows).

Results of the audit indicated that:

- differences in mature timber volumes between the inventory database and the audit were not significantly different for either the entire land base or the operable land base.
- in immature stands, site index was underestimated in the inventory database by more than 3m in 12 of 20 stands (60%).
- 82% of stands assessed for non-forest classification were correct (the provincial minimum standard is 85%).

2.4 INVENTORY ISSUES

The next timber supply review for the TSA could begin as early as November 2007. Even if the preparation of the data package that supports the timber supply analysis took a year to produce, it would likely be too soon for any new inventory data to be available. This is a key consideration in deciding on timelines for any new inventory initiative or, alternatively, for choosing timelines for the timber supply review.

Key inventory issues that have been identified as important by Kalum TSA stakeholders include:

1. **Low statistical precision for inventory attributes associated with immature types and mature species other than hemlock**. With the completion of the statistical analysis and attribute adjustment following the 2004/05 Phase II work in the TSA, the precision of age, height, volume, and site index attributes in the database, for hemlock leading stands older than 120 years, is considered to be acceptable (a 95% probability that the sampling error is ± 15%). The reliability of database information on age, height, and volume for young stands (< 120 years) and for older stands dominated by species other than hemlock, is not as certain however. The Phase II work did not address immature stands and only seven mature, non-hemlock stands were sampled. While sampling error targets are met for two of the attributes in the non-hemlock, mature stratum (table 4), the basis for this assertion comes from a relatively small sample.

Table 4. Sampling errors (α = 95%) from the 2004 Phase II ground sampling**.**

Stratum	Age	Height	Volume	# Samples
Mature, Not Hw	23.6%	4.1%	11.8%	7

It should also be noted that the volume sampling error for mature hemlock leading stands is still somewhat high at about 13%. The objective for some business units has been 10% in the past.

2. **Inaccurate site index estimates for immature stands**. Phase II ground sample work was used to adjust height and age and thus derived site index values for stands greater than 120 years of age. This likely improved that accuracy of site productivity estimates although, as noted above, the sample intensity in stands with species other than hemlock was low. There was no equivalent adjustment for immature stands. What is known about the accuracy of site index values in young stands in the Kalum comes from the last

inventory audit. The inventory audit concluded that site index in immature stands was more than 3m lower in the inventory database than in sampled stands, 60% of the time. The chief forester, in his 1999 Timber Supply Analysis noted that stands less than 20 years of age occupy 27% of the timber harvesting land base, and stands between 20 and 100 years old occupy 29% of the timber harvesting land base.[4] He further noted that uncertainty regarding estimates of site productivity for regenerated stands could significantly change the mid-and long-term timber supply.

Given the inventory audit findings and the relatively large contribution of young stands to the allowable annual cut, it would appear that more accurate site index estimates would be a high priority. It should be noted, however, that the site index estimates commonly used in the database are derived; that is they are calculated based on age and height attributes in the database and site index curves developed for each species. These derived estimates have often been shown to be an inaccurate indication of the true productive capacity of the site. For example, in the 1998 OGSI (old growth site index) study, it was found that site index estimates for hemlock-leading stands greater than 140 years of age within the CWH biogeoclimatic zone were 10 metres lower than those for adjacent managed stands on the same ecological sites. OGSI and SIBEC estimates could be used to adjust the inventory database but the preference to date has been to make the adjustments in post inventory applications such as timber supply analysis. The chief forester applied these conversion factors to the Kalum base case for example. Nonetheless, it could be argued that, rather than undertaking further ground sampling to achieve better derived site index estimates in young stands, it would be more appropriate to simply use the OGSI estimates or possibly, SIBEC correlations once the PEM validation for the area is completed. However, given the need to acquire better information on the precision of young stand attributes identified in bullet one above, and the propensity of inventory experts to use site index values derived from inventory attributes rather than other sources, the priority for new derived site index estimates may be higher than would otherwise indicated.

