Canadian Forest Products TFL 30
Pilot Change Monitoring Inventory
Sample Plan

Prepared for

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1. INTRODUCTION

1.1 TERMS OF REFERENCE

J.S. Thrower & Associates Ltd. (JST) is completing this pilot[1] Change Monitoring Inventory (CMI) sample plan for Canadian Forest Products Ltd.'s (Canfor's) Tree Farm License (TFL) 30. Kerry Deschamps, *MScF*, *RPF* is the contact person for Canfor and Guillaume Thérien, *PhD* is the JST project manager. This report will be submitted to the Ministry of Sustainable Resources Management (MSRM) – Terrestrial Inventory Branch (TIB) and the Prince George Forest Region (PGFR) and must be approved before field sampling can begin.

1.2 BACKGROUND

Canfor is implementing a monitoring program in an effort to ensure that the growth and yield (G&Y) models provide realistic growth projections for post-harvest regenerated (PHR) stands on TFL 30. Canfor has recently completed Vegetation Resources Inventory (VRI), Terrestrial Ecological Mapping (TEM), and Site Index Adjustment (SIA) projects on TFL 30 to improve G&Y model inputs. The next logical step is to monitor the output generated by the G&Y models to ensure they accurately reflect the actual G&Y of PHR stands on the TFL.

TFL 30 (also known as the McGregor Model Forest) is part of an international network of model forests aimed at accelerating the implementation of sustainable forest development practices. The monitoring program is a key element of a model forest.

1.3 GOALS & OBJECTIVES

The overall goals for this CMI program on TFL 30 are to:

1. *Define Canfor's CMI business needs.*
2. *Develop a flexible sample design that meets these business needs and that can be modified to address potential future needs.*
3. *Install sample plots across targeted areas on the TFL.*
4. *Maintain the program by re-measuring plots according to a predetermined schedule.*
5. *Compare actual with predicted G&Y for the sampled area at each measurement.*
6. *Analyze the information to detect practically significant differences, should they occur.*

The objective for the CMI project being completed by JST is to address the first three goals. Canfor will do the plot maintenance and subsequent analysis.

[1] Until the MSRM finalize the CMI standards and procedures, all CMI projects in BC are considered pilot projects.

2. TFL 30 LANDBASE

2.1 GEOGRAPHIC LOCATION

Canfor's TFL 30 is located northeast of Prince George on the McGregor Plateau between Highway 97 on the west and the western foothills of the Rocky Mountains on the east. The TFL covers 181,000 ha (Table 1) of which 157,000 ha (87%) is the productive forest landbase (PFLB).

Table 1. Area distribution by land type.

Land Type	Area (ha)	% of TFL	% of Forested
Entire TFL	180,520		
Non-Forested	9,461	5%	
Forested	171,060	95%	
Non-Productive	14,136	8%	8%
Productive	156,924	87%	92%

2.2 FOREST COVER

Eighty-seven (87) percent of the polygons in the PFLB are either spruce (Sx) or balsam (Bl) leading (Table 2). Almost 70% are either SxBl or BlSx stands. Due to the impact of spruce weevil on spruce stands, Canfor will regenerate an increasing portion of the landbase in lodgepole pine (Pl) leading stands. Approximately 50% of the TFL is in age class 8 and 9 and only 14% in age class 3 to 6. The current annual allowable cut is 350,000 m^3, which is about 1,000 ha/year.

Table 2. TFL 30 PFLB area distribution by leading species and age class.

