Using FPInterface to Estimate Availability of Forest-Origin Biomass in British Columbia: Prince George TSA

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Abstract

Based on inventory information and a 20-year harvest queue, estimates of the amount of biomass available from forest harvest residues are estimated in $10 increments of delivered cost. For the Prince George Timber Supply Area, 155,000 odt/year is projected to be available at $60/odt at six delivery points in the TSA.

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1. Executive summary

In 2011 FPInnovations used FPInterface to develop and demonstrate a method for estimating available forest-origin biomass in British Columbia's Timber Supply Areas: the test case was the Quesnel TSA. In 2012 the method was refined and applied to the Williams Lake TSA. The method was subsequently applied to the Prince George TSA, and the results from that analysis are reported here. The biomass inventory was based on 20-year harvest and road network plans for Crown land (excluding Woodlot Licenses, Tree Farm Licenses, Community Forest Agreements, and First Nations tenures) provided by the British Columbia Ministry of Forests, Lands and Natural Resources. Delivery points for biomass (i.e., possible bioenergy mill sites) were designated at Prince George, Bear Lake, Dunkley, Vanderhoof, Fort St James, and Fraser Lake. Additionally, the town of Burns Lake, which is actually in the Lakes TSA but is just outside the boundary of the Prince George TSA, was designated as a mill site to see if any volume would logically flow there for least cost. All planned blocks were assumed to be clearcut harvested, processed at roadside, and accessible to comminution operations.

The total biomass delivered to the seven delivery points over Years 1 to 10 was projected to be 8.8 million ODT. About 1.5 million ODT (or approximately, 150 000 ODT/year) were available at $60/ODT. The amount of biomass available in Years 11 to 20 was about 160 000 ODT/year at $60/ODT. If the acceptable price of delivered biomass rises to $90/ODT, then available biomass would be about three times greater.

More than half the available volume at $60/ODT in Years 1 to 10 is available at Fort St James. As the price rises, more volume becomes available at each location. Prince George, Dunkley, and Bear Lake, in particular, receive much more volume in Years 11 to 20 than in the first.

2. Introduction

In order to progress toward full implementation of a bioeconomy in British Columbia a key piece of information is needed—i.e., a detailed inventory of economically available biomass.

To address this need, in 2011 FPInnovations undertook a project in partnership with the Inventory Branch of the British Columbia Ministry of Forests, Lands and Natural Resource Operations (MFLNRO). The specific goals of the project were to develop a process for calculating biomass inventories in Timber Supply Areas in the Central Interior. The projections of biomass availability were based on 20-year harvest and road network plans for Crown land (excluding Woodlot Licenses, Tree Farm Licenses, Community Forest Agreements, and First Nations tenures) provided by the British Columbia Ministry of Forests, Lands and Natural Resource Operations (MFLNRO).

In 2011 FPInnovations developed a method for estimating available forest-origin biomass in British Columbia's Timber Supply Areas (TSA), using FPInterface: the test case was the Quesnel TSA (Friesen & Goodison, 2011). In 2012 this method was refined and applied to the Williams Lake TSA (Friesen, 2012), and also to the Prince George TSA, for which the outcomes are reported here. The aim in providing this information is to help decision makers better understand biomass availability when preparing industrial proposals.

Detailed introductory statements describing the background and rationale of this project and the greater project as a whole are in Friesen & Goodison (2011).

3. Objectives

As abridged from the report about the Quesnel TSA (Friesen & Goodison, 2011) the objectives were:

Calculate biomass supply for volume based tenures in the Prince George Timber Supply Area (TSA). The desired outputs are:

a. A map showing delivered cost of biomass from point of origin by cost gradation

b. A table showing the amount of biomass delivered at different price points – The market value of 1 oven-dried tonne (ODT) of biomass is not clear, but $60 was set as the agreed-upon threshold at which to determine commercial biomass availability.

4. Methods

Overall process

The basic methodology was established during analysis of the Quesnel TSA (Friesen & Goodison, 2011), which was the first TSA to be examined, which was then modified for the Williams Lake TSA analysis (Friesen, 2012). Any differences or points of particular saliency are noted in the Methods section below.

Data acquisition

Data layers for the Prince George TSA (excluding Woodlot Licenses, Tree Farm Licenses (TFL), Community Forest Agreements, and First Nations tenures), including Vegetation Resources Inventory polygons with attributes and road linework with attributes, were acquired from MFLNRO. The MFLNRO also supplied a 20-year harvest raster.

The harvest raster for the Prince George TSA was in four 5-year periods and not in twenty 1-year periods, which was the case for the Quesnel TSA.

Data transformation

See the report regarding the Quesnel TSA (Friesen & Goodison, 2011) for details about the data-transformation process.

Biomass equations

FPInterface species are tied to biomass equations. In the analysis of the Quesnel TSA (Friesen & Goodison, 2011), these equations are based on the Canadian national tree above-ground biomass equations (Lambert et al. 2005). Although this equation set included trees from all across Canada, including western and northern Canada, there were very few samples from British Columbia. More recently Ung et al. (2008) have released tree equations for British Columbia (accepted by the MFNRLO) and these were incorporated into FPInterface for the 2011–12 analyses that were undertaken for the Williams Lake, Prince George, and Burns Lake TSAs.

FPInterface parameters

Tree species associations

Because of the new set of British Columbia tree above-ground biomass equations that were now available in FPInterface, species not previously well represented could be associated with dedicated equations.

The species associations for the Prince George analysis are listed in Table 1.

Table 1. Tree species associations

Vegetation resources inventory	FPInterface biomass equation
cottonwood	other poplars
trembling aspen	trembling aspen
subalpine fir	alpine fir
western redcedar	western redcedar
white birch	white birch
Douglas-fir	Douglas-fir (Interior)
western hemlock	western hemlock
tamarack	western larch
western larch	western larch
lodgepole pine	lodgepole pine
spruce	white spruce
white spruce	white spruce
Engelmann spruce	white spruce
Sitka spruce	white spruce
hybrid spruce	white spruce
black spruce	white spruce

Road classes

Unlike the data provided for the analysis of the Quesnel TSA, the road data set for the Prince George TSA contained no road classes. However, FPInterface has the ability to assign road classes based on the amount of volume hauled over each section of road. The volume hauled is for merchantable volume, as calculated by FPInterface. The volumes and speeds associated with each road class were assigned according to Table 2.

Table 2. Road class associations

FPInterface road class	Volume		Road speed		
	Minimum (m^3)	Maximum (m^3)	Posted speed (km/h)	Empty haul [a] (km/h)	Loaded haul [b] (km/h)
Paved	5 000 001	50 000 000	90	86	77
Class 1	1 000 001	5 000 000	70	67	60
Class 1 (off highway)	0	0	70	67	60
Class 2	500 001	1 000 000	50	48	43
Class 3	100 001	500 000	40	38	34
Class 4	50 001	100 000	20	19	17
Class 4 (operational)	0	0	20	19	17
Class 5 (winter)	0	50 000	20	19	17

[a] 95% of posted speed. [b] 85% of posted speed.

General parameters

The price of fuel can have significant impacts on the model's results. Some equipment in the model can use diesel while other equipment is eligible for marked fuel. A price of $1.25/L was assigned, which was near to commercial rates for diesel at this time but was slightly higher than the current price of marked fuel.

The program's default values for productivities and costs of forestry equipment rely on a long history of FPInnovations studies and on other information gathered by FPInnovations. If an operator has specific values or costs they wish to apply to any phase or machine, these can be used instead of the defaults. For this project the default values were used. To verify their suitability the default values were compared with machine costs listed in the Interior Appraisal Manual and were found to be close approximates.

Based on a terrain classification system developed by the Canadian Pulp and Paper Association (CPPA) (Mellgren, 1980), average slope for the Prince George TSA was assigned to CPPA Class 3 (20 to 32%). Ground strength was rated as CPPA Class 2 (good), and ground roughness was rated as CPPA Class 2 (slightly even).

