# Change Monitoring Inventory

## Ground Sampling Quality Assurance Procedures

Prepared by
Ministry of Sustainable Resource Management
Terrestrial Information Branch
for the Terrestrial Ecosystem Task Force
Resources Inventory Committee

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The Resources Inventory Committee consists of representatives from various ministries and agencies of the Canadian and the British Columbia governments as well as from First Nations peoples. RIC objectives are to develop a common set of standards and procedures for the provincial resources inventories, as recommended by the Forest Resources Commission in its report "The Future of our Forests".

For further information about the Resources Inventory Committee and its various Task Forces, please access the Resources Inventory Committee Website at:
http://www.for.gov.bc.ca/ric.

## Terrestrial Ecosystems Task Force

The Vegetation Inventory Working Group was formed in 1993 and issued their final report in March 1995 on a "Proposed New Inventory" for British Columbia. The Ministry of Forests, Resources Inventory Branch, in cooperation with the Ministry of Environment and other Ministry of Forests branches and consultants, developed the suite of Vegetation Resources Inventory Procedures based on the recommendations in that report. Many individuals were involved in writing the original version of the various Vegetation Resources Inventory Procedures documents.

For questions concerning the content of this publication please contact the:

Vegetation Resources Inventory Coordinator
c/o Ministry of Sustainable Resource Management
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## Introduction

The Ministry of Forests, Resources Inventory Branch, is establishing Change Monitoring Inventory (CMI) ground sample plots across the Province on a grid to monitor the changes and trends over time of the timber and non-timber resources of British Columbia. These samples are to be re-measured periodically on a 5 to 10 year cycle. A quality assurance audit is performed concurrently with the ground sampling.

Two monitoring/checking processes are used to ensure that quality field measurements are being collected in the ground sampling phase:

Quality Assurance is an external process, whereby the work is evaluated based on approved standards by an independent auditor and rated as having passed or failed. The auditor must be an experienced individual capable of conducting quality measurements and assessments to ensure the ground sampling procedures have been conducted within standards. There should be an arm's length relationship between the QA examiner and the crew being evaluated.

Quality Control is an internal process, whereby the proponent, delegate or contractor ensures that the fieldwork is being done to the required standards in accordance with the procedures. This is the opportunity for the proponent/delegate/contractor to provide additional training to field crews.

The procedures described here are the quality assurance procedures of the Ministry of Forests to be implemented on CMI ground sampling plots. It is expected that field sampling crews will have their own quality control procedures.

The objectives of the audit are to:

- provide feedback to improve sample quality
- provide information for contract administration.

The auditor identifies substandard sampling work and provides feedback to improve the crews' performance. Another important aspect of the auditor's work is to provide positive feedback to sampling crews on a task well done.

An important issue for contract managers is whether the completed work is acceptable. Pass/fail standards have been established for important attributes. Pass /fail standards have also been established for compiled sample results, such as gross and net volumes. If the audit shows a batch does not meet these standards, the batch fails and must be revisited.

A separate document, *Change Monitoring Ground Sampling Quality Assurance Standards,* provides the standards of accuracy for CMI attributes measured from ground samples. A standard is a maximum allowable error for a given attribute. The standards are based on levels of precision achievable by auditors and were developed in consultation with a group of auditors in the various fields.

It is intended that quality assurance audits will be carried out as soon as possible after the samples are completed.

The flowchart in Figure 1 provides an overview of the ground sampling and audit process for the CMI.