	Age Class									Total	
Spp	1	2	3	4	5	6	7	8	9	(ha)	(%)
Sx	25,251	7,210	1,750	899	1,126	1,527	5,568	47,473	1,892	92,696	61%
Bl	212	1,007	2,636	2,365	4,493	4,220	6,304	18,584	97	39,919	26%
Pl	1,728	648	14	112	168	278	955	2,086		5,988	4%
Ep	856	1,663	623	89	151	53	158	44		3,637	2%
Hw	8	2		34	160	382	814	1,126	305	2,831	2%
At	1,448	156	31	32	13	27	92	15		1,815	1%
Fd	249	52	18	66	95	71	76	875	119	1,620	1%
Sb		27	6	23	124	198	469	412		1,259	1%
Ac	57	148	172	30	24	26	53	345	190	1,046	1%
Cw	8							195	53	255	0%
Total (ha)	*29,817*	*10,913*	*5,250*	*3,650*	*6,354*	*6,784*	*14,488*	*71,156*	*2,655*	*151,066*[1]	
(%)	*20%*	*7%*	*3%*	*2%*	*4%*	*4%*	*10%*	*47%*	*2%*		

[1] There are 5,858 ha non-sufficiently restocked (NSR).

2.3 ECOLOGICAL DESCRIPTION

The TFL is dominated by the Sub-Boreal Spruce (SBS) biogeoclimatic (BGC) zone with small areas of the Interior Cedar-Hemlock (ICH) in the southeast and Engelmann Spruce-Subalpine Fir (ESSF) in the northeast. Approximately 80% of the PFLB is in the SBSvk and SBSwk1 BGC subzones (Figure 1).

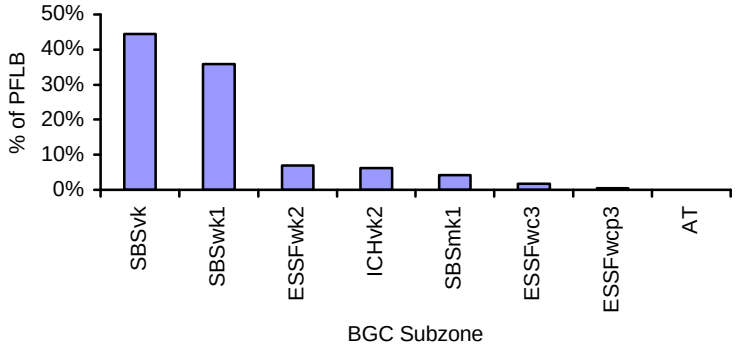

Figure 1. TFL 30 PFLB area distribution by BGC subzone.

3. BUSINESS NEEDS

3.1 OVERVIEW

The objectives of a CMI program must be clearly defined and evaluated considering costs, benefits, uncertainty in G&Y tools, and future management changes. The business needs described below outline the main reasons Canfor initiated a CMI program on TFL 30. The program is designed to address the primary and secondary needs in the short term and the other needs in the longer term. The need to closely monitor PHR stands' G&Y will likely decrease over time as we better understand how these stands grow.

3.2 PRIMARY NEEDS

Canfor's primary business needs for the monitoring program are to track the actual net merchantable mean annual increment (MAI) in PHR stands and to monitor site index estimates. Yield in PHR stands is expected to be higher than in natural stands on the same site. Canfor will begin harvesting PHR stands in approximately 25 years, and so it is imperative that the MAI of these stands be monitored and the Management Plan reflect actual PHR stand yields.

PHR site index estimates in the last timber supply analysis were assigned based on the TEM and the SIA projects completed in 2000.[2] As recommended in the SIA report, these site index estimates must be closely monitored as the adjustment method relied on assumptions and a model that must be verified in the field.

3.3 SECONDARY NEED

Canfor believes that harvesting and silvicultural activities on TFL 30 will not significantly impact the richness and abundance of native plants.[3] Information is needed to support this assumption. Plant diversity information by BGC site association will be collected on undisturbed sites in and around TFL 30. This will establish the baseline to which the monitoring data will be compared. Plots in stands between 1 and 14 years old will be installed for plant diversity monitoring. Additional plots in stands older that 14 years may be installed to monitor plant diversity following pre-1987 silvicultural treatments (brushing) and incremental silvicultural activities (spacing, fertilization).