3. **Potentially inaccurate taper equations and decay estimates in young stands in the inventory database.** In his 1999 timber supply analysis report the chief forester indicated that if existing volumes were actually 10% greater than those used for the base case, the current AAC could be maintained until decade five – two decades longer than in the base case. Not surprisingly, the analysis demonstrated that timber supply is quite sensitive to estimates of existing stand volume. Stakeholders in the Kalum TSA have long maintained that volume recovery from harvested stands is substantially lower than what is indicated in the inventory database. To provide greater precision around this issue, NVAF sampling was conducted in 2004 for stands greater than 120 years of age (35% of the trees were species other than hemlock, 47% were hemlock, and 18% were dead trees). The study assessed the accuracy of taper equations and decay estimates (net factoring) but did not find large differences (hemlock volumes were overestimated by about 5% and balsam/pine/spruce volumes were overestimated by about 7%). No sampling was conducted in stands younger than 120 years of age. It may be that similar

[4] Using recent adjustments to the TSA boundaries and the definition of operable, GIS analysis conducted as part of this project, indicate that stands less than 120 years occupy 48.3% of the landbase.

reductions are appropriate for younger stands but without further NVAF sampling, this cannot be ascertained.

4. **Inadequate aerial photos and old polygon line work**. As noted above, there have been a number of concerns in the past about the accuracy of the Kalum inventory. As a result, Phase II work was undertaken in 2004 to address decay estimates and the accuracy of height, age, and site index estimates in stands greater than 120 years of age. With further NVAF work (~ 30 trees) and limited ground sampling (~42 clusters) it is expected that the statistical precision of the existing data for old stands could be improved (reducing sampling error from 15% to 10%), and the accuracy of height, age, site index, and decay estimates in young stands could also be improved. It is unknown whether the spatial accuracy of polygon line work for the existing inventory is adequate. It is known however, based on analysis done in the preparation of the strategic inventory plans for the Nass TSA and TFL 41, that the 2001 and 2003 aerial photos are inappropriate for development of any new timber inventory.

   Given the vintage of the polygon linework in the existing inventory and the need to periodically update the database, there may be justification to undertake a new Phase I VRI complete with photo acquisition. The case would be strongest if there were other users that also needed new photography. Because it typically takes a couple of years to acquire and interpret all the photos for all parts of an inventory unit, this information is unlikely to be available for the next scheduled timber supply review (Nov. 2007). Another issue is that the database adjustments completed in 2004/2005 (based on the Phase II ground sampling and NVAF sampling) would have to be redone for the new database generated from the new Phase I inventory. It would also mean that the additional Phase II work described above would ideally be delayed until after the Phase I work is completed. This would not preclude undertaking Phase II field sampling concomitantly with Phase I work, but would mean that the analysis and adjustment would be done afterwards. Finally, if the additional Phase II work described in preceding bullets were undertaken, there is no indication that the existing inventory would not be adequate for the next few years for both operational use and timber supply analysis.

5. **Inaccurate wood quality estimates.** Stakeholders in the TSA have not only been concerned about recoverable wood volumes but also about wood quality (merchantability). VRI log grades are collected in ground samples and this information can be used to determine log grade profile within the inventory database. Call grading has also been conducted but never validated. The data from the 2004 sample should be revisited to determine if it is possible to extract log grade information from it and used in validation of any call grading. In any future NVAF sampling, this information should be compiled. Additionally, in future NVAF destructive sampling it may be beneficial to have a scaler assess log grade independently to evaluate the accuracy of VRI grade estimates. NVAF destructive data could also include a measurement of uneconomic sound wood to evaluate sensitivity around VRI net volume estimates.

6. **Potential inaccuracies in existing OGMA and seral stage classifications**. During the inventory attribute adjustment process conducted as part of the 2004 Phase II sampling

project, it was determined that the inventory ages were substantially overestimated relative to ground samples (adjustment factors used were 0.724 for hemlock and 0.719 for other species). As a result of the adjustment process, 49,441 ha were reclassified from age class 9 to a younger age class. This reclassification will have a substantial impact on recently identified old growth management areas (OGMAs) as well as seral stage targets recommended in the biodiversity guidebook. OGMA locations may have to be changed and a re-analysis of the degree to which seral stage targets have been met will be required. While this is not strictly an inventory issue, the database must be processed to a point that it can be used by planning foresters and others involved in forest management.