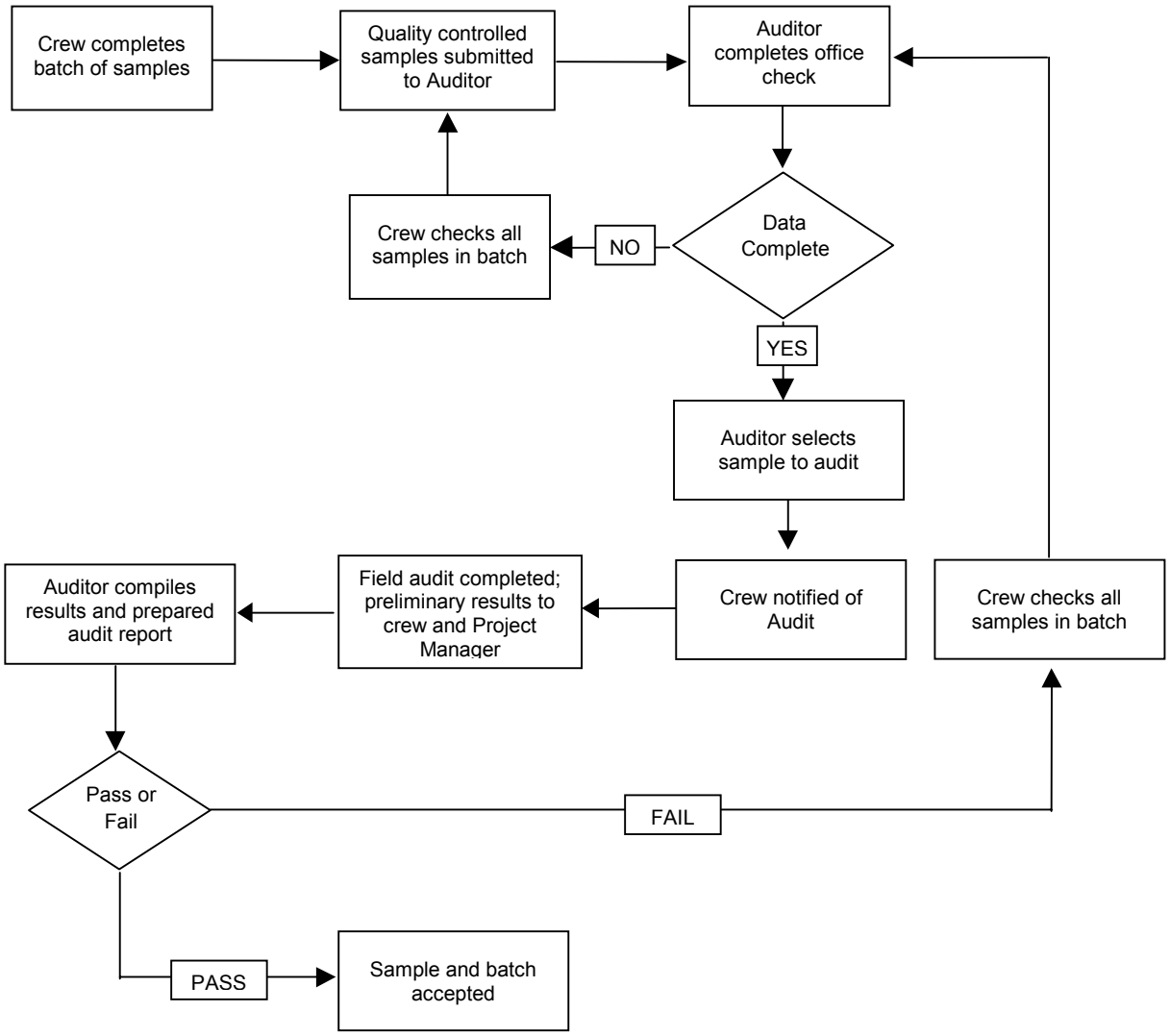


**Figure 1. Flowchart of the ground sampling and audit process.**

# Objectives

The audit process has two main objectives:

- to provide feedback to improve sample quality
- to provide information for contract administration.

## Feedback

Feedback from the audits is important for the continual improvement in sample establishment. The auditor will note any problems found in the audits so that the field crews will be aware of areas where they may require improvement. Positive feedback is also valuable in improving sample measurements. To successfully accomplish this objective the crews should be audited early in the project and subsequent batches should be audited as soon as possible after they are submitted. The field crews will benefit from accompanying the auditor in the field and are encouraged to attend especially on the initial audits

## Contract Administration

The audit provides the contract administrator with information about the quality of the work being completed. Standards have been established for the location, measurement and submission of samples. Pass/fail standards have been set for key attributes as well as compiled results. Contract administrators will use the pass/fail criteria as the basis for payment.