3.4 OTHER NEEDS

3.4.1 Spruce Weevil

The G&Y and other impacts of spruce weevil are a significant concern on TFL 30. Canfor recently produced a map of spruce weevil hazard using the work of Stuart Taylor, *RPF*[4], and data collected for the

[2] J.S. Thrower & Associates Ltd. 2000. Potential site index estimates for the major commercial tree species on TFL 30. Unpubl. Report, Contract No. NWP-041-007. 15 pp.
[3] Canadian Forest Products Ltd. 2001. Sustainable Forest Management Plan Tree Farm Licence 30, Canadian Forest Products - Prince George Operations, June 27,2001, p. 35.
[4] Taylor, S.P. 1997. Relationships between white spruce vulnerability of the white pine weevil and ecological site conditions in the interior of British Columbia. Fac. Nat. Res. Env. Studies, UNBC. 75 pp.

SIA project. Monitoring the results of spruce weevil attack in high hazard areas will help understand the G&Y impacts the spruce weevil may have on the TFL.[5]

3.4.2 TIPSY Inputs

TIPSY is currently the preferred model for generating G&Y estimates of PHR stands on TFL 30 and elsewhere in BC. Stand establishment information is required to initialize TIPSY, but often this information is estimated using current stand conditions, or the establishment data available are unreliable. Monitoring of PHR stands will help refine the stand establishment data input for TIPSY to predict future stand conditions on the TFL. Assuming the TIPSY model is correct, it will be possible to modify the input to obtain the observed G&Y attributes.

4. SAMPLE DESIGN

4.1 OVERVIEW

The key features of the sample design are:

1) Sample points are located randomly across the TFL in stands between 1 and initially less than 30 years of age.
2) Samples are 400-m^2 circular plots centered at the random points.
3) Measurements are taken for tree attributes only in stands between 15 and 30 years and for ecological data only in stands between 1 and 14 years.
4) Sample plots in a measurement period will be installed over more than one year.
5) Sample plots will be remeasured about every 5 years (funding permitting).

4.2 OBJECTIVES

The primary objective of the CMI program on TFL 30 is to:

Monitor the change in net merchantable volume and site index in PHR stands.

The secondary objectives of the CMI program are to:

1. Monitor plant diversity in recently disturbed stands.
2. Use a flexible design that can be modified for future potential information needs.

4.3 TARGET POPULATION

The target population for the CMI program is all PHR stands. However, in 2001, the program will focus on polygons aged 15 to 30 years (18,177 ha, Table 3). In 2002, plots will be installed in polygons 1 to 14 years (25,072 ha) to monitor plant diversity and in polygons 15 to 30 years (based on the age in 2001) to complete the monitoring objectives. The target population will increase

Table 3. Population size by age group.

Current Stand Age (yrs)	To Be Established In	Area (ha)
15-30	2001-2005	18,177
10-14	2006-2010	12,468
5-9	2011-2015	6,736
1-4	2016-2020	5,868

[5] Monitoring will not provide direct evidence on the losses due to spruce weevil as it is impossible to establish control areas with no weevil incidence.

in the future as more polygons are harvested. In the next five years, we expect that an additional 12,468 ha will have reached 15 years and thus will be included in the target population for CMI sampling.

4.4 SAMPLE SIZE

The sample size for the 2001 field season is 36 plots (Table 4). This is about one plot/500 ha, which is equivalent to one plot/2.25 km on a grid system. We suggest increasing the total sample size to 70-100 plots, which would give a reasonable sample size in important subsets of the population, such as the SBSvk or SBSwk1 BGC subzones. Doubling the 2001 sample size increases the sampling intensity to about one plot/250 ha. This sampling intensity would create approximately 20 new monitoring plots per 5-year period (based on the current rate of harvest). As more confidence is gained in G&Y projections, the remeasurement period can be lengthened or some plots can be dropped to reduce sampling costs.

Table 4. 2001 sample size by species group.