Topping diameter

Although British Columbia regulations require a topping diameter of 10 cm for most merchantable species, the Quesnel TSA analysis (Friesen & Goodison, 2011) used 12.5 cm to reflect more common industrial practise. Rounding in FPInterface meant the topping diameter was set at 13 cm for the Quesnel TSA analysis. Refinements to the program allowed the topping diameter to be set to 12.5 cm for the Prince George TSA analysis.

Utilization of lodgepole pine and mountain pine beetle-attacked wood: considerations

As for Quesnel, harvesting standing trees for biomass purposes is not generally considered economic in British Columbia because their recovery must cover full costs of planning, developing and harvesting stands, in addition to costs for biomass recovery operations. However, because of mortality due to mountain pine beetle some whole logs were included for biomass chipping. Although the THLB (timber harvesting land base) proportion attribute includes mortality attributed to mountain pine beetle, because of continuing attack by the beetle and degradation of mountain pine beetle logs, 30% of lodgepole pine volume was removed from availability as merchantable volume. Half of this (15% of total lodgepole pine volume) was estimated to become available for whole log chipping or grinding at roadside and the remainder was counted as loss (Table 3).

Table 3. Utilization of mountain pine beetle-affected stems

Stems converted to merchantable logs (%)	Stems converted to biomass (%)	Stems unutilized (%)
70	15	15

Time frame

The data identified 20 years of harvest. As in the analysis of the Quesnel TSA, an examination of the merchantable output showed a falldown projected for Years 11 to 20. Therefore, and to be consistent with the methodology used for the Quesnel TSA, the base case was considered to be the 10-year harvest, although results for both the 10-year scenario and the 20-year scenario are included here.

Mill locations

With the largest population in the TSA, Prince George is an obvious location for reception of biomass. Additionally, the communities of Bear Lake, Dunkley, Vanderhoof, Fort St. James, and Fraser Lake were selected for their population sizes, existing mills, relative dispersion, or potential for future development. Additionally, Burns Lake, which is actually in the Lakes TSA but just outside the boundary of the Prince George TSA, was designated as a delivery point to see if volume near there would flow there at least cost. Biomass transport was optimized in the program for whichever delivery point was closest (least cost) to a given block.

Biomass calculations

The biomass calculations in FPInterface produce an amount of total available biomass once merchantable roundwood has been removed. For this project only biomass transported to roadside was considered recoverable, and biomass likely to remain at the stump was not. Once it is transported to roadside, some biomass becomes unavailable due to handling and technical losses. The remainder is considered recovered biomass. Figure 2 shows this breakdown for the base case 10-year harvest.

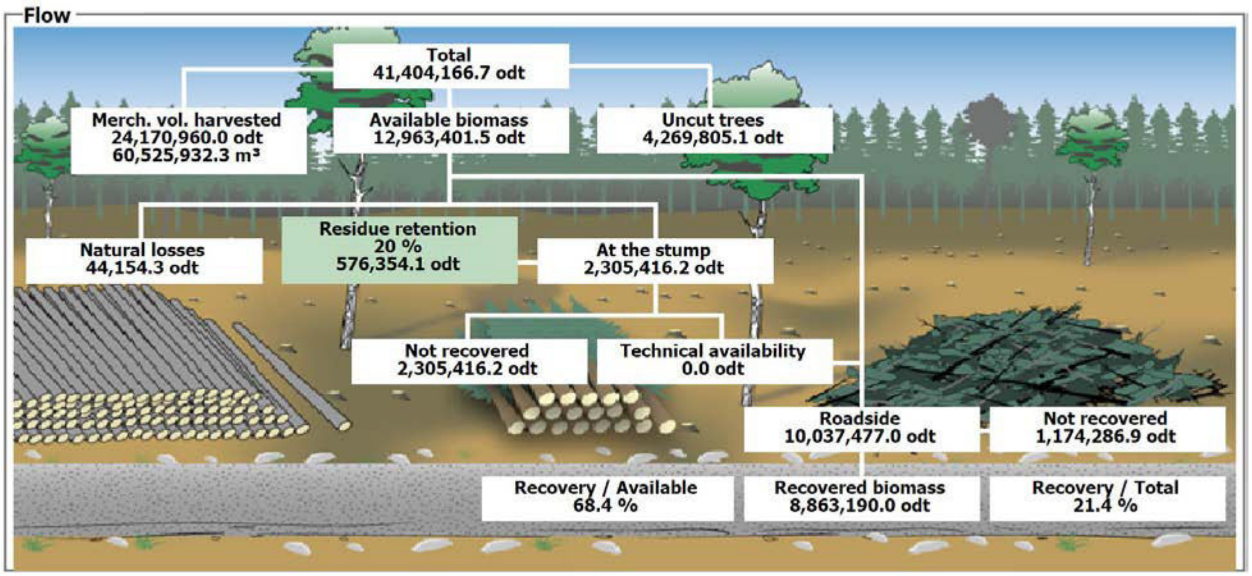

Figure 1. Recoverable biomass, Prince George TSA: 10-year harvest base case.

5. Results and discussion

Summary — key results

Key results from the base case runs for 10 and 20 years of harvest are summarized in Tables 4 and 6. More detailed results are in Appendix 2.

Table 4. Harvest availability for bioenergy, by delivery point and cost per ODT: 10-year base case

Delivery point	At $60/ODT (ODT)	At $75/ODT (ODT)	At $90/ODT (ODT)	At $105/ODT (ODT)	Yearly at $60/ODT (ODT)
Prince George mill	43 513	363 818	518 122	670 352	4 351
Dunkley mill	12 452	15 163	15 857	15 958	1 245
Vanderhoof mill	305 933	641 999	722 287	772 610	30 593
Fraser Lake mill	92 665	172 119	244 357	255 893	9 267
Fort St. James mill	948 370	1 928 676	2 489 893	2 978 725	94 837
Bear Lake mill	93 735	366 227	495 268	502 316	9 374
Burns Lake proxy	1 420	198 772	278 360	280 312	142
Total	1 498 087	3 686 773	4 764 145	5 476 166	149 809

Table 5. Harvest availability for bioenergy, by delivery point and cost per ODT: 20-year base case

Delivery point	At $60/ODT (ODT)	At $75/ODT (ODT)	At $90/ODT (ODT)	At $105/ODT (ODT)	Yearly At $60/ODT (ODT)
Prince George mill	233 053	1 136 536	1 630 052	1 796 373	11 653
Dunkley mill	106 834	185 333	186 234	187 085	5 342
Vanderhoof mill	437 877	881 173	1 014 861	1 061 119	21 894
Fraser Lake mill	151 016	204 195	249 886	262 332	7 551
Fort St. James mill	1 389 235	3 050 193	3 885 792	4 370 609	69 462
Bear Lake mill	759 737	1 404 388	1 538 073	1 547 117	37 987
Burns Lake proxy	4 849	243 544	335 150	335 150	242
Total	3 082 600	7 105 362	8 840 047	9 559 785	154 130

More than half the available volume at $60/ODT in Years 1 to 10 is available at Fort St James (Table 5). As the price rises, more volume is available at each location. Prince George, Dunkley, and Bear Lake, in particular, receive much more volume (at $60/ODT) in Years 11 to 20 (Table 5) than in Years 1 to 10 (Table 4).

Given that the available residue biomass consisted of a large percentage of lodgepole pine—about 56% in Years 1 to 10 and 41% over both decades—and that much of the standing mature pine forest had been attacked by mountain pine beetle, production was checked for falldown in Years 11 to 20. These results reflect the harvest plan and show that the biomass harvest in Years 11 to 20 is only 56% of the first: however, the distribution of biomass means that there is no falldown in availability at the $60/ODT price point. Further, in Years 1 to 10 44% of planned harvest is from non-pine stands, but in Years 11 to 20 80% is from non-pine stands. The lodgepole pine harvest in Years 11 to 20 is 25% of that in Years 1 to 10 in the harvest queue.