In addition to the key issues discussed above, a number of other forest management issues have been identified by stakeholders in the area as follows:

- Operability: This is something that is defined by users of inventory data based on inventory attributes rather than a directly measured attribute of the forest. This issue does not necessarily require further sampling but operability could be more accurately defined with more accurate Phase I attributes.
- Availability of predictive ecosystem mapping: This is an application for inventory data and is not currently measured directly during inventory activities. It is possible, however, for skilled photo interpreters, using softcopy technology, to interpret air photos to obtain site series and add it to the inventory database. Additionally, the likelihood of having an accuarate PEM product with poor inventory information is low.
- Minimum harvest age: More accurate information on height and diameter would help mills match logging with mill requirements. The decision on what is allowed to be logged, however, is a policy decision, not a data decision.
- Impact of WTPs, RMZs, OGMAs, VQOs etc on timber supply: Better inventory data obtained through VRI could result in more accurate impact estimates but this is essentially a GIS analysis and does not necessarily require more data to be collected.
- OAF values: Operational adjustment factors are an input variable in TASS, the model used to predict future volumes for managed stands. Currently the inventory database does not provide OAF values. While inventory protocols could potentially be changed to collect OAF values, there are already other systems in place to obtain this information.
- Better yield curves: Yield curves are used in VDYP to project future volumes and have a fundamental impact on timber supply. However, the curves have traditionally been developed through a growth and yield program using permanent sample plot data. Development of more accurate curves could be done in the future through change monitoring but this is a long term endeavour and is beyond the scope of a basic inventory program. Licensees may want to consider, however, how the phase II samples from immature stands could be used in a monitoring program.

2.5 VRI ACTIVITIES AND PRODUCTS

There are a number of VRI products and activities that could be used to address the issues identified in section 2.3. Some options have been summarized below. Actual recommendations are summarized in Section 3.0 – the inventory plan.

2.5.1 Phase One Photo Acquisition and Interpretation

A Phase I inventory involves subjective delineation of polygons and photo estimation of attributes for all polygons in an inventory unit from medium scale aerial photographs (1:15,000 or 20,000). This includes interpretation of conventional attributes such as: species, age, and height, as well as additional attributes such as: basal area, and soil moisture and nutrient classification. The VRI Phase I product is a spatial database consisting of unadjusted photo-interpreted estimates. In most modern VRI work, statistical adjustment is completed for a Phase I database. Statistical adjustment is the process of adjusting the values of the photo-interpretation variables using ground sampling observations obtained in a Phase II VRI. In each sampled polygon, field measurements are compared to photo-estimated values to develop adjustment factors, usually by groups (e.g. leading species). These factors are then applied to all polygons in the photo interpretation database group to produce the final adjusted database.

In the Kalum TSA, one option to address poor quality and outdated photography, and perceptions that polygon linework may be inaccurate, is to acquire new photography and use it to develop new maps and an updated attribute database. Phase II ground sampling, completed in 2004, could be used in place of, or in addition to, ground calls.

VRI Phase I photo acquisition and interpretation is estimated to cost $1.00 to $1.50/ha. Costs could be reduced by restricting the target area to the forest landbase only. Benefits from conducting this work could include:

- Complete 1:20,000 colour photo coverage of the TSA. The photos would be useful in a Phase I inventory and in many other forest management applications.
- Possible improvements in the accuracy of polygon attribute values, particularly important for immature stands (~ 57 % of the THLB) and stands with species other than hemlock leading. More accurate attribute values lead to more accurate future timber supply analyses and operational analyses such as timber harvest planning, WTP, RMZ, VQO, and OGMA delineation, and post-harvest survey work.
- Improved quality/accuracy of information available for inoperable stands, which may lead to a reconsideration of their accessibility and merchantability.
- New attributes such as height and age on secondary species as well as basal area and density for all species. This information will be used in VDYP7 and should improve estimates of existing and projected stand volumes.

