MINISTRY OF FORESTS

Design Vehicle Configuration Analysis and CSA-S6-00 Implication Evaluation Phase II

2003 November 19 Our Ref: 1579

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Executive Summary

The Ministry of Forests (BCMoF) had previously commissioned Buckland & Taylor Ltd. to conduct of review of the Forest Service Bridge Design and Construction Manual and CAN/ CSA-S6-00 (CHBDC) to determine if the existing BCMoF Design Vehicle configurations are reasonably representative of the logging vehicles now being used in the BC forest industry and if these configurations are appropriate for use with the load factors in CHBDC.

A survey of logging truck weights conducted by Forest Engineering Research Institute of Canada (FERIC) provided the base data for this analysis and the results of this study were presented to the BCMoF in a report entitled 'MoF Design Vehicle Configuration Analysis and CSA-S6-00 Implication Evaluation' dated 2003 January 04 (draft report dated 2002 May 13). Although the report made some recommendations for revisions to the L75 Design Vehicle and corresponding load factors, it was concluded that insufficient data was available to accurately assess the L100, L150 and L165 Design Vehicles or trucks conducting movements of logging equipment. Although truck loadings and bridge design capacity requirements could vary significantly between operationing regions and individual operators, comments received from personnel involved in the industry indicated that most companies were having forestry bridges designed for load levels that exceeded the maximum measured weights of most of the logging trucks.

The BCMoF subsequently engaged FERIC to conduct a survey of forest companies to obtain the required additional data on logging truck weights and to determine the design capacities required by the forest companies in various regions of the province. The BCMoF also extended Buckland & Taylor Ltd.'s original assignment to include the assessment of this new data.

The additional survey data on the gross vehicle weights of the logging trucks operating in both the Interior and Coastal regions of BC was analyzed and was considered to be appropriate for use in the derivation of live load factors. Live load factors were derived for the L100 (Interior region) plus the L150 and L165 (Coastal region) Design Vehicle configurations as these are the design loadings specified for most bridges in the province.

Bridge components designed for the L100 and L150 Design Vehicles were found to be slightly deficient if governed by short span loadings (axle groups) and somewhat over designed if governed by longer span loadings (gross vehicle weights). This is similar to the findings for the L75 Design Vehicles in the previous phase of this study. The L165 Design Vehicle was found to provide conservative bridge designs on both short and longer spans for the current population of logging trucks transiting these bridges.

The derived live load factors varied significantly for bridge components governed by short span loadings and those by long span loadings. In addition, significant variation was observed in the live load factors derived for the various Design Vehicle Configurations. Therefore, the application of a single live load factor for all design cases will result in cases of under and over design of bridge components. Modifications to the existing Design Vehicle Configuration weight and distributions of weights to the axles are required to allow the use of a single live load factor for all design cases. Modified Design Vehicle Configurations were developed for use with the 1.7 live load factor specified by CHBDC. The adoption of 1.7 as the live load factor would also allow the direct use of the provisions of CHBDC for the design of forestry bridges.

The CL-W configuration from CHBDC was also assessed as an alternative loading model but was also found to require significant modification to provide a consistent level of safety for all bridge span lengths.

Theoretical loadings for lowbed trucks transporting logging equipment were assessed and the base characteristics of these loadings were found to be similar to those for overload trucks operating on the highway. Therefore, it is recommended that the provision of Section 14 of CHBDC pertaining to permit trucks be used to assess the acceptability of these trucks on forestry bridges. The lowbed truck weights developed for this study did not appear to govern over the Design Vehicle for the design of the bridges. However, bridge operator may wish to provide additional bridge capacity to allow for somewhat heavier lowbed trucks that may operate currently or in the future.

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1 Introduction

The Ministry of Forests (BCMoF) had previously commissioned Buckland & Taylor Ltd. to conduct a review of the Forest Service Bridge Design and Construction Manual and CAN/CSA-S6-00 (CHBDC) to determine the following:

- Do the existing BCMoF Design Vehicle Configurations produce force effect envelopes that are reasonably representative for the logging vehicles now being used in the British Columbia forest industry?
- Are the existing BCMoF Design Vehicle Configurations appropriate for use with the load factors in CHBDC?

The results of this study were presented in a report to BCMoF entitled' MoF Design Vehicle Configuration Analysis and CSA-S6-00 Implication Evaluation' dated 2003 January 04 (draft report dated 2002 May 13) [1]. The report made recommendations for revisions to the L75 Design Vehicle load model and to the corresponding load factors. However, the study concluded that the data provided was insufficient to properly assess the appropriateness of the BCMoF Design Vehicles for L100, L150 and L165 loadings for the logging trucks currently using the forestry road system. In addition, no information had been obtained to describe the trucks transporting logging equipment on forestry roads.

On 2002 September 10, a seminar was held to present the study findings to a number of invited personnel from BCMoF, Ministry of Transportation and from several other companies or organizations involved with forestry bridges. Input received from the seminar attendees indicated that although minimum load carrying capacities for the design of forestry bridges were not imposed on the forest companies, generally forestry companies were having bridges designed for load levels that exceeded the maximum measured weights of most of the logging trucks.

The BCMoF subsequently engaged the Forest Engineering Research Institute of Canada (FERIC) to survey forestry companies to obtain weigh scale information that describes the gross vehicle weights of the logging vehicles operating in various regions of the province and to determine company policy and practices regarding the load capacity levels required for their bridges. In addition, FERIC survey the operators of low bed trucks conducting the movements of logging equipment to determine the configurations of the trucks and typical weights of equipment being transported.

The BCMoF has extended Buckland & Taylor Ltd.'s original assignment to analyze the new data collected by FERIC and to reassess the appropriateness of the existing BCMoF Design Vehicle Configurations and to determine if these configurations are appropriate for use with the provisions of CAN/CSA-S6-00 (CHBDC) [2]. If appropriate, recommendations for revisions to the BCMoF Design Configurations and applicable load factors are to be provided. Similarly, information pertaining to trucks conducting logging equipment moves is assessed and recommendations developed for assessing the suitability of these types of loads on forestry bridges.

A draft report detailing the findings of this study was issued to the BCMoF on 2003 June 27. BCMoF distributed the draft report to various forestry related companies or individuals for review and comment. Written comments were received from Mr. Allan Bradley, P.Eng., of FERIC and Mr. Paul King, P.Eng., of Rapid-Span Structures Ltd. Subsequently, the report was modified to address these comments.

2 Methodology

2.1 General

For a bridge design standard to provide the desired level of safety, it is essential that all aspects governing the design process are considered in a consistent manner. The level of safety provided is dependent on the variations and interrelationships between the various bridge loadings, member resistances and structural behaviours of the bridge system. The level of safety provided can be significantly affected if modifications are made to any of the design requirements without considering the impact on the overall design philosophy.

The load factors provided by a bridge design standard are typically based on the expected statistical variations of the actual bridge loadings from the specified design loads. New truck configurations or changes in the level of weight enforcement can significantly alter these statistics and change the level of safety provided. Measurements of the actual truck populations being considered are required to assess the appropriateness of the requirements in the design standard.

This study does not consider fatigue loadings.

2.2 Study Procedures

The logging truck weight data provided by FERIC has been used to assess the level of safety provided by the current BCFS Vehicle Configurations for L100, L150 and L165 type forestry bridges [3]. The following describes the general methodology used for this study:

- Each set of the logging truck weight data provided is analyzed to determine if the data is reasonably consistent with the other data sets and to identify and investigate potential outliers in the data. All compatible data sets are combined to produce an overall data set of logging truck weights for both the Coastal and Interior regions. The overall data set is compared to the truck weight data developed during the previous phase of this study and any significant differences investigated.
- Based on the overall data sets and the appropriate Design Vehicle Configurations, statistics describing the expected Gross Vehicle Weight (GVW) of the maximum annual truck are generated.
- Based on the maximum annual truck statistics, corresponding live load factors are developed which will provide levels of safety consistent with CHBDC and the previous phase of this study. The new data provided for this

study describes GVWs and not individual axle or axle group loadings. Therefore, live load factors for short spans are developed by adjusting the GVWs statistics based on the ratios of short span force effects to longer span force effects determined in the previous study phase.

- Where appropriate, the BCFS Design Vehicle Configurations are modified to allow the use of a single set of live load factors for all Design Vehicle Configurations and all span lengths. The CL-W design configuration (CHBDC) is assessed to determine if it appropriately represents the logging truck loadings.
- The weights of trucks transporting logging equipment that were generated by FERIC are assessed and compared to the weights of the logging trucks. Recommendations for live load factors to be applied to these vehicles are developed based on the results of this assessment.

2.3 Limitations of Study

This study is not a comprehensive review or check of all aspects of either CAN/CSA-S6-00 or the Forest Service Bridge Design Manual [3] with respect to their suitability for the design of forest service bridges. The study concentrated only on the issues of design truck loadings and load factors.

3 Survey of Logging Trucks

3.1 Phase I Data Collection

The previous phase of this study, Phase I, was based on a portable weigh scale field survey program that provided detailed measurements of the weights and dimensions for logging truck operating in various regions of the Province. The data collected during Phase I was considered sufficient to provide appropriate descriptions of the following:

- the axle weights, gross vehicle weights and dimensions of logging trucks that operate on the highway system;
- the axle weights (including side to side variations in axle weight distributions), gross vehicle weights and dimensions of logging trucks, generally conforming to L75 loading, operating in the Interior regions; and
- the side to side variations in axle weight distributions and the variation in axle weights relative to variations in gross vehicle weights for off highway logging trucks (L150-L165) in coastal regions.

However, the data collected during Phase I was considered to be insufficient for describing the following:

- the characteristics of logging trucks generally conforming to the L100 design vehicle;
- the gross vehicle weights of off highway logging trucks operating in the coastal regions (L150-L165);
- the characteristics of trucks transporting logging equipment; and
- the typical design capacities for the logging bridges on which these trucks operate in various regions of the Province.

3.2 Phase II Data Collection

The goal of the Phase II data collection program was to provide the information that was not available for Phase I. Although field surveys using portable weigh scales can supply information on all aspects of truck weights and dimensions, the time and expense required to measure each truck necessitates a smaller sample size and fewer survey locations. Since larger data samples from multiple locations were desired for Phase II, a different method of data collection was implemented for this Phase.

It was recognized that many of the forest companies use weigh scales to track the weight of timber being delivered to their mills or intermediate staging areas. Extensive amounts of this data were available which typically consisted of a truck weight, both loaded and unloaded, and the truck identification (truck number and basic truck configuration). Although this data only describes the gross vehicle weights of the logging trucks, it can be used in conjunction with the results of the Phase I study to assess axle loadings. Data collected during Phase I was considered to provide a reliable description of the distributions of axle weights within a truck configuration relative to the gross vehicle weight of the truck configuration. Therefore, FERIC canvassed forestry companies to obtain weigh scale records of logging truck operations for both interior and coastal regions. In addition to the weigh scale records, FERIC also canvassed the forestry companies for information regarding the load capacities of the bridges in their road systems and the operational policies applied to the use of these bridges.

Truck transportation of logging equipment between sites is not a frequent event and the truck weights are not typically measured or recorded. Therefore, FERIC canvassed firms that conduct movements of logging equipment to obtain information regarding the configuration and weight of the trucks transporting the logging equipment, the types and weights of logging equipment being transported and the typical load capacities of the bridges that are transited.

3.3 Collected Data

Extensive amounts of weigh scale data were collected for logging trucks operating in the Interior and Coastal regions of BC. Tabular and graphical summaries of the truck gross vehicle weights are provided for the overall survey results and for each survey location in Appendices A and B for the Interior and Coastal data sets, respectively.

The weigh scale data was provided by the forestry companies on the condition that the specific sources of the data would remain confidential and not be published or shared. Therefore, company names and operating locations have been replaced with alpha numeric designations. A complete electronic copy of all data sets provided for this study have been supplied to the BCMoF.

3.3.1 Data Interior Region

Weigh scale data pertaining to logging trucks operating in the Interior regions were supplied by a number of forestry companies that use trucks considered to conform to the L100 designation. Table 1 provides a partial summary of the data provided by forest companies participating in the study. Tabular and graphical summaries of the truck gross vehicle weights provided by each company at various locations are provided in Appendix A.

3.3.2 Data Coastal Region

Weigh scale data pertaining to logging trucks operating in the Coastal regions were supplied by a number of forestry companies. Table 2 provides a partial summary of the data provided by forest companies participating in the study. Tabular and graphical summaries of the truck gross vehicle weights provided by each company at various locations are provided in Appendix B.

3.3.3 Logging Equipment Moves

Survey data pertaining to the weights of trucks transporting logging equipment on forestry roads is provided in Appendix C. Again the locations of operations and names of contractors have been replaced by alpha numeric designations.

The truck gross vehicle weight and axle group weights provided are not based on weigh scale measurements but have been developed by FERIC based on information supplied by the trucking companies. Trucking companies supplied the types of logging equipment that they transport, the weights of trucks and lowbed trailers they operate and descriptions of how the various pieces of equipment could be positioned on the trailer. Based on this information FERIC developed expected gross vehicle weights for each supplied truck/logging equipment configuration. In addition, FERIC used a computer model (Load Xpert software - Heavy Haul Plus) to estimate the axle weights of the heaviest truck/logging equipment combinations, with the equipment shifted between the forward and rear most positions identified by the lowbed operator. Although these truck and axle group weights can not be used to develop statistical variations of the loadings, they do provide a useful basis for establishing the likely magnitude of the loadings. The governing load carrying capacity of local bridges for each operating area have also been supplied.

Table 1: Logging Truck Weigh Scale Data for BC Interior Locations Using L100 Trucks

Company	Location	Dates	No. of Trucks	Bridge Types in System	Load Controls
1	1 - Sample A	2002 Jan 01 - Feb 28	2212	L75 bridges.	Load limit is 68 tonnes, 55 tonnes limit on payload lifter
1	1 - Sample B	2002 Sept 01 - Oct 31	2470	L75 bridges.	Load limit is 68 tonnes, 55 tonnes limit on payload lifter
2	1	2002 Jan 02 - Feb 01	198	L100 and L75 Bridges plus a 63.5 tonne highway bridge.	Trucks exceeding 63.5 tonne limit on highway bridge incur missed trip.
3	1	2002 Feb	236	All bridges L100.	Payload limited to 41 tonnes, capacity of jack ladder lift in yard.
4	1	2002 Jun 11 - Sept 20	122	L75 standard.	L75 only exceeded on routes with no bridges.
4	2	2000 Jun 12 - 2002 Oct 28	20962	Only 10-12 bridges but all L100.	All loads except cleanup capped 59 tonnes net weight, stacker limit.
4	3	2002 Jan 02 - Apr 03	7635	L100 standard or trucks limited to bridge ratings.	Does not pay for wood over established target payload limit.
4	4	2002 Jan 02 - Apr 03	8529	L100 standard or trucks limited to bridge ratings.	None provided
5	1 - Sample A	2002 Jan 01 - Feb 28	4826	Both permanent and temporary bridges L100.	Generally tied to stacker limits (54 t).
5	1 - Sample B	2002 Aug 01 - Sep 30	1889	Both permanent and temporary bridges L100.	Generally tied to stacker limits (54 t).
5	2 - Sample A	2002 Jan 01 - Feb 28	7772	Both permanent and temporary bridges L100.	Generally tied to stacker limits (54 t).
5	2 - Sample B	2002 Aug 01 - Sep 30	2071	Both permanent and temporary bridges L100.	Generally tied to stacker limits (54 t).
5	3 - Sample A	2002 Jan 01 - Feb 28	3800	Both permanent and temporary bridges L100.	Generally tied to stacker limits (54 t).

Table 1: Logging Truck Weigh Scale Data for BC Interior Locations Using L100 Trucks

Company	Location	Dates	No. of Trucks	Bridge Types in System	Load Controls
5	3 - Sample B	2002 Aug 01 - Sep 30	4823	Both permanent and temporary bridges L100.	Generally tied to stacker limits (54 t).
6	1	2002 Jan 03 - Feb 28	1869	All bridges L100	None provided.
7	1	2002 Jan 02 - Feb 28	6529	L100 rated bridges except for few down rated bridges subject to load restrictions.	Stacker has a 57 t lift capacity and do not pay beyond this limit.
8	1	2002 Jan 02 - Feb 28	3584	Last 3 years all L100 but previously L75 to L100.	Don't pay for portion of loads that exceed limits.
9	1	2001 Oct 01 - Nov 30	2509	Permanent bridges L100 but temporary bridges L75 or L100.	Don't pay for portion of loads over 49 tonnes but could be heavier after sitting in lake.

Table 2: Logging Truck Weigh Scale Data for BC Coastal Locations

Company	Location	Dates	No. of Trucks	Bridge Types in System	Load Controls
1	1	2001 Jun 18 - Jun 29	54	All L165	No target weight limits, only a 'safely built load'' per WCB.
1	2	2001 Jan 24 - Jan 31	86	All L165	No target weight limits, only a 'safely built load' per WCB.
1	3	2000 Jan 26 - 2003 Feb 11	180	All L165	No target weight limits, only a 'safely built load' per WCB.
1	4	2000 Nov 07 - 2001 Feb 22	74	All L165	No target weight limits, only a 'safely built load' per WCB.
1	5	2000 Apr 17 - 2000 Apr 28	60	All L165	No target weight limits, only a 'safely built load' per WCB.
1	6	2000 Mar 16 - 2000 Mar 20	66	All L165	No target weight limits, only a 'safely built load' per WCB.

Table 2: Logging Truck Weigh Scale Data for BC Coastal Locations (Continued)

Company	Location	Dates	No. of Trucks	Bridge Types in System	Load Controls
1	7	1999 Dec 01 - 2000 Feb 29	181	All L165 except for two down rated to L150 due to steepness of grade.	Loadermen directed to keep loads to average size.
1	8	1999 Dec 01 - 2000 Feb 29	409	All L165 except for two down rated to L150 due to steepness of grade.	Loadermen directed to keep loads to average size.
2	1	2002 Apr 02 - Jun 29	2497	All bridges L165 but two L150 bridges. Bridges down rated lower are restricted to highway loadings.	Loads limited to what driver believes is safe.
3	1	2002 Jan 01 - Oct 31	2952	L100 standard.	5-axle "fat trucks" limited to about 60 t
3	2	2002 Jan 01 - Oct 31	7461	L100 standard.	Limited to 53 t due to derailment concerns.

3.4 Discussion of Survey Data

3.4.1 Interior Region

Weigh scale measured logging truck gross vehicle weights, 82,036 in total, were provided by nine forestry companies from a total of 18 operating locations in the Interior Region. The combined distribution of the truck weights from all these interior locations is shown on Figure 1.

Approximately 65% of the trucks exceed the gross vehicle weight of the L75 Design Vehicle (68,000 kg) but only 240 of the trucks, 0.3%, exceed the gross vehicle weight of the L100 Design Vehicle (90,700 kg). Note that Companies 3 and 4 did not include trucks with weights less than 70,000 kg in their data samples.

The lack of a high peak in the distribution near the weight corresponding to the L100 Design Vehicles indicates that the L100 Design Vehicle loading is not generally used as a loading target for industry operations. Survey responses indicated that capacities of lifts or stackers governed the payload weights at many locations. Non payment for loads exceeding set limits also restricted the maximum sizes of the loads at many of the operations.

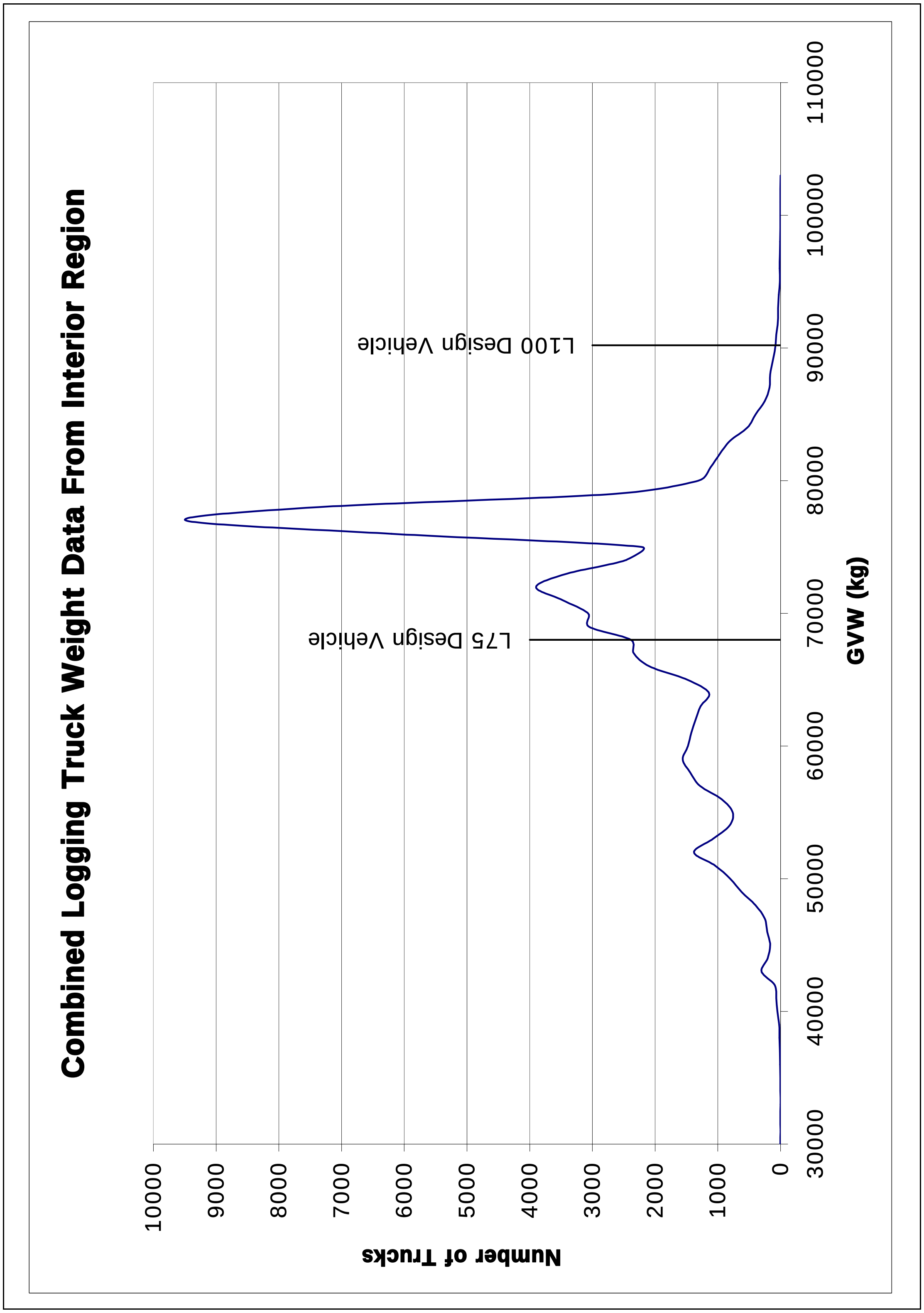


Figure 1: Combined Logging Truck Weight Data From Interior Region

For many of the operations, the capacity of stackers loading or unloading the trucks, 54 to 55 tonnes lift limits, appears to provide an effective upper limit on the truck weights in the range of 80 to 85 tonnes, for Companies 5, 6, 7, 8 and 9. However, Companies 1, 3 and 4 appear to exceed weights of 90 to 100 tonnes with or without a stacker lift limit. This indicates that there can be significant variation in maximum truck loadings between operations using L100 bridge standards.

It was noted that Interior Company 1 is reported to use L75 bridges (68 tonnes) but the survey data indicates that approximately 20% of the trucks exceed this weight and maximum of up to 91 tonnes are reported.

Only the relatively small data sample produced by Interior Company 4 at Location 1, 122 trucks, indicated that all truck weights at that location were consistently less than the L75 Design Vehicle for a route that operated L75 bridges. All other locations contained significant numbers of trucks with weights in excess of the L75 Design Vehicle. However, most of these locations also used L100 bridges in their operations and the heavier trucks may have been restricted from the L75 routes.

FERIC indicated that while many interior operations use L75 bridges/truck configurations, the survey generally targeted interior operations using L100 bridges and or trucks with loaded weights that typically exceeded the L75 configuration. FERIC also indicated that some of the interior companies are in the process of upgrading their bridge standards from L75 to L100.

3.4.2 Coastal Region

Three coastal forestry companies provided weigh scale measured gross vehicle weights for 14,020 truck loads from 11 Coastal Region operations. The combined distribution of the truck weights from all the provided coastal operations is shown on Figure 2.

The distribution of coastal truck weights is clearly bimodal and is considered to represent two separate categories of logging trucks. Note that the lower mode is composed entirely of data provided by Coastal Company 3 at Location 1, which may have included data on lighter weight truck types where other operations did not. The lower peak likely represents highway legal logging truck configurations operating on or off the highway. The higher peak is considered to represent the five axle wide berth trucks that operate in the Coastal Region. Of the 5,400 trucks

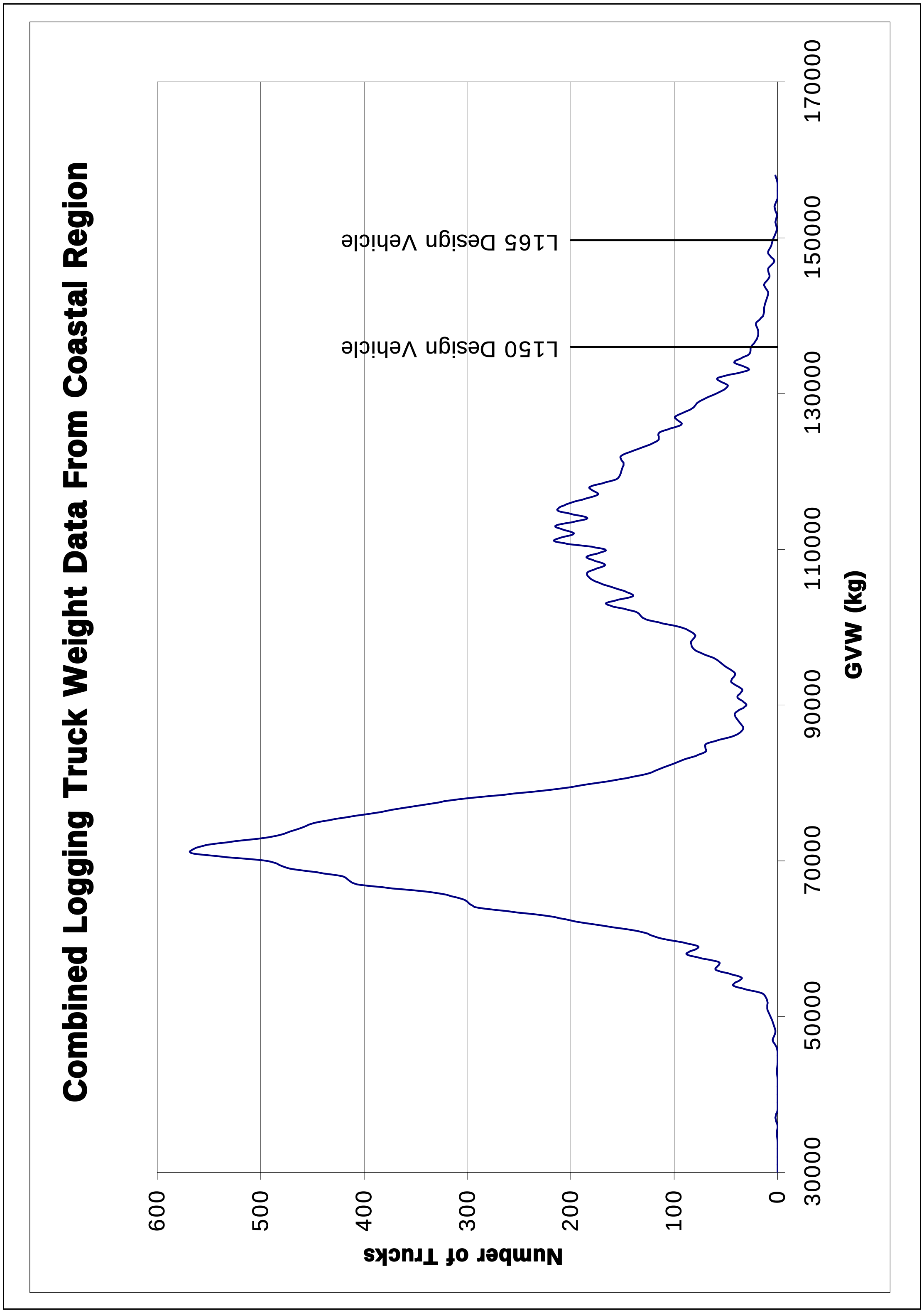


Figure 2: Combined Logging Truck Weight Data From Coastal Region

with weights exceeding 90,000 kg, 168 (3%) exceed the weight of the L150 Design Vehicle (136,000 kg) and 7 (0.1%) exceed the weight of the L165 Design Vehicle (149,700 kg).