The base case run showed that a total of 1.5 million ODT would be available at the seven delivery points in Years 1 to 10 at a cost of no more than $60/ODT (Table 4). The available amount nearly triples to 4.8 million ODT at $90/ODT. The total amount of biomass available at any price from the 10-year base case is 8.9 million ODT.

Annualized, the base case shows that approximately 150 000 ODT/year from harvest residue (at $60/ODT) could become available at the seven delivery points during Years 1 to 10 (Table 4), provided it is not already fully or partially allocated. During Years 11 to 20, a slightly lesser amount of 154 000 ODT/year would be available (Table 5), although the location of the availability increases significantly in the eastern portion of the TSA at Prince George, Dunkley, and Bear Lake.

The biomass ratio (the ratio of recovered biomass to recovered merchantable roundwood) for the base case is 37%. This is slightly higher than is usually predicted for harvest residues, partially because 15% of the lodgepole pine stems were designated for biomass. If only slash (harvest residues, no stems) is used to produce biomass, the biomass ratio becomes 21%. Based on other FPInnovations studies, this is a typical number for roadside harvesting in the Central Interior.

Base case

Some of the more significant settings in FPInterface for the base case are listed in Table 6.

The topping diameter is discussed above in section 3.5.4. In the analysis of the Quesnel TSA, the harvest system was set to "full tree" and then processing activities were set to occur at roadside. However, FPInterface has a harvest setting called "full tree with roadside processing" that is backed with a different set of data points, and which was used for runs subsequent to the Quesnel run. The change produces a very small variation in results (>2%), so it was decided to use this new setting because it more accurately describes operations typical to Interior British Columbia.

Figure 2 presents an isometric map of biomass costs, and Table 7 presents cost-availability data. The "Merchantable volume" column is biomass from mountain pine beetle stems and the "Residues" column is biomass from tops and branches. The "Residues" are cheaper because the costs of harvest are applied to merchantable stems. For biomass from "Merchantable volume" all costs of harvest are applied to biomass (instead of being written off against roundwood) making this biomass much more expensive. The table shows that purpose-harvested wood for biomass is expensive and is not economic below $100/ODT.

The output report for the base case (Appendix 1) shows that comminution costs average $31.80/ODT. For the forest residues (slash) component, the remainder of the costs are transport costs. For the full stem (merchantable stems) component, the average harvest cost is $69.35/ODT[1], comminution costs are $31.80/ODT, and transport costs make up the balance.

In Figure 3 the graph of available biomass shows bimodal (two-hump) distribution. The first mode is biomass from forest residues, while the second mode reflects full stems from mountain pine beetle-affected lodgepole pine (merchantable volume).

[1] $24.63 x 8 863 190 / 3 147 679

Table 6. FPInterface parameters: base case[a]

Run descriptor	Base case
run name	PG10yr-19mar
output name	PG10yr-19mar-28base
transfer yards	PG, BearL, VH, FSJ, DU, FL, BurnsL
year(s) analyzed	1-10
species attribute linking	BC
haul speeds	graduated
haul speeds at 95% / 85% of posted	y
transport shifts / day	1
transport hours / shift	10
transport days / year	180
transport fuel price / litre	$1.25
average slope	20-32
slash used for biomass	y
full stem used for biomass	n
Pl utilization of THLB merch timber (%)	70
Pl unutilized merch used for biomass (%)	15
Pl stems for biomass chipped where?	roadside
Pl merch stemwood for biomass directed where	closest yard
chips destination	closest yard
topping diameter (cm)	12.5
truck used for chips	3-axle
truck used for logs	B-train
harvesting fuel price / litre (x3)	$1.25
harvesting shifts / day (x3)	1
harvesting hours / shift (x3)	10
harvesting days / yr (x3)	180
harvesting system	full tree with roadside processing
on site biomass treatment (roadside)	comminution
recovery season	winter
slash freshness	fresh
slash pre-piled at roadside	y
grinder size type	horizontal 600 kW
biomass fuel price / litre (x2)	$1.25
biomass hours / shift (x2)	10
biomass shifts / day (x2)	1
biomass days / yr (x2)	180
indirect costs - biomass ($ value)	$0.00
indirect costs - harvesting ($ value)	$0.00

a The parameters highlighted in yellow indicate differences from those used for the analysis of the Quesnel TSA (Friesen & Goodison, 2011).

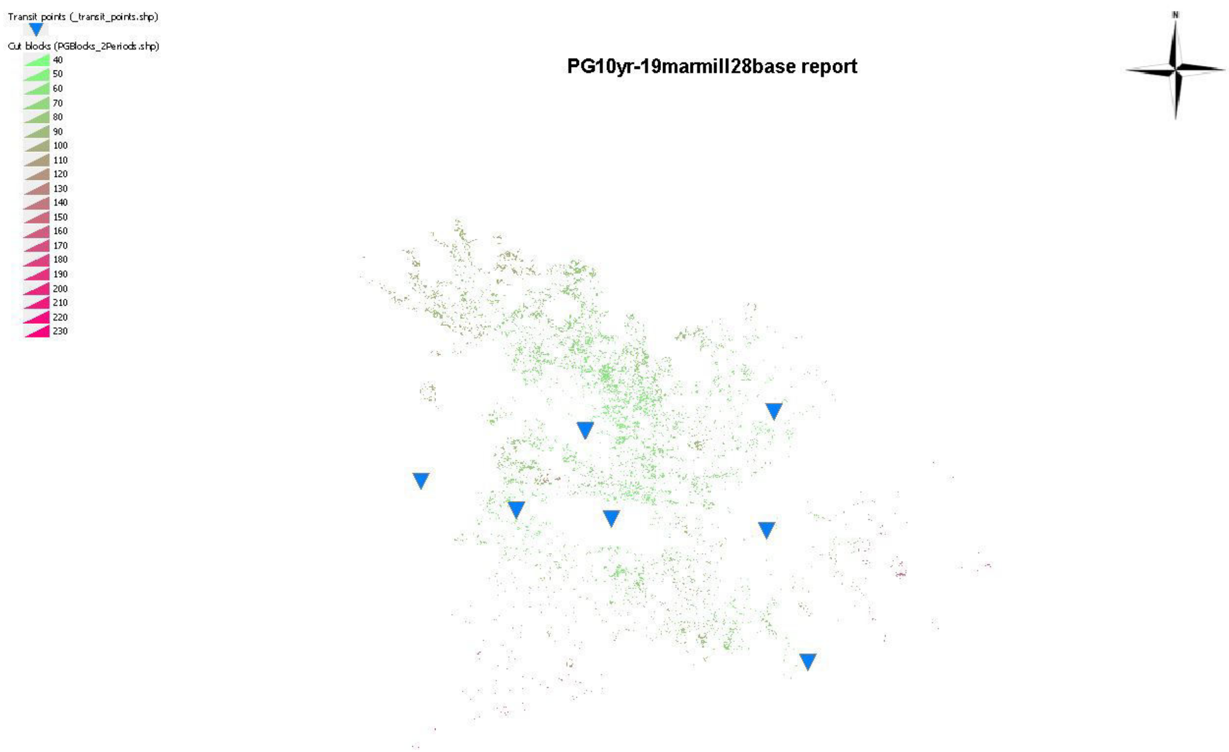

Figure 2. Cost of delivered biomass from point of origin, in increments of $10/ODT: 10-year base case. L to R: Burns Lake, Fraser Lake, Fort St James, Vanderhoof, Prince George, Bear Lake, and Dunkley. The cost of biomass from roadside residues is averaged with the cost of residue obtained from mountain pine beetle stems. Blocks closest to the delivery points have the lowest delivered costs and are the greenest in colour. Blocks furthest from the mills are the most expensive and the reddest.