However, there is no assurance that a new Phase I inventory will actually yield more accurate stand attribute estimates. This would have to be tested in a subsequent audit. As noted in section 2.3, the Phase II ground sampling and NVAF analysis and adjustments completed in 2004/2005 would have to be redone and further Phase II work on immature types and species other than hemlock would need to be deferred. It would also mean deferring the next timber supply analysis for three to four years and would preclude undertaking any innovative approaches to image acquisition such as the LIDAR/Hyperspectral approach (see below) for as much as 5 to 10 years. Current information indicates that, if the additional Phase II work described in section 2.3 were undertaken, the existing inventory database would be entirely acceptable for both operational use and timber supply analysis.

2.5.2 Acquisition of Phase I Data with a LiDAR/Hyperspectral System

The University of Victoria in partnership with Terra Remote Sensing Inc. of Sidney, B.C. has developed an integrated imaging platform. This platform is centered on three imaging technologies: digital photography, LiDAR, and hyperspectral imaging. The simultaneous collection, and integration, of data from all three sensors is made possible through the use of GPS (local base stations and on-board collection) and real-time navigation hardware and firmware. Positional accuracy better than 1 pixel is attainable. The instruments are permanently mounted in a twin engine Navajo aircraft. The relatively high speed of the aircraft allows for acquisition of up to 200 square km^2 per day, depending on pixel resolution. This platform was successfully flown last year in British Columbia, Alberta, and California.

To date the emphasis of the University of Victoria team has been on the extraction of forest attributes including inventory information, ecological data, and forest health information. In 2006, they initiated a pilot project with Canfor and the MoF in TFL 18 near Clearwater. In this project they acquired data for 60,000 ha of the TFL and are now processing and analysing the data to derive species composition, stand height, gap structure, and vertical canopy structure. It is possible with this system to map and measure individual trees.

One of the strengths of the approach being developed is it's repeatability and consistency over large areas (in contrast to variable interpretation in a conventionally produced inventory). Costs are initially higher ($4.00 to $5.00/ha) than is common with traditional aerial photography, data acquisition and interpretation, however, because of the detail and range of data collected it may often be possible to spread the costs amongst many users. For example one of the initial products of the LiDAR is a bare earth model. This is a digital elevation model where the height influences of vegetation has been removed and a more realistic representation of the ground surface is developed. This approach can typically generate an elevation model in with resolutions of 2-5 metres, depending on the vegetation density. Thus, projects such as PEM, TEM, terrain mapping and TRIM could partner to extract specific products from the data following VRI acquisition, potentially sharing the cost of data acquisition.

2.5.3 Phase Two Ground Sampling and Net Volume Adjustment Factors

Phase II ground sampling is the field measurement of timber, ecology, range, and/or coarse woody debris values at one or more locations within selected sample polygons. Sample polygons are selected using the probability proportional to size with replacement (PPSWR) method and plots are established in clusters within selected polygons.

NVAF sampling involves detailed stem analysis of sample trees, calculation of actual net volume, and calculation of the ratio between actual net volume and estimated net volume (where estimated net volume is obtained from net factoring and taper equations). NVAF data is used to adjust the estimated net tree volume to account for hidden decay and taper equation bias. NVAF should be performed in conjunction with timber emphasis plots. The application of NVAF produces statistically valid VRI ground sample volumes, and it is a mandatory activity of a VRI ground sample inventory.

The issues of decay, taper equation bias, and site index estimates in young stands (< 120 years of age), and the issue of low statistical precision of inventory attributes in older stands other than hemlock, could be addressed through the establishment of approximately 42 Phase II ground samples and 30 NVAF trees. It is possible that this work could be conducted in 2007 and potentially made available during the data package preparation phase of the next timber supply review scheduled to begin November, 2007. Benefits from conducting this work would include:

- More accurate decay estimates in young stands.
- Better estimates of derived site index.
- An overall sampling error (for volume) for mature stands of ~ 10%.
- Increased statistical power of inventory attributes associated with immature stands and non-hemlock leading mature stands.
- Log grade information for the immature stratum and a measure of the accuracy of VRI grade estimates (if a scaler were involved in the NVAF sampling).
- Increase accuracy of OGMA seral stage classification through more age samples,
- Provide a basis for developing more accurate taper equations or adjustments to taper for stands with species other than hemlock leading.