# Audit Principles

## Plot Selection

An audit system requires a statistically valid sample of ground samples. For the sample to be valid, four criteria must be met:

1. Batches of samples must be established. The criteria for defining a batch will be discussed at the pre-work conference.

2. Audit samples must be chosen randomly within each batch.

3. The selection probability (i.e., number of audit samples divided by total number of samples) must be known and recorded.

4. The list of samples included in a batch must be recorded with all samples having a chance of being selected.

It is recommended that a minimum of 10% of all samples should be audited and that auditing be more frequent at the beginning of the project.

### Sample Batches

The exact batch sizes for each project will vary, however the following are some principles that should be kept in mind when determining batch size and composition. To ensure early detection of potential errors the initial batch(s) should be small (3-5 samples) and should be separated by crew leader. Future batch sizes and the composition of each, (crew leader or company) will be based on the outcome of the initial audits.

### Pass/Fail Attributes

Pass/fail standards have been set on selected attributes to ensure that the work meets minimum standards. These pass/fail attributes are outlined in the CMI *Ground Sampling Quality Assurance Standards.*

### Batch Submission Requirements

It is expected that all submitted batches will be complete as set out in the pre-work conference. This includes requirements for air photos, maps, field cards and any other project specific information. The field cards for all samples in the batch must be complete before the auditor will field audit any sample in the batch. All samples in the batch will be returned if the batch is not complete when submitted.

### Evolution of Procedures and Standards

The VRI has a change management process in place and any required changes to the ground sampling procedures and standards are referred through this process.

Feedback concerning ground sampling standards should be directed to:

Vegetation Resources Inventory Coordinator
Terrestrial Information Branch
Ministry of Sustainable Resource Management
722 Johnson Street
P.O. Box 9993
Victoria, B.C. V8W 9R7
Telephone: (250)387-1314

http://www.for.gov.bc.ca/resinv/Veginv/ChangeMgmt00/change.htm

## General Procedures

1. Select the samples to audit.
2. Perform office checking.
3. Perform field audit.
4. Prepare audit summary.

# Detailed Procedures

The following procedure is to be followed in auditing ground sampling data collection for the Change Monitoring Inventory.

## Selecting Sample Plots to Be Audited

1. Determine the batch to be audited.
2. Randomly select the sample(s) to audit from the batch and document the selection. If weather, safety or access restrictions do not allow the sample to be audited, another audit sample may be randomly selected to satisfy contract administration requirements. Any time an audit sample is replaced the reasons must be documented.

## Office Checking

Complete an office evaluation of all samples in the batch. If any of the samples are incomplete or errors are noted, all samples will be returned and the audit will take place when the completed batch is returned. All corrections or additions to the field cards, after the field crew has left the field, must be done in **red** ink on the original cards.

If all samples in the batch are complete, then a thorough office check of the selected audit sample will be done.

1. Complete an office evaluation of the air photo location and map information, and an initial assessment of the plot data, looking for errors or omissions. Any concerns will be documented for the field audit.

2. Notify the field crew and project manager that an audit will take place. It is recommended that the original field crew accompany the auditor, especially in the early phase of the project.

## Field Audit

The Change Monitoring ground samples can take from one to three days for the original "three person" field crew to complete. The intent is to complete the ground sample audit in one day with a two or three person audit crew. Therefore it is "usually" necessary to split the sample and only re-measure a portion of the sample. The selection of which attributes and the number of attributes to be measured should be made prior to visiting the field site. The suggested methodology for splitting the plot is listed below.