Table 7. Cost-availability, delivery to receiving points in the Prince George TSA: 10-year base case [a]

Supply summary

Recovered biomass to	Merchantable volume (odt)	Residues (odt)	Total biomass (odt)
10 $/odt	0.0	0.0	0.0
20 $/odt	0.0	0.0	0.0
30 $/odt	0.0	0.0	0.0
40 $/odt	0.0	0.0	0.0
50 $/odt	0.0	139,290.7	139,290.7
60 $/odt	0.0	1,503,473.3	1,503,473.3
70 $/odt	0.0	2,960,268.5	2,960,268.5
80 $/odt	0.0	4,263,777.4	4,263,777.4
90 $/odt	0.0	4,817,202.1	4,817,202.1
100 $/odt	0.0	5,382,722.1	5,382,722.1
110 $/odt	15,826.5	5,537,697.5	5,553,524.0
120 $/odt	230,093.8	5,600,264.1	5,830,357.9
130 $/odt	1,239,605.3	5,638,181.9	6,877,787.2
140 $/odt	2,063,912.8	5,660,302.9	7,724,215.7
150 $/odt	2,638,076.0	5,667,545.1	8,305,621.1
160 $/odt	2,982,807.1	5,672,951.1	8,655,758.2
170 $/odt	3,077,926.5	5,692,125.3	8,770,051.8
180 $/odt	3,099,569.5	5,696,167.2	8,795,736.7
190 $/odt	3,109,835.7	5,701,083.4	8,810,919.1
200 $/odt	3,123,066.3	5,709,044.3	8,832,110.6
210 $/odt	3,130,825.5	5,712,204.1	8,843,029.5
220 $/odt	3,133,624.4	5,713,724.1	8,847,348.5
230 $/odt	3,136,170.6	5,713,724.1	8,849,894.7
240 $/odt	3,139,900.6	5,715,511.0	8,855,411.7
250 $/odt	3,143,552.9	5,715,511.0	8,859,063.9
260 $/odt	3,146,282.9	5,715,511.0	8,861,793.9
270 $/odt	3,146,282.9	5,715,511.0	8,861,793.9
280 $/odt	3,146,282.9	5,715,511.0	8,861,793.9
290 $/odt	3,147,006.0	5,715,511.0	8,862,517.1
300 $/odt	3,147,006.0	5,715,511.0	8,862,517.1
310 $/odt	3,147,679.0	5,715,511.0	8,863,190.0
Maximum cost	**301.48 $/odt**	**239.76 $/odt**	

[a] The amount of biomass delivered is divided into $10 increments based on delivered cost

Figure 3. Cost availability of biomass in the Prince George TSA: 10-year base case

Residue cost calculator, by mill

Based on the Excel output from FPInterface, it was now possible to see how much biomass was available at each delivery point at a price point specified by the user. Appendix 1 of this report consists of an Excel workbook, “Residue Cost Calculator, by Delivery Point”. A snip of the sheet can be seen in Figure 4. The amount of ODT available at a particular price point was determined for each delivery point (labelled “transfer yards”).

This calculator shows the available biomass from residues only. Because full stem biomass (15% of lodgepole pine volume) does not become available until prices are above $100/ODT, amounts up to $100/ODT also reflect total biomass available.

Calculators for both the 10-year base case and the 20-year scenario are included in Appendix 1.

	A	B	C	D	E	F	G	H	I	J	K
1	**Prince George - 10 year harvest**				amounts available at		$60	/odt	Transfer yard: PG mill	43,513	odt
2									Transfer yard: Dunkley mill	12,452	odt
3	(does not include biomass from 15% Pl full stem - min price $110/odt)								Transfer yard: Vanderhoof mill	305,933	odt
4									Transfer yard: Fraser Lake mill	92,665	odt
5									Transfer yard: FSJames mill	948,370	odt
6									Transfer yard: Bear Lake mill	93,735	odt
7									Transfer yard: Burns Lake proxy	1,420	odt
8									Total	1,498,087	odt
9											

Figure 4. Snip of “Residue cost calculator, by delivery point”

Issues and improvements since the Quesnel TSA analysis

Some of the issues encountered during the runs for the Quesnel TSA (Friesen & Goodison, 2011) were addressed and evolved toward resolved during the analyses of the Williams Lake TSA (Friesen, 2012) and the Prince George TSA.

The structure of the Vegetation Resources Inventory data is essentially unchanged. The sorting of species into columns by leading species, second species, etc., in a data set was not made available, but FPInnovations developed a way to perform this task that minimized processing time.

Similarly, the block aggregation process, which was necessitated by the immense size of the data set that proved too unwieldy for productive run processing and scenario-building in FPInterface, was brought into a manageable time frame through experience and repetition. This aggregation process could still be codified and, if possible, automated for future projects.

The MFLNRO's road data set contained many unjoined road intersections and overly long segments that required extensive data cleaning. This proved very time-consuming. As much as possible, road snapping should be accomplished before new projects are undertaken. Perhaps a protocol for snapping can be established.

The road snapping completed by FPInterface was targeted, i.e., not all roads in the data set were snapped. In order to speed processing, many roads were eliminated from the dataset. It is possible that sub-optimal paths resulted and estimated costs for delivery were too high, although much effort was directed to avoiding this.

A significant improvement was made to FPInterface in that targeted British Columbia biomass equations are now available in the program. These equations, in combination with other minor improvements to the program, should have improved the accuracy of the predicted results.

The multiple delivery point function, allowing blocks to be delivered to the nearest mill, which had not been working for the Quesnel runs, was repaired. This allowed the "Residue Cost Calculator, by Delivery Point" to be constructed; the isometric map showing colour-coded costs to each delivery point by block of origin is now produced directly in FPInterface. Continued enhancement of the program is encouraged in order shorten the model's run time in future projects.

6. Conclusions

We developed a method for estimating available forest-origin biomass for British Columbia Timber Supply Areas, using the Quesnel TSA as a test case (Friesen & Goodison, 2011). Based on that experience, estimates were made for the Williams Lake TSA (Friesen 2012) and the Prince George TSA. The biomass inventory was based on 20-year harvest and road network plans for Crown land (excluding Woodlot Licenses, Tree Farm Licenses, Community Forest Agreements, and First Nations tenures) that were provided by British Columbia Ministry of Forests, Lands and Natural Resources. Delivery points for biomass (possible bioenergy mill sites) were designated at Prince George, Bear Lake, Dunkley, Vanderhoof, Fort St James, and Fraser Lake. Additionally, the town of Burns Lake which is just outside of the TSA, was designated as a mill site to see if any volume would logically flow there for least cost. All planned blocks were assumed to be clearcut harvested, processed at roadside, and accessible to comminution operations.

The total biomass delivered to the seven delivery points for Years 1 to 10 was projected to be 8.8 million ODT, of which 1.5 million ODT, or approximately, 150 000 ODT/year, is available for $60/ODT. The amount of biomass available in Years 11 to 20 was projected to be about 160 000 ODT/year at $60/ODT. If the acceptable price of delivered biomass rose to $90/ODT, then available biomass would be about three times greater.

More than half the available volume at $60/ODT in Years 1 to 10 is available at Fort St. James. As the price rises, more volume becomes available at each location. Prince George, Dunkley, and Bear Lake, in particular, receive much more volume in Years 11 to 20 than in Years 1 to 10.

Improvements to the method that was devised using the Quesnel TSA as a test case centered around the use of British Columbia-specific biomass equations and efforts to speed up the transformation of MFLNRO data into a format that was usable by FPInterface. Since then, enhancements have led to improvements in results handling and presentation. Data cleaning associated with the roads layer (road snapping) proved to be very time consuming, so further enhancements related to this are still needed. Run time would be faster if polygon data could be acquired from the MFLNRO in a format more easily digestible by FPInterface. Generally, further enhancement and development of FPInterface are encouraged, in order to speed up the run time of future projects.

7. References

Friesen, C. (2012). *Using FPInterface to estimate available forest-origin biomass in British Columbia: Williams Lake TSA* (Technical Report). Vancouver, British Columbia: FPInnovations.

Friesen, C., & Goodison, A. (2011). *Using FPInterface to estimate available forest-origin biomass in British Columbia: Quesnel TSA* (Technical Report). Vancouver, British Columbia: FPInnovations.

Lambert, M-C., Ung, C-H., & Raulier, R. (2005). Canadian national tree aboveground biomass equations. *Canadian Journal of Forest Research* 35:1996–2008.