Spp	Area		Sample
	(ha)	(%)	Size
Sx	15,199	84%	30
Pl	841	5%	2
Others	2,136	12%	4
Total	*18,177*	*100%*	*36*

4.5 SAMPLE LOCATION

The samples were randomly selected from the target population using probability proportional to size (polygon area) with replacement (PPSWR).[6] Prior to selecting the samples, the target population (stands 15-30 years) was stratified into three species groups (Sx, Pl, Others). Sample allocation within stratum was proportional to stratum area. The sample list is given in Appendix II. A random point using the provincial 100-m grid will be selected within each sample polygon. In 2002 sample locations for the 15-30 cohort will be chosen using the method used in 2001.

In 2002, the population will be stratified by subzone, and sample locations will be chosen for the 1-14 year cohort. Sample allocation for that cohort will be proportional to subzone area.

4.6 PLOT DESIGN

The plot design follows the MSRM standard CMI protocol for tree attributes (Figure 2). The main plot is 400 m^2 (11.28-m radius) where all trees greater than 9.0 cm are measured and tagged. Trees between 4 and 9 cm are measured and tagged in the small tree plot (100 m^2, 5.64-m radius), and all trees above breast height are measured and tagged in the regeneration plot (19.6 m^2, 2.50-m radius). We also suggest some additions to the MSRM standards (listed in Section 4.8). While not required by the MSRM standards and procedures, data will be recorded by quadrant,

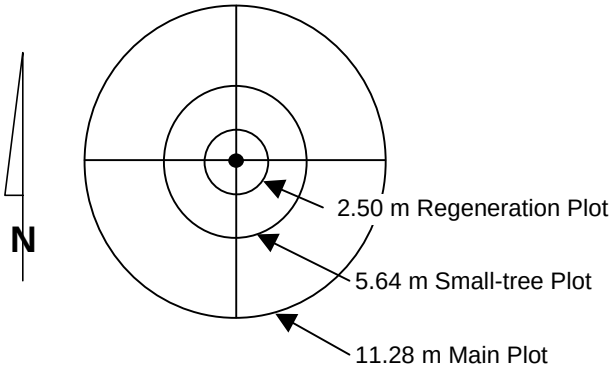

Figure 2. Monitoring sample plot.

[6] One option would have been to revisit the VRI plots installed between 1997 and 1999 on TFL 30. However, because of the time elapsed since the first VRI plots were measured and the difference in plot configuration, we preferred selecting a new set of samples.

numbered 1-4 clockwise starting with the Northeast quadrant.

An 11.28-m radius plot will be used for the 1-14 year cohort. No quadrant divisions will be used.

4.7 REMEASUREMENT PERIOD

We recommend that Canfor re-measure these CMI plots every 5 years to coincide with the 5-year Management Plan cycle. The remeasurement period can be lengthened if the monitoring program becomes onerous or if Management Plan cycles are lengthened.

4.8 PLOT MEASUREMENTS

4.8.1 Overview

For plots in stands 15-30 years of age, most tree attributes (Cards 8-11) will be collected. Stump data on Card 10 will not be collected. Information will not be collected on ecological, coarse woody debris, or range data in the first measurement period for these plots.

For plots in 1-14 year old stands, only ecological data will be collected. Site classification and site features for pin location (Card 12), site features for dominant stratum (Card 13), and the entire Cards 14 and 15 will be used. Card 16 will not be used. Tree attributes, coarse woody debris, and range data will not be collected on these plots.

4.8.2 Plot Cards

The MSRM VRI plot cards will be used for the CMI sample. Some modifications of the VRI cards are needed to accommodate information that is not collected in VRI (e.g., information on additional site trees, quadrant of main plot, etc.).

4.8.3 Plot Establishment

For both stand age groups, navigation to the plot and establishment methods will follow the MOF CMI standards and procedures using VRI plot cards 1 to 3. If the sample polygon boundary crosses a plot location, a diagram will be drawn to clearly explain where the boundary is situated. For stands in the 15-30 years cohort, trees outside the sample polygon will be identified on the plot cards.