1. Perform a field audit of the selected sample.
    - Audit fully the locating and marking of the sample location.
    - After the plot location has been assessed the suggested procedures to split the sample plot are as follows:

**[A] Tree component**

| | |
|---|---|
| Large trees | Randomly select one quadrant to re-measure. If less than 20 trees are encountered in this quadrant then randomly select an additional quadrant to re-measure. The full suite of measurements are taken on the selected trees plus the determination of missing or extra trees within the selected quadrant(s). |
| Small tree plot | If time does not permit a full re-measurement of the small trees by classes conduct a total count ignoring the class breaks for the small trees. |
| Stumps | Re-measure all stump attributes. |
| Age and Height tree selection | Confirm the selection of all "age height" trees for top height and all site trees for all quadrants. |
| Stem mapping | Re-measure the stem mapped trees and sample IPC marking. |
| Reference pin to IPC distance | Re-measure the distance and bearing from the Reference pin to the IPC pin. |

**[B] Ecological Component**

| | |
|---|---|
| Coarse woody debris | • Select randomly one transect.<br>• For round pieces collect species, diameter and decay class for the piece.<br>• For accumulations and/or odd shaped pieces, collect species, horizontal length and vertical depth on transect, and decay class for the piece. |
| Range data | • Use the same transect as randomly selected for the CWD.<br>• Measure all values for the one transect. |
| Ecological Description [EP] | Collect the following attributes [1] Uniformity, [2] Biogeoclimatic unit, [3] Site series and coverage, [4] SMR, [5] SNR, [6] Land cover classification, [7] Slope, [8] Aspect, [9] Elevation, [10] Surface shape, and [11] Meso slope. Collect 7 to 11 on card ED if required. |
| Tree and shrub layers [ET] | Collect the following attributes [1] Uniformity, [2] Biogeoclimatic unit, [3] Site series and coverage, [4] SMR, [5] SNR, [6] Land cover classification, [7] Slope, [8] Aspect, [9] Elevation, [10] Surface shape, and [11] Meso slope. Collect 7 to 11 on card ED if required. |

| | |
|---|---|
| Herb and moss layers [EH] | Collect data as usual for those species with ≥ 1 % coverage. Do the overall % cover estimate for the C, and applicable D layers. |
| Succession inter-pretations [EO] | Collect all attributes as usual excluding attribute 29 (tree succession species). |

2. Complete a "blind" audit of the field data without checking the original field cards. The auditor will have to review the basic plot size data and plot procedures used but must not review the actual collected data. This independent estimate is required to quantify the measurement reliability.

3. After collecting the initial audit data, crosscheck the original plot data in the field to validate similar data and assess measurement differences.
   - If errors are detected in the initial audit data these errors will be noted but the audit sample data should not be changed.
   - No changes are to be made to the original field data cards at this time. If clerical errors or data omissions have been identified that must be corrected, to enable the data to be processed, the entries will be entered in **red** ink on the original field cards. The project manager decides who will enter the data.
   - Document the major discrepancies or favourable measurements found, in the comments section on one of the field cards before leaving the sample
4. The preliminary audit results should be presented to the field crew and project manager as soon as practical following the audit.

## Preparing the Audit Summary

1. Complete a summary report for each audit sample. Summary reports will vary by project and the format will be determined at the pre-work conference. An example of a summary report is found in Appendix 2.

2. Compile the audit sample to determine whether the data meets the established pass/fail criteria. If the pass/fail criteria are not met, the sample fails. In this case the “batch” of work will fail and the crew will be instructed to revisit, at their own cost, all samples in the batch to correct the items identified as contributing to the rejection. The batch of samples will then be subject to an additional audit.

3. Provide feedback to the field crews and project manager about any items that may need work.

4. The project manager will be advised in "writing" of the samples that comprised the batch, which sample was selected for audit, and the results of the audit. The audit summary will be attached for reference.