Although there are no true load controls on the wide berth off highway logging trucks, relatively few of the truck weights reach or exceed the weights of the L150 or L165 Design Vehicles. This indicates that operational practicalities, such as the maximum volume of wood that can be practically loaded or unloaded unto a truck or steep grades, control the maximum truck weights. The general shape of the weight distributions and maximum truck weights do not vary significantly between the various populations.

A comparison was made between the truck weight data collected in Phase I and Phase II for the wide berth off highway trucks used in the Coastal Region. The average gross vehicle weight for the Phase I survey population was about 10% lower than that for the Phase II survey population and the coefficient of variation of the population was also slightly less for Phase I than for Phase II. Although the Phase I population was on average somewhat lighter and less variable than the Phase II population, they are considered to be close enough to be from the same truck population. Possible reasons for the Phase I sample being lighter are that a lighter type of wood was being harvested or that the much smaller sample size did not capture areas where heavier trucks were operating.

In general, most companies now claim to use only L165 bridges and lower rated bridges are only used in areas with restricted truck loadings or where only highway legal traffic operates.

3.4.3 Short Spans and Other Spans

Loads on trucks vary. The position of the load on a truck also varies. For this reason, the weight on a single axle, or a few axles, can vary more than the total weight of the vehicle.

The consequence of this is that short span bridges or parts of bridges, which only support one axle or axle group at a time, see more variation in the loads applied to them than occurs on longer spans that support the entire vehicle.

Canadian Standard CAN/CSA-S6-00 groups these members into ’Short Spans’ and ’Other Spans’. The two groups must both be considered to cover all situations. For logging trucks the results of Phase I of this study determined that ’Short Spans’ are spans of less than 15 m and ’Other Spans’ are greater than 15 m.

4 Analysis of Logging Truck Data

4.1 General Methodology

In accordance with the Phase II study plan, FERIC's surveys in the Interior regions targeted operations generally using L100 bridges forestry bridges. Surveys conducted in the Coastal regions indicated that L165 bridges was the primary bridge standard. Therefore, the L100 and L165 design vehicle loadings will be used to derive live load factors for the logging truck populations surveyed in Phase II for Interior and Coastal regions, respectively. The implications to existing bridges or new bridges sized for other design loadings are discussed in Section 6.0.

For each region, Interior and Coastal, the data sets from each survey location were combined to form an overall distribution of logging truck weights. With only very minor exceptions, all data sets were considered to represent the same population of logging trucks. The exceptions were several locations where the truck weights were substantially lighter but relatively few in number and do not impact the governing truck weight statistics.

For Phase I of the study complete vehicle dimensions and individual axle weights were available for each logging truck. From this data maximum force effects generated by each truck on spans of varying lengths were calculated from which the event statistical parameters for the maximum force effects were derived. Event statistical parameters refer to individual events, such as the passage of a single truck. Since only the gross vehicle weights of the logging trucks were available for Phase II of the study, the variations of the gross vehicle weights were used to derive the statistical parameters. However, the use of event statistical parameters based on gross vehicle weights is only appropriate for simple span moments and shears on 'Other Spans' (bridges with simple spans greater than 15 m).

The event statistical parameters are converted into maximum annual statistical parameters which describe the variations of the maximum force effect expected to be generated on a bridge by the heaviest truck in a one year period. These are the statistics that are used to derive live load factors appropriate for use with the Design Vehicle on longer spans.

For bridges or bridge components governed by 'Short Span' loadings, axle loads, or negative moments on continuous bridges the maximum annual statistics for 'Other Spans' were adjusted by the ratios of 'Short Span' to 'Other Spans' statistics derived in Phase I of the study. These statistics are then used to derive live load factors for 'Short Span' bridges.

4.2 Interior Region

The distribution of logging truck weights for the combined survey populations collected for the Interior Region, targeting operations using L100 bridges/trucks, are shown on Figure 1. A normal distribution was fit to the upper tail and first peak of this distribution with the statistical parameters of a mean of 68.0 tonnes and a coefficient of variation of 13.5%. This distribution represents the event distribution for the heaviest trucks on the Interior forestry bridges.

The logging truck event statistics were converted into maximum annual truck statistics following the method contained in Kennedy et al. [4]. The maximum L100 annual truck statistics derived for 'Other Spans' in the Interior region are a mean of 99.2 tonnes and coefficient of variation of 5.04%. This means that on average the heaviest truck to cross a bridge in a one year period is 99.2 tonnes. An approximate annual population of 5000 loaded highway logging trucks was assumed to be using a typical bridge based on the number of trucks observed during the time periods reported in the survey populations. Note that the maximum annual truck statistics are relatively insensitive to large changes in the number of annual trucks using a bridge. For Interior bridges designed to the L100 Design Vehicle (90.7 tonnes) the mean annual maximum truck weight (99.2 tonnes) divided by the weight for which the bridge was designed (90.7 tonnes) results in a bias coefficient of 99.2/90.7 = 1.094. This applies to 'Other Spans'.

Phase I of this study identified that the maximum annual force effect statistics varied depending on length of span being considered and for negative moment regions on continuous spans. Since the Phase II data only provided gross vehicle weights a direct assessment of these effects is not possible for this survey population. Therefore, maximum annual statistics for 'Short Spans' and negative moment regions have been derived by scaling the observed characteristics by the same ratios found for L75 category trucks in Table 5.3.4 of the Phase I report [1]. For example, the ratio of Phase I bias coefficient for 'Short Spans' and 'Other Spans' is 1.41/1.195 = 1.18. Therefore, the bias coefficient for 'Short Spans' in Phase II is taken as 1.18 times the observed value for 'Other Spans' (1.094) to give 1.18*1.094 = 1.29 for 'Short Spans'. Coefficient of variations were taken as the same for all types of force effects because all the values are small and have very little effect on the load factors produced. The resulting maximum annual statistical parameters for the various types of force effects are shown in Table 3.

Table 3: Bias Coefficients for Maximum Annual Force Effects on L100 Interior Bridges

Force Effect	L75 Bias Coeff. Phase I	Ratio Phase I (Force Effect/ 'Other Span')	Bias Coeff. taken for L100 (1.094*ratio)	Assumed L100 Coefficient of Variation
Simple Span Moments and Shears ('Other Spans')	1.195	1.00	1.094	0.0504
Moments and Shears 'Short Spans'	1.41	1.18	1.29	0.0504
Negative Moments 20m spans	1.55	1.30	1.42	0.0504
Negative Moments 40 m spans	1.295	1.08	1.19	0.0504

4.3 Coastal Region

The distribution of logging truck weights for the combined survey populations collected for the Coastal Region are shown on Figure 2. A normal distribution was fitted to the upper tail and first peak of this distribution with the statistical parameters of a mean of 111.3 tonnes and a coefficient of variation of 12.3%. This distribution represents the event distribution for the heaviest trucks on the Coastal forestry bridges.

The logging truck event statistics were converted into maximum annual truck statistics following the method contained in Kennedy et al. [4]. The maximum annual truck statistics derived for 'Other Spans' in the Interior region are a mean of 157.0 tonnes and coefficient of variation of 3.8%. An approximate annual population of 2,500 loaded highway logging trucks was assumed to be using a typical bridge based on the number of trucks observed during the time periods reported in the survey populations. Assuming that Coastal bridges are designed for L165 Design Vehicles (149.7 tonnes) the mean of the maximum annual truck statistics for 'Other Spans' results in a bias coefficient of 1.049 (157.0 tonnes/ 149.7 tonnes).

As with the truck population for Interior region, the axle weights for the Coastal region trucks are expected to be more variable than the gross vehicle weights of the trucks. Since statistics for various force effects had not been generated for the Coastal region trucks in Phase I the ratios between the Phase I L75 data are again used to derive maximum annual statistics for 'Short Spans' and negative moments. However, the L165 Design Vehicle has a heavier front tandem axle compared to the rear tandem axle which allows this model to produce higher short span loadings relative to the longer span loadings. This differs from the L75, L100 and L150 Design Vehicles which have even weights for the front and rear tandem axles. This heavier front tandem axle produces moments and shears on short spans that are 17.3% higher then would be achieved using equally weighted tandem axles. Therefore, the bias coefficients for the L165 vehicles on short spans can be reduced by a ratio of 1.173. For Coastal region trucks the resulting maximum annual statistical parameters for the various types of force effect are shown in Table 4.

Table 4: Bias Coefficients for Maximum Annual Force Effects on Coastal Bridges

Force Effect	L75 Bias Coeff. Phase I	Ratio Phase I (Force Effect/ 'Other Span')	Bias Coeff. for L165 Phase II	Assumed L165 Coefficient of Variation
Simple Span Moments and Shears ('Other Spans')	1.195	1.00	1.049	0.038
Moments and Shears 'Short Spans'	1.41	1.18	1.24/1.173 = 1.057	0.038
Negative Moments 20m spans	1.55	1.30	1.36	0.038
Negative Moments 40 m spans	1.295	1.08	1.14	0.038

4.4 Transport of Logging Equipment

FERIC's survey determined theoretical weights for a variety of lowbed trucks transporting various types of logging equipment. Since this data is not based on actual measurements of truck weights, it is not appropriate for the derivation of live load factors. However, it does provide an indication of how the weights of the lowbeds transporting logging equipment compare to the loadings considered in the design of the bridges in the region.

4.4.1 Interior Region

For all but one operating area in the Interior, FERIC's survey identified the local bridges as L100 designs. For the lowbed/logging equipment combination considered by FERIC, the ratios of lowbed gross vehicle weights to the gross vehicle weight of the BCMoF L100 Design Vehicle varied from 0.507 to 0.847. Since these ratios are less than 1.0, it is likely that the L100 bridges have sufficient capacity to carry these loadings. See Section 6.4 for related discussion.

One operating area was identified as having local bridges with L75 designs and the heaviest lowbed truck loadings (Madill 122 Grapple Yarder). This results in ratios of lowbed gross vehicle weights to the gross vehicle weight of the BCMoF L75 Design Vehicle up to 1.312. Although these bridges may have proven to be adequate when evaluated for the lowbed truck loadings, the substantially larger ratio of lowbed weight to design vehicle weights indicates that significant variability can exist in the overload practices at various operations.

4.4.2 Coastal Region

Most operating areas in the Coastal regions are identified as having L165 bridges. However, several areas were identified as having L75, L100 and L150 bridges. The maximum ratio of lowbed weights to design vehicle weights are 1.678 for L75 bridges, 0.909 for L100 bridges, 1.051 for L150 bridges and 1.098 for L165 bridges. See Section 6.4 for related discussion.

5 Derivation of Logging Truck Load Factors

5.1 General

The same methodology used to calibrate live load factors for logging trucks in Phase I of this study was used for Phase II of the study. The base calibration methodology is described in detail in Kennedy et al. [4].

5.2 Other Statistical Parameters

The statistical parameters recommended in the Commentary to Section 14 of CHBDC [2] for all bridge loadings other than trucks and dynamic load allowance were used in the calibration process. These parameters are shown in Table 5.

Table 5: Statistical Parameters for Other Loadings and Resistances

Type of Loading, Analysis or Resistance	Bias Coefficient	Coefficient of Variation
Dead Load Type 1 (D1)	1.03	0.08
Dead Load Type 2 (D2)	1.05	0.10
Dead Load Asphalt (D3)	1.03	0.30
Dynamic Load, Other Spans	0.40	0.80
Dynamic Load, Short Spans	0.67	0.60
Resistance, Plastic Moment Steel (R)	1.126	0.095

Statistical parameters for lateral distribution of live loads used in the calibration were also obtained from CHBDC but were modified for off-highway vehicles to include the statistics for side to side unbalanced loading of trucks. Only statically determinate lateral distribution of live load is considered since this is the general method employed on forestry bridges. These statistical parameters are shown in Table 6.

Table 6: Statistical Parameters for Lateral Distribution of Live Load

Analysis Type	Bias Coefficient	Coefficient of Variation
Statically Determinate	0.93	0.089

Dead load and resistance factors used in the calibration process were also consistent with CHBDC and are shown in Table 7.

Table 7: Dead Load Factors and Resistance Factors

Load or Resistance Factor	Reliability Index, β						
	2.50	**2.75**	**3.00**	**3.25**	**3.50**	**3.75**	**4.00**
α_{D1}	1.05	1.06	1.07	1.08	1.09	**1.10**	1.11
α_{D2}	1.10	1.12	1.14	1.16	1.18	**1.20**	1.22
α_{D3}	1.25	1.30	1.35	1.40	1.45	**1.50**	1.55
ϕ_R	0.95	0.95	0.95	0.95	0.95	**0.95**	0.95

5.3 Live Load Factor Interior Region

Live load factors were derived for the Interior region logging trucks for use with the BCMoF L100 Design Vehicle in accordance with the methodology described in Section 5.1 for reliability indices, β, from 2.50 to 4.00 for both 'Short Spans' and 'Other Spans', as shown in Table 8. Live load factors for the typical new design value of β = 3.75 (for annual maximum loads) are shown in bold type. The derivations were based on the statistical parameters in Section 5.2.

Table 8: Live Load Factors for BCMoF L100 Design Vehicle

Force Effect Type	Span	Reliability Index, β						
		2.50	**2.75**	**3.00**	**3.25**	**3.50**	**3.75**	**4.00**
Positive Moments and Shear Forces	Short Spans (< 15m)	1.42	1.50	1.57	1.65	1.74	**1.83**	1.92
	Other Spans (> 15m)	1.09	1.14	1.19	1.25	1.30	**1.36**	1.42
Negative Moments	20 - 25 m	1.41	1.47	1.54	1.60	1.67	**1.74**	1.82
	> 25 m	1.18	1.24	1.29	1.35	1.40	**1.47**	1.53

Note that live load factors derived for the same traffic using the BCMoF L75 Design Vehicle would be higher by a ratio of 1.33. Therefore, using the L75 Design Vehicle would require load factors of 1.81 on 'Other Spans' and 2.43 on 'Short Spans'. However, these load factors could be reduced if the heavy trucks are restricted from bridges designed for the L75 loading.

5.4 Live Load Factors Coastal Region

Live load factors were derived for the Coastal region logging trucks for use with the BCMoF L165 Design Vehicle in accordance with the methodology described in Section 5.1 for reliability indices, β, from 2.50 to 4.00 for both 'Short Spans' and 'Other Spans', as shown in Table 9. Live load factors for the typical value of $\beta = 3.75$ for design of new bridges are shown in bold type. The derivations were based on the statistical parameters in Section 5.2.

Table 9: Live Load Factors for BCMoF L165 Design Vehicle

Force Effect Type	Span	Reliability Index, β						
		2.50	**2.75**	**3.00**	**3.25**	**3.50**	**3.75**	**4.00**
Positive Moments and Shear Forces	Short Spans (< 15m)	1.15	1.21	1.27	1.34	1.41	**1.47**	1.55
	Other Spans (> 15m)	1.05	1.09	1.14	1.19	1.24	**1.29**	1.35
Negative Moments	20 - 25 m	1.35	1.40	1.46	1.53	1.59	**1.66**	1.73
	> 25 m	1.13	1.18	1.23	1.28	1.34	**1.40**	1.46

Note that although the L150 Design Vehicle is lighter than the L165 Design Vehicle the L150 Design Vehicle stipulates a higher side to side unbalanced loading which effectively makes the two design vehicles produce the similar demands on longer span standard two girder forestry bridges. For shorter span bridges the L165 Design Vehicle produces higher force effects since the weight of the front tandem axle has been increased relative to the rear tandem axle. Therefore, the same live load factors apply to both the L150 and L165 Design Vehicles on longer span bridges but the L150 Design Vehicle should have higher live load factors for short span bridges.

5.5 Live Load Factor for Transportation of Logging Equipment

Although live load factors for lowbed transporting logging equipment could not be derived directly from the survey data, a rationale for the selection of live load factors appropriate for use with these vehicles can be developed.

Even though these lowbeds are typically operating in off highway situations, they are loaded and operate in a similar fashion to overload trucks operating on the highway system. Therefore, the provisions of Section 14 of CHBDC for permit vehicles could be applied to the lowbeds transporting logging equipment.

FERIC and BCMoF have reported that the movement of logging equipment from one area to another is reported to be an infrequent event and that the loaded vehicles are not typically weighed. Therefore, these vehicles would generally fit the Permit - Single Trip or PS category. The actual truck loading must be determined by a qualified engineer and any bridges to be crossed be evaluated for these loadings using the live load factors for PS type traffic from Table 14.12.3.2(d) of CHBDC.

The live load factors for Permit Controlled or PC traffic, which are lower yet, could also be applied to these trucks if the requirements of CHBDC Section 14 are met.

6 Discussion of Design Models and Load Factors

6.1 Level of Safety Provided by Current Forestry Standard

The current standard for forest bridge design requires that a live load factor of 1.6 be applied with the BCMoF L75, L100, L150 and L165 Design Vehicles.

During the previous phase of this study [1], it was determined that the L75 Design Vehicle required live load factors ranging from 1.46 for long spans to 1.99 for short spans. These live load factors would increase to 1.83 and 2.43 if the truck population collected for L100 bridge operations were to operate on L75 bridges. Such a large increase in the live load factors required for safe passage of L75 trucks indicates the need for careful control of truck weights in areas containing bridges designed for differing loadings. At least one of the operators, Company 1, included in the Phase II survey used both L75 and L100 bridges in their systems this is an issue of concern. However, FERIC indicated that many forestry companies recognize that load restrictions are required on bridges that do not meet the L100 standard. Therefore, the potential overloading on L75 type bridges may be less than indicated above in many cases.

Live load factors derived for use with the L100 Design Vehicle, based on the current population of logging trucks in the Interior region, ranged from 1.36 for positive moments on spans over 15 m to 1.83 for moments and shears on spans less than 15 m. This indicates that for the current truck population the L100 design standard results in an 18% over design for live loadings on longer spans and under design by 14% on shorter spans. Under design or over design of bridges in these ranges may not be overly alarming in terms of safety or construction costs but it does point to significant inconsistency in the design process. In terms of safety, some increase, possibility approaching 14%, in the loadings or load factors governing short spans for L100 bridges (Interior region) is warranted by the indicated potential for under design.

A somewhat conservative situation was identified for the Coastal region where the live load factors derived for the L165 design loading for the current truck population ranged from 1.29 on longer spans to 1.47 on short spans. This indicates that for the current truck population the longer spans and the shorter spans are over designed for the L165 live loadings by 24% and 9%, respectively. The difference between the live load factors for short and longer spans is less for the L165 bridges than for the other bridges. This is due to the design vehicle having a higher portion of the total vehicle loading on the front tandem axles which more effectively models the actual force effects produced on short spans by the truck population.

FERIC's survey indicated that L150 bridges are not typically specified by Coastal operators but some older L150 bridges or down rated L165 bridges remain in the system. The companies operating L150 or lower rated bridges indicated that additional load restrictions applied to trucks operating on these routes. The L150 produces loadings similar to those for the L165 on longer spans, due to the higher side to side unbalance, and could use the same live load factor of 1.29 for design. However, on short span components the L150 produces lower force effects since the front tandem axle weight has not been increased over the rear tandem axle weight. Therefore, the L150 design live load factor for short spans should be 1.73 which is slightly higher than the 1.6 currently specified.

Increases in the design live load factors or the design vehicle heaviest axle loadings are indicated for the L75, L100 and L150 design vehicles to be consistent with the demands posed on short span bridge components by the current population of logging trucks. However, all the current design vehicles are at least somewhat conservative for the design of longer span bridge components.

6.2 BCMoF Design Vehicles

Ideally, a bridge design standard should provide design vehicle configurations that are to be applied with a consistent live load factor while maintaining a consistent level of safety on bridges of all span lengths and for all force effect types.

The differences between the live load factors derived for the various BCMoF Design Vehicle configurations (L75, L100, L150 and L165) demonstrates that large variations exist in the distributions of the truck population weights relative to the respective design vehicle weights. For example trucks in the L100, L150 and L165 populations rarely exceed the weight of the design vehicle while vehicles in the L75 population commonly exceed the design vehicle weight. This indicates that unless the design vehicle configurations are altered, no one live load factor can produce consistent levels of safety for all cases.

The sizeable differences between the live load factors required for short spans and longer spans for the current BCMoF Design Configurations indicates that they do not produce a consistent ratio of design loadings to actual loadings over the practical range of forestry bridge span lengths. These models tend to overestimate the forces produced by the actual truck population on longer spans and, with the exception of the L165, underestimate these forces on shorter spans. This results in unbalanced bridge designs or the need for higher live load factors for the design of short spans compared to those required for longer spans. Note that using different load factors for bridge components governed by shorter span loadings than those used for longer span components complicates the design process and introduces an artificial step function into the design of bridges.

As discussed previously, the reason for the imbalance in the modelling of loadings between short and longer spans is the higher variability of axle group loadings compared to gross vehicle weights on actual trucks. This results in the ratio of maximum axle group weight to design axle group weight being significantly higher than the ratio of maximum gross vehicle weight to design gross vehicle weight. Ideally these two ratios need to be reasonably similar for a single live load factor to produce a consist level of design safety while minimizing construction costs on all practical bridge spans. This is accomplished for highway bridges in CHBDC and to some extent on the L165 by artificially increasing the loading on one of the design vehicle axle groups and reducing it on others while maintaining the overall weight of the design vehicle.

The BCMoF Design Vehicle configurations could be modified in the following manners to result in configurations that produce consistent ratios of force effects for all practical forestry bridge span lengths.

- Increase the weight of the first tandem axle group by the ratio of derived live load factors for short spans by those for other spans while lowering the rear tandem axle group weight by the same amount. For the L100 Design Vehicle this ratio is 1.83/1.36 = 1.35, which results in a 70 kN increase in each axle of the front tandem and a 70 kN decrease in each axle of the rear tandem. This allows the lower load factors derived for each Design Vehicle type on longer spans, $\alpha_L = 1.36$ for L100, to be used for all bridge spans. Although this maintains the current gross vehicle weights of the design vehicles, the maximum axle loadings are effectively increased on all but the L165 and each Design Vehicle Configuration would require a different live load factor.
- In order to achieve a consistent live load factor for use with all Design Vehicle Configurations, the total weights and modified individual axle loadings of each configuration would have to be further modified by multiplying all axle loadings by the ratio of the longer span live load factor over the selected live load factor. Although any live load factor could be selected as the uniform design value, it seems reasonable to select the CHBDC value of 1.7. The modifications required to the existing BCMoF Design Vehicle to be used with a live load factor of 1.7 are shown on Figures

3 and 4. Modifying the Design Vehicle Configurations for use with a live load factor of 1.7 also allows the other provisions of CHBDC to be used directly for the design of forestry bridges if desired, including the bridge evaluation provisions. The problem with this method is that a L100 truck no longer weighs 100 tons. An alternative is to scale the design weights so that the total is, e.g., 100 tons and then have a "logging truck adjustment factor" (LTAF) for use with S6-00. The LTAF would vary for each of the L75-L165 truck categories. One could also take this opportunity to go metric.

- Alternatively, entirely new design vehicle configurations and live load factors could be developed. The primary benefit of this alternative is that it provides a cleaner break from the past practice which is sometimes more acceptable than a series of modifications.

The modified Design Vehicle Configurations typically produce higher loadings on short span bridge components, those governed by axle loadings, and lower loadings on longer span components. These models have been developed assuming that the bridge designs are governed by the current population of logging trucks. However, it has been suggested that some of the current Design Vehicle Configurations were established with higher weights than required for the logging trucks to better accommodate logging equipment being moved on lowbed trucks. Although the lowbed truck weight data developed for this study suggests that these vehicles do not typically govern the design of forestry bridges, the operators of these bridges may wish to maintain weight capacity contingency for their operations.

6.3 Comparison to CHBDC Design Provisions

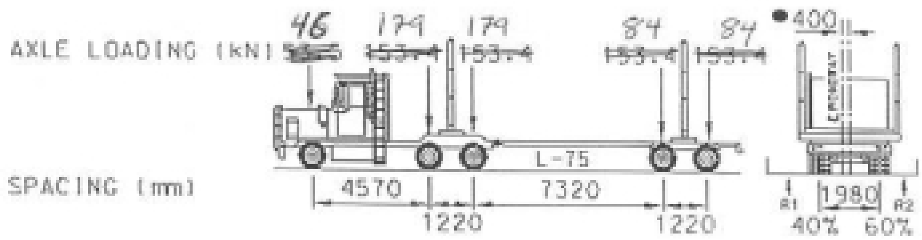
The suitability of the CL-W truck configuration from CHBDC was studied for the design and evaluation of forestry bridges. The CL-W truck configuration model describes the distribution of weight to the truck axle loadings with the total weight of the truck, W, being the specified legal loading for the roadway/bridges. Although the CL-W model was developed to produce the higher levels of axle loadings suitable for highway trucks, the increased axle loadings are not sufficient for the current population of forestry trucks. The CL-W truck configuration would have to be modified to be suitable for application to forestry bridges. Therefore, the use of the CL-W truck configuration does not offer any advantages over the modified BCMoF Design Vehicle configurations previously discussed.