It should be noted that Phase II ground sampling activities are not dependent on the outcomes of Phase I photo-acquisition and interpretation products. It may be advantageous in the Kalum TSA to implement ground sampling prior to any photo interpretation, due to the amount of information that can be derived from ground sampling and applied to resolving recognized business issues.

3. INVENTORY PLAN

3.1 OVERVIEW

This section outlines a preliminary strategic inventory plan that could be used to address forest management issues defined by the stakeholders in the Kalum TSA. The toolbox of activities described below will be discussed with stakeholders, revised as necessary, and then used to develop a Vegetation Resources Inventory Project Implementation Plan (VPIP).

3.2 PHOTO ACQUISITION AND INTERPRETATION

3.2.1 Objectives

The objective with photo acquisition and interpretation is to produce an updated VRI with more accurate attribute information and polygon delineation. The information and the aerial photos themselves would be used in addressing a variety of forest management issues both within the timber harvest land base and outside it (OGMA delineation for example). It would include interpretation of conventional attributes such as species, age, and height; and additional attributes such as basal area, soil moisture and nutrient classification. Normally the VRI Phase I product is a spatial database consisting of unadjusted photo-interpreted estimates. Because of perceived budget limitations, timber supply review timelines, and uncertainties regarding the quality of linework in the existing inventory, it is recommended that photo interpretation be deferred until completion of Phase 2 activities noted below. It is expected, however, that air photo acquisition and scanning would be completed however.

It is also recommended that consideration be given in the future to testing the practicality and utility of the LIDAR/Hyperspectral approach to the acquisition of inventory data. This may be done on a smaller test area or, if the technology has matured enough, for a larger operational unit.

3.2.2 Target Area

It is expected that photos will be obtained for the entire TSA but will not include any large adjacent parks or protected areas. Future interpretation would likely be based on funding and needs identified at the time and, in the past, has typically included the entire landbase excluding large parks and protected areas.

3.2.3 Target Attributes

All attributes listed on the VRI photo interpretation attribute form should be targeted. A list of these attributes and the most recent photo interpretation standards can be found at: http://ilmbwww.gov.bc.ca/risc/pubs/teveg/vri-photointerp2k2/photo_interp2k2.pdf.

3.2.4 Standards

The acquisition and scanning of air photos will be in accordance with standards set by ILMB"s Base Mapping and Geomatic Services (BMGS). Interpretation will be conducted in accordance with the air and ground call calibration standards and standards for photo interpretation published and updated from time to time on the VRI website:

3.3 VRI TIMBER EMPHASIS GROUND PLOTS AND NVAF SAMPLING

3.3.1 Inventory Objectives

It is recommended that additional timber emphasis, Phase II ground samples be established, and additional NVAF work be undertaken. The objectives in undertaking this work are:

- Improve the statistical validity of timber age, height, volume, and site index estimates in stands less than 120 years of age.
- Obtain more accurate information on decay in young stands (<120 years old).
- Obtain an overall volume sampling error in mature stands of 10% at the 95% level of probability.
- Ensure that the inventory database reflects the findings of the Phase II work.
- Obtain inventory information in a timely manner so that it will be available for the next timber supply analysis.

3.3.2 Target Population

The target population for this work is the vegetated treed portion of the operational land base within the Kalum TSA. There are two separate strata for this work: mature stands greater than 120 years of age and immature stands older than 30 years but less than 120 years of age.

3.3.3 Sample Size

Ground Sampling

It is estimated that 92 sample clusters would be required to achieve an overall sampling error of 10% for volume in stands in the operational portion of the vegetated treed land base. Because 50 samples were already established in 2004, however, only another 42 would be required in 2007. Using area-based weighting, 8 additional clusters are needed in mature stands (in 2004 all 50 were established in mature stands) and 34 are needed in immature stands. This sample size is a conservative estimate based on the formula: Sample Size = t^2 x CV^2/SE^2, where the estimated coefficient of variation for volume is 48% and the target sampling error is 10% (at a 95% probability level). The actual CV of the Kalum was determined to be 37% using data from the inventory audit. Due to the differences in sample design between the inventory audit and VRI ground sampling, however, the CV was inflated to 48% for the purpose of determining sample sizes. If the greater emphasis was to be given to non-hemlock leading stands the 8 samples could change or potentially all be allocated to non-hemlock leading types.