# Appendix 1 - Auditor's List

## Vegetation Resources Inventory

**Project** Jones Creek **Auditor** J. Smith

**Sampling Crew Leader** Bob Johnson **Tree Attributes** ☐ **Ecological Attributes** ☐

| Random Order | Plot Cluster No. | Date Sample Completed | Audit Batch | Audited (Partial / Full) | Date Audited | Pass / Fail | Comments |
|---|---|---|---|---|---|---|---|
| 1 | 27 | May12 | 1 | | | | |
| 2 | 23 | May 13 | 1 | Full | May21 | Pass | |
| 3 | 7 | May15 | 1 | | | | |
| 4 | 13 | May16 | 2 | | | | |
| 5 | 17 | May17 | 2 | Full | May 26 | Fail | |
| 6 | 11 | May18 | 2 | | | | |
| 7 | 3 | May19 | 2 | | | | |
| 8 | 15 | May20 | 2 | | | | |
| 9 | 19 | May23 | 3 | | | | |
| 10 | 8 | May24 | 3 | | | | |
| 11 | 20 | May25 | 3 | | | | |
| 12 | 4 | May26 | 3 | Full | June1 | Pass | |
| 13 | 13 | May28 | 2 | | | | Re-audit |
| 14 | 17 | May28 | 2 | | | | Re-audit |
| 15 | 11 | May29 | 2 | Full | June1 | Pass | Re-audit |
| 16 | 3 | May29 | 2 | | | | Re-audit |
| 17 | 15 | May30 | 2 | | | | Re-audit |
| 18 | 47 | June1 | 4 | | | | |
| 19 | 54 | June2 | 4 | | | | |
| 20 | 12 | June3 | 4 | | | | |
| 21 | 46 | June4 | 4 | | | | |
| 22 | 5 | June7 | 4 | | | | |
| 23 | 1 | June8 | 4 | | | | |
| 24 | 16 | June9 | 4 | | | | |
| 25 | 25 | June10 | 4 | Partial | June12 | Pass | |
| 26 | | | | | | | |
| 27 | | | | | | | |
| 28 | | | | | | | |
| 29 | | | | | | | |
| 30 | | | | | | | |
| 31 | | | | | | | |
| 32 | | | | | | | |
| 33 | | | | | | | |
| 34 | | | | | | | |
| 35 | | | | | | | |

# Appendix 2 – Audit Selection List

**Project**: Jones Creek

| Random Order | Sample Number | Audit Selection | |
|---|---|---|---|
| 1 | 27 | Full | Crew Leader Bob Johnson |
| 2 | 23 | | |
| 3 | 7 | | Batch # 1 |
| 4 | | | |
| 5 | | | Random # selected 2 |
| 6 | | | |
| 7 | | | Date May 17, 2001 |
| 8 | | | |
| 9 | | | Auditor J. Smith |
| 10 | | | |
| 11 | | | |
| 12 | | | Ecology ❑ |
| 13 | | | Trees ☑ |
| 14 | | | |
| 15 | | | |

| Random Order | Sample Number | Audit Selection | |
|---|---|---|---|
| 1 | 13 | Full | Crew Leader Bob Johnson |
| 2 | 17 | | |
| 3 | 11 | | Batch # 2 |
| 4 | 3 | | |
| 5 | 15 | | Random # selected 2 |
| 6 | | | |
| 7 | | | Date May 23, 2001 |
| 8 | | | |
| 9 | | | Auditor J. Smith |
| 10 | | | |
| 11 | | | |
| 12 | | | Ecology ☑ |
| 13 | | | Trees ☑ |
| 14 | | | |
| 15 | | | |

# Appendix 3 - Sample Audit Report

## Office Check

Sample Number: _____

Field Crew: _____ Original Sample Date:_____

Audit Crew: _____ Date of Check: _____

Complete any comments as required in the following sections.