APPENDIX B

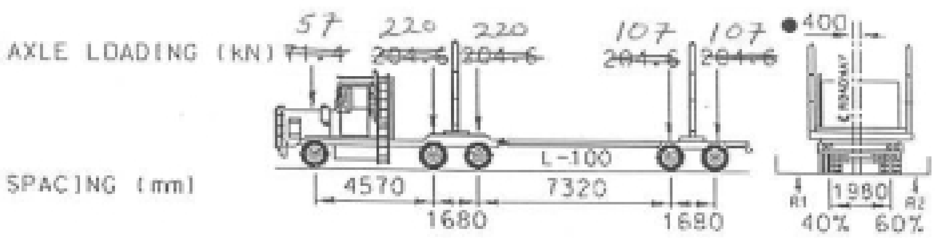
VEHICLE LOADING DIAGRAMS

Logging truck design loads on forest road bridges

Ministry of Forests



L-75 (OFF HIGHWAY) GVW ~~68,040~~ 58,300 kg



L-100 (OFF HIGHWAY) GVW ~~90,680~~ 72,530 kg

● Above eccentricity applies only to bridges with 2 girders 3000 apart.
For non standard deck widths, increase eccentricity by 50% of deck width over 4300.

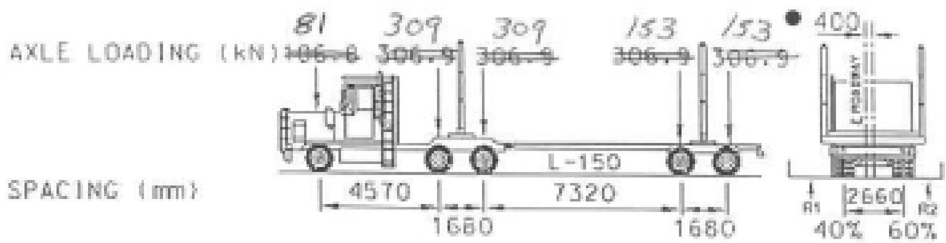
Figure 3: Modified BCMoF L75 and L100 Design Vehicle Configurations

Forest Service Bridge Design and Construction Manual

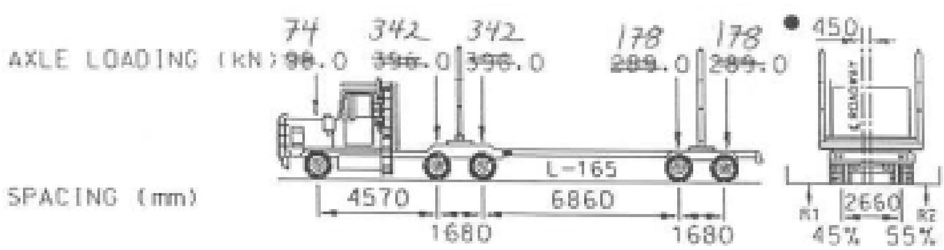
VEHICLE LOADING DIAGRAMS

Logging truck design loads on forest road bridges

Ministry of Forests



L-150 (OFF HIGHWAY) GVW ~~136,090~~ 102,450 kg



L-165 (OFF HIGHWAY) GVW ~~149,700~~ 113,557 kg

● Above eccentricity applies only to bridges with 2 girders 3600 apart.
For non standard deck widths, increase eccentricity by 50% of deck width over 4900.

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Figure 4: Modified BCMoF L150 and L165 Design Vehicle Configurations

6.4 Transportation of Logging Equipment

The transportation of logging equipment on lowbed trailers over forestry bridges is not fundamentally different from permit trucks transporting similar equipment on the highway system. In fact we understand that some logging equipment is often transported on the highway system. Therefore, it is reasonable that the provision of CHBDC Section 14 - "Evaluation" be applicable to these loadings on forestry bridges as well as highway bridges. Note that such evaluations are to be conducted by or under the direction of a qualified engineer.

Section 14 of CHBDC allows the application of lower live load factors than used in design when the loaded weights of the trucks are better controlled. The better the level of load control, the lower the live load factor and the higher the truck loading that can be allowed.

Logging equipment tends to have relatively fixed weights with little variation and can be considered to be represented by the Permit Single Trip or PS category in Section 14. The live load factors associated with this load category should allow vehicles on bridges with weights significantly in excess of the original design vehicle weights for those bridges. If additional load controls are placed on the trucks, such as confirmation of weights or supervised bridge crossings, lower live load factors from the Permit Bulk (PB) or Permit Controlled (PC) categories could be applied to obtain higher load capacities.

Most of the theoretical weights for lowbed trucks conducting movements of logging equipment developed by FERIC are less than those for the original design vehicle loadings and do not govern the bridge capacity. Using live load factors for PS traffic typically allows a 10% to 20% increase in loading over that for the original design vehicle. Load increases of up to 40% can be achieved if the requirements for PC traffic are met. Note that on shorter span bridges the addition of axles to the lowbed truck can effectively spread out the load or remove a portion of the load from the bridge and further increase load carrying capacity.

6.5 Bridge Decks

Members of the forestry bridge industry have expressed concern that the higher axle loadings recommended for the L75, L100 and L150 Design Vehicles will significantly impact the design of bridge components such as concrete decks.

This issue was discussed at the BCMoF seminar held on 2002 September 10. The discussions indicated that bridge decks designed for the existing Design Vehicle Configurations were performing well under the current traffic conditions. It was also noted that bridge decks often have higher capacities than expected and typically suffer from durability problems rather than overload failures. Various participants of the seminar suggested that additional study of the behaviour and capacities of the forestry bridge decks be conducted prior to adopting these recommendations for the design of bridge decks.

6.6 Future Changes in Forestry Truck Traffic

The findings presented in this report are representative of the logging truck weight data provided by a survey conducted by FERIC. The conclusions of this report are not necessarily applicable to unidentified logging truck populations that differ significantly from those considered in this study. In addition, should the weights or configurations of the logging trucks or lowbed equipment movers change significantly in the future the recommendations of this report may not be applicable.

7 Conclusions and Recommendations

The levels of safety provided by forestry bridges designed in accordance with the current BCMoF standard were assessed for the weights of logging trucks currently using the forestry road system.

Bridge components designed for the L100 and L150 Design Vehicles were found to be slightly deficient if governed by short span loadings (axle groups) and somewhat over designed if governed by longer span loadings (gross vehicle weights). This is similar to the findings for the L75 Design Vehicles in the previous phase of this study.

The L165 Design Vehicle was found to provide conservative bridge designs on both short and longer spans for the current population of logging trucks transiting these bridges.

At least one company operating in the Interior region uses both L75 and L100 bridges on their road system. The survey information indicates that some level of load control is in place to prevent the L100 trucks from crossing the L75 bridges. However, it should be noted that a L100 trucks crossing an L75 bridge could create significant overstresses, especially on bridge components governed by short span loadings.

The derived live load factors varied significantly for bridge components governed by short span loadings and those by long span loadings. In addition, significant variation was observed in the live load factors derived for the various Design Vehicle Configurations. Therefore, the application of a single live load factor for all design cases will result in cases of under and over design of bridge components.

Modifications to the existing Design Vehicle Configuration weight and distributions of weights to the axles are required to allow the use of a single live load factor for all design cases. Modified Design Vehicle Configurations were developed for use with the 1.7 live load factor specified by CHBDC. The adoption of 1.7 as the live load factor would also allow the direct use of the provisions of CHBDC for the design of forestry bridges.

The CL-W design configuration was assessed for the design of forestry bridges but was found to require modification to provide consistent levels of safety and cost efficiency. Therefore, the design configuration did not offer advantages over the existing BCMoF Design Vehicle configurations.

The characteristics and theoretical weights of lowbed trucks transporting logging equipment were reviewed and were found to be similar to trucks operating under overload permits on the highway system. It is recommended that these vehicles be assessed in accordance with the provisions for permit type traffic in Section 14 of CHBDC.

Although the weights of the lowbed trucks developed for this study do not appear to govern the design of forestry bridges, bridge operators may wish to acheive additional truck weight capacity for the bridges. Such a contingency could allow the passage of lowbed trucks that may be heavier than those considered in this study.

Should the weights or configurations of trucks transiting forestry bridges increase or change significantly in the future, these recommendations should be reviewed to determine it they remain appropriate.

8 References

[1] Buckland & Taylor Ltd. report to Ministry of Forests, Design Vehicle Configuration Analysis and CSA-S6-00 Implication Evaluation, 2003 January 04.

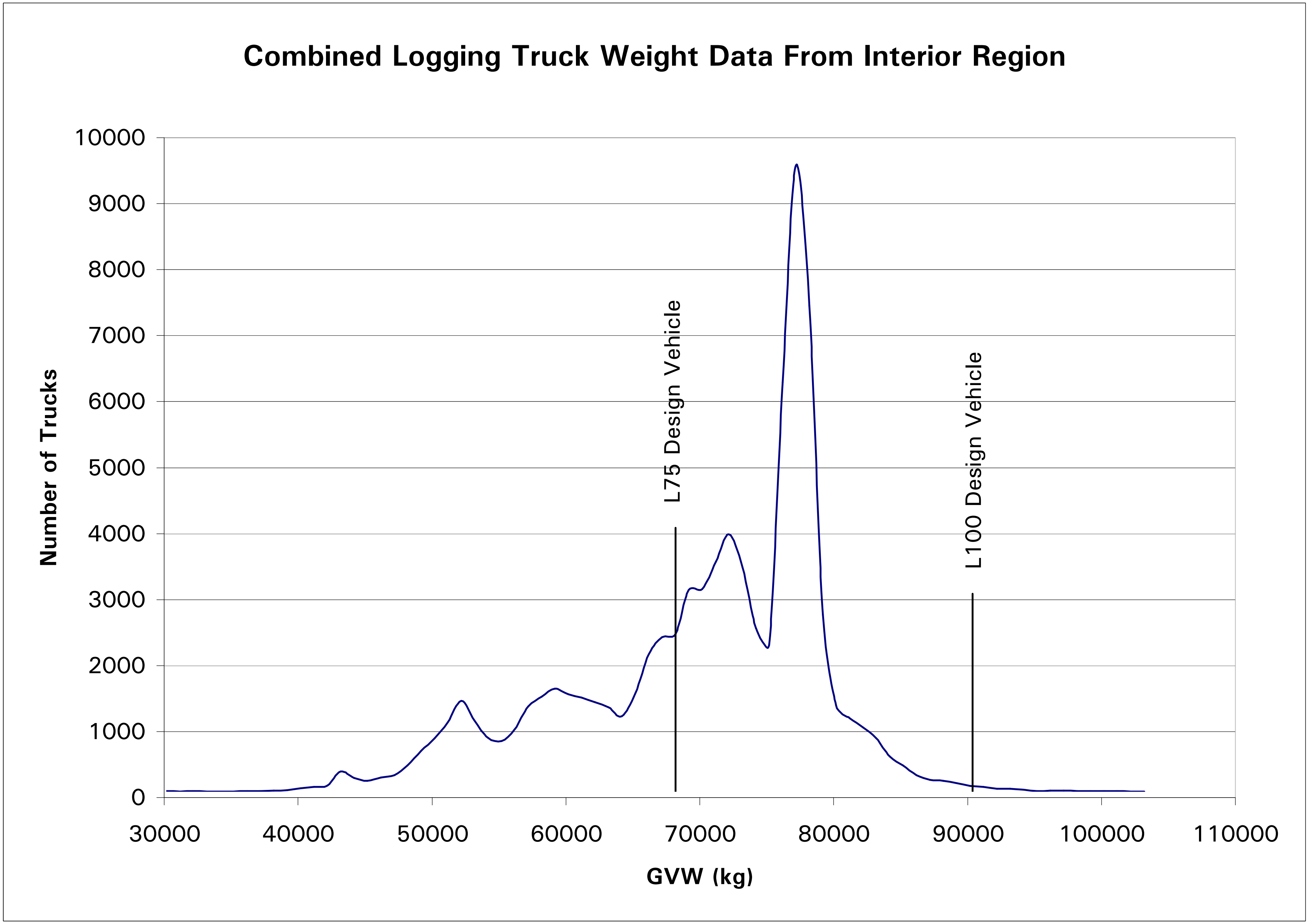
[2] Canadian Standards Association.'CAN/CSA-S6-00 Canadian Highway Bridge Design Code'. (Canadian Standards Association, Toronto, 2000).

[3] Ministry of Forests,'Forest Service Bridge Design and Construction Manual', Resource Tenures and Engineering Branch, 1999 July 30.

[4] Kennedy, D.J.L., Gagnon, D.P., Allen, D.E., and MacGregor, J.G.,'Canadian highway bridge evaluation: load and resistance factors', Can. J. Civ. Eng. 19 (1992) 992-1006.

Appendix A
Interior Region Truck Weight Summaries

Interior BC - Total



Interior BC - Total

Truck Weight (kg)	No. of Trucks
28000	1
29000	0
30000	4
31000	1
32000	4
33000	1
34000	3
35000	2
36000	7
37000	10
38000	17
39000	22
40000	50
41000	68
42000	95
43000	302
44000	204
45000	164
46000	211
47000	251
48000	399
49000	620
50000	805
51000	1048
52000	1378
53000	1080
54000	815
55000	762
56000	940
57000	1287
58000	1442
59000	1561
60000	1477
61000	1422
62000	1353
63000	1275
64000	1142
65000	1490

Truck Weight (kg)	No. of Trucks
66000	2087
67000	2340
68000	2390
69000	3056
70000	3069
71000	3480
72000	3897
73000	3399
74000	2475
75000	2218
76000	6202
77000	9482
78000	7366
79000	2678
80000	1313
81000	1116
82000	973
83000	807
84000	531
85000	396
86000	251
87000	178
88000	166
89000	125
90000	88
91000	70
92000	43
93000	40
94000	29
95000	10
96000	13
97000	12
98000	9
99000	4
100000	4
101000	4
102000	2
103000	0
Total Trucks:	**82036**

Interior Company 1 - Location 1 Sample A

Truck Weight (kg)	No. of Trucks
40000	0
41000	3
42000	2
43000	1
44000	8
45000	12
46000	18
47000	30
48000	37
49000	38
50000	26
51000	24
52000	33
53000	46
54000	46
55000	56
56000	61
57000	87
58000	91
59000	136
60000	114
61000	97
62000	152
63000	156
64000	150
65000	144
66000	113
67000	79
68000	67
69000	56
70000	43
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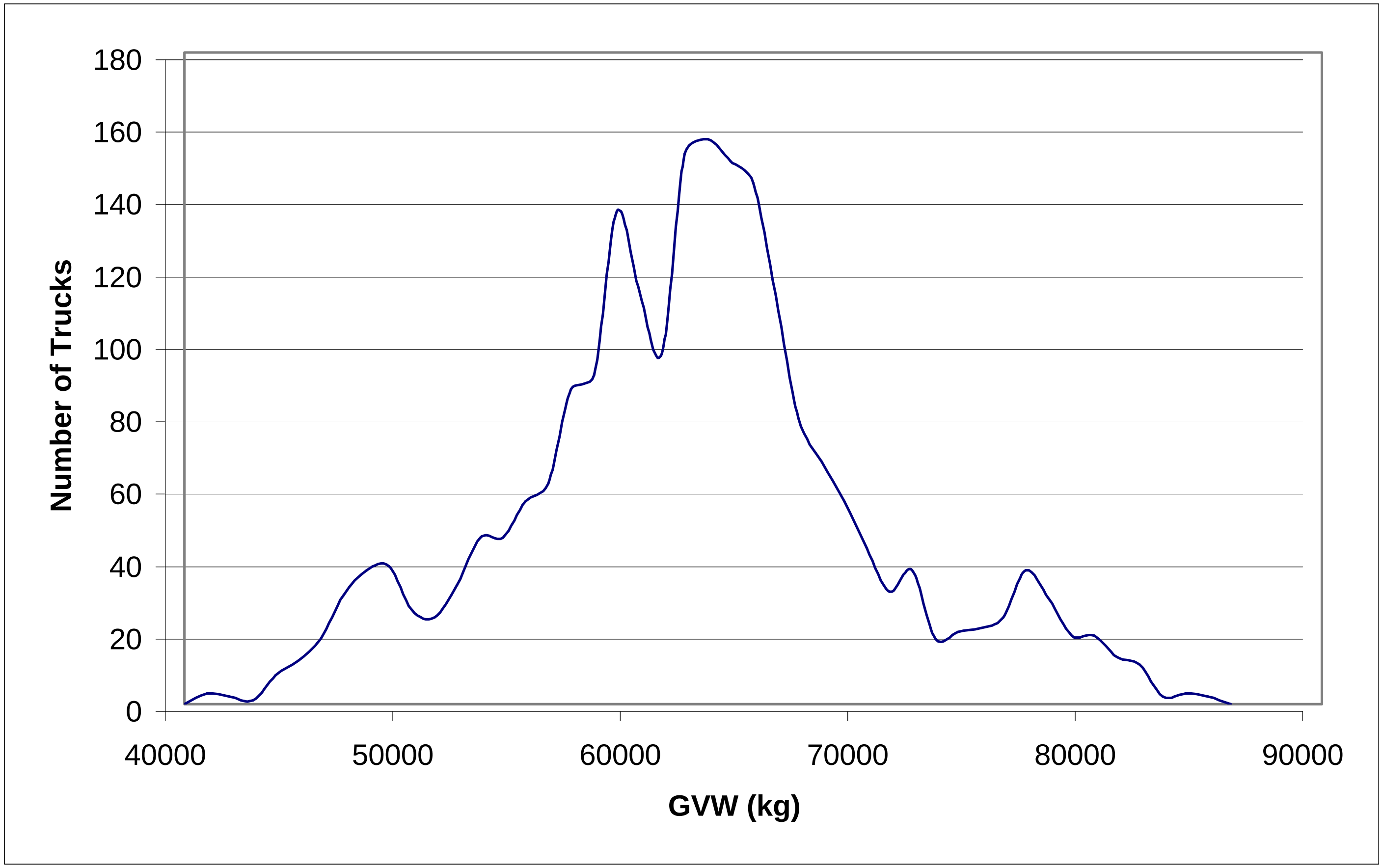
76000	24
77000	37
78000	29
79000	19



Truck Weight (kg)	No. of Trucks
80000	19
81000	13
82000	11
83000	2
84000	3
85000	2
86000	0

Total Trucks: 2212

Dates: Jan 1 - Feb 28 2002

Interior Company 1 - Location 1 Sample B

Truck Weight (kg)	No. of Trucks
36000	0
37000	1
38000	1
39000	2
40000	2
41000	2
42000	7
43000	6
44000	4
45000	17
46000	24
47000	25
48000	32
49000	23
50000	43
51000	28
52000	35
53000	42
54000	50
55000	56
56000	82
57000	113
58000	138
59000	105
60000	120
61000	125
62000	160
63000	169
64000	165
65000	175
66000	120
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68000	94
69000	73
70000	42
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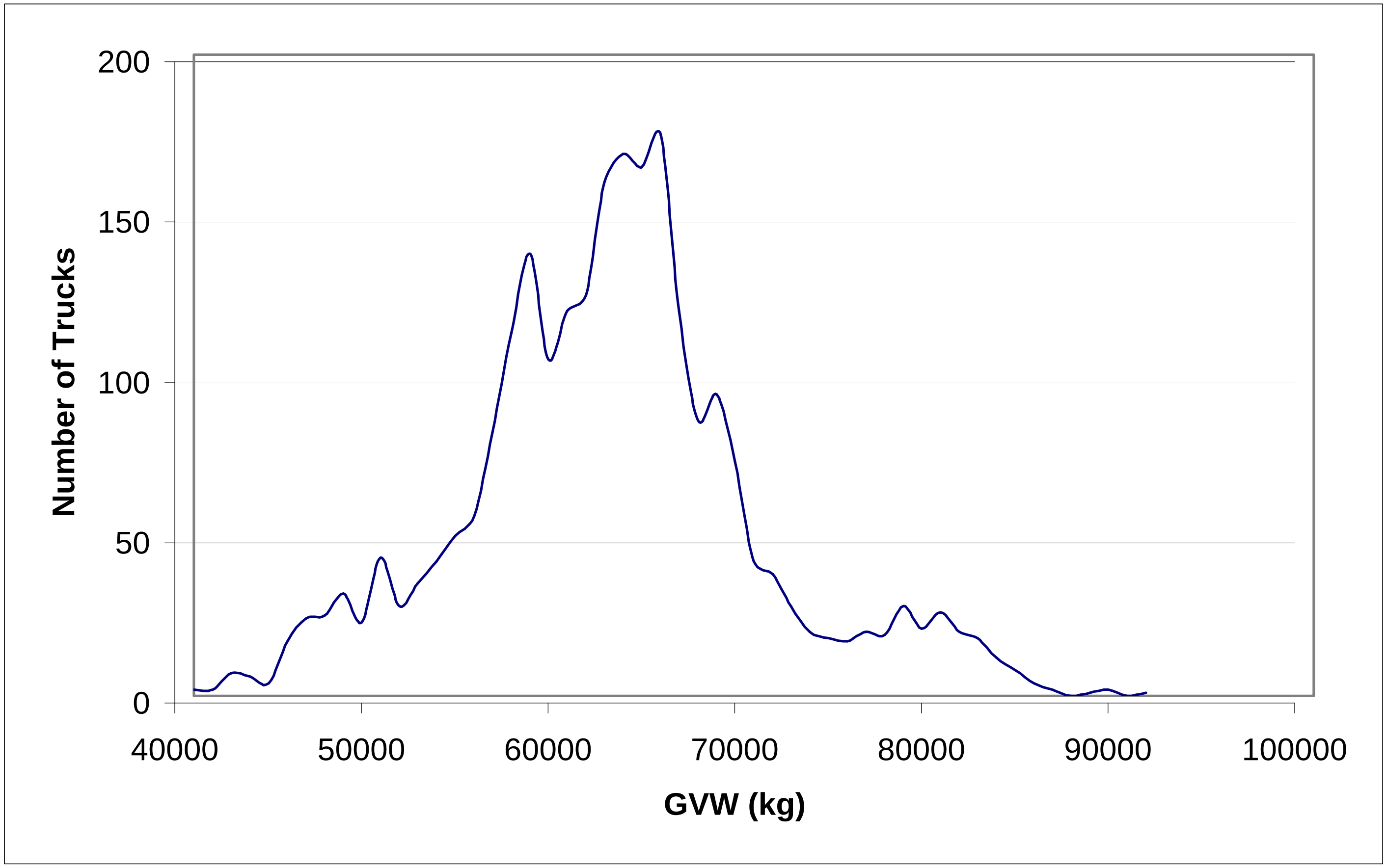
72000	28
73000	20
74000	18
75000	17



Truck Weight (kg)	No. of Trucks
76000	20
77000	19
78000	28
79000	21
80000	26
81000	20
82000	18
83000	12
84000	8
85000	4
86000	2

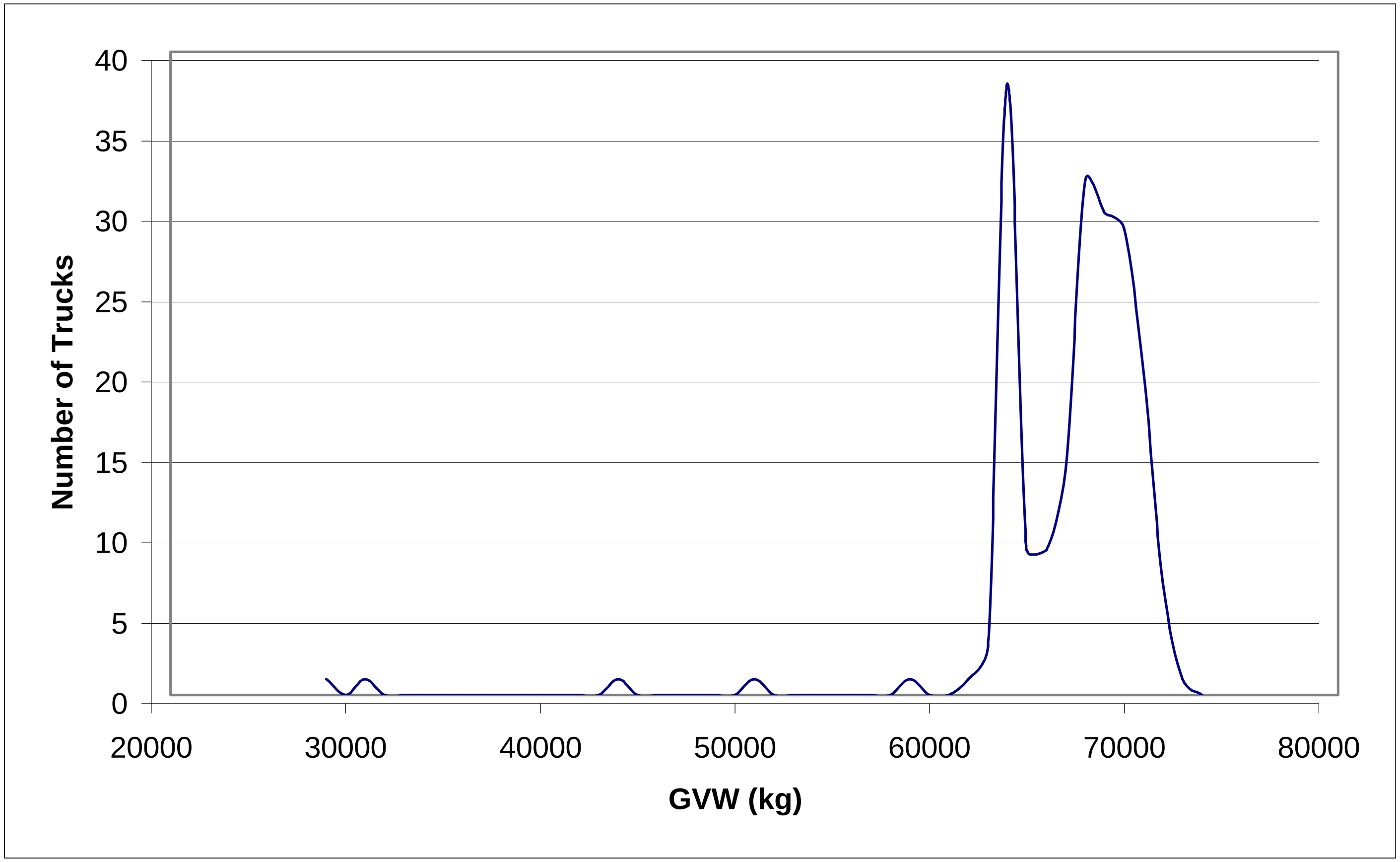
Truck Weight (kg)	No. of Trucks
87000	0
88000	1
89000	2
90000	0
91000	1

Total Trucks: **2470**

Dates: **Sep 1 - Oct 31 2002**

Interior Company 2 - Location 1

Truck Weight (kg)	No. of Trucks
28000	1
29000	0
30000	1
31000	0
32000	0
33000	0
34000	0
35000	0
36000	0
37000	0
38000	0
39000	0
40000	0
41000	0
42000	0
43000	1
44000	0
45000	0
46000	0
47000	0
48000	0
49000	0
50000	1
51000	0
52000	0
53000	0
54000	0
55000	0
56000	0
57000	0
58000	1
59000	0
60000	0
61000	1
62000	3
63000	38
64000	9
65000	9
66000	14
67000	32