NVAF Sampling
With respect to the proposed NVAF work, the CVs determined in the 2004 study for various species groups and the target sampling errors used at the time, provide some guidance for determining a sample size for NVAF in immature stands.

Table 5. Coefficients of variation and sample sizes from NVAF work in 2004.

	CV	Target Sampling Error
hemlock	**31.3**	**8 to 12%**
pine/balsam/spruce	**17.5**	**12 to 15%**
cedar	**12.0**	**12 to 15%**
dead potential	**40.9**	**20 to 30%**
all trees		**6 to 10%**

If immature stands were treated as a separate population, and it were assumed that CV's for mature NVAF trees were equal to or higher than for immature trees, a conservative sample size might be ~ 30 trees to achieve a sampling error of 10%. It is expected that decay in these immature stands will be less than in the older stands and the variation amongst trees may be smaller, however, taper error is still a concern and this justifies a higher sample size.

3.3.4 Sample Selection

Ground sample polygons would be selected randomly using the probability proportional to size with replacement (PPSWR) method and plots would be established in clusters within selected polygons. The VRI Vegetation Resources Inventory Sample Selection Procedures for Ground Sampling, ver. 3.3, 2002 should be used to guide sample selection. NVAF trees are selected from within the polygons in which ground samples were obtained. It is recommended that the 30 trees proposed for NVAF sampling be selected randomly from within 10 of the ground sample polygons.

3.3.5 Sampling Standards

VRI Timber Emphasis Plots (TEPs) will be established in accordance with the most recent version of the *VRI Ground Sampling Procedures Manual* , and the document *Vegetation Resources Inventory Data Collection Standards for VRI Ground Sampling*. NVAF work will be conducted in accordance with the most recent version of the *Net Volume Adjustment Factor Sampling Standards and Procedures*. These manuals are currently available at: http://www.for.gov.bc.ca/hts/vri/standards/index.html#sampleselection.

3.4 IMPLEMENTATION

3.4.1 Timelines

This VSIP outlines seven potential categories of work to be completed:

1. air photo acquisition,
2. ground calls and air photo interpretation,
3. map preparation,
4. database preparation,
5. Phase II ground sampling,
6. Phase II NVAF sampling, and
7. Phase II data analysis and database adjustment.

Phase II field work would ideally follow the air photo acquisition and interpretation tasks so that Phase II samples can be selected from an updated database and newly delineated polygons. However, if the risk of inappropriate polygon selection were not considered to be too great, ground sampling and NVAF sampling could be completed concomitantly with air photo acquisition and interpretation. Phase II analysis and database adjustment would normally be completed after photo interpretation and the unadjusted Phase I database has been completed, however, because of budget constraints and timber supply analysis timelines, it is recommended that the Phase II work begin in 2007. This will mean that analysis and adjustment stemming from the phase II work will need to be repeated once photo interpretation is completed. The additional cost associated with this should not be more than ~$15,000. Recommended timelines for all tasks, assuming the acquisition of air photos and phase II work begins in 2007, and that interpretation occurs subsequent to this, is shown in the gannt chart below.

Table 6. VRI timelines with photo acquisition.

	2007 Su	2007 Wi	2008 Su	2008 Wi	2009 Su	2009 Wi
Photo acquisition						
Photo interpretation						
Map preparation						
Phase II Gd Sampling						
Phase II NVAF						
Analysis and Adjustm						
Adjusted Dbase						

The timelines indicated in the table 6 could be achieved if all aspects of the project went smoothly and there were sufficient funding and certified crews available. Although the scenario suggested above means that updated linework (maps) will not be available until three years from now, it does provide a reasonable inventory by 2008, possibly in time for the currently scheduled timber supply analysis.