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8. Appendix

Appendix 1

Residue cost calculator, by delivery point

Appendix 2

Output maps and cost-availability tables

2.1 10-Year Base Case

2.2 20-Year Base Case

FPInterface™

Territory:	Unknown territory
Sector:	Unknown sector
Cut block:	<Multiple selection>

Statistics - Selected Items

Area	213,236.4 ha
Number of cut blocks	767
Recovered biomass	8,863,190.0 odt
Recovery rate	41.6 odt/ha
Biomass odt / Merchantable m³	0.1475 odt/m³
Delivered products	
• Chips	100 %
• Bundles	0 %
• Trunks and Residues	0 %
Energy balance	32 : 1
Available energy	32,575,515 MWh
Fuel consumption	13.0 L/odt

Cost

Harvesting	24.63 $/odt
Biomass recovery	31.80 $/odt
Transfer yard	0.00 $/odt
Transportation	37.98 $/odt
Stumpage fees	0.00 $/odt
Road network - Maintenance	0.81 $/odt
Indirect costs	0.00 $/odt
Total	**95.22 $/ odt**

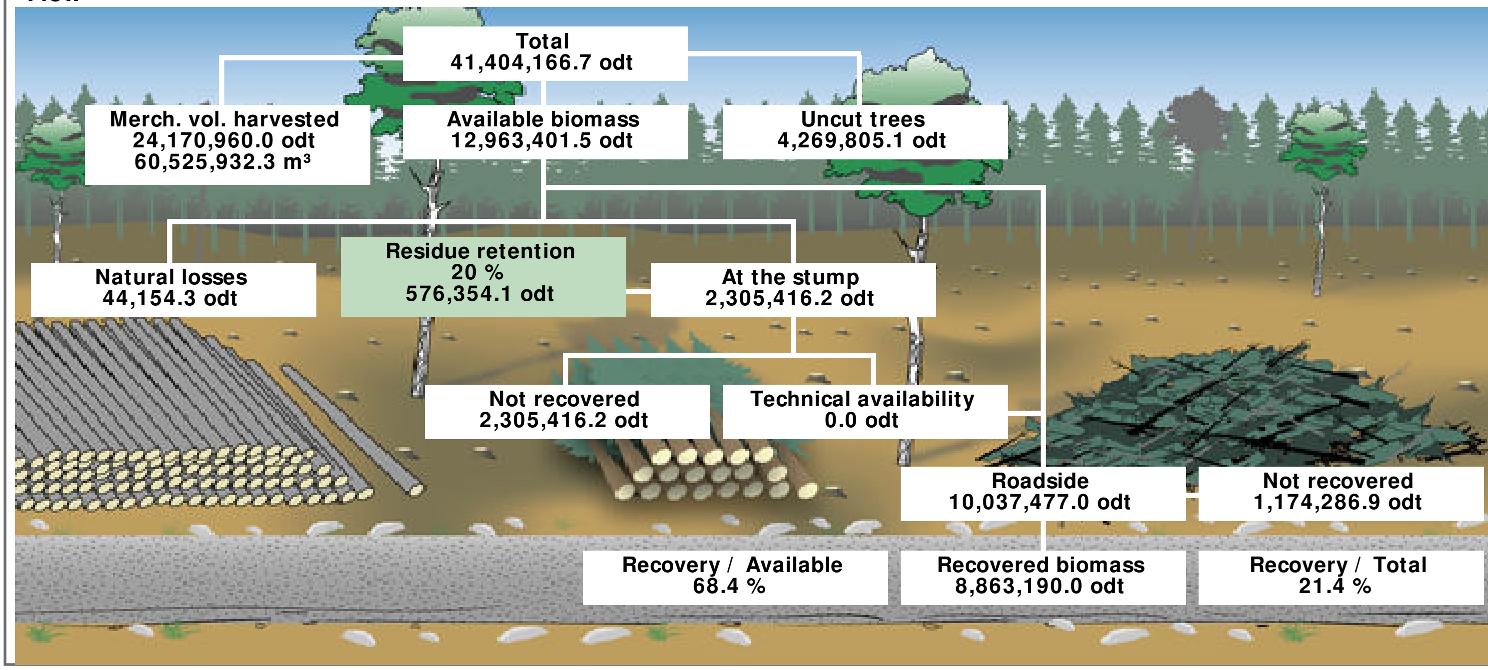
Revenue

Sale value	0.00 $/odt
Silvicultural discount	0.00 $/odt

Net

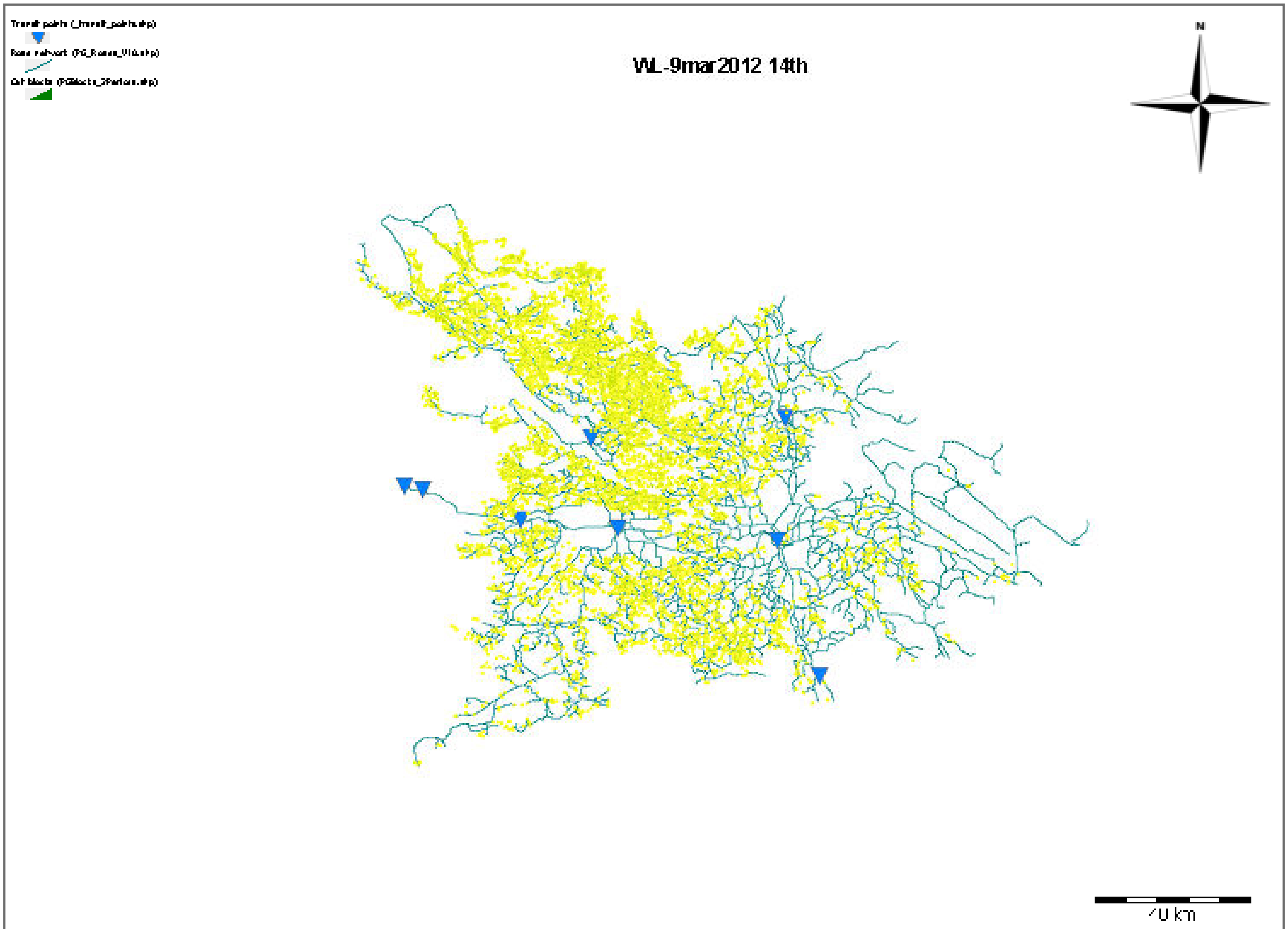
Profit	-95.22 $/odt

Flow



Products

Product name	odt	odt/ m³	odt/ ha
Lodgepole pine-biomass	3,147,679.0	51.7894	14.76
Lodgepole pine (residues)	2,655,767.4	0.0829	12.45
Spruce (residues)	1,776,463.8	0.1148	8.33
Lodgepole pine-biomass (residues)	569,093.0	0.0829	2.67
Trembling aspen (residues)	337,727.9	0.1287	1.58
Abies lasiocarpa (Ba (residues)	191,882.7	0.1091	0.90
Douglas fir (residues)	149,001.7	0.1490	0.70
Paper birch (residues)	15,580.2	0.1955	0.07
Western hemlock (residues)	14,953.4	0.0994	0.07
Western redcedar (residues)	4,488.7	0.0990	0.02
Western larch (residues)	552.4	0.3778	0.00
	8,863,190.0	**0.1475**	**41.57**



767 selected site(s) / 767

Area covered: 213,236 ha / 213,236 ha

Recovery summary

	Volume(odt)	Area(ha)	Number of cut blocks
• Biomass recovery location			
At the stump	0.0	0.0	0
Roadside	8,863,190.0	213,236.4	767
• Recovery season			
Summer	0.0	0.0	0
Winter	8,863,190.0	213,236.4	767
• Residue freshness			
Fresh	8,863,190.0	213,236.4	767
Brown	0.0	0.0	0
Brittle	0.0	0.0	0

Supply summary