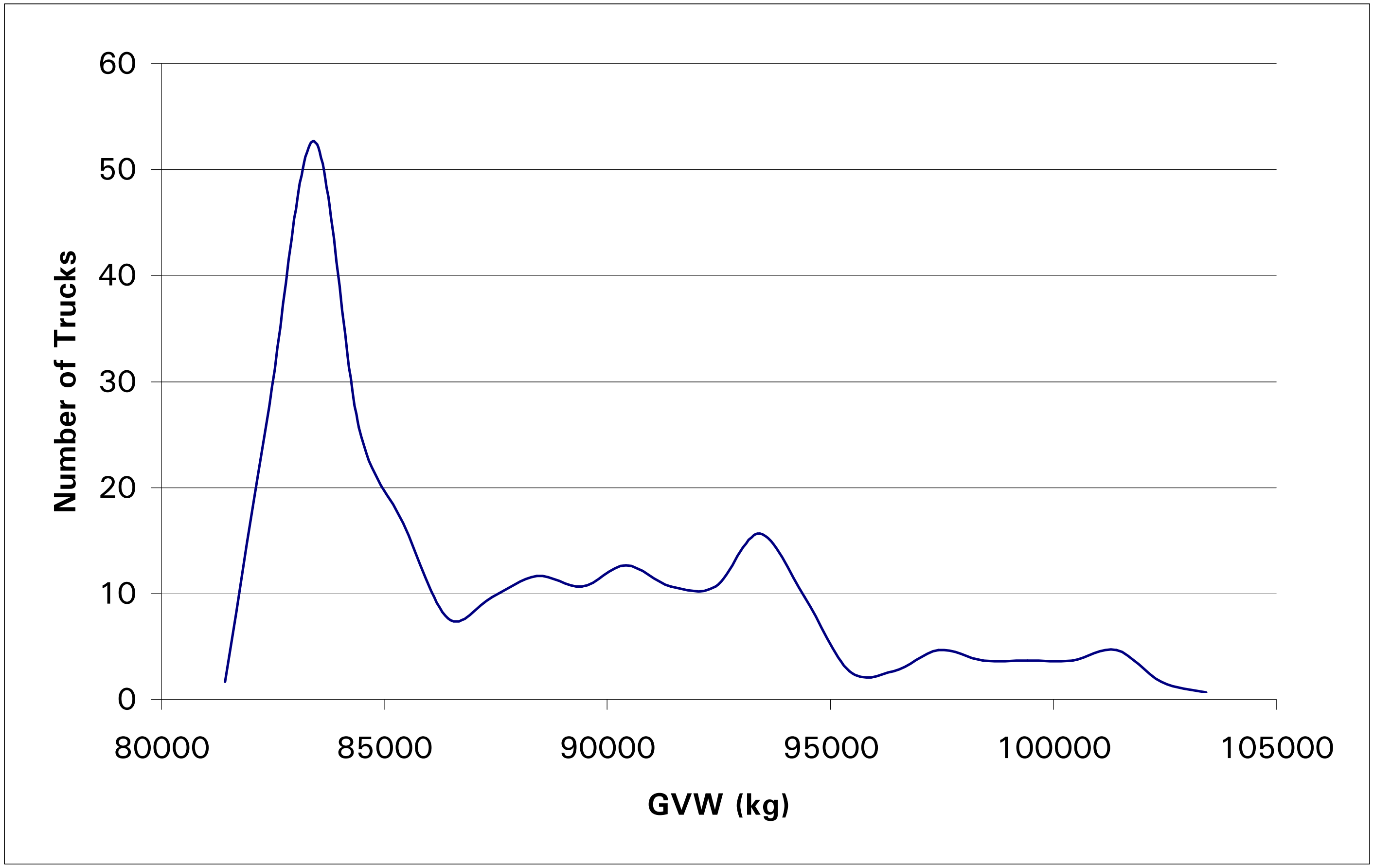
Truck Weight (kg)	No. of Trucks
68000	30
69000	29
70000	20
71000	7
72000	1
73000	0

Total Trucks: **198**

Dates: **Jan 2 - Feb 1 2002**

Interior Company 3 - Location 1

Truck Weight (kg)	No. of Trucks
81000	1
82000	27
83000	52
84000	25
85000	16
86000	7
87000	9
88000	11
89000	10
90000	12
91000	10
92000	10
93000	15
94000	9
95000	2
96000	2
97000	4
98000	3
99000	3
100000	3
101000	4
102000	1
103000	0

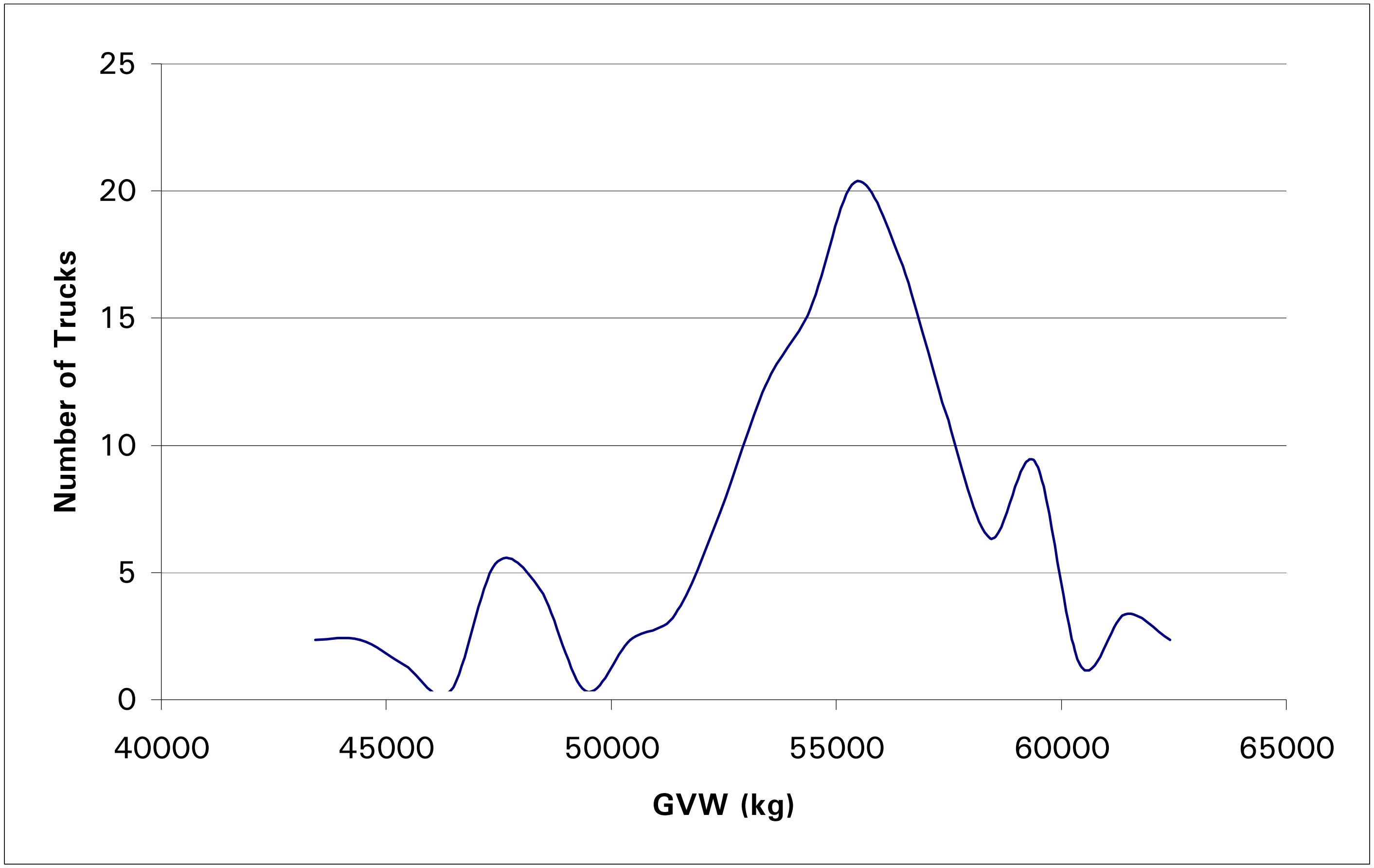


Total Trucks: 236

Dates: Feb 2002

Interior Company 4 - Location 1

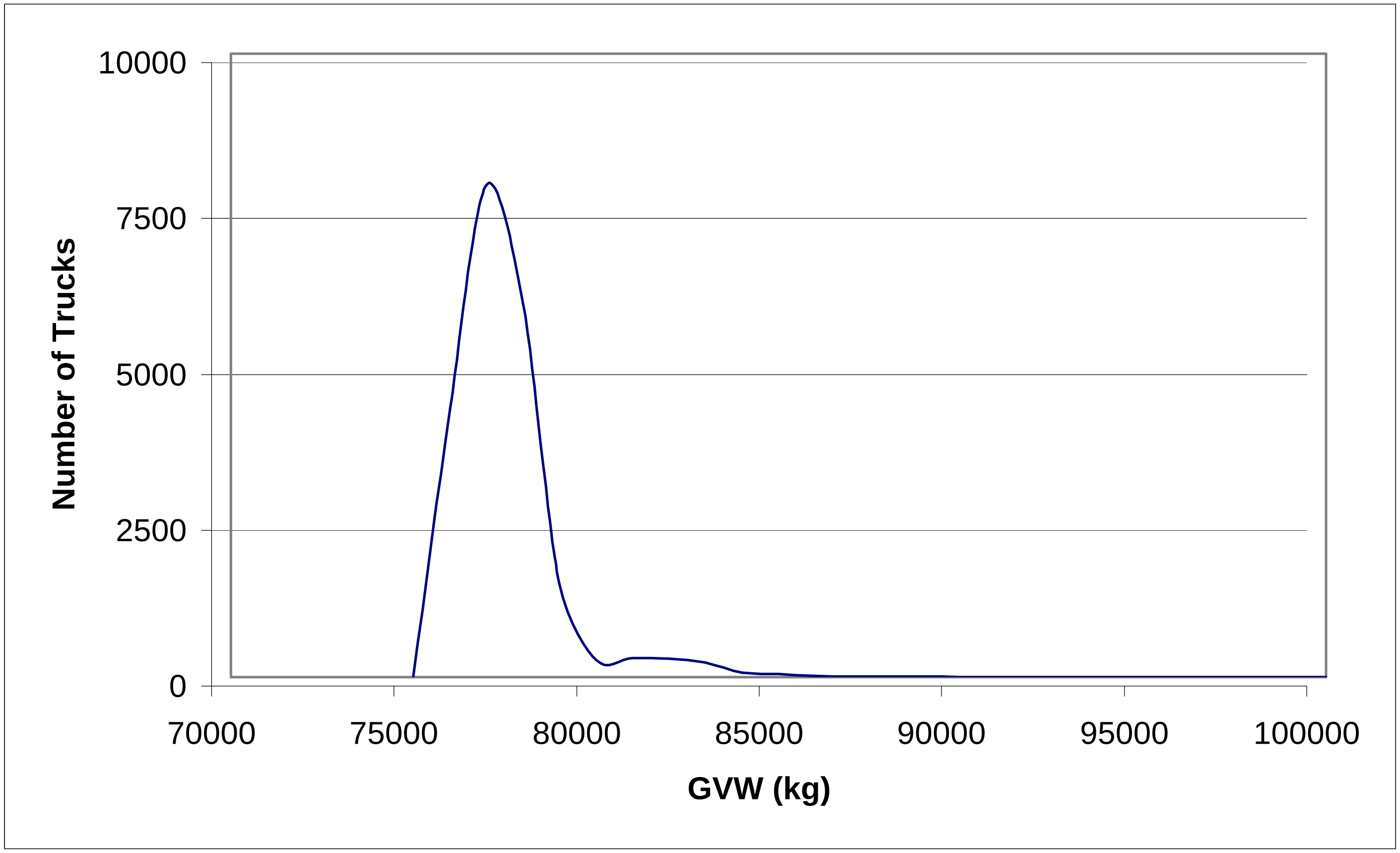
Truck Weight (kg)	No. of Trucks
43000	2
44000	2
45000	1
46000	0
47000	5
48000	4
49000	0
50000	2
51000	3
52000	7
53000	12
54000	15
55000	20
56000	17
57000	11
58000	6
59000	9
60000	1
61000	3
62000	2



Total Trucks: 122
Dates: 2002 Jun 11 - Sep 20

Interior Company 4 - Location 2

Truck Weight (kg)	No. of Trucks
75000	0
76000	4301
77000	7894
78000	5981
79000	1497
80000	274
81000	308
82000	298
83000	232
84000	72
85000	46
86000	16
87000	6
88000	9
89000	9
90000	4
91000	3
92000	4
93000	5
94000	0
95000	1
96000	0
97000	1
98000	0
99000	0
100000	0
101000	0
102000	1
103000	0

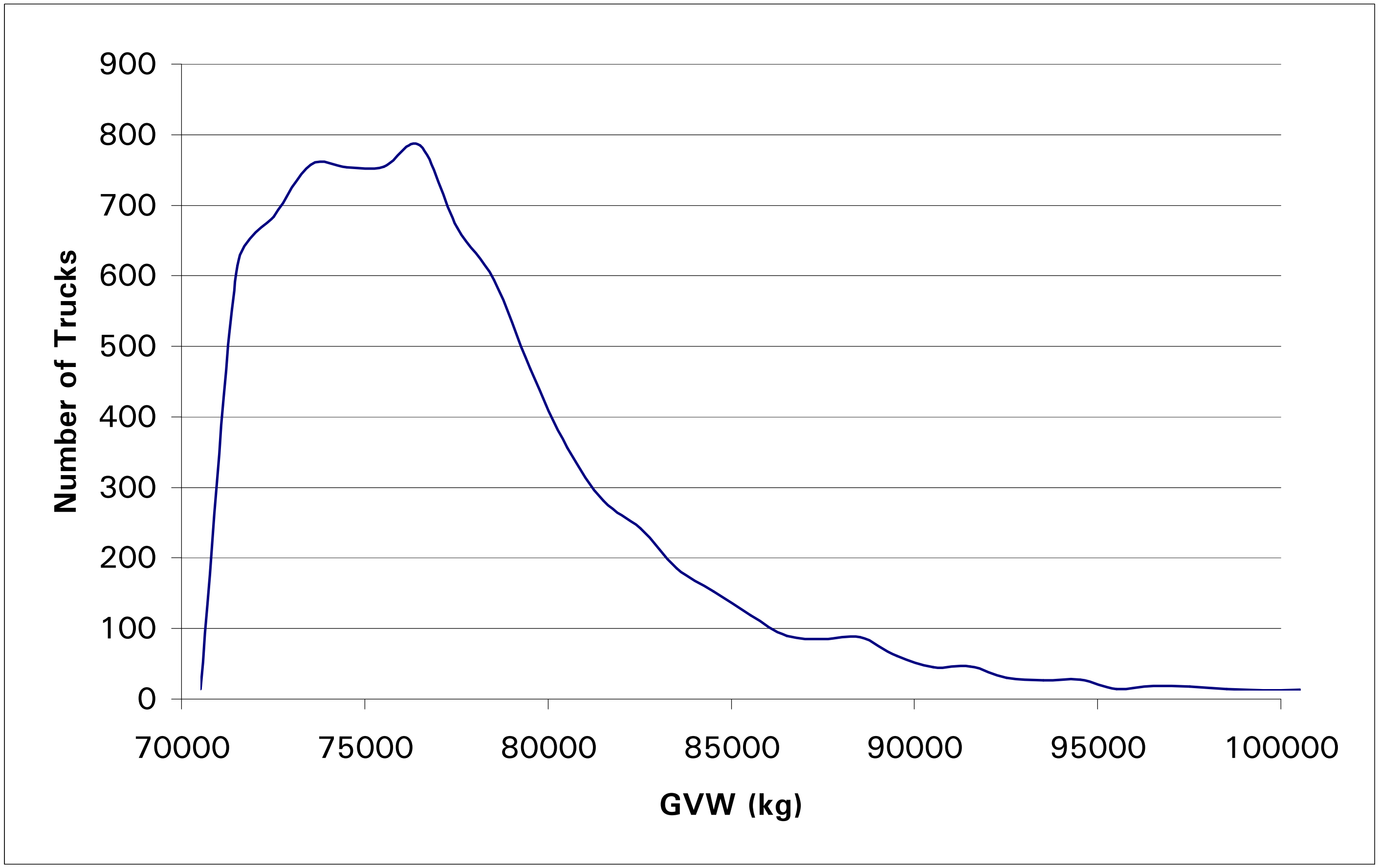


Total Trucks: **20962**

Dates: **2000 Jun 12 - 2002 Oct 28**

Interior Company 4 - Location 3

Truck Weight (kg)	No. of Trucks
70000	2
71000	602
72000	671
73000	745
74000	741
75000	742
76000	772
77000	656
78000	582
79000	456
80000	344
81000	269
82000	230
83000	173
84000	140
85000	106
86000	77
87000	73
88000	75
89000	49
90000	33
91000	34
92000	18
93000	14
94000	15
95000	2
96000	6
97000	5
98000	2
99000	0
100000	1

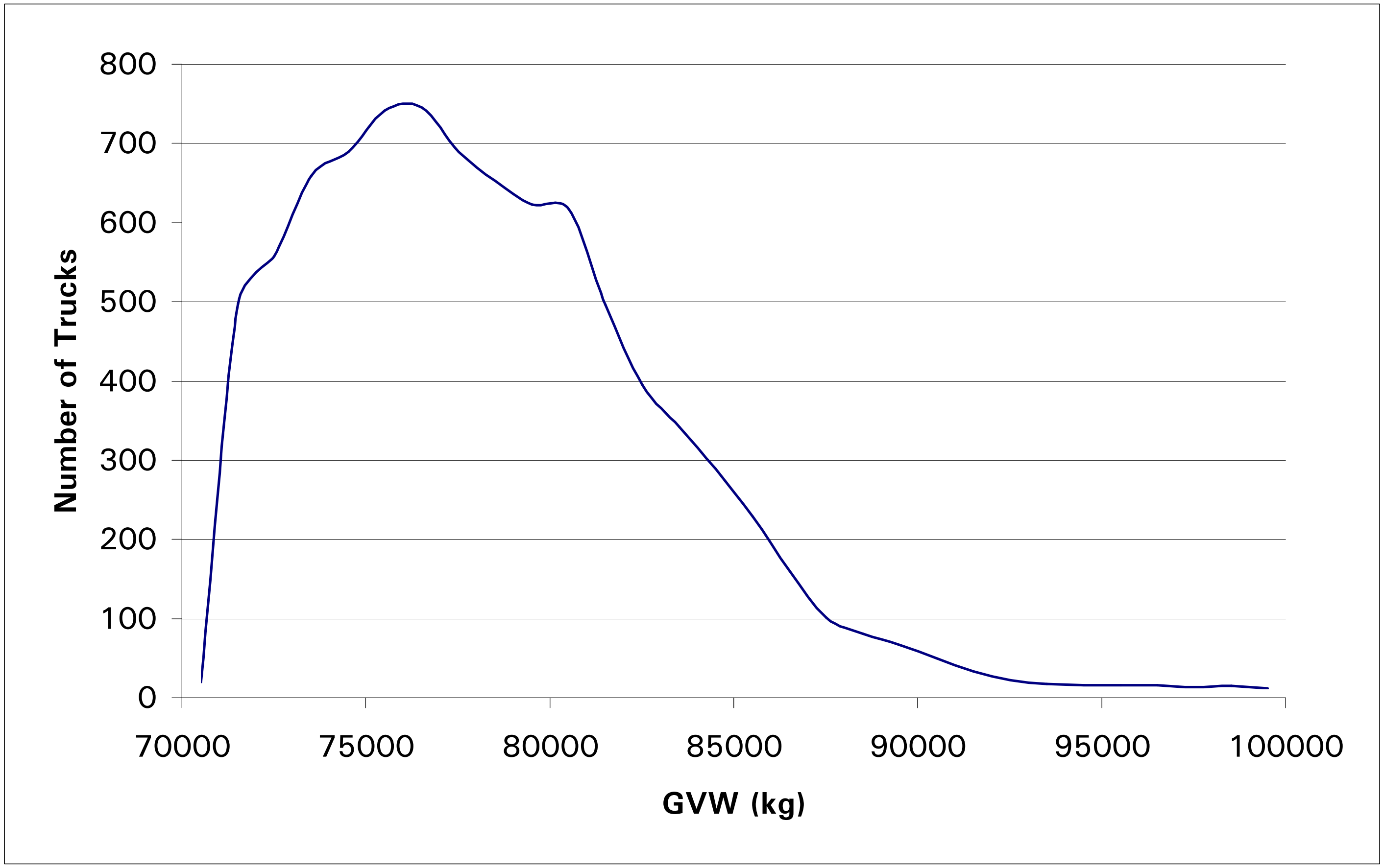


Total Trucks: **7635**

Dates: **2002 Jan 2 - Apr 3**

Interior Company 4 - Location 4

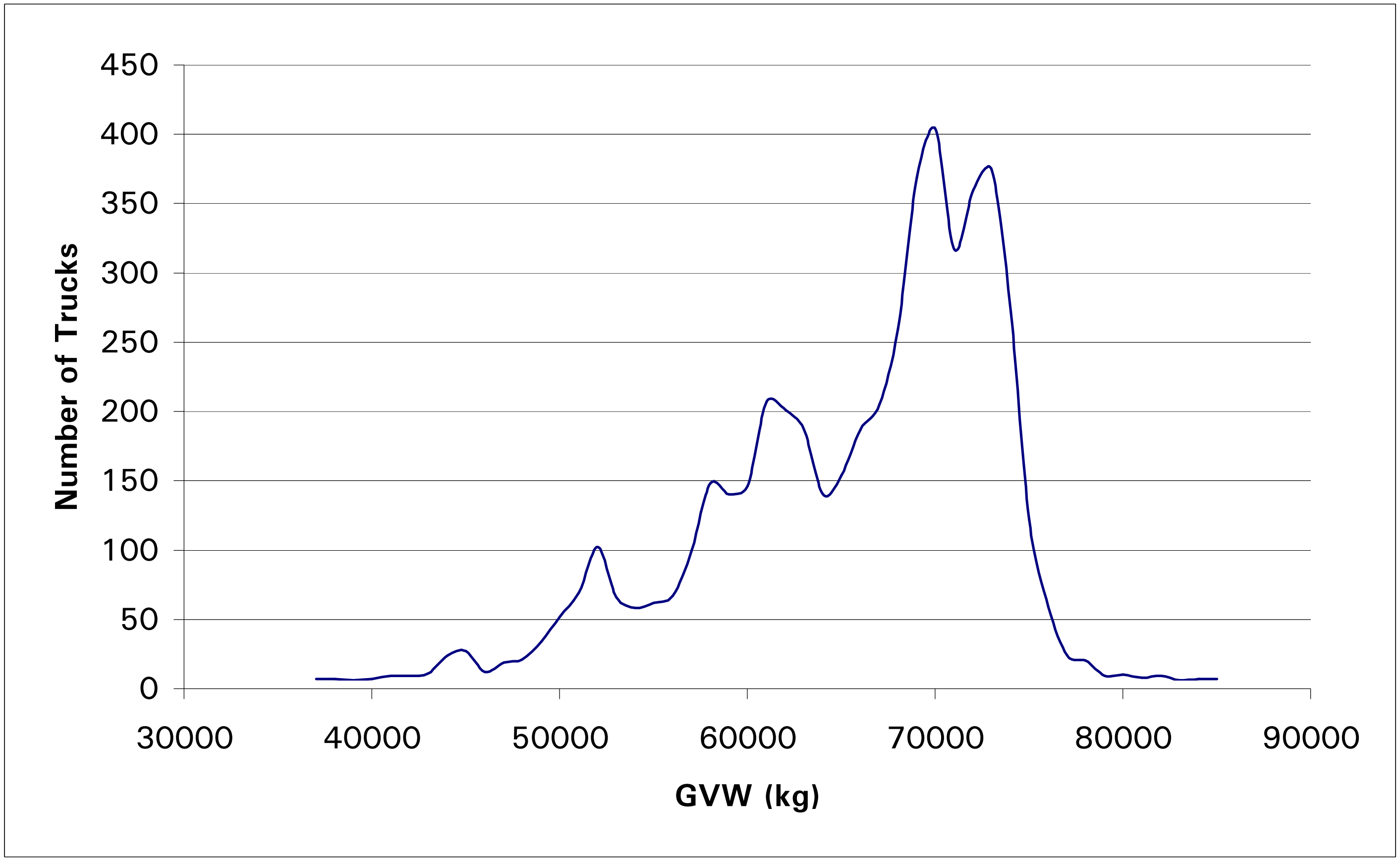
Truck Weight (kg)	No. of Trucks
70000	9
71000	486
72000	547
73000	648
74000	678
75000	730
76000	734
77000	678
78000	642
79000	612
80000	605
81000	485
82000	384
83000	331
84000	278
85000	218
86000	149
87000	90
88000	70
89000	55
90000	39
91000	22
92000	11
93000	6
94000	5
95000	5
96000	5
97000	2
98000	4
99000	1



Total Trucks: **8529**
Dates: **2002 Jan 2 - Apr 3**

Interior Company 5 - Location 1 Sample A

Truck Weight (kg)	No. of Trucks
36000	1
37000	1
38000	0
39000	1
40000	3
41000	3
42000	5
43000	18
44000	21
45000	6
46000	13
47000	15
48000	28
49000	46
50000	63
51000	96
52000	60
53000	52
54000	56
55000	61
56000	94
57000	142
58000	134
59000	140
60000	201
61000	195
62000	181
63000	134
64000	148
65000	181
66000	199
67000	253
68000	363
69000	398
70000	311
71000	354
72000	368
73000	266
74000	116
75000	53