3.4.2 Project Implementation Plan

Once stakeholder input and approval of this VSIP has been obtained, a VPIP will be prepared in accordance with *Vegetation Resources Inventory Guidelines for Preparing a Project*

Implementation Plan for Ground Sampling and Net Volume Adjustment Factor Sampling, Ver. 2.0, March 2006 and *Vegetation Resources Inventory Guidelines for Preparing a Project Implementation Plan for Photo Interpretation*, Ver. 2.0, April 2006. It is expected that a VPIP for the Kalum TSA will be completed before the end of March, 2007.

3.4.3 Roles and Responsibilities

The three major stakeholder groups in the Kalum TSA are the forest licensees, the Ministry of Forests Analysis and Inventory Branch, and the Integrated Land Management Bureau. Roles and responsibilities of each in the VRI process are summarized below.
Licensees:

- Identify funding sources and relative priorities.
- Approve VSIP and VPIP products.
- Manage the implementation of the project implementation plan.
- Submit plans to the FIA fund manager (Price Waterhouse Coopers) for funding approval
- Submit plans to Forest Analysis and Inventory Branch for technical review.
- Submit data to Forest Analysis and Inventory Branch

Forest Analysis and Inventory Branch

- Develop standards and make them available to Licensee and inventory contractors.
- Develop yield models used in the inventory and timber supply analysis process.
- Provide technical advice and support.
- Review and approve plans to ensure the products will meet MoF business needs.
- Undertake inventory audits and report them to stakeholders.

Integrated Land Management Bureau

- Develop data archiving standards and make them available to inventory proponents.
- Maintain the Land and Resource Data Warehouse.
- Upload all inventory information to the LRDW.
- Ensure inventory users have appropriate access to the data warehouse.

4. COSTS

Estimated sample sizes and preliminary costs for the Kalum TSA VRI activities are listed in Table 7. More accurate and detailed costs for VRI activities will be included in the VPIPs once stakeholder feedback is received.

Table 7. Potential costs for VRI activities in the Kalum TSA

VRI Project Component	Unit Cost (est.)	Total Cost[1]
Photo acquisition	$0.080 - $0.090 / ha.	$17,000 - $45,900
Scanning	$0.045 / ha.	$9,000 - $24,300
VRI Phase 1 QA Audit (Third Party)	$ 0.030 / ha.	$6,000 - $16,200
Photo Interpretation and data prep	$0.90 - $ 1.10/ ha.	$220,000 - $ 594,000
Total Phase I Costs	$1.06 - $1.30	**$255,000 - $683,000**
Timber Emphasis Plot - timber and ecology data collection **[option 1 - 42 clusters]**	$1500 / sample	$63,000
Timber Emphasis Plot - timber data collection **[option 2 - 42 clusters]**	$1300 / sample	*$54,600*
Phase II QA Audit (Third Party)	$1000 / sample	$4,200
TEP heli costs (15% plots@ 1500)		$10,000
Compilation and analysis		$7,500
Inventory file adjustment		$6,000
sub total		**$90,700**
NVAF (30 trees)	$600 / tree	$18,000
NVAF QA Audit (Third Party)	$600 / tree	$1,800
Compilation and analysis		$5,000
Inventory file adjustment		$3,000
sub total		**$27,800**
Total Phase II Costs		**$118,500**[2]
All VRI Projects		**$801,500**[3]

[1] Target area is ranged between 200,000 and 540,000 ha.
[2] Cost includes TEP timber and ecology data collection [option 1]
3 Maximum costs from Phase I section.

5. APPROVAL

I have read and concur with the Kalum TSA VRI Strategic Inventory Plan, dated February 15th, 2007. It is understood that this is an agreement-in-principle and does not commit the signatories to completing the inventory activities outlined within the plan. Modifications to this plan or more detailed plans need to be reviewed and approved by the signatories.

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BC Timber Sales, Skeena Business Area

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West Fraser Timber Ltd.

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Coast Tsimshian Resources Limited Partnership

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Manager
Vegetation Resource Inventory; Forest Analysis & Inventory Branch

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