Recovered biomass to	Merchantable volume (odt)	Residues (odt)	Total biomass (odt)
10 $/odt	0.0	0.0	0.0
20 $/odt	0.0	0.0	0.0
30 $/odt	0.0	0.0	0.0
40 $/odt	0.0	0.0	0.0
50 $/odt	0.0	139,290.7	139,290.7
60 $/odt	0.0	1,503,473.3	1,503,473.3
70 $/odt	0.0	2,960,268.5	2,960,268.5
80 $/odt	0.0	4,263,777.4	4,263,777.4
90 $/odt	0.0	4,817,202.1	4,817,202.1
100 $/odt	0.0	5,382,722.1	5,382,722.1
110 $/odt	15,826.5	5,537,697.5	5,553,524.0
120 $/odt	230,093.8	5,600,264.1	5,830,357.9
130 $/odt	1,239,605.3	5,638,181.9	6,877,787.2
140 $/odt	2,063,912.8	5,660,302.9	7,724,215.7
150 $/odt	2,638,076.0	5,667,545.1	8,305,621.1
160 $/odt	2,982,807.1	5,672,951.1	8,655,758.2
170 $/odt	3,077,926.5	5,692,125.3	8,770,051.8
180 $/odt	3,099,569.5	5,696,167.2	8,795,736.7
190 $/odt	3,109,835.7	5,701,083.4	8,810,919.1
200 $/odt	3,123,066.3	5,709,044.3	8,832,110.6
210 $/odt	3,130,825.5	5,712,204.1	8,843,029.5
220 $/odt	3,133,624.4	5,713,724.1	8,847,348.5
230 $/odt	3,136,170.6	5,713,724.1	8,849,894.7
240 $/odt	3,139,900.6	5,715,511.0	8,855,411.7
250 $/odt	3,143,552.9	5,715,511.0	8,859,063.9

260 $/odt	3,146,282.9	5,715,511.0	8,861,793.9
270 $/odt	3,146,282.9	5,715,511.0	8,861,793.9
280 $/odt	3,146,282.9	5,715,511.0	8,861,793.9
290 $/odt	3,147,006.0	5,715,511.0	8,862,517.1
300 $/odt	3,147,006.0	5,715,511.0	8,862,517.1
310 $/odt	3,147,679.0	5,715,511.0	8,863,190.0
Maximum cost	**301.48 $/ odt**	**239.76 $/ odt**	

FPInterface™

Summary report

Biomass

[PG20yr-23mar]

Territory:	Unknown territory
Sector:	Unknown sector
Cut block:	<Multiple selection>

Statistics - Selected Items

Area	356,064.2 ha
Number of cut blocks	1606
Recovered biomass	13,825,935.5 odt
Recovery rate	38.8 odt/ha
Biomass odt / Merchantable m³	0.1359 odt/m³
Delivered products	
• Chips	100 %
• Bundles	0 %
• Trunks and Residues	0 %
Energy balance	32 : 1
Available energy	49,895,367 MWh
Fuel consumption	12.8 L/odt

Cost

Harvesting	19.97 $/odt
Biomass recovery	31.80 $/odt
Transfer yard	0.00 $/odt
Transportation	36.53 $/odt
Stumpage fees	0.00 $/odt
Road network - Maintenance	0.72 $/odt
Indirect costs	0.00 $/odt
Total	**89.01 $/ odt**