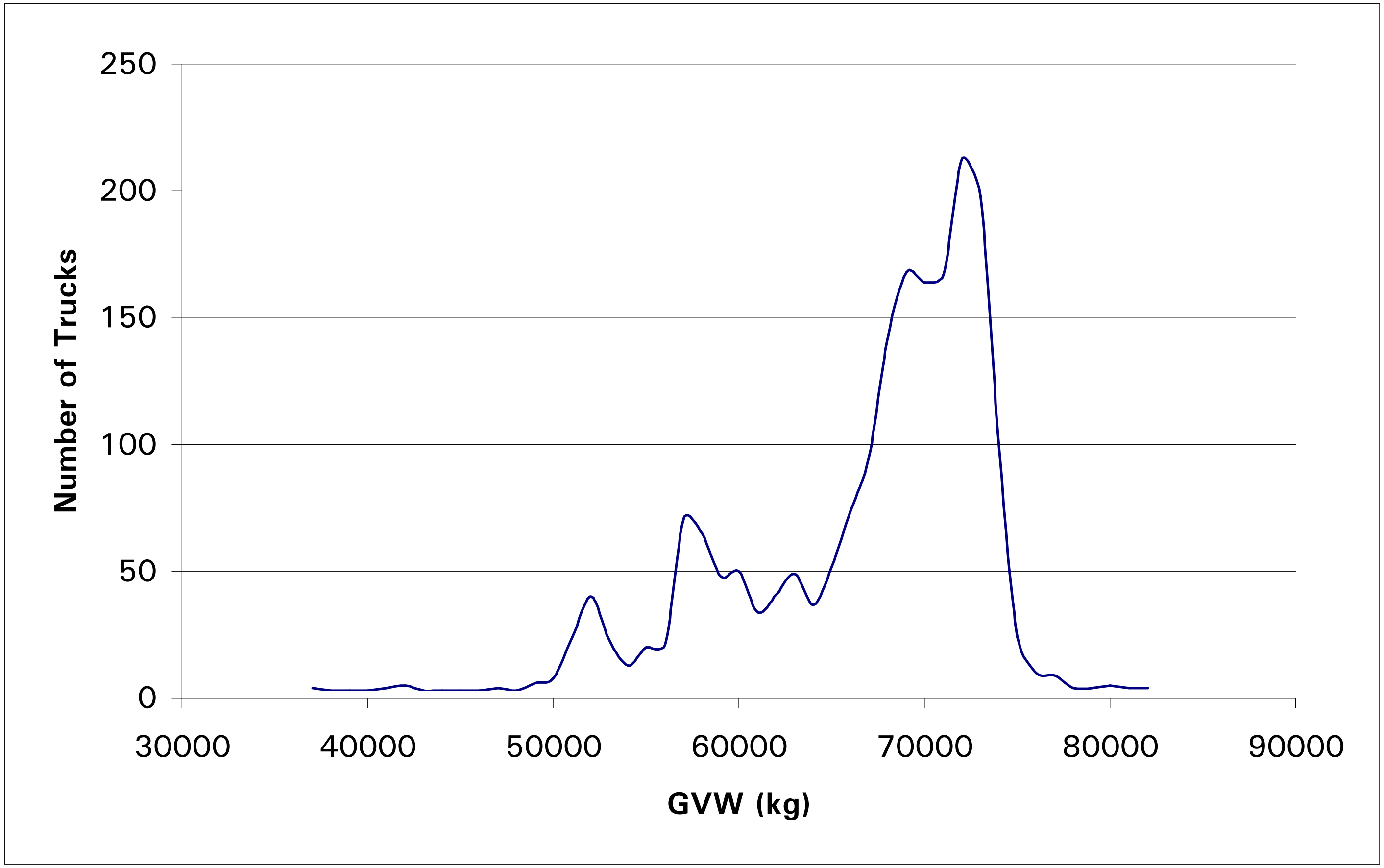


Truck Weight (kg)	No. of Trucks
76000	18
77000	14
78000	3
79000	4
80000	2
81000	3
82000	0
83000	1
84000	1

Total Trucks: 4826
Dates: 2002 Jan 1 - Feb 28

Interior Company 5 - Location 1 Sample B

Truck Weight (kg)	No. of Trucks
36000	1
37000	0
38000	0
39000	0
40000	1
41000	2
42000	0
43000	0
44000	0
45000	0
46000	1
47000	0
48000	3
49000	5
50000	21
51000	37
52000	20
53000	10
54000	17
55000	18
56000	68
57000	62
58000	45
59000	47
60000	31
61000	38
62000	46
63000	34
64000	49
65000	71
66000	93
67000	139
68000	165
69000	161
70000	164
71000	210
72000	195
73000	95
74000	21

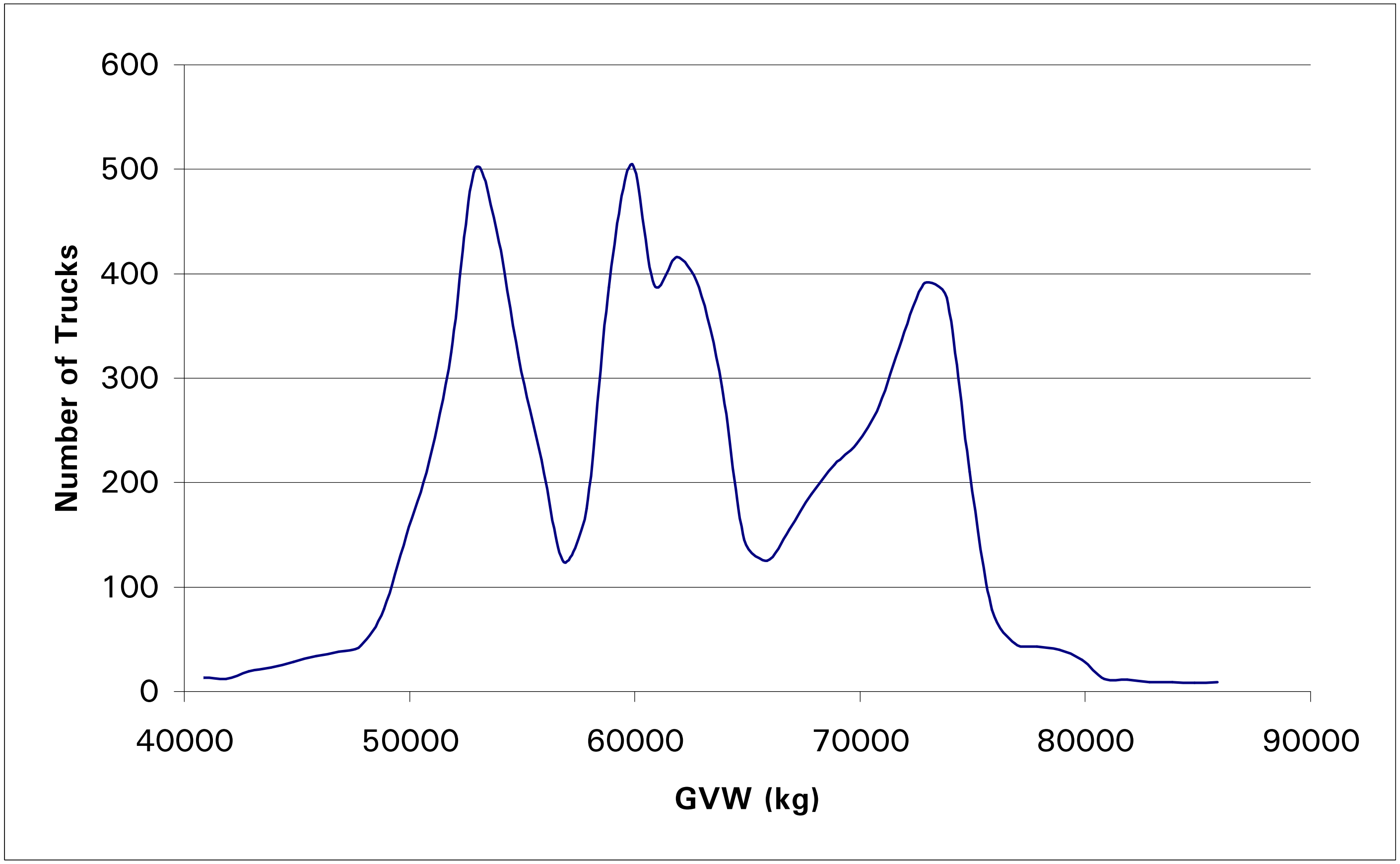


Truck Weight (kg)	No. of Trucks
75000	7
76000	6
77000	1
78000	1
79000	2
80000	1
81000	1

Total Trucks: 1889
Dates: 2002 Aug 1 - Sep 30

Interior Company 5 - Location 2 Sample A

Truck Weight (kg)	No. of Trucks
38000	1
39000	0
40000	6
41000	5
42000	12
43000	16
44000	21
45000	27
46000	31
47000	37
48000	72
49000	142
50000	213
51000	318
52000	491
53000	435
54000	313
55000	215
56000	117
57000	168
58000	380
59000	498
60000	383
61000	409
62000	380
63000	285
64000	138
65000	118
66000	148
67000	182
68000	210
69000	230
70000	267
71000	329
72000	384



Truck Weight (kg)	No. of Trucks
73000	370
74000	203
75000	71
76000	39
77000	36
78000	33

Truck Weight (kg)	No. of Trucks
79000	23
80000	5
81000	4
82000	2
83000	2
84000	1

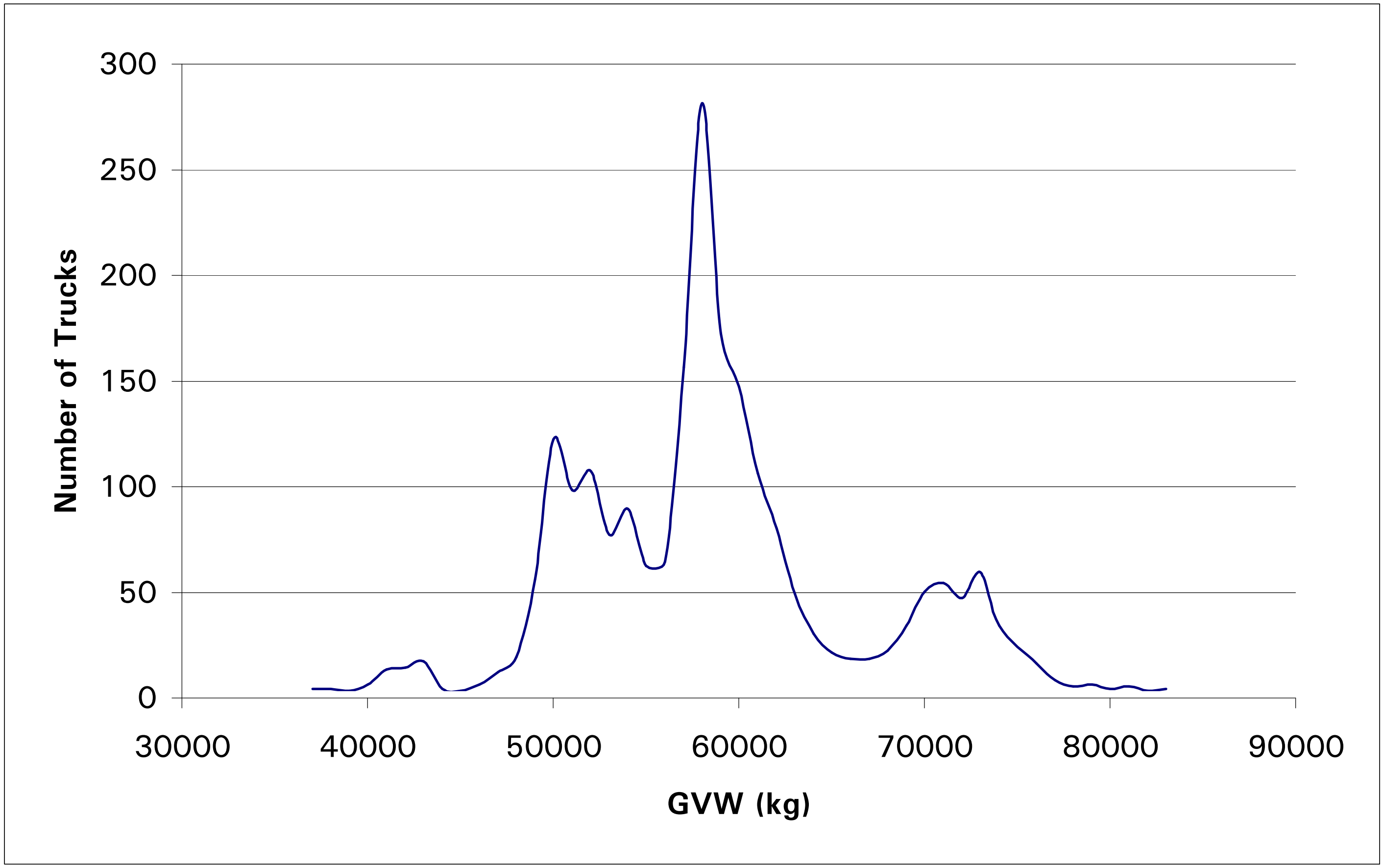
Truck Weight (kg)	No. of Trucks
85000	2

Total Trucks: **7772**

Dates: **2002 Jan 1 - Feb 28**

Interior Company 5 - Location 2 Sample B

Truck Weight (kg)	No. of Trucks
36000	1
37000	1
38000	0
39000	3
40000	10
41000	11
42000	14
43000	1
44000	0
45000	3
46000	9
47000	16
48000	53
49000	119
50000	95
51000	104
52000	74
53000	86
54000	59
55000	61
56000	153
57000	278
58000	169
59000	144
60000	103
61000	77
62000	46
63000	27
64000	18
65000	15
66000	15
67000	19
68000	31
69000	47
70000	51
71000	44
72000	56
73000	31
75000	13

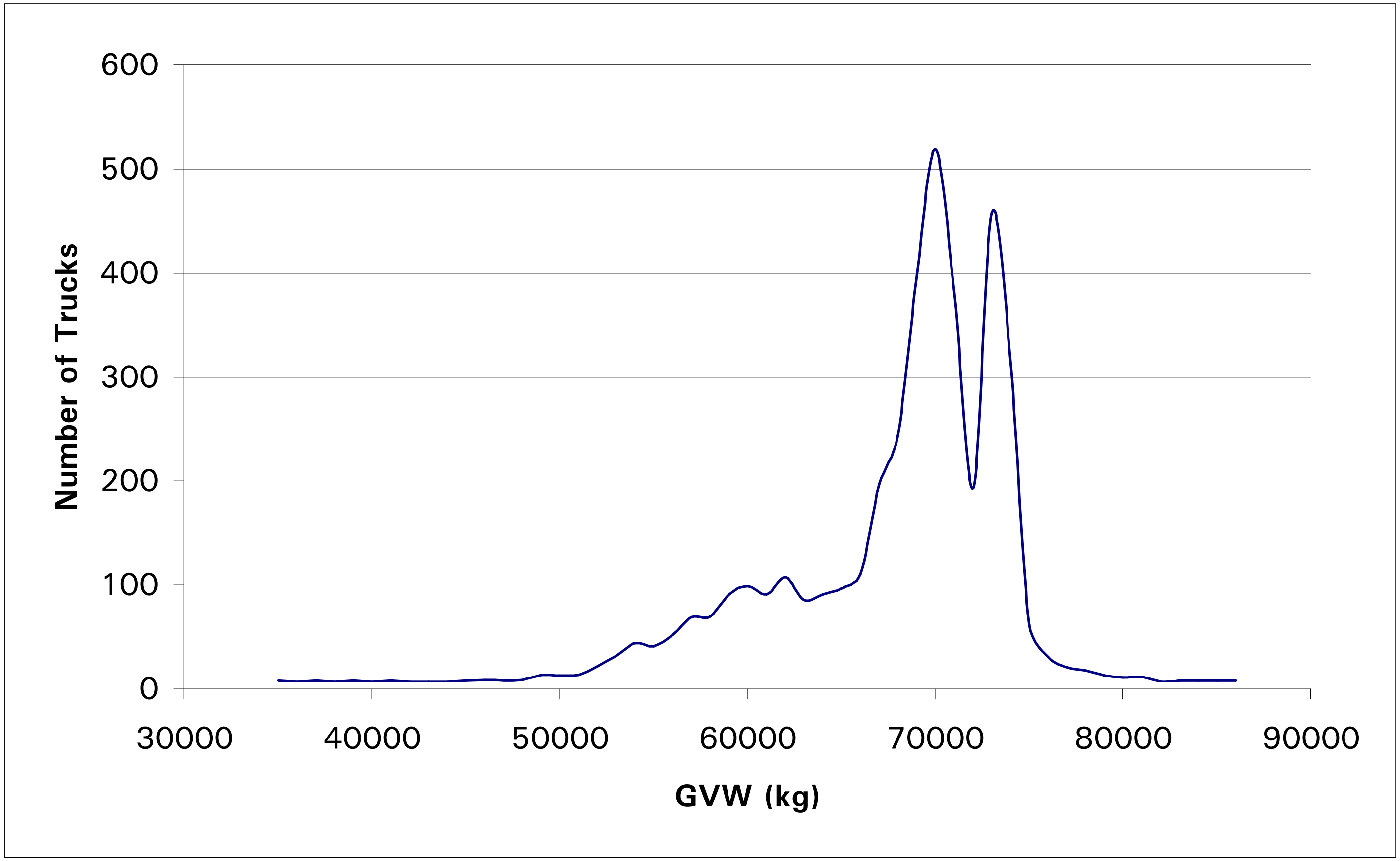


Truck Weight (kg)	No. of Trucks
76000	5
77000	2
78000	3
79000	1
80000	2
81000	0
82000	1

Total Trucks: 2071
Dates: 2002 Aug 1 - Sep 30

Interior Company 5 - Location 3 Sample A

Truck Weight (kg)	No. of Trucks
34000	1
35000	0
36000	1
37000	0
38000	1
39000	0
40000	1
41000	0
42000	0
43000	0
44000	1
45000	2
46000	1
47000	2
48000	7
49000	6
50000	7
51000	15
52000	25
53000	37
54000	34
55000	45
56000	62
57000	63
58000	84
59000	92
60000	84
61000	101
62000	79
63000	84
64000	90
65000	104
66000	191
67000	237
68000	391
69000	512



Truck Weight (kg)	No. of Trucks
70000	374
71000	187
72000	451
73000	305
74000	55
75000	24
76000	14

Truck Weight (kg)	No. of Trucks
77000	11
78000	6
79000	4
80000	5
81000	0
82000	1
83000	1

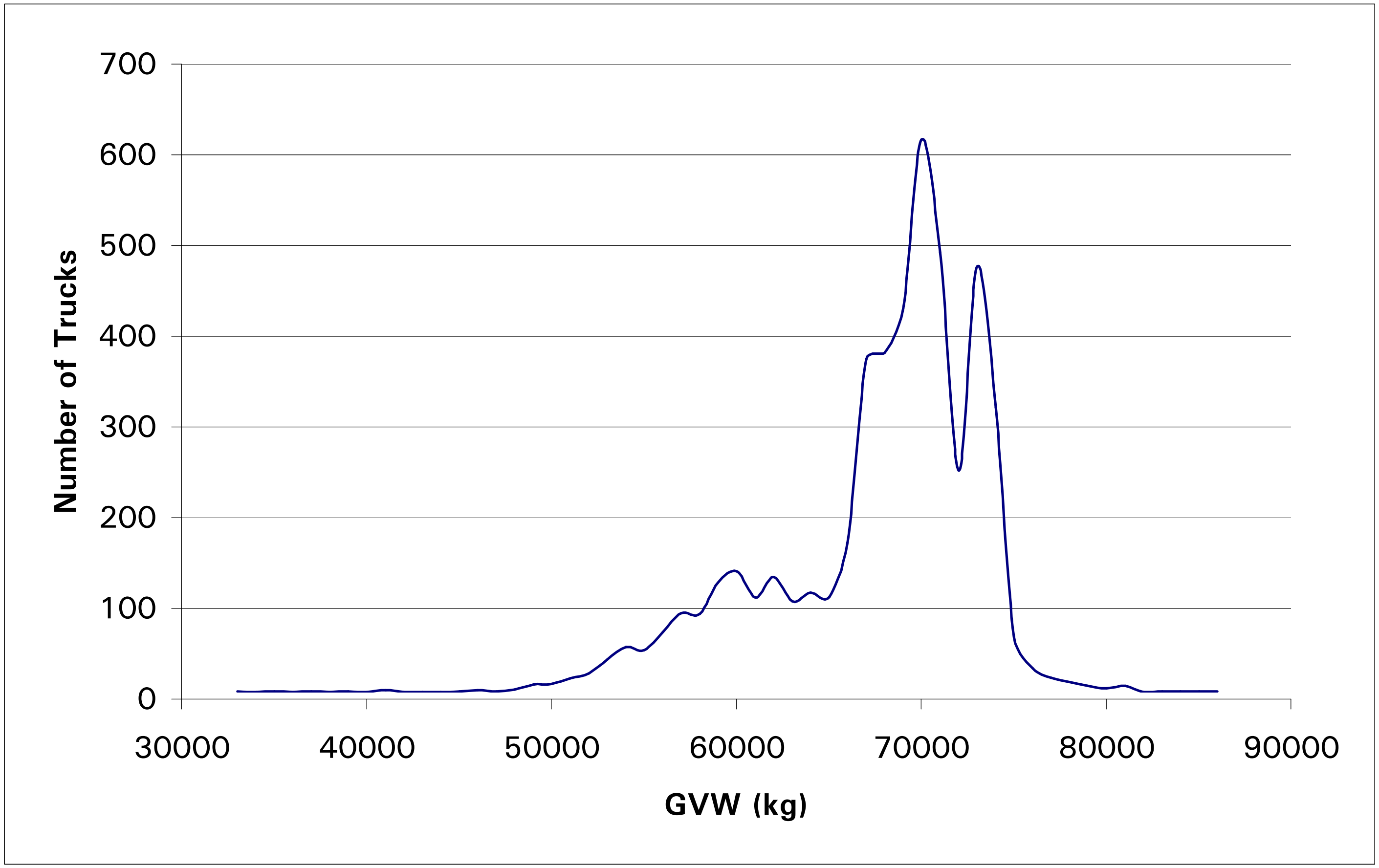
Truck Weight (kg)	No. of Trucks
84000	1
85000	1

Total Trucks: **3800**

Dates: **2002 Jan 1 - Feb 28**

Interior Company 5 - Location 3 Sample B

Truck Weight (kg)	No. of Trucks
32000	1
33000	0
34000	1
35000	0
36000	1
37000	0
38000	1
39000	0
40000	2
41000	0
42000	0
43000	0
44000	1
45000	2
46000	1
47000	3
48000	8
49000	9
50000	15
51000	21
52000	36
53000	50
54000	46
55000	66
56000	87
57000	86
58000	121
59000	133
60000	104
61000	127
62000	100
63000	110
64000	105
65000	165
66000	367
67000	374
68000	423
69000	609
70000	485
71000	244



Truck Weight (kg)	No. of Trucks
72000	469
73000	314
74000	61
75000	26
76000	16
77000	11
78000	7
79000	4
80000	7
81000	0
82000	1

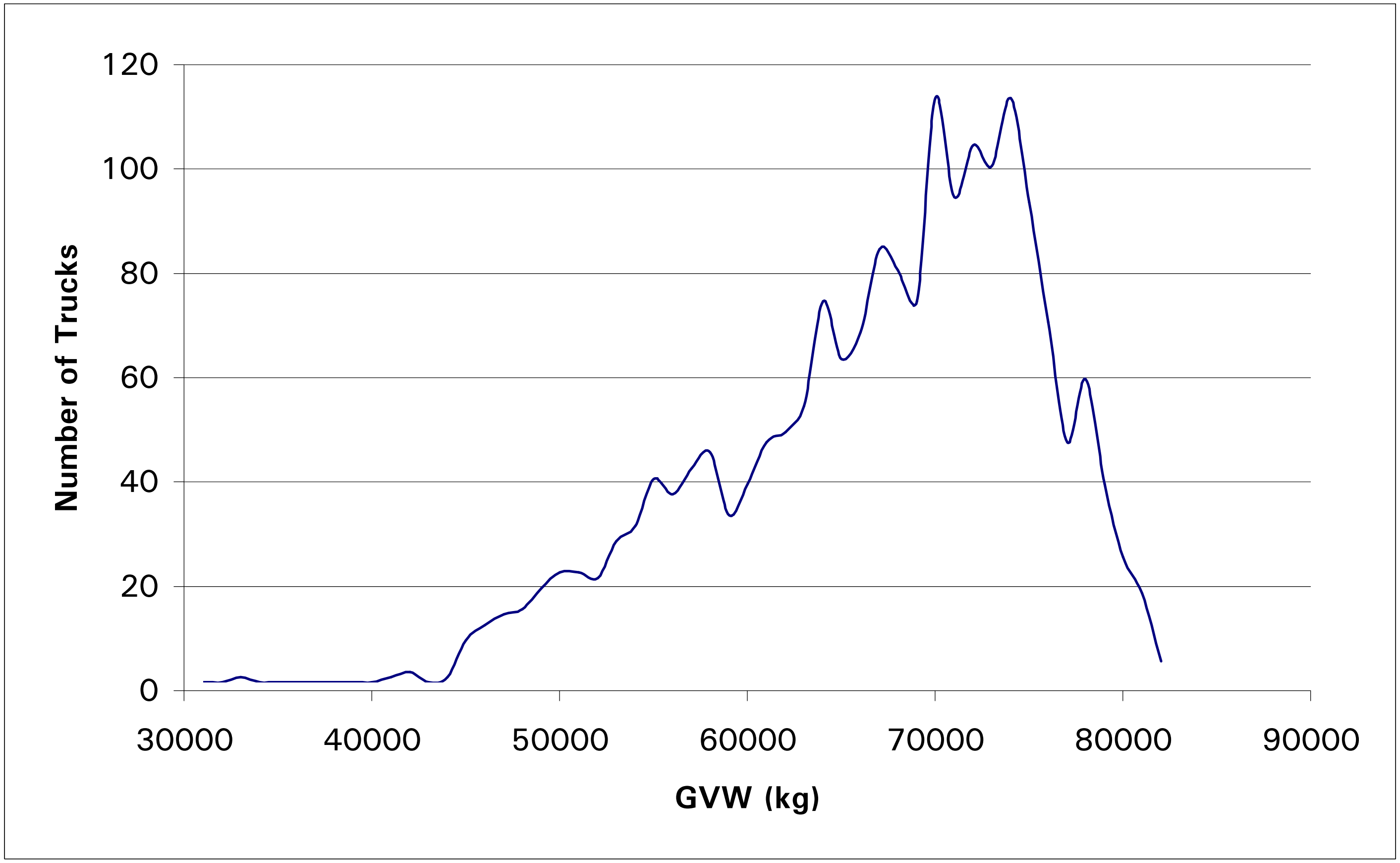
Truck Weight (kg)	No. of Trucks
83000	1
84000	1
85000	1

Total Trucks: 4823

Dates: 2002 Aug 1 - Sep 30

Interior Company 6 - Location 1

Truck Weight (kg)	No. of Trucks
30000	0
31000	0
32000	1
33000	0
34000	0
35000	0
36000	0
37000	0
38000	0
39000	0
40000	1
41000	2
42000	0
43000	1
44000	8
45000	11
46000	13
47000	14
48000	18
49000	21
50000	21
51000	20
52000	27
53000	30
54000	39
55000	36
56000	41
57000	44
58000	32
59000	38
60000	46
61000	48
62000	53
63000	73
64000	62
65000	67



Truck Weight (kg)	No. of Trucks
66000	83
67000	79
68000	73
69000	112
70000	93
71000	103
72000	99

Truck Weight (kg)	No. of Trucks
73000	112
74000	92
75000	69
76000	46
77000	58
78000	38
79000	24