**A. Field Navigation and Plot Layout**
Compass Card [CP], Cluster Header Card [CH], Cluster Layout Card [CL]

**B. Tree Measurements**
Tree Detail Card [TD], Tree Loss Indicators Card [TL], Small Tree and Stump Card [TS], Auxiliary Plot Card

**C. Ecological Measurements**
Ecological Description 1 [EP], Ecological Description 2 [ED], Tree and Shrub Layers [ET], Herb and Moss Layers [EH], Succession Interpretations [EO]; unknown samples correctly processed

**D. Range and Coarse Woody Debris Measurements**
Range Transect 1 [RS], Range Transect 2 [RT], Coarse Woody Debris Transect 1 [EW], Coarse Woody Debris Transect 2 [EC]; clipped samples processing

*(If necessary, please attach page for additional comments)*

# Summary Audit Report
# Establishment And Tree Attributes

Sample Number: _____

Field Crew: _____ Original Sample Date: _____

Audit Crew: _____ Date of Check: _____

**Field Navigation**

1. Tie point/tie line

_____

_____

_____

_____

2. Reference tree/pin

_____

_____

_____

_____

3. Integrated plot marking

_____

_____

_____

_____

4. Large Tree measurements:

   [a] Plot type/ prism selection

_____

_____

_____

_____

[b] Trees In/Out

| **Plot** | **Original** | **Check** | **Comments** |
|---|---|---|---|
| Integrated | | | |
| North | | | |
| East | | | |
| South | | | |
| West | | | |
| **Total** | | | |

Comments: _____

_____

_____

_____

5. Completion of Auxiliary Plots/Split Plots/Border Plots

_____

_____

_____

_____

6. Attribute Measurement Error calculations

| **Attribute** | **Number of measurements** | **Measurements out of range** | **Percentage acceptable** |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

7. Site Index Values

| Plot | Site Tree | Original | | | Audit | | | % Diff. |
|---|---|---|---|---|---|---|---|---|
| | | Age | Height | SI | Age | Height | SI | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

**RECOMMENDATIONS**

_____

_____

_____

_____

Training Required: Yes ❑ No ❑

Attributes requiring training: _____

_____

I hereby confirm that the above information was collected as recorded.

Auditor [signature]:_____ Date:_____

*(If necessary, please attach page for additional comments)*

# Summary Audit Report
# Ecological Attributes

Sample Number: _____

Field Crew: _____ Original Sample Date: _____

Audit Crew: _____ Date of Check: _____

1. Coarse Woody Debris measurements

2. Range measurements

3. Site Classification

4. Site Features

5. Soil Features

6. Soil Description

7. Tree and Shrub Layers

8. Herb and Bryoid Layers

9. Succession Interpretation

10. Processing of Unknown Species

| Attribute | Number of measurements | Measurements out of range | Percentage acceptable |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
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| | | | |
| | | | |
| | | | |

**RECOMMENDATIONS**

_____

_____

_____

_____

Training Required: Yes ❑ No ❑

Attributes requiring training: _____

_____

I hereby confirm that the above information was collected as recorded.