4.8.4 Tree Tags

Brown tree tags will be affixed at breast rather than stump height as recommended in the MSRM CMI procedures. This should simplify the establishment and remeasurement work without making the plot unduly visible.

4.8.5 Top Height Trees

The largest diameter tree in the first quadrant will be identified as the top height ("T") tree and its height and age measured. The MSRM standard is to select the top height tree from the 5.64-m radius plot, however, selecting from the first quadrant better suits our plot design.

4.8.6 Site Trees

The height and age of the largest diameter tree of each species in each quadrant will be measured. These trees will be coded as "S" trees if suitable[7] for site index estimation and as "D" trees if not. If the

[7] A suitable tree is dominant or co-dominant; not a residual, open-grown or wolf tree; free of damage, suppression and other factors that could have affected height growth by more than 5%.

largest diameter tree of a given species is not suitable, the next largest diameter suitable tree will be selected (coded as "O" trees). If a tree is selected as a site tree, it will be tagged even if it is below the official tagging limit.

4.8.7 Heights

Height of all trees in the CMI plot will be measured as recommended in the MSRM CMI procedures.

4.8.8 Spruce Weevil

The crew will record the number of attacks on a tree in the last five years. As trees grow, it becomes more difficult to assess the number of years attacked by spruce weevil. There is therefore a negative bias correlated with age when estimating weevil attack. However we think this information could be useful to monitor spruce weevil population levels. Column 56 on Card 8 will be used to record the number of attacks in the last five years.

4.9 DATA MANAGEMENT

JST will enter the data using the VRI data entry program (VIDE). The data will then be sent to the MSRM to be compiled. The MSRM will supply the plot- and species-level summary files to JST for analysis.

4.10 ANALYSIS & INTERPRETATION

The first measurement will provide yield estimates that can be used to audit PHR stand yield. A minimum of two measurements is needed to estimate change (i.e., stand growth). After the second measurement, differences between measured and predicted change for the main attributes of interest can be estimated. Graphical analysis of the data can include plotting actual versus predicted values and plotting differences (actual-predicted) versus stand age or any other variable. The statistical analysis can include the average differences and associated confidence intervals.

The graphical and statistical analysis methods are tools to examine the data for possible overall trends of over- or under-prediction; these analyses are not meant as definitive tests. If the analyses suggest over- or under-prediction, then sources of the differences should be identified. For example, for volume estimates, potential sources of error are the differences between the inventory inputs to the model and the actual stand attributes. Potential inventory attributes to examine include stocking, site index, treatment, species composition, stand structure, and pest or disease incidence.

In the future, as the CMI program develops, it will become possible to post-stratify the data to examine issues on subsets of the PHR stands. A minimum stratum size is approximately 30 plots.

4.11 FUTURE MODIFICATIONS

Future modifications to the CMI program could include:

1. **Decreasing sample intensity**

The sampling intensity was selected to build an adequate CMI program as quickly as possible; however, the program will become increasingly expensive, as more plots are included in the sample over time. To reduce costs, the sampling intensity of a new stand cohort can be decreased or plots can be dropped from the program. Decreasing sampling intensity is possible if the G&Y models are accurate for the 15 to

20 year old stands. Dropping plots is possible if we believe that the G&Y models can predict growth with reliable accuracy in a certain stratum (e.g., BGCsubzone) within the target population.

2. **Increasing measurement period**

Increasing the measurement period is an effective method to reduce sampling costs while maintaining all plots in the program. This option is preferred if we believe that all plots contribute useful information to the CMI program and that historical data is too valuable to be discontinued.

3. **Adding other information**

Management priorities and strategies change over time and it is important that the CMI program can accommodate different business needs. The proposed program fits this requirement. New tree measurement can be added such as branch size, wood quality, or spatial location. Coarse woody debris or ecological data not currently collected could also be added. When adding information, one must remember that growth can only be estimated after a minimum of two measurements, or five years for the current program.