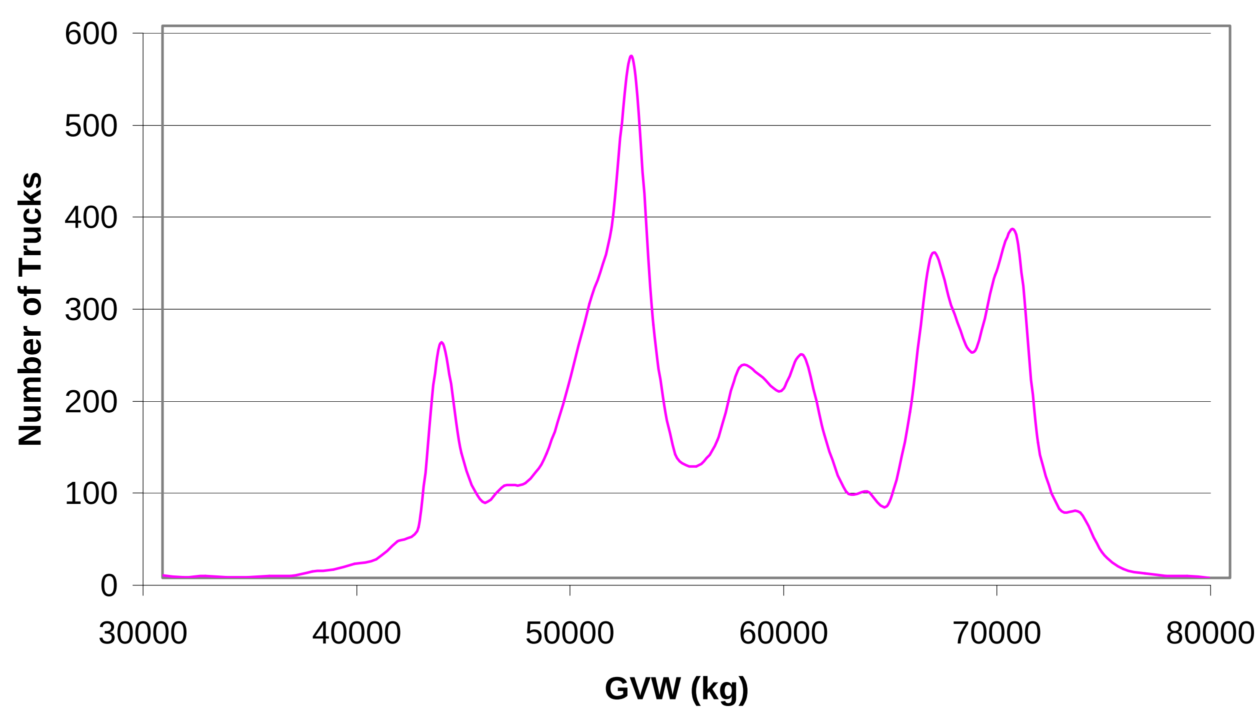
Truck Weight (kg)	No. of Trucks
80000	17
81000	4

Total Trucks: **1869**

Dates: **2002 Jan 3 - Feb 28**

Interior Company 7 - Location 1

Truck Weight (kg)	No. of Trucks
30000	3
31000	1
32000	2
33000	1
34000	1
35000	2
36000	2
37000	7
38000	9
39000	15
40000	20
41000	40
42000	55
43000	255
44000	136
45000	83
46000	100
47000	103
48000	135
49000	209
50000	298
51000	378
52000	566
53000	275
54000	134
55000	121
56000	150
57000	228
58000	220
59000	203
60000	242
61000	156
62000	94
63000	94
64000	80
65000	180
66000	350
67000	293
68000	246
69000	329

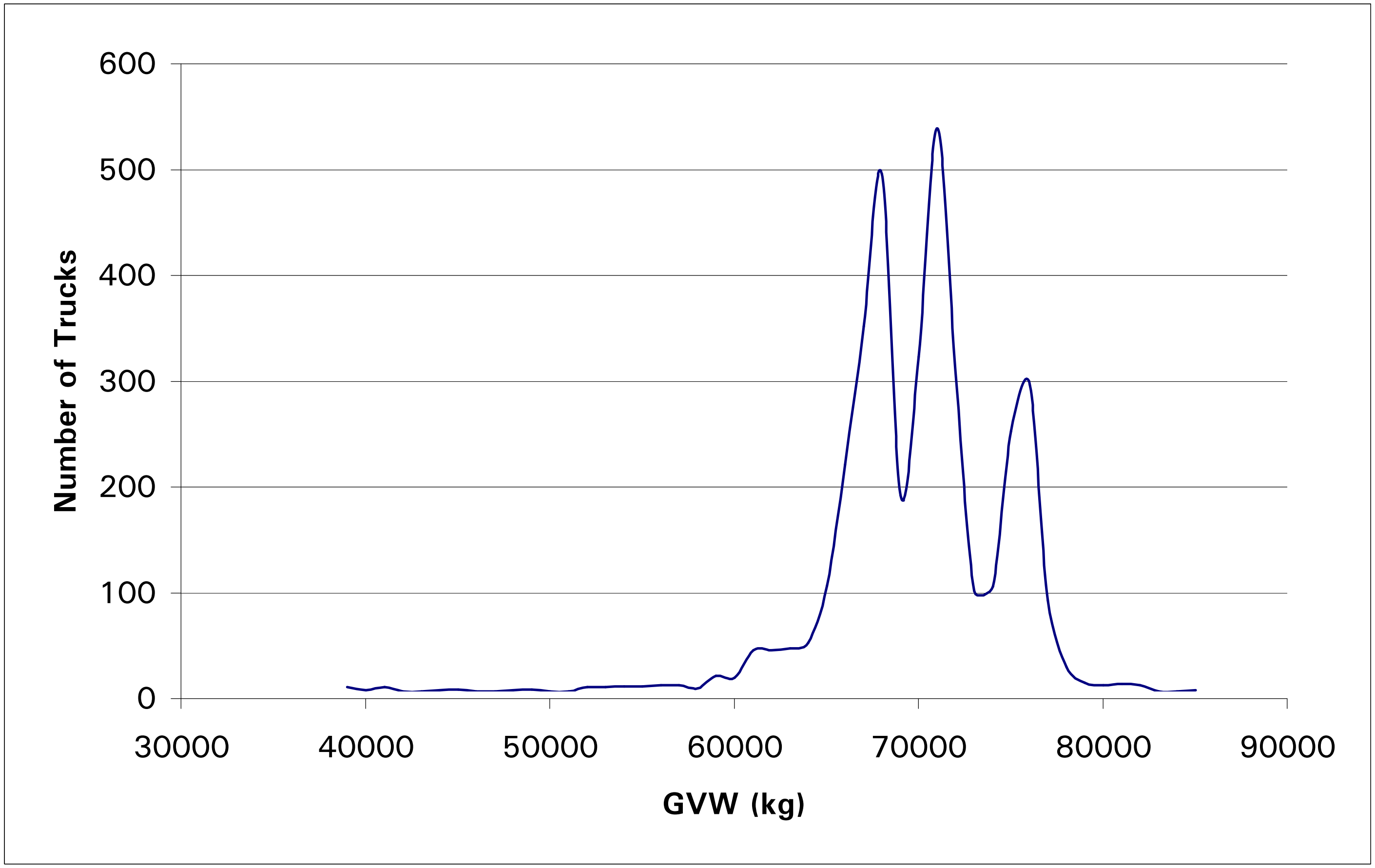


Truck Weight (kg)	No. of Trucks
70000	373
71000	147
72000	75
73000	71
74000	28
75000	10
76000	5
77000	2
78000	2
79000	0

Total Trucks: 6529
Dates: 2002 Jan 2 - Feb 28

Interior Company 8 - Location 1

Truck Weight (kg)	No. of Trucks
38000	4
39000	1
40000	4
41000	0
42000	0
43000	1
44000	2
45000	0
46000	0
47000	1
48000	2
49000	0
50000	0
51000	4
52000	4
53000	5
54000	5
55000	6
56000	6
57000	3
58000	15
59000	13
60000	39
61000	39
62000	41
63000	46
64000	100
65000	214
66000	345
67000	489
68000	185
69000	316
70000	532
71000	295
72000	95
73000	99
74000	246
75000	290
76000	86
77000	23



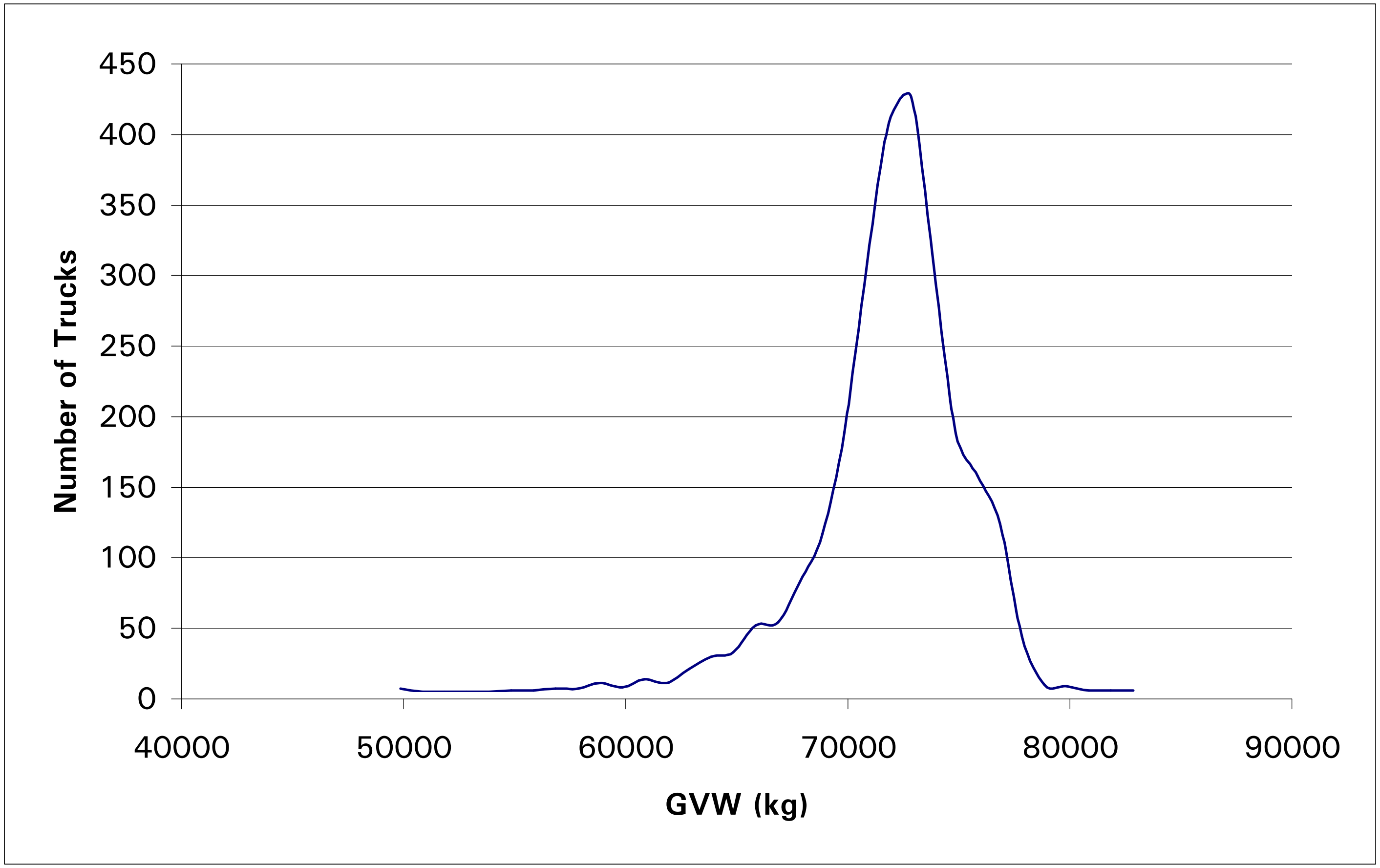
Truck Weight (kg)	No. of Trucks
78000	8
79000	6
80000	7
81000	6
82000	0
83000	0
84000	1

Total Trucks: 3584

Dates: 2002 Jan 2 - Feb 28

Interior Company 9 - Location 1

Truck Weight (kg)	No. of Trucks
49000	2
50000	0
51000	0
52000	0
53000	0
54000	1
55000	1
56000	2
57000	2
58000	6
59000	3
60000	9
61000	6
62000	16
63000	25
64000	28
65000	47
66000	49
67000	78
68000	112
69000	184
70000	303
71000	403
72000	421
73000	305
74000	183
75000	153
76000	119
77000	39
78000	5
79000	4
80000	1
81000	1
82000	1

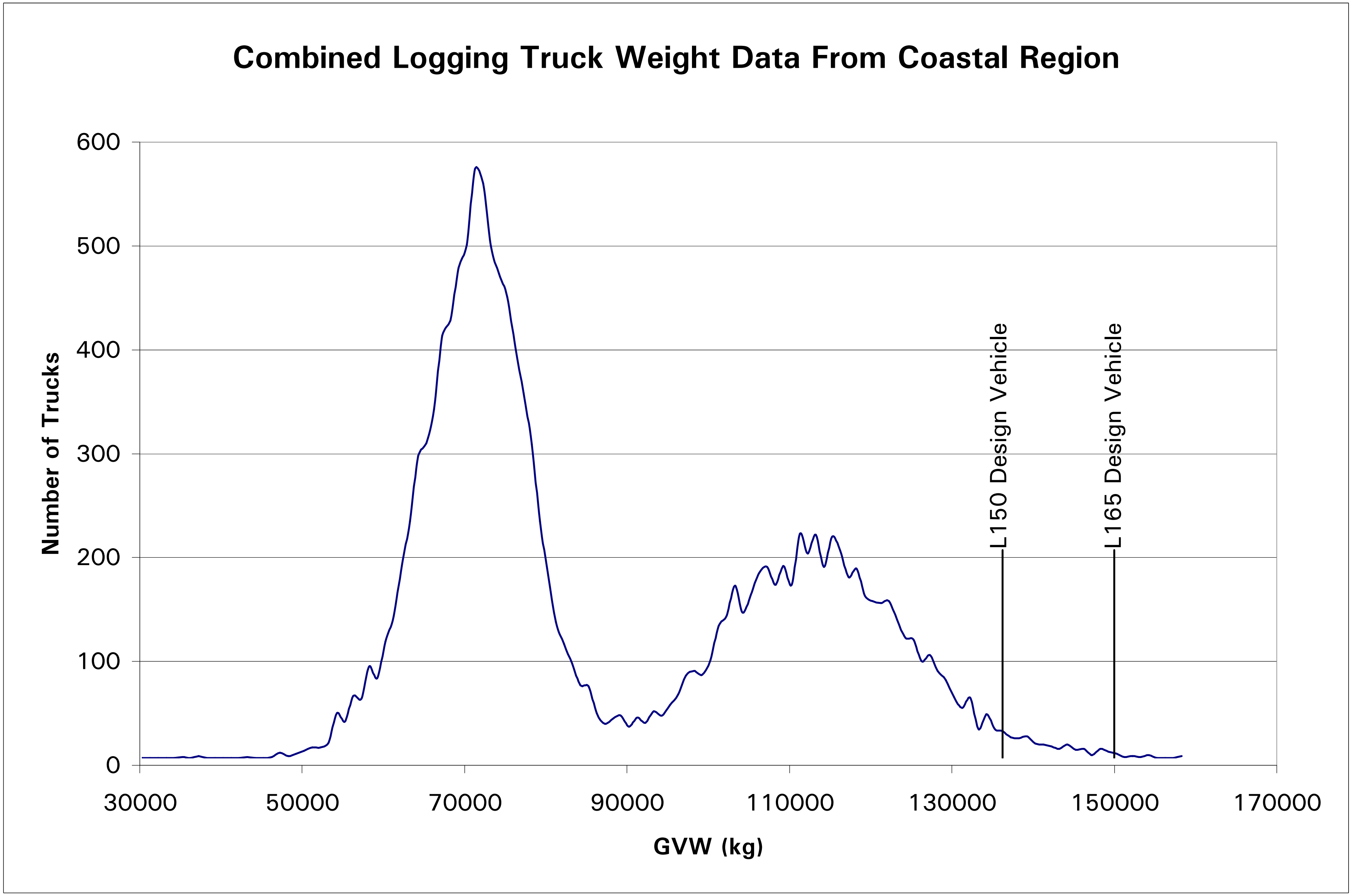


Total Trucks: **2509**

Dates: **2001 Oct 1 - Nov 30**

Appendix B
Coastal Region Truck Weight Summaries

Coastal BC - Total



Coastal BC - Total

Truck Weight (kg)	No. of Trucks
13000	1
14000	0
15000	0
16000	0
17000	0
18000	1
19000	0
20000	0
21000	0
22000	1
23000	0
24000	0
25000	1
26000	3
27000	0
28000	4
29000	1
30000	0
31000	0
32000	0
33000	0
34000	0
35000	1
36000	0
37000	2
38000	0
39000	0
40000	0
41000	0
42000	0
43000	1
44000	0
45000	0
46000	1
47000	5
48000	2
49000	4
50000	7
51000	10
52000	10

Truck Weight (kg)	No. of Trucks
53000	15
54000	43
55000	35
56000	60
57000	57
58000	88
59000	77
60000	112
61000	136
62000	185
63000	228
64000	291
65000	303
66000	336
67000	407
68000	421
69000	472
70000	494
71000	567
72000	553
73000	493
74000	466
75000	444
76000	395
77000	351
78000	302
79000	228
80000	176
81000	131
82000	110
83000	91
84000	70
85000	69
86000	43
87000	33
88000	38
89000	41
90000	30
91000	39
92000	34

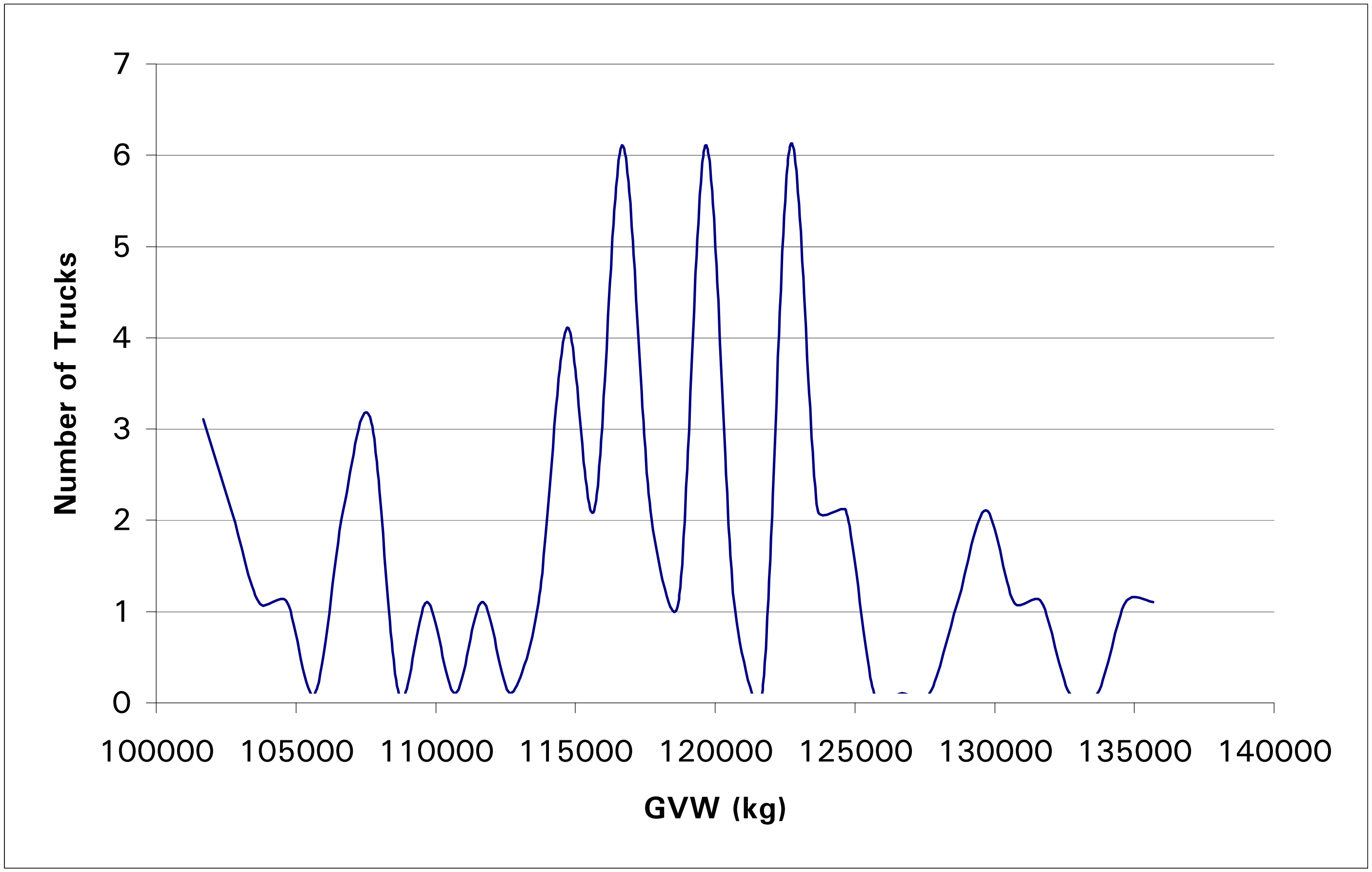
Truck Weight (kg)	No. of Trucks
93000	45
94000	41
95000	51
96000	61
97000	79
98000	84
99000	80
100000	94
101000	127
102000	137
103000	166
104000	140
105000	157
106000	178
107000	184
108000	167
109000	185
110000	167
111000	216
112000	197
113000	215
114000	184
115000	213
116000	199
117000	174
118000	182
119000	156
120000	151
121000	149
122000	151
123000	133
124000	116
125000	114
126000	93
127000	99
128000	84
129000	75
130000	59
131000	48
132000	58

Truck Weight (kg)	No. of Trucks
133000	28
134000	42
135000	28
136000	26
137000	20
138000	19
139000	21
140000	14
141000	13
142000	11
143000	9
144000	13
145000	8
146000	9
147000	3
148000	9
149000	6
150000	4
151000	1
152000	2
153000	1
154000	3
155000	0
156000	0
157000	0
158000	2

Total Trucks: **14020**

Coastal Company 1 - Location 1

Truck Weight (kg)	No. of Trucks
101000	3
102000	2
103000	1
104000	1
105000	0
106000	2
107000	3
108000	0
109000	1
110000	0
111000	1
112000	0
113000	1
114000	4
115000	2
116000	6
117000	2
118000	1
119000	6
120000	1
121000	0
122000	6
123000	2
124000	2
125000	0
126000	0
127000	0
128000	1
129000	2
130000	1
131000	1
132000	0
133000	0
134000	1
135000	1

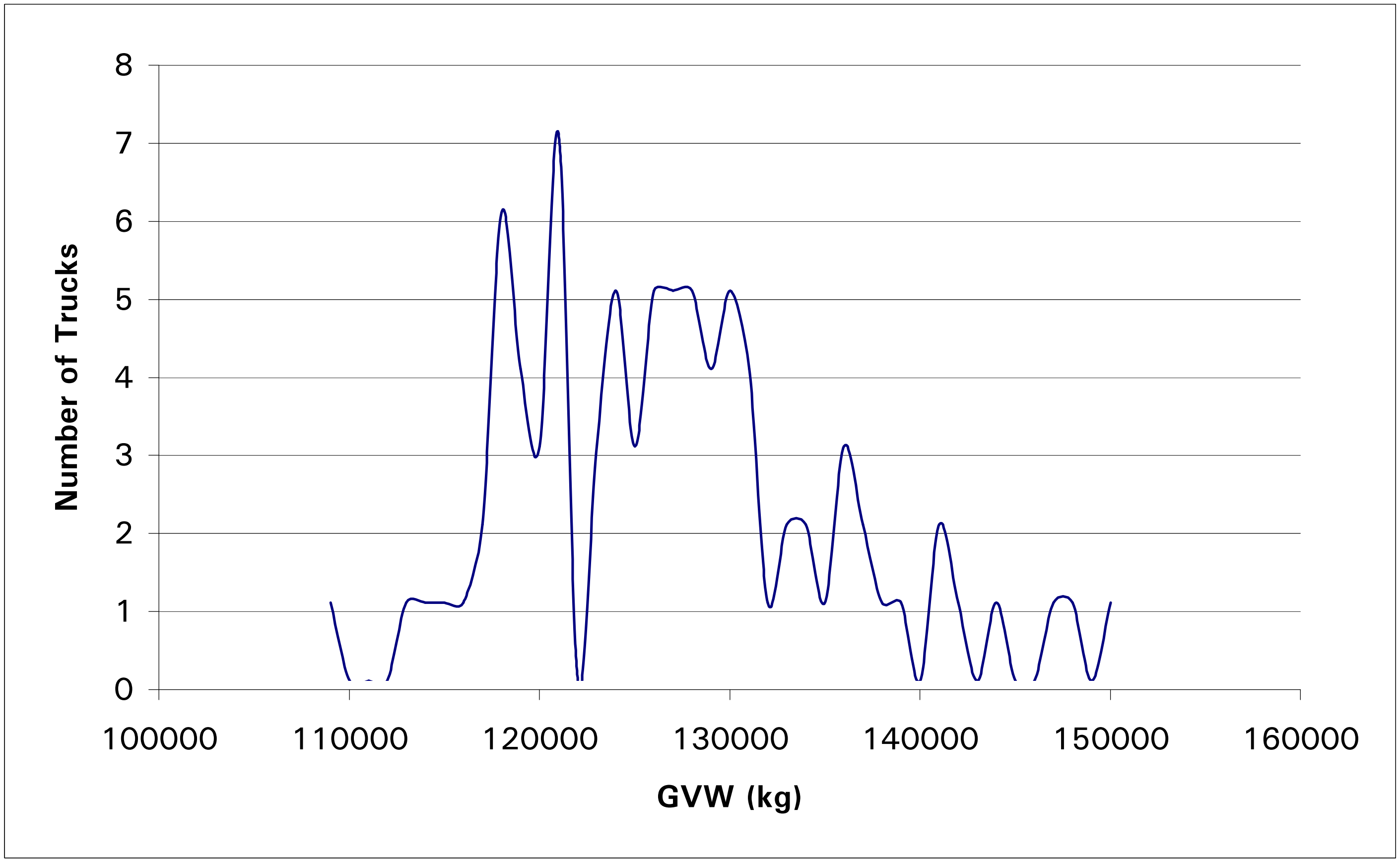


Total Trucks: 54

Dates: 2001 Jun 18 - Jun 29

Coastal Company 1 - Location 2

Truck Weight (kg)	No. of Trucks
108000	1
109000	0
110000	0
111000	0
112000	1
113000	1
114000	1
115000	1
116000	2
117000	6
118000	4
119000	3
120000	7
121000	0
122000	3
123000	5
124000	3
125000	5
126000	5
127000	5
128000	4
129000	5
130000	4
131000	1
132000	2
133000	2
134000	1
135000	3
136000	2
137000	1
138000	1
139000	0
140000	2
141000	1
142000	0
143000	1
144000	0
145000	0
146000	1
147000	1