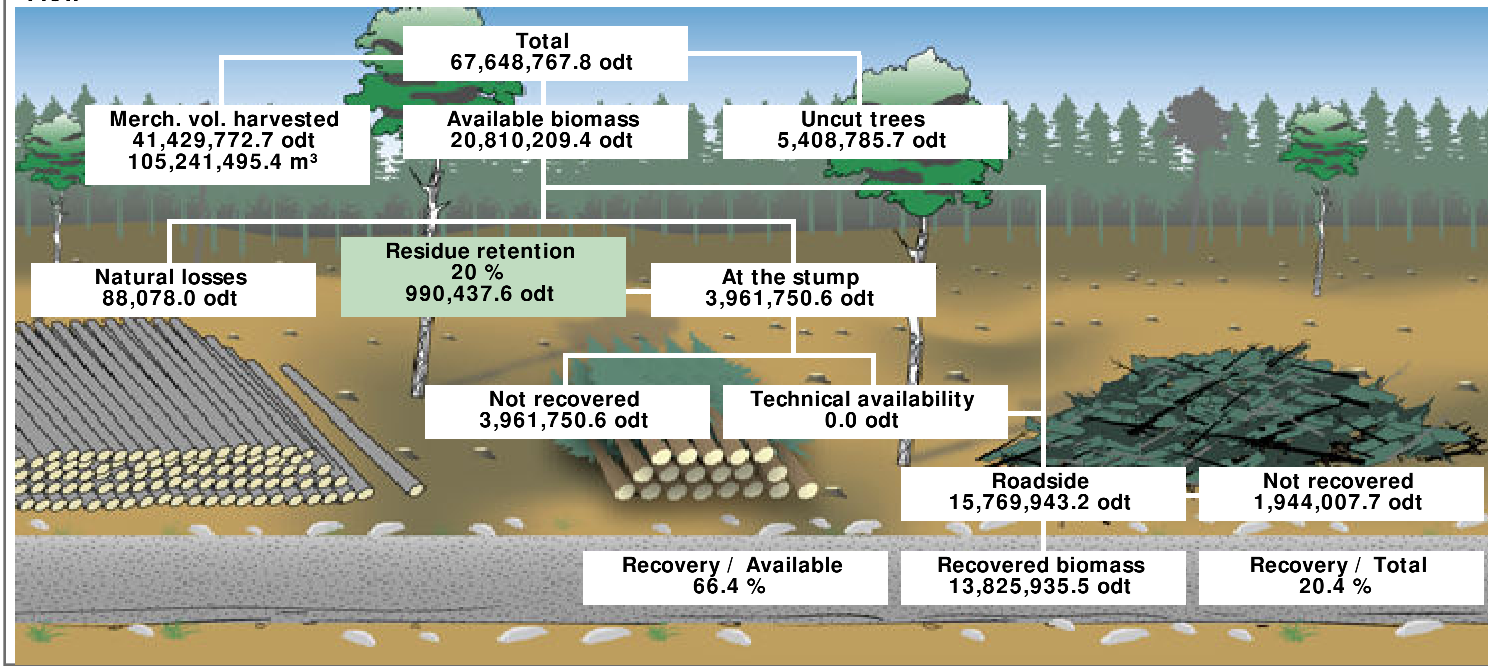
Revenue

Sale value	0.00 $/odt
Silvicultural discount	0.00 $/odt

Net

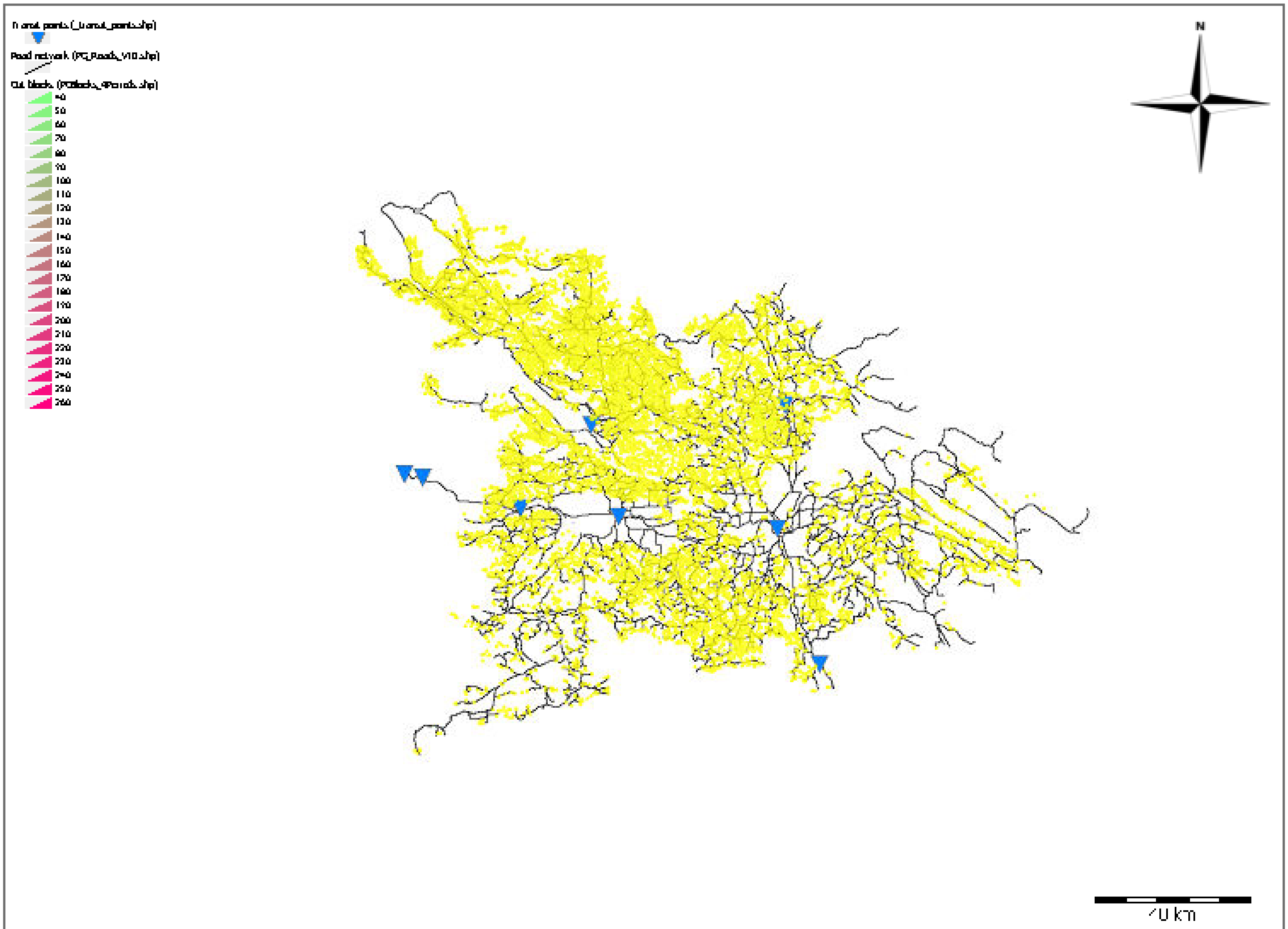
Profit	-89.01 $/odt

Flow



Products

Product name	odt	odt/ m³	odt/ ha
Lodgepole pine-biomass	4,004,095.5	40.2732	11.25
Spruce (residues)	3,819,567.9	0.1073	10.73
Lodgepole pine (residues)	3,315,196.5	0.0811	9.31
Lodgepole pine-biomass (residues)	710,399.2	0.0811	2.00
Abies lasiocarpa (residues)	672,765.2	0.1034	1.89
Trembling aspen (residues)	592,323.3	0.1223	1.66
Douglas fir (residues)	509,960.9	0.1454	1.43
Paper birch (residues)	89,852.2	0.2038	0.25
Western hemlock (residues)	59,620.0	0.0989	0.17
Western redcedar (residues)	51,584.1	0.0987	0.14
Western larch (residues)	570.6	0.3820	0.00
	13,825,935.5	**0.1359**	**38.83**



1606 selected site(s) / 1606

Area covered: 356,064 ha / 356,064 ha

Recovery summary

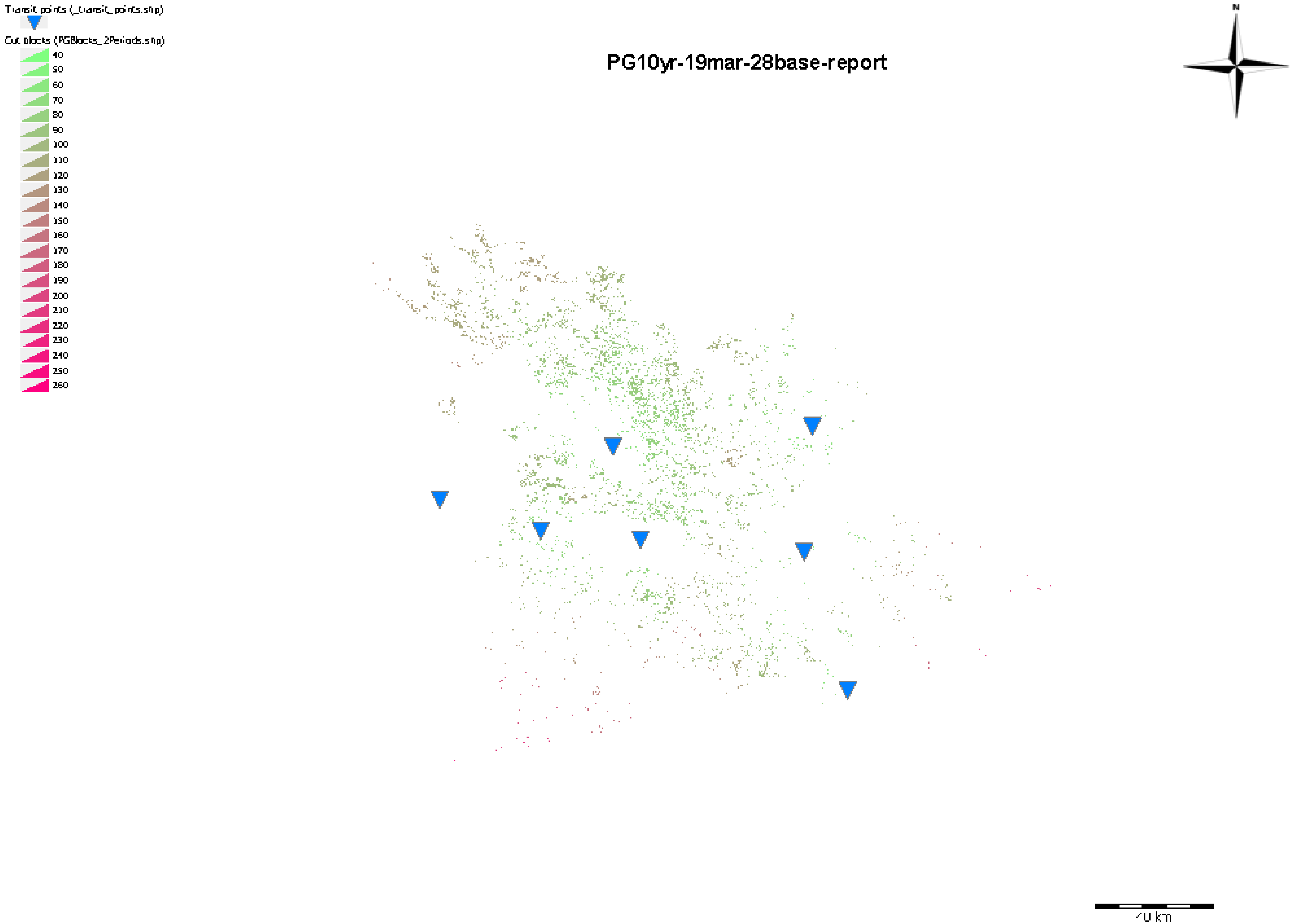
	Volume(odt)	Area(ha)	Number of cut blocks
• Biomass recovery location			
At the stump	0.0	0.0	0
Roadside	13,825,935.5	356,064.2	1,606
• Recovery season			
Summer	0.0	0.0	0
Winter	13,825,935.5	356,064.2	1,606
• Residue freshness			
Fresh	13,825,935.5	356,064.2	1,606
Brown	0.0	0.0	0
Brittle	0.0	0.0	0