5. SCHEDULE

The objective is to start field sampling in September and to complete work in mid-October (Figure 3). Analysis and reporting will take place before the end of the fiscal year.

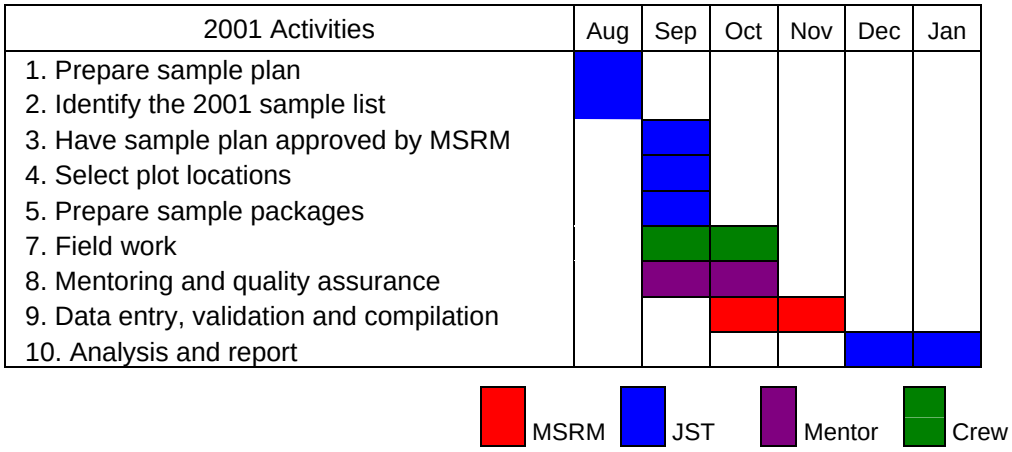

Figure 3. CMI implementation schedule in 2001.

6. ROLES AND RESPONSIBILITIES

6.1 CANFOR

Canfor will:

- Coordinate the project.
- Communicate with MSRM.
- Monitor project budget and progress, and communicate to MSRM.
- Ensure the sample packages are assembled and complete.

- Oversee ground-sampling activities.
- Ensure quality assurance is complete.
- Assist in coordinating technical expertise where required.

6.2 MSRM (TIB AND PGFR)

MSRM will:

- Approve the CMI sample plan.
- Mentor field crews at the beginning of the fieldwork.
- Perform quality assurance of the fieldwork.
- Compile data.
- Check data after initial compilation.

6.3 JST

JST will:

- Prepare the sample plan.
- Select the plot locations.
- Transfer plot locations from GIS to air photos.
- Prepare sample packages.
- Complete the fieldwork.
- Complete quality control of fieldwork.
- Enter data.
- Complete quality control on data entry.
- Analyze and report on the data.

APPENDIX I – PLOT MODIFICATIONS FROM MSRM CMI STANDARDS

Difference between MSRM CMI standards and TFL 30 procedures.

Item	MSRM Standards	TFL 30 Procedure
Plot Establishment		
Plot layout	No quadrant	4 quadrants, split in the cardinal directions, numbered 1 to 4, starting with the Northeast quadrant.
Tags	Affixed at stump height	Affixed at breast-height
Timber Attributes		
Top height tree	Selected in a 5.64-m radius plot	Selected in the Northeast quadrant
Leading Species Site Tree	Collected	Not directly collected
Second Species Site tree	Collected if the second species represents at least 20% of basal area	Not directly collected
Other site trees	Collected for all species representing at least 20% of basal area	Collected for all species present in the plot. These site trees will include the MSRM leading and second species.
Spruce Weevil Attack	Not collected	Number of attacks in the last five years recorded in Column 56 on Card 8.
Ecology		
Ecological Description 1 (Card 12)	Collected	Site classification and site features for pin location collected for 1-14 year cohort; Soil features for pin location and soil description for pin location not collected
Ecological Description 2 (Card 13)	Collected	Site features for dominant stratum collected for 1-14 year cohort; Soil features for dominant stratum and soil description for dominant stratum not collected
Tree and Shrub Layer (Card 14)	Collected	Collected for 1-14 year stratum
Herb and Moss Layer (Card 15)	Collected	Collected for 1-14 year stratum
Succession interpretation	Collected	Not collected
Coarse Woody Debris	Collected	Not collected
Range	Collected	Not collected