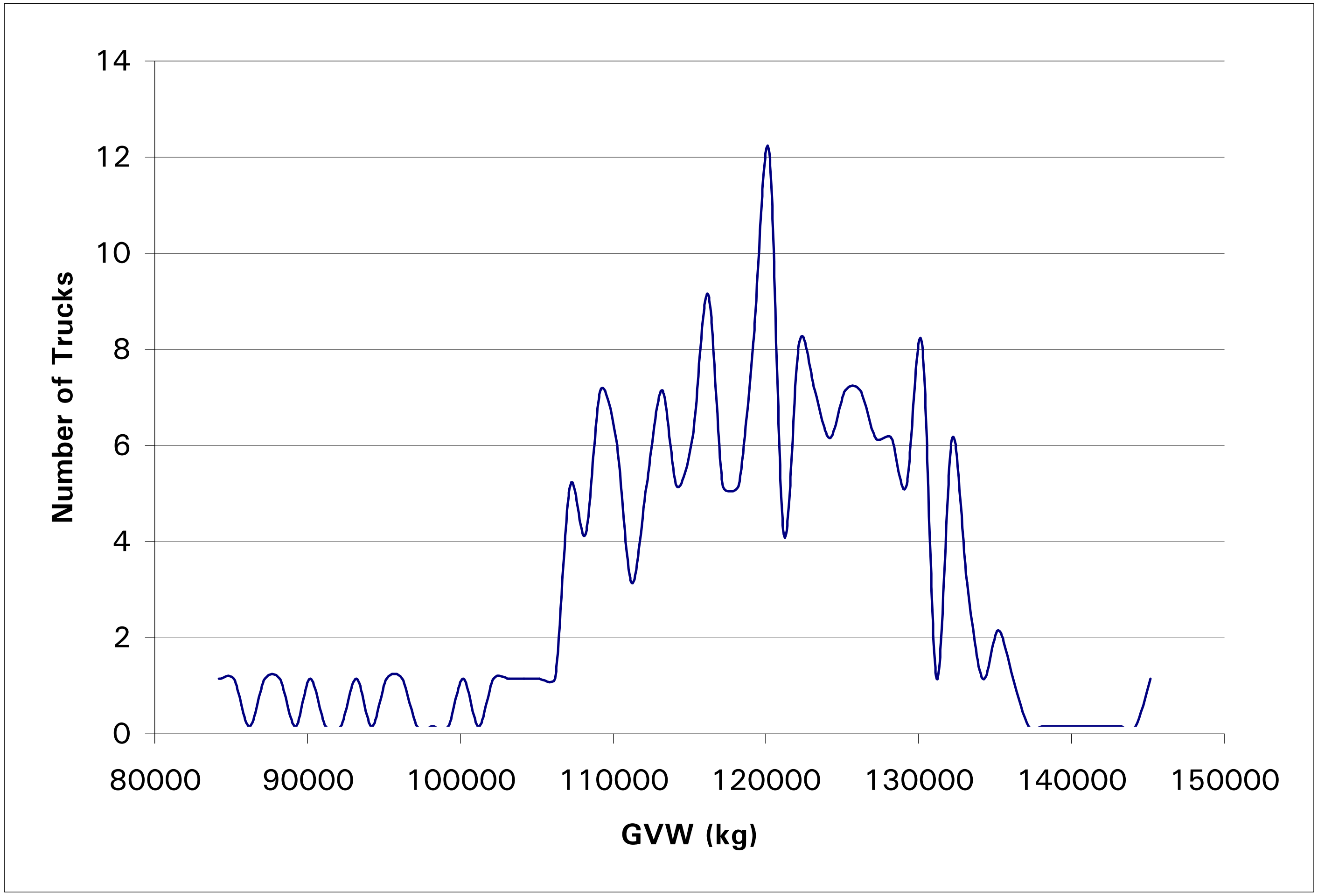
Truck Weight (kg)	No. of Trucks
148000	0
149000	1

Total Trucks: **86**

Dates: **2001 Jan 24 - Jan 31**

Coastal Company 1 - Location 3

Truck Weight (kg)	No. of Trucks
83000	1
84000	1
85000	0
86000	1
87000	1
88000	0
89000	1
90000	0
91000	0
92000	1
93000	0
94000	1
95000	1
96000	0
97000	0
98000	0
99000	1
100000	0
101000	1
102000	1
103000	1
104000	1
105000	1
106000	5
107000	4
108000	7
109000	6
110000	3
111000	5
112000	7
113000	5
114000	6
115000	9
116000	5
117000	5
118000	8
119000	12
120000	4
121000	8
122000	7
123000	6



Truck Weight (kg)	No. of Trucks
124000	7
125000	7
126000	6
127000	6
128000	5
129000	8
130000	1
131000	6
132000	3

Truck Weight (kg)	No. of Trucks
133000	1
134000	2
135000	1
136000	0
137000	0
138000	0
139000	0
140000	0
141000	0

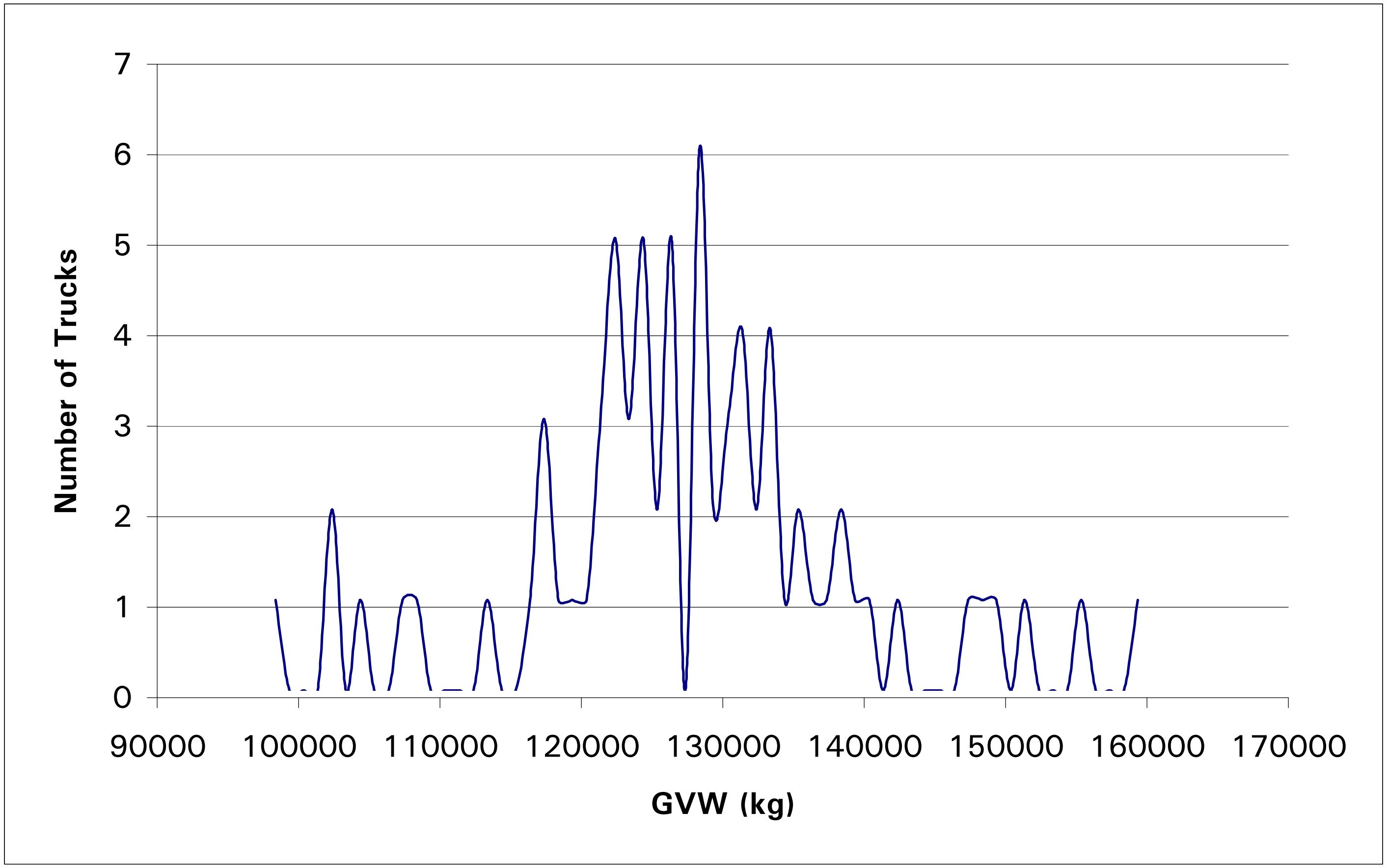
Truck Weight (kg)	No. of Trucks
142000	0
143000	0
144000	1

Total Trucks: **180**

Dates: **2000 Jan 26 - 2002 Feb 11**

Coastal Company 1 - Location 4

Truck Weight (kg)	No. of Trucks
97000	1
98000	0
99000	0
100000	0
101000	2
102000	0
103000	1
104000	0
105000	0
106000	1
107000	1
108000	0
109000	0
110000	0
111000	0
112000	1
113000	0
114000	0
115000	1
116000	3
117000	1
118000	1
119000	1
120000	3
121000	5
122000	3
123000	5
124000	2
125000	5
126000	0
127000	6
128000	2
129000	3
130000	4
131000	2
132000	4
133000	1
134000	2
135000	1
136000	1



Truck Weight (kg)	No. of Trucks
137000	2
138000	1
139000	1
140000	0
141000	1
142000	0
143000	0
144000	0
145000	0
146000	1
147000	1

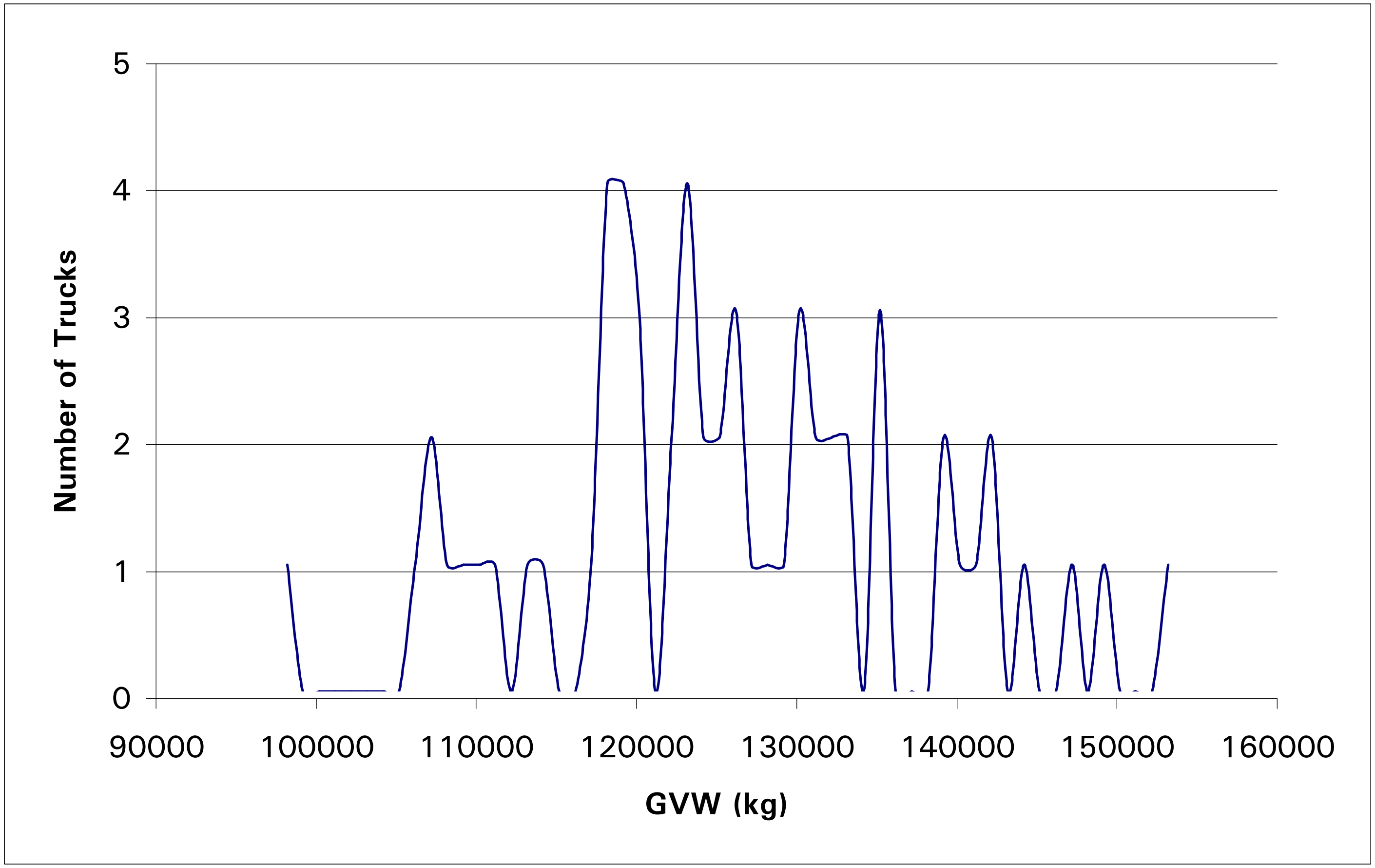
Truck Weight (kg)	No. of Trucks
148000	1
149000	0
150000	1
151000	0
152000	0
153000	0
154000	1
155000	0
156000	0
157000	0
158000	1

Total Trucks: 74

Dates: 2000 Nov 7 - 2001 Feb 22

Coastal Company 1 - Location 5

Truck Weight (kg)	No. of Trucks
97000	1
98000	0
99000	0
100000	0
101000	0
102000	0
103000	0
104000	0
105000	1
106000	2
107000	1
108000	1
109000	1
110000	1
111000	0
112000	1
113000	1
114000	0
115000	0
116000	1
117000	4
118000	4
119000	3
120000	0
121000	2
122000	4
123000	2
124000	2
125000	3
126000	1
127000	1
128000	1
129000	3
130000	2
131000	2
132000	2
133000	0
134000	3
135000	0
136000	0



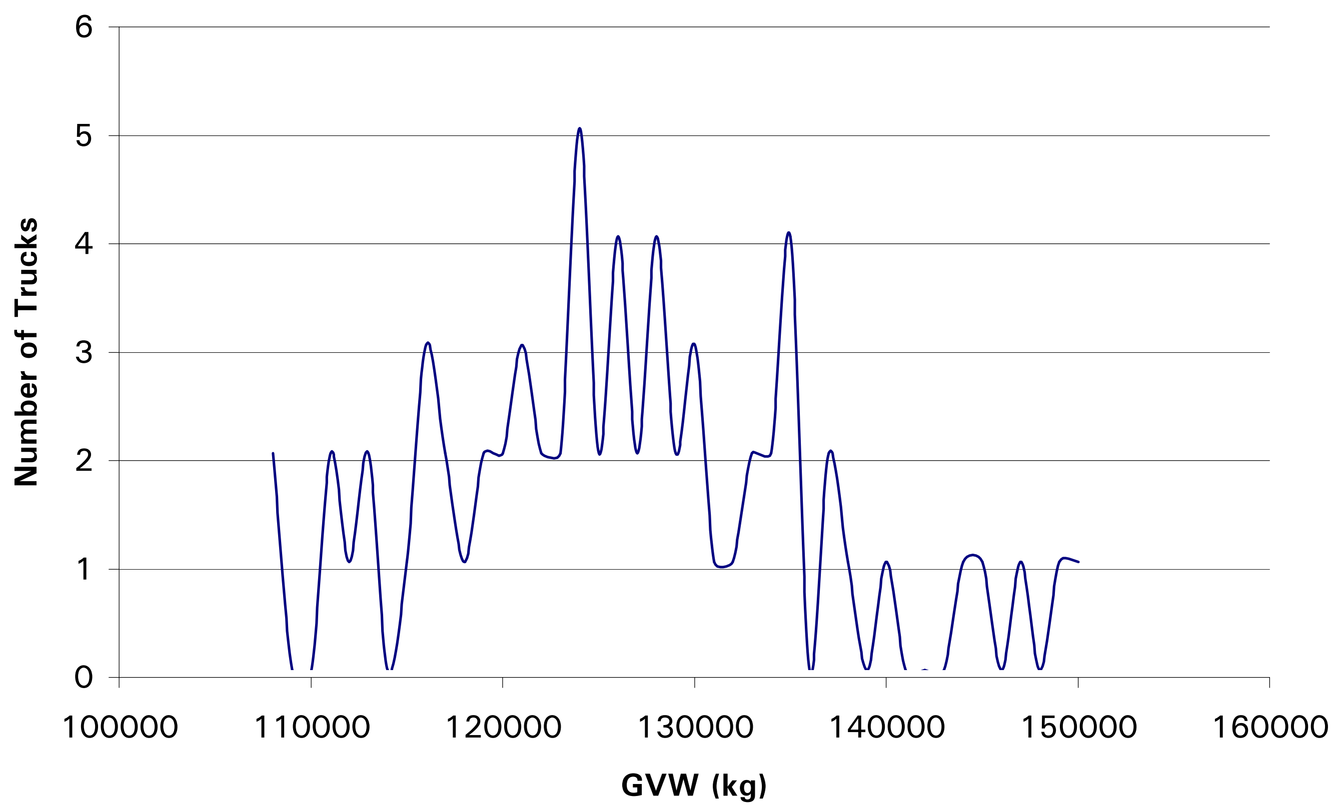
Truck Weight (kg)	No. of Trucks
137000	0
138000	2
139000	1
140000	1
141000	2
142000	0
143000	1
144000	0
145000	0
146000	1
147000	0

Truck Weight (kg)	No. of Trucks
148000	1
149000	0
150000	0
151000	0
152000	1

Total Trucks: 60
Dates: 2000 Apr 17- 2000 Apr 28

Coastal Company 1 - Location 6

Truck Weight (kg)	No. of Trucks
107000	2
108000	0
109000	0
110000	2
111000	1
112000	2
113000	0
114000	1
115000	3
116000	2
117000	1
118000	2
119000	2
120000	3
121000	2
122000	2
123000	5
124000	2
125000	4
126000	2
127000	4
128000	2
129000	3
130000	1
131000	1
132000	2
133000	2
134000	4
135000	0
136000	2
137000	1
138000	0
139000	1
140000	0
141000	0
142000	0
143000	1
144000	1
145000	0
146000	1



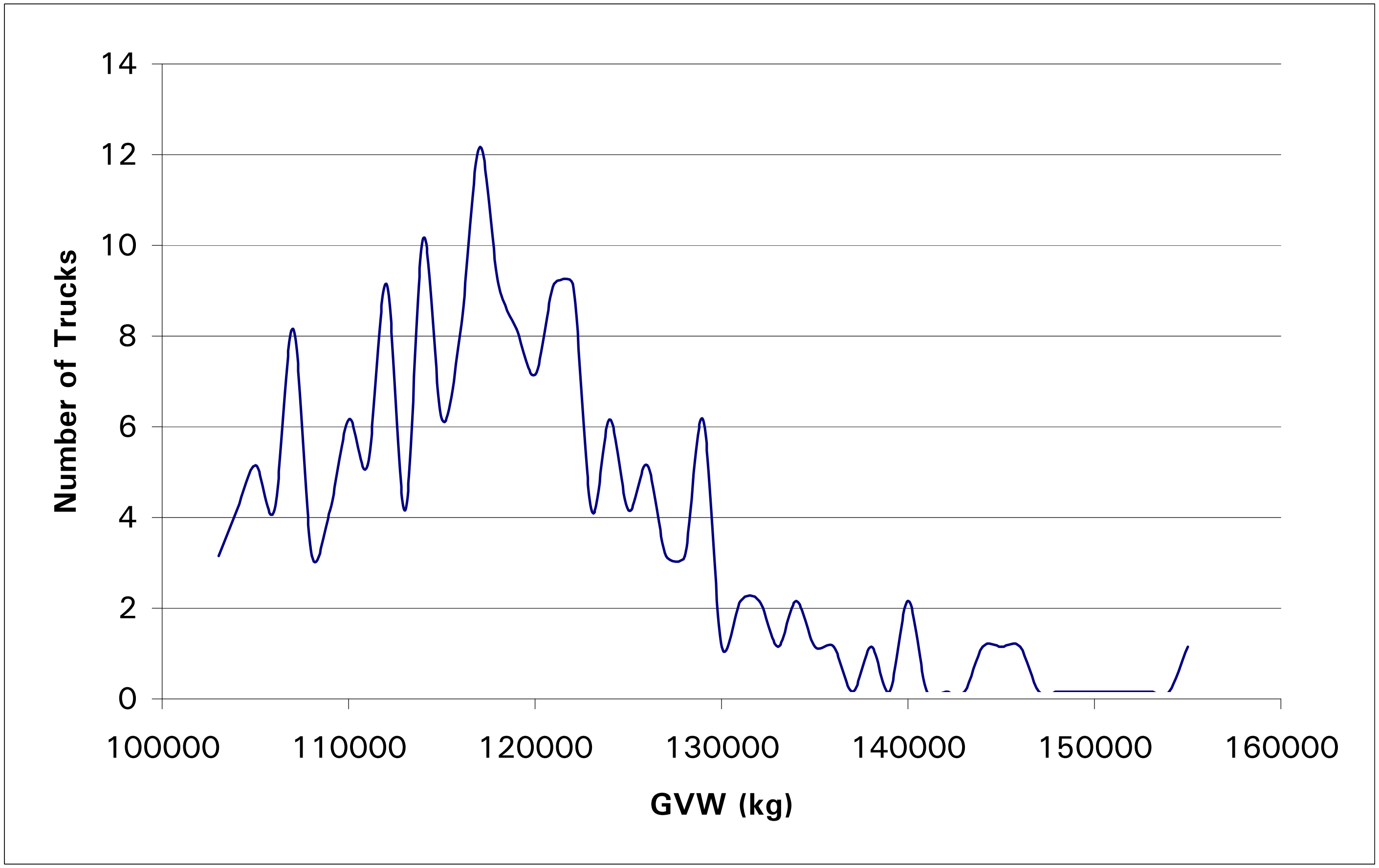
Truck Weight (kg)	No. of Trucks
147000	0
148000	1
149000	1

Total Trucks: **66**

Dates: **2000 Mar 16-**
2000 Mar 20

Coastal Company 1 - Location 7

Truck Weight (kg)	No. of Trucks
102000	3
103000	4
104000	5
105000	4
106000	8
107000	3
108000	4
109000	6
110000	5
111000	9
112000	4
113000	10
114000	6
115000	8
116000	12
117000	9
118000	8
119000	7
120000	9
121000	9
122000	4
123000	6
124000	4
125000	5
126000	3
127000	3
128000	6
129000	1
130000	2
131000	2
132000	1
133000	2
134000	1
135000	1
136000	0
137000	1
138000	0
139000	2
140000	0
141000	0



Truck Weight (kg)	No. of Trucks
142000	0
143000	1
144000	1
145000	1
146000	0
147000	0
148000	0
149000	0
150000	0
151000	0
152000	0

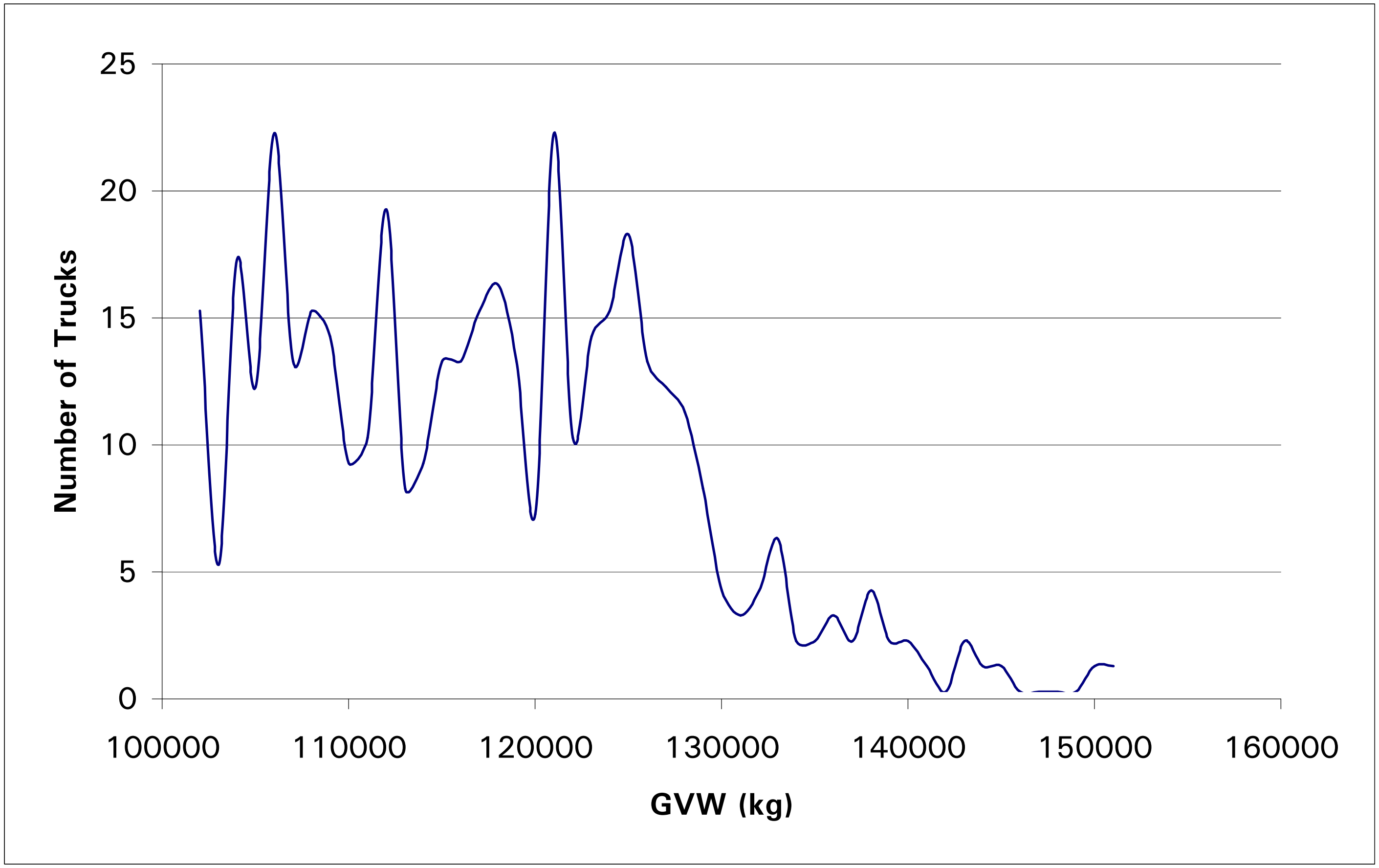
Truck Weight (kg)	No. of Trucks
153000	0
154000	1