Supply summary

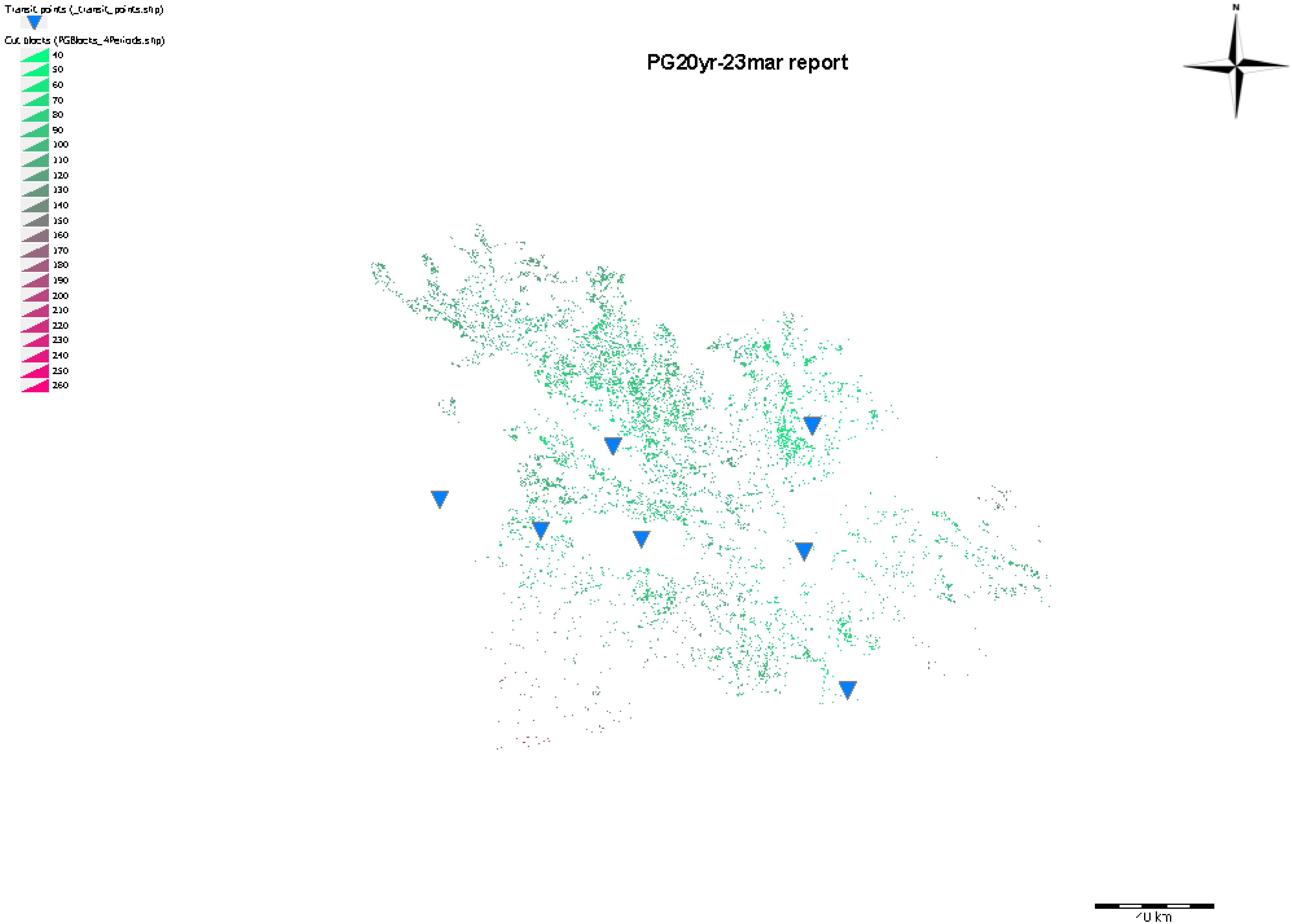
Recovered biomass to	Merchantable volume (odt)	Residues (odt)	Total biomass (odt)
10 $/odt	0.0	0.0	0.0
20 $/odt	0.0	0.0	0.0
30 $/odt	0.0	0.0	0.0
40 $/odt	0.0	0.0	0.0
50 $/odt	0.0	596,214.9	596,214.9
60 $/odt	0.0	3,048,050.6	3,048,050.6
70 $/odt	0.0	5,894,894.5	5,894,894.5
80 $/odt	0.0	7,909,814.9	7,909,814.9
90 $/odt	0.0	8,868,187.9	8,868,187.9
100 $/odt	37.1	9,419,102.4	9,419,139.5
110 $/odt	33,402.2	9,631,170.7	9,664,572.8
120 $/odt	279,297.7	9,696,800.7	9,976,098.5
130 $/odt	1,420,507.4	9,724,781.2	11,145,288.6
140 $/odt	2,444,972.4	9,760,943.2	12,205,915.6
150 $/odt	3,382,867.9	9,771,619.9	13,154,487.8
160 $/odt	3,720,259.5	9,799,465.2	13,519,724.7
170 $/odt	3,916,862.5	9,807,420.9	13,724,283.4
180 $/odt	3,945,587.4	9,810,975.5	13,756,562.9
190 $/odt	3,959,154.1	9,814,308.6	13,773,462.6
200 $/odt	3,974,037.0	9,818,533.0	13,792,570.0
210 $/odt	3,984,315.2	9,820,053.0	13,804,368.3
220 $/odt	3,986,416.1	9,820,053.0	13,806,469.2
230 $/odt	3,987,652.6	9,821,840.0	13,809,492.6
240 $/odt	3,993,147.6	9,821,840.0	13,814,987.6
250 $/odt	3,997,368.5	9,821,840.0	13,819,208.5

260 $/odt	3,999,541.2	9,821,840.0	13,821,381.2
270 $/odt	4,001,936.0	9,821,840.0	13,823,775.9
280 $/odt	4,002,699.4	9,821,840.0	13,824,539.3
290 $/odt	4,003,422.5	9,821,840.0	13,825,262.5
300 $/odt	4,003,422.5	9,821,840.0	13,825,262.5
310 $/odt	4,003,422.5	9,821,840.0	13,825,262.5
320 $/odt	4,004,095.5	9,821,840.0	13,825,935.5
Maximum cost	**311.12 $/ odt**	**228.81 $/ odt**	

PG10yr-19mar-28base-report



PG20yr-23mar report



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