APPENDIX II – TFL 30 CMI SAMPLE LIST

Table 5. TFL 30 CMI sample list for 2001.

Plot No	Map	Stand	Spp	Spp Group	Elevation (m)	Age (yrs)	Subzone	Area (ha)
MP-001	93I011	4610	Ep	Others	680	25	SBSwk1	130.9
MP-002	93J020	1770	At	Others	643	16	SBSwk1	119.1
MP-003	93I011	5770	Ep	Others	682	27	SBSwk1	55.0
MP-004	93J029	6580	Fd	Others	746	27	SBSwk1	17.5
MP-005	93J030	13020	Pl	Pl	633	23	SBSwk1	16.2
MP-006	93J030	7820	Pl	Pl	612	20	SBSwk1	7.4
MP-007	93J030	9790	Sx	Sx	873	15	SBSvk	265.5
MP-008	93J030	12340	Sx	Sx	776	17	SBSvk	214.9
MP-009	93I021	3490	Sx	Sx	734	17	SBSvk	174.1
MP-010	93I012	9770	Sx	Sx	859	20	SBSvk	112.0
MP-011	93I031	7450	Sx	Sx	706	16	SBSvk	104.5
MP-012	93I021	2560	Sx	Sx	729	16	SBSvk	100.6
MP-013	93I012	2670	Sx	Sx	761	16	SBSvk	100.0
MP-014	93I012	90	Sx	Sx	677	20	SBSvk	71.8
MP-015	93I011	4730	Sx	Sx	671	20	SBSwk1	66.6
MP-016	93J029	10730	Sx	Sx	758	15	SBSwk1	62.6
MP-017	93I012	2980	Sx	Sx	748	26	SBSvk	60.7
MP-018	93J030	7040	Sx	Sx	888	15	SBSvk	58.4
MP-019	93I021	10960	Sx	Sx	662	21	SBSwk1	57.1
MP-020	93I021	1850	Sx	Sx	725	17	SBSvk	49.3
MP-021	93J029	1730	Sx	Sx	854	25	SBSwk1	48.8
MP-022	93I011	1110	Sx	Sx	670	24	SBSvk	47.9
MP-023	93I021	4100	Sx	Sx	699	17	SBSvk	43.4
MP-024	93J030	4070	Sx	Sx	794	19	SBSwk1	43.2
MP-025	93J029	11410	Sx	Sx	767	30	SBSwk1	43.1
MP-026	93I003	7920	Sx	Sx	884	19	ICHvk2	40.0
MP-027	93J038	4300	Sx	Sx	831	25	SBSwk1	30.2
MP-028	93I011	2350	Sx	Sx	648	26	SBSwk1	25.6
MP-029	93J018	860	Sx	Sx	636	26	SBSmk1	21.9
MP-030	93J039	3820	Sx	Sx	819	18	SBSwk1	19.0
MP-031	93I021	14710	Sx	Sx	634	18	SBSvk	14.8
MP-032	93J038	4210	Sx	Sx	817	17	SBSwk1	14.2
MP-033	93I031	8160	Sx	Sx	723	17	SBSvk	10.7
MP-034	93J030	11530	Sx	Sx	683	15	SBSwk1	9.2
MP-035	93J030	6880	Sx	Sx	715	20	SBSwk1	6.3
MP-036	93I021	3100	Sx	Sx	767	18	ICHvk2	2.7