Total Trucks: **181**

Dates: **1999 Dec 1-**
2000 Feb 29

Coastal Company 1 - Location 8

Truck Weight (kg)	No. of Trucks
101000	15
102000	5
103000	17
104000	12
105000	22
106000	13
107000	15
108000	14
109000	9
110000	10
111000	19
112000	8
113000	9
114000	13
115000	13
116000	15
117000	16
118000	13
119000	7
120000	22
121000	10
122000	14
123000	15
124000	18
125000	13
126000	12
127000	11
128000	8
129000	4
130000	3
131000	4
132000	6
133000	2
134000	2
135000	3
136000	2
137000	4
138000	2
139000	2
140000	1



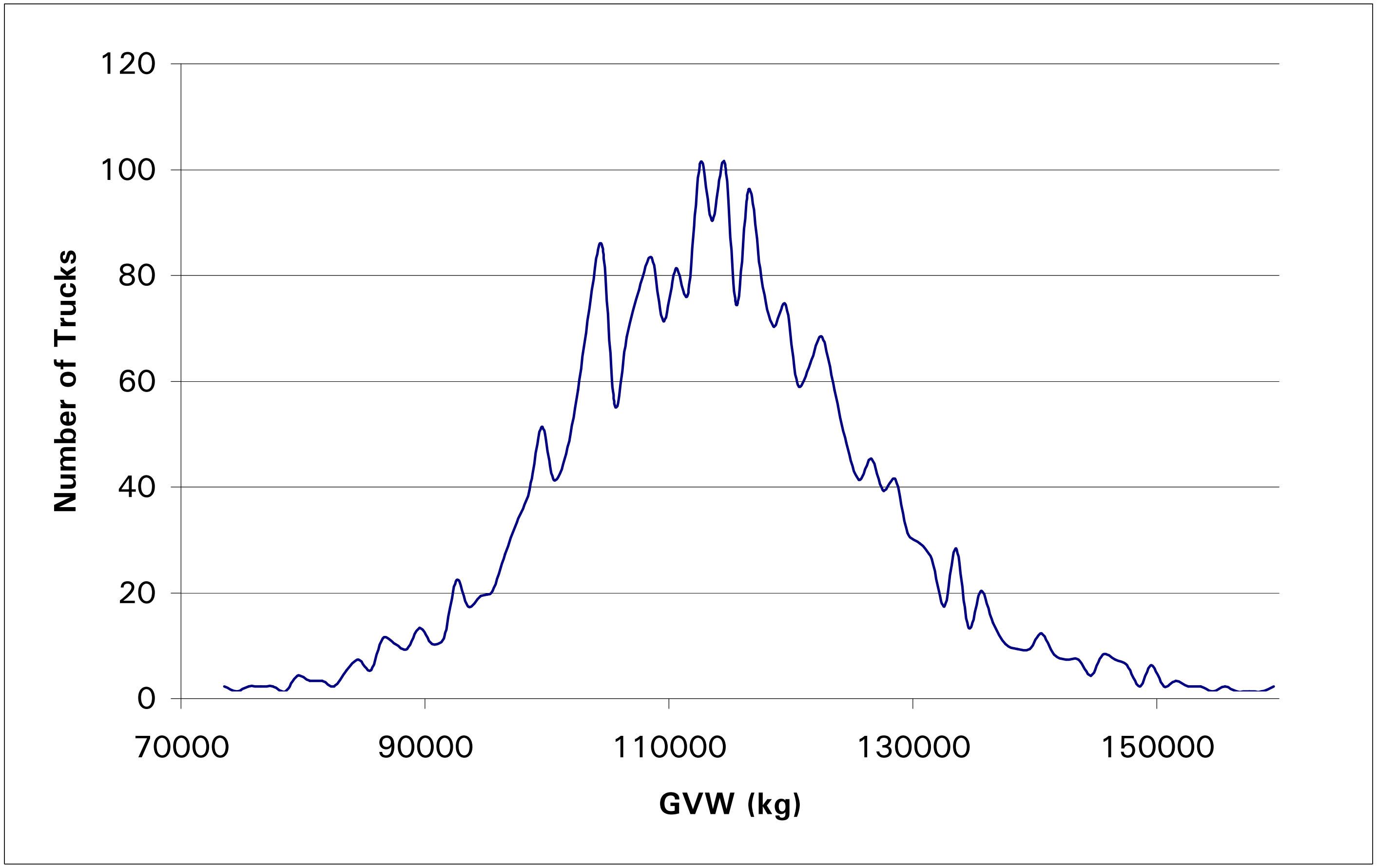
Truck Weight (kg)	No. of Trucks
141000	0
142000	2
143000	1
144000	1
145000	0
146000	0
147000	0
148000	0
149000	1
150000	1

Total Trucks: 409

Dates: 1999 Dec 1-
2000 Feb 29

Coastal Company 2 - Location 1

Truck Weight (kg)	No. of Trucks
72000	1
73000	0
74000	1
75000	1
76000	1
77000	0
78000	3
79000	2
80000	2
81000	1
82000	4
83000	6
84000	4
85000	10
86000	9
87000	8
88000	12
89000	9
90000	10
91000	21
92000	16
93000	18
94000	19
95000	26
96000	32
97000	38
98000	50
99000	40
100000	45
101000	57
102000	74
103000	84
104000	54
105000	67
106000	76
107000	82
108000	70
109000	80
110000	75
111000	100



Truck Weight (kg)	No. of Trucks
112000	89
113000	100
114000	73
115000	95
116000	78
117000	69
118000	73
119000	58
120000	62
121000	67
122000	57

Truck Weight (kg)	No. of Trucks
123000	47
124000	40
125000	44
126000	38
127000	40
128000	30
129000	28
130000	25
131000	16
132000	27
133000	12

Truck Weight (kg)	No. of Trucks
134000	19
135000	13
136000	9
137000	8
138000	8
139000	11
140000	7
141000	6
142000	6
143000	3
144000	7

Coastal Company 2 - Location 1 (Continued)

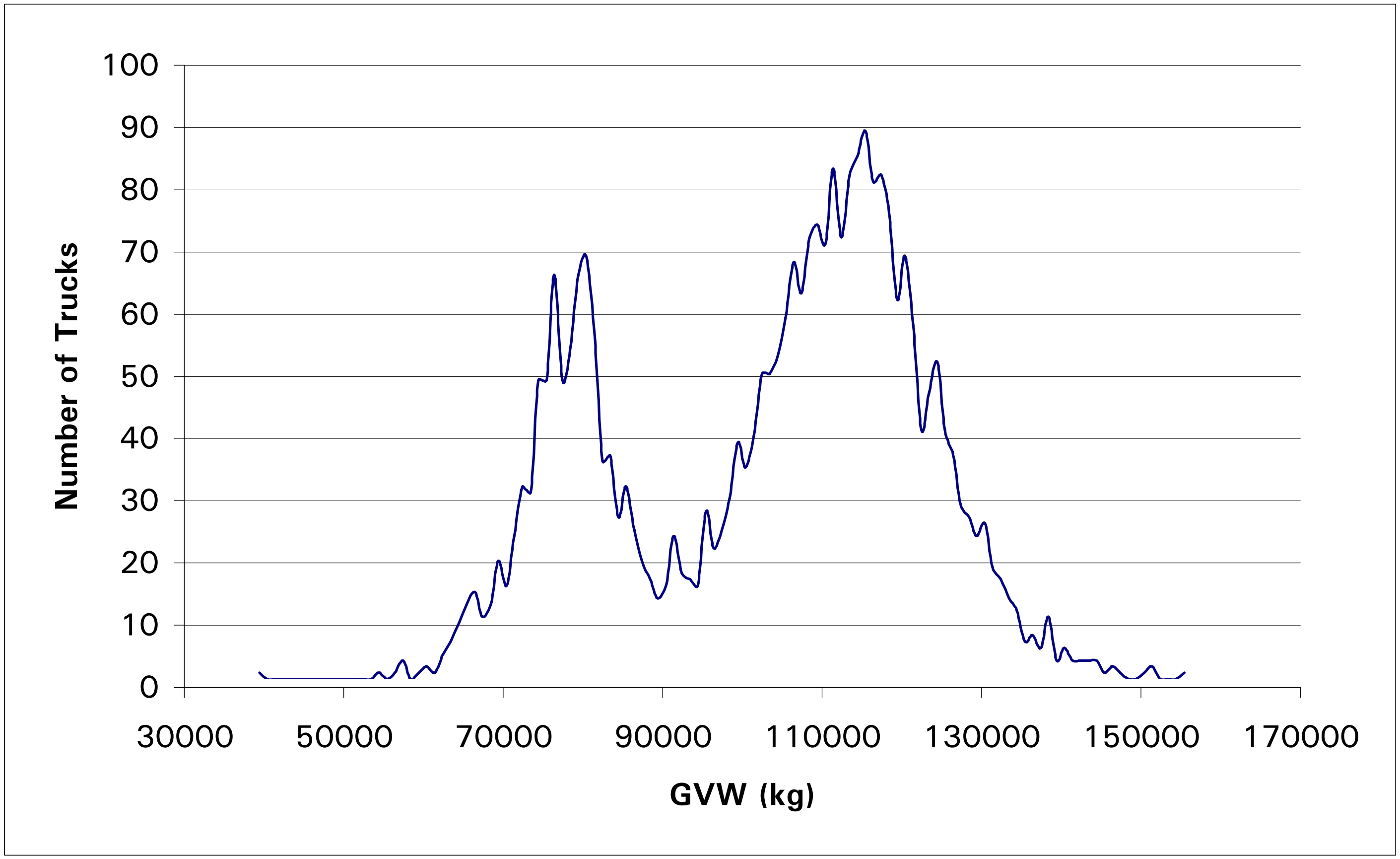
Truck Weight (kg)	No. of Trucks
145000	6
146000	5
147000	1
148000	5
149000	1
150000	2
151000	1
152000	1
153000	0
154000	1
155000	0
156000	0
157000	0
158000	1

Total Trucks: **2497**

Dates: **2002 Apr 2-**
2002 Jun 29

Coastal Company 3 - Location 1

Truck Weight (kg)	No. of Trucks
37000	1
38000	0
39000	0
40000	0
41000	0
42000	0
43000	0
44000	0
45000	0
46000	0
47000	0
48000	0
49000	0
50000	0
51000	0
52000	1
53000	0
54000	1
55000	3
56000	0
57000	1
58000	2
59000	1
60000	4
61000	6
62000	9
63000	12
64000	14
65000	10
66000	12
67000	19
68000	15
69000	23
70000	31
71000	30
72000	48
73000	48
74000	65
75000	48
76000	53



Truck Weight (kg)	No. of Trucks
77000	65
78000	68
79000	56
80000	35
81000	36
82000	26
83000	31
84000	24
85000	19
86000	16
87000	13

Truck Weight (kg)	No. of Trucks
88000	15
89000	23
90000	17
91000	16
92000	15
93000	27
94000	21
95000	24
96000	29
97000	38
98000	34

Truck Weight (kg)	No. of Trucks
99000	39
100000	49
101000	49
102000	52
103000	58
104000	67
105000	62
106000	71
107000	73
108000	70
109000	82

Coastal Company 3 - Location 1 (Continued)

Truck Weight (kg)	No. of Trucks
110000	71
111000	81
112000	84
113000	88
114000	80
115000	81
116000	75
117000	61
118000	68
119000	57
120000	40
121000	46
122000	51
123000	40
124000	36
125000	28
126000	26
127000	23
128000	25
129000	18
130000	16
131000	13
132000	11
133000	6
134000	7
135000	5
136000	10
137000	3
138000	5
139000	3
140000	3
141000	3
142000	3
143000	1
144000	2
145000	1
146000	0
147000	0
148000	1
149000	2

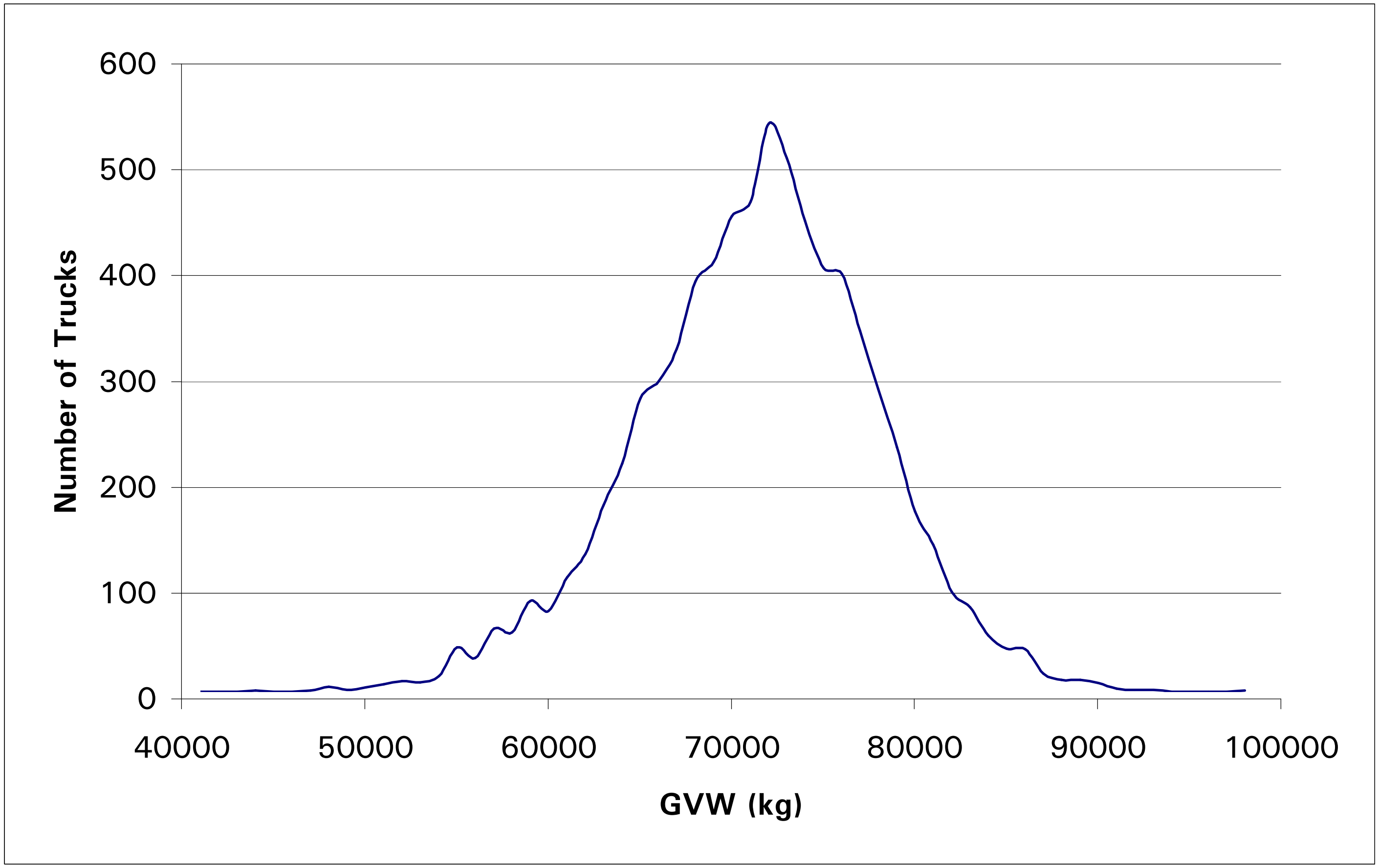
Truck Weight (kg)	No. of Trucks
150000	0
151000	0
152000	0
153000	1

Total Trucks: **2952**

Dates: **2002 Jan 1- 2002 Oct 31**

Coastal Company 3 - Location 2

Truck Weight (kg)	No. of Trucks
13000	1
14000	0
15000	0
16000	0
17000	0
18000	1
19000	0
20000	0
21000	0
22000	1
23000	0
24000	0
25000	1
26000	3
27000	0
28000	4
29000	1
30000	0
31000	0
32000	0
33000	0
34000	0
35000	1
36000	0
37000	1
38000	0
39000	0
40000	0
41000	0
42000	0
43000	1
44000	0
45000	0
46000	1
47000	5
48000	2
49000	4
50000	7
51000	10
52000	9



Truck Weight (kg)	No. of Trucks
53000	15
54000	42
55000	32
56000	60
57000	56
58000	86
59000	76
60000	108
61000	130
62000	176
63000	216

Truck Weight (kg)	No. of Trucks
64000	277
65000	293
66000	324
67000	388
68000	406
69000	449
70000	463
71000	537
72000	504
73000	445
74000	400

Truck Weight (kg)	No. of Trucks
75000	395
76000	341
77000	286
78000	231
79000	170
80000	139
81000	94
82000	80
83000	53
84000	41
85000	40

Coastal Company 3 - Location 2 (Continued)

Truck Weight (kg)	No. of Trucks
86000	17
87000	11
88000	11
89000	8
90000	3
91000	2
92000	2
93000	0
94000	0
95000	0
96000	0
97000	1

Total Trucks: 7461

Dates: 2002 Jan 1- 2002 Oct 31

Appendix C
Logging Equipment Transport Data

Summary of Lowbed Axle Weights

FERIC Lowbed Axle Weight Modelling Results

Interior BC

Operating Area	Contractor	Local Bridges	Lowbed Tractor	Lowbed Trailer	Heaviest Equipment Type	Heaviest Equipment Weight (kg)	Steer Axle Weight(kg)	Load at Front of Working Deck: Drive Axles' Weight (kg)	Load at Front of Working Deck: Trailer Axles' Weight (kg)	Load at Front of Working Deck: Booster/Jeep Weight (kg)	Load Centred on Working Deck: Drive Axles' Weight (kg)	Load Centred on Working Deck: Trailer Axles' Weight (kg)	Load Centred on Working Deck: Booster/Jeep Weight (kg)	Load at Rear of Working Deck: Drive Axles' Weight (kg)	Load at Rear of Working Deck: Trailer Axles' Weight (kg)	Load at Rear of Working Deck: Booster/Jeep Weight (kg)	Walking equipment across bridges
1	1	L100	Freightliner	Aspen T/A with booster	CAT 330 Feller Buncher	46363	5500	34424	18152	9983	30849	20535	11175	27273	22919	12367	Equipment always stays on lowbed
2	1	L100	Kenworth T800	1999 Peerless tandem axle (T/A)	Thunderbird TSY155 yarder	45500	5500	24395	33296		27127	30564		21664	36027		Equipment always stays on lowbed
			Kenworth T800	2000 Peerless T/A	CAT D8 bulldozer	40900	5450	26712	25938		25579	27071		24540	28110		Equipment always stays on lowbed
			Kenworth T800	2001 Peerless T/A	Thunderbird TSY155 yarder	45500	5350	26534	30564		23802	33296		Not done in practise			Equipment always stays on lowbed
3	1	L100	Kenworth T800	1999 Peerless Tridem	Thunderbird TSY155 yarder	45500	4400	29194	29440		26463	32171		23732	34902		Equipment always stays on lowbed
4	1	L75	Kenworth T800	1981 Brentwood T/A	Thunderbird TSY155 yarder	49780	5978	29593	31579		27175	34040		24647	36613		Sometimes walk machines across
			Kenworth T800	2003 Aspen Tridem with booster	Madill 122 Grapple Yarder	59810	6038	Not done in practise			35231	35796	12103	34000	36736	12417	Equipment always stays on lowbed
			Kenworth T800	Aspen Tridem	Madill 122 Grapple Yarder	59810	6050	Not done in practise			36384	40991		35209	42187		Equipment always stays on lowbed
5	1	L100	Freightliner	1987 Knight Heavy Duty T/A	Madill 120 Grapple Yarder	43930	5000	25055	31675		21326	35404		Not done in practise			Equipment always stays on lowbed
			Western Star	1998 Peerless Tridem with Jeep	Madill 120 Grapple Yarder	43930	5000	20546	31281	8959	18756	33849	8181	17089	36240	7456	Equipment always stays on lowbed
6	1	L100	Kenworth W900	1990 Peerless Tridem	Madill 120 Grapple Yarder	47627	5500	28883	35044		26708	37219		24533	39394		Equipment always stays on lowbed
			Kenworth W900	Knight Tridem	Madill 120 Grapple Yarder	47627	5500	28314	35573		26260	37624		24206	39681		Equipment always stays on lowbed
			Western Star	1995 Aspen Tridem	Madill 120 Grapple Yarder	47627	5450	28937	34990		26913	37014		24787	39140		Equipment always stays on lowbed
7	1	L100	Kenworth T800	1988 Aspen T/A with Booster	Madill 3800 Feller Buncher	45268	5300	33211	18549	10182	35489	17031	9423	30860	20117	10966	Equipment always stays on lowbed
			Kenworth T800	1989 Aspen T/A	Madill 3800 Feller Buncher	45268	5300	30928	28726		27632	32022		24232	35422		Equipment always stays on lowbed
	2	L100	Freightliner	1995 Brentwood Tridem	Madill 123 Grapple Yarder w/o tower	56818	4820	Not done in practise			Not done in practise			35015	36993		Equipment always stays on lowbed
			Freightliner	1996 Aspen Tridem	Madill 123 Grapple Yarder w/o tower	56818	4820	Not done in practise			34346	35572		32521	37397		Equipment always stays on lowbed
8	1	L100	Freightliner COE	Aspen Tridem 60 Ton GVW	Cat 330 Log Loader	46364	5000	32893	29109		29878	32125		26768	35234		Equipment always stays on lowbed
	2		Freightliner COE	1998 Peerless Tridem 50 Ton GVW	Cat 330D Log Loader	50000	5000	36972	30935		33769	34137		30567	37340		Equipment always stays on lowbed
9	1	L100	Freightliner Tridem	2000 Peerless Tridem	Madill 124 w/o boom & gantry	51040	5080	35633	29227		31944	32916		28256	36604		Equipment always stays on lowbed
			Western Star Tridem	1997 Peerless Tridem	Madill 124 w/o boom & gantry	51040	4830	33576	31834		32007	33403		30439	34971		Equipment always stays on lowbed
10	1	L100	Western Star	1998 Peerless Tridem	Hitachi 270	27900	4800	23031	20169		21423	21777		19758	23442		Equipment always stays on lowbed
			Western Star	1994 Aspen T/A	Hitachi 270	27900	4800	23666	17505		21528	19643		19337	21834		Equipment always stays on lowbed
11	1	L100	International	2002 Aspen tridem	Butt & Top Loader	46000	5500	31043	28557		29206	30394		27370	32230		Equipment always stays on lowbed
	2	L100	Western Star	1992 Aspen Tridem	Butt & Top Loader	37000	5200	31536	23764		29377	25923		27292	28008		Equipment always stays on lowbed
	3	L100	Kenworth T800	1991 Aspen Tridem	Butt & Top Loader	37000	5500	30434	19886		26643	23677		22928	27392		Equipment always stays on lowbed
					Maximum Axle Group Load (kg)		6050	36972	35573	10182	36384	40991	12103	35209	42187	12417	
					Maximum Equipment Load (kg)	59810											

Coastal BC

Operating Area	Contractor	Local Bridges	Lowbed Tractor	Lowbed Trailer	Heaviest Equipment Type	Heaviest Equipment Weight (kg)	Steer Axle Weight(kg)	Load at Front of Working Deck: Drive Axles' Weight (kg)	Load at Front of Working Deck: Trailer Axles' Weight (kg)	Load at Front of Working Deck: Booster/Jeep Weight (kg)	Load Centred on Working Deck: Drive Axles' Weight (kg)	Load Centred on Working Deck: Trailer Axles' Weight (kg)	Load Centred on Working Deck: Booster/Jeep Weight (kg)	Load at Rear of Working Deck: Drive Axles' Weight (kg)	Load at Rear of Working Deck: Trailer Axles' Weight (kg)	Load at Rear of Working Deck: Booster/Jeep Weight (kg)	Walking equipment across bridges
1	1	L165	Pacific P16	1974 Willock 16-wheel 120Ton	American 7220 Super Snorkel G.Y.	104545	11717	70241	70486		69032	71716		67582	73191		Equipment always stays on lowbed
		L165	Pacific P16	1971 Willock 16-wheel 100Ton	American 7220 Grapple Yarder	79605	12316	63250	65805		61545	67538		59652	69464		Equipment always stays on lowbed
2	1	L165	Mack CL315	Columbia T/A 16-wheel	American 7280 Grapple Yarder	92727	10900	61253	61058		56307	66004		Not done in practise			Equipment always stays on lowbed
3	1	L165	Kenworth HD	1978 Peerless T/A	Madill 044 Grapple Yarder	97784	10643	72714	67048		64325	75590		Not done in practise			Equipment always stays on lowbed
4	1	L165	Pacific P16	Smith T/A 16-wheel 120Ton	American 7280 Grapple Yarder	92727	11322	68413	71041		67145	72320		65876	73599		Equipment always stays on lowbed
5	1	L165	Hayes HDX	1978 OTAM T/A 16-wh 120Ton	Madill 075 Line Loader	98582	12506	74881	72901		68816	79016		Not done in practise			Equipment always stays on lowbed
6	1	L165	Pacific P16	Modified Aspen 16-wh	Madill 044 Grapple Yarder	97784	10518	63225	57201		55359	65118		52662	67833		Equipment always stays on lowbed
7	1	L165	Pacific P16 (modified)	1981 Knight T/A	Madill 044 Grapple Yarder	97784	9608	63426	58706		55695	66488		53119	69082		Sometimes walk equipment across bridges
8	1	L165	Pacific Signature 600	1979 Columbia T/A 120Ton	Madill 144 Grapple Yarder	115258	11700	79939	72619		71591	80967		Not done in practise			Equipment always stays on lowbed
9	1	L150	Pacific P16	1972 Columbia T/A 100Ton	Madill 044 Grapple Yarder	97784	9800	74968	58176		67157	65987		59345	73799		Equipment always stays on lowbed
10	1	L150	Pacific P16	Knight T/A	Cypress 6280	67227	7070	44572	51285		41003	54854		Not done in practise			Sometimes walk equipment across bridges
	2	L100	Western Star	Aspen T/A 50 Ton with booster axle	Cypress 6280	67227	6000	31484	32899	12090	30759	33383	12332	30033	33867	12573	Sometimes walk equipment across bridges
11	1	L75	Kenworth HD	Willock T/A 16-wh 100 Ton with 8-wh Jeep	Cypress 7280 w/o 10T counterweight	83636	4200	34018	45964	29944	32391	49172	28364	30763	52380	26783	Equipment always stays on lowbed
12	1	L150	Freightliner	1995 Aspen 120Ton Tridem	Komatsu PC300LC	33930	4037	24277	23173		22441	25009		20533	26917		Equipment always stays on lowbed
13	1	L165	Hayes HDX	1989 Smith T/A	Madill 075 Line Loader	98582	12773	79016	71841		70884	80111		Not done in practise			Will walk equipment across bridges with steep approaches
					Maximum Axle Group Load (kg)		12773	79939	72901	29944	71591	80967	28364	67582	73799	26783	
					Maximum Equipment Load (kg)	115258											