Auditor [signature]:_____ Date:_____

# Appendix 4 - Height Calculation Worksheet

## Vegetation Resources Inventory
## Ground Sampling Height Calculation Worksheet

**Project:** Jones Creek **Auditor:** J. Smith

**Sample Number:** 23 **Crew Leade** Bob Johnson

| Plot | Tree Number | Audit Height | Original Height | Absolute Difference | Percentage Difference | Comments |
|---|---|---|---|---|---|---|
| IPC | 1 | 21.6 | 22.3 | 0.7 | 3.2% | |
| IPC | 2 | 35.5 | 35.1 | 0.4 | 1.1% | |
| IPC | 3 | 26.2 | 27.3 | 1.1 | 4.2% | |
| IPC | 4 | 2.4 | 2.6 | 0.2 | 8.3% | curved stem |
| IPC | 5 | 12.8 | 12.6 | 0.2 | 1.6% | |
| IPC | 6 | 16.8 | 17.5 | 0.7 | 4.2% | Broken top |
| IPC | 8 | 8.7 | 9.0 | 0.3 | 3.4% | |
| IPC | 9 | 3.1 | 3.0 | 0.1 | 3.2% | |
| IPC | 10 | 27.1 | 26.8 | 0.3 | 1.1% | |
| IPC | 11 | 28.3 | 28.8 | 0.5 | 1.8% | |
| IPC | 12 | 23.0 | 22.7 | 0.3 | 1.3% | |
| IPC | 13 | 8.3 | 8.6 | 0.3 | 3.6% | |
| IPC | 14 | 16.8 | 16.9 | 0.1 | 0.6% | |
| IPC | 15 | 34.8 | 34.1 | 0.7 | 2.0% | |
| IPC | 16 | 25.9 | 26.2 | 0.3 | 1.2% | |
| IPC | 17 | 2.2 | 2.3 | 0.1 | 4.5% | |
| IPC | 18 | 28.0 | 27.7 | 0.3 | 1.1% | |
| IPC | 19 | 35.8 | 34.9 | 0.9 | 2.5% | |
| IPC | 20 | 4.8 | 5.0 | 0.2 | 4.2% | |
| IPC | 21 | 16.8 | 16.7 | 0.1 | 0.6% | |
| IPC | 22 | 4.7 | 4.6 | 0.1 | 2.1% | |
| IPC | 23 | 27.1 | 27.1 | 0.0 | 0.0% | |
| | | | | 0.0 | | |
| | | | | 0.0 | | |
| Totals | 22 | 410.7 | | 7.9 | | |

Average Percentage Diference = Total Absolute Difference/Total Audit Height *100

Average Percentage Difference = 1.9%

# Appendix 5 - DBH Calculation Worksheet

## Vegetation Resources Inventory
## Ground Sampling DBH Calculation Worksheet

**Project:** Jones Creek **Auditor:** J. Smith

**Sample Number:** 23 **Crew Leade** Bob Johnson

| Plot | Tree Number | Audit DBH | Original DBH | Absolute Difference | Percentage Difference | Comments |
|---|---|---|---|---|---|---|
| IPC | 1 | 23.3 | 23.5 | 0.2 | 0.9% | |
| IPC | 2 | 56.9 | 57.2 | 0.3 | 0.5% | |
| IPC | 3 | 34.0 | 34.7 | 0.7 | 2.1% | |
| IPC | 4 | 4.1 | 4.0 | 0.1 | 2.4% | |
| IPC | 5 | 16.9 | 17.0 | 0.1 | 0.6% | |
| IPC | 6 | 89.0 | 91.2 | 2.2 | 2.5% | |
| IPC | 8 | 12.8 | 12.6 | 0.2 | 1.6% | |
| IPC | 9 | 5.3 | 5.5 | 0.2 | 3.8% | original measured below whorl |
| IPC | 10 | 52.7 | 52.9 | 0.2 | 0.4% | |
| IPC | 11 | 45.8 | 47.0 | 1.2 | 2.6% | |
| IPC | 12 | 34.7 | 34.7 | 0.0 | 0.0% | |
| IPC | 13 | 12.9 | 12.8 | 0.1 | 0.8% | |
| IPC | 14 | 23.8 | 23.6 | 0.2 | 0.8% | |
| IPC | 15 | 74.9 | 75.9 | 1.0 | 1.3% | |
| IPC | 16 | 51.1 | 50.9 | 0.2 | 0.4% | |
| IPC | 17 | 4.9 | 5.0 | 0.1 | 2.0% | |
| IPC | 18 | 39.8 | 39.6 | 0.2 | 0.5% | |
| IPC | 19 | 60.0 | 61.8 | 1.8 | 3.0% | |
| IPC | 20 | 7.9 | 7.8 | 0.1 | 1.3% | |
| IPC | 21 | 24.6 | 24.6 | 0.0 | 0.0% | |
| IPC | 22 | 7.2 | 7.4 | 0.2 | 2.8% | |
| IPC | 23 | 59.0 | 58.4 | 0.6 | 1.0% | |
| | | | | 0.0 | | |
| | | | | 0.0 | | |
| Totals | 22 | 741.6 | | 9.9 | | |

Average Percentage Diference = Total Absolute Difference/Total Audit DBH *100

Average Percentage Difference = 1.3%