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The Oregon DOT Slow-Speed Weigh-In--Motion (SWIM) Project: Final Report

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THE OREGON DOT
SLOW-SPEED WEIGH-IN-MOTION
(SWIM) PROJECT

FINAL REPORT

by

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THE OREGON DOT SLOW-SPEED WEIGH-IN-MOTION (SWIM) PROJECT

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1.0 INTRODUCTION

Weigh-in-motion (WIM) systems have provided an effective means of data collection for pavement research and facility design, traffic monitoring, and weight enforcement for over 40 years. In weight enforcement, WIM systems have been increasingly used to screen potentially overweight vehicles. Vehicles that exceed weight limits as measured on a WIM scale are then weighed on a static scale, which is subject to accuracy standards specified by the National Institute of Standards and Technology (1998). The use of WIM for screening purposes reduces queuing at weigh stations, resulting in considerable savings for both truckers and enforcement agencies. To date, however, WIM systems have not been certified for direct applications to weight enforcement.

The accuracy of WIM-measured axle and vehicle weights has improved over time. Field research has led to better understanding and control of pavement, vehicle and environmental factors that contribute to errors in measuring dynamic weights. This understanding is reflected in a standard specification for installation and calibration of WIM scales (ASTM, 1994).

Many of the vehicle characteristics affecting variation in measured dynamic loads increase exponentially with speed, making it very difficult to infer static weight with any precision at highway speeds. However, under slow (under 10 mph) speed conditions, WIM scales appear to be capable of estimating static gross vehicle weight to within ±10% (or better) with 95 percent confidence. Thus the potential for direct use of slow-speed weigh-in-motion (SWIM) systems in weight enforcement is being considered in the U.S. SWIM systems are already being used for enforcement in the UK., much of Eastern Europe, the Middle East, Asia and South America. The precision standard that is commonly employed for enforcement applications of WIM scales in these areas is ±5% at the 95% confidence level (Curnow, 1998).

Handbook 44 (NIST, 1998) does not contain acceptance and maintenance tolerances for WIM scales. Tolerances specified for portable wheel-load weighers in *Handbook 44* are ± 1% and ± 2% for acceptance and maintenance, respectively, and this is thought to be the performance that WIM systems will need to achieve to be certified by NIST for weight enforcement. If it can be demonstrated that such applications of WIM systems are feasible, the tactical enforcement and planning consequences would be far-reaching (Hajek et al., 1992; Krukar and Evert, 1990).

This report presents findings from a year-long field test of a SWIM system located at the Wyeth Weigh Station on I-84 (west-bound), five miles east of the Cascade Locks, Oregon, P.O.E. The report is organized as follows. Section 2 presents the measures of accuracy and precision employed in the study. This section also contains a discussion of measurement error and its implications, as well as a regression model whose purpose is to estimate correction factors that can be used to improve accuracy and precision. Section 3 describes alternative types of WIM systems and summarizes the precision standards developed by the American Society for Testing and Materials (ASTM) for different applications. In Section 4, the findings of earlier studies are reviewed. In Section 5, the test site is described, while Section 6 explains the data recovery process. The statistical analysis of the weight data is reported in Section 7 and conclusions are presented in Section 8.

2.0 ACCURACY AND PRECISION

Evaluation of the accuracy and precision of the WIM scale employs a standard procedure (ASTM, 1994). Axle weights are measured by WIM scales and compared to the corresponding weights recorded by static scales for a sample of vehicles. WIM scale accuracy is represented as follows:

$$\text{Accuracy} = [(W_d - W_s)/W_s)] * 100, \text{ where} \tag{1}$$

W_d = axle or vehicle weight measured by a WIM scale;
W_s = axle or vehicle weight measured by a static scale.

A WIM scale is defined to be accurate if the mean value of equation 1 for a sample of weight observations does not differ significantly from zero. To the extent that the mean value of equation 1 differs from zero, a systematic error (i.e., bias) exists in the WIM measure of vehicle or axle weight. As Izadmehr and Lee (1987b) point out, proper calibration of WIM scales can potentially eliminate systematic error, and thus a considerable amount of attention has been devoted to designing error-minimizing calibration procedures (Davies and Sommerville, 1987; Faghri et al., 1995; Izadmehr and Lee, 1987a, 1987b; Lee and Machemehl, 1985; Jacob et al., 1993; Papagiannakis, 1995; Papagiannakis et al., 1995). It is now generally accepted that systematic error is minimized when, among other things, WIM system calibration draws a sample of vehicles from the traffic stream that is representative of the vehicle population that the system is intended to weigh.

To test for accuracy, a confidence interval is calculated around the mean as follows:

$$A \pm Z_{\alpha/2} * (S_A/n^{.5}), \text{ where} \tag{2}$$

A = the mean percentage difference between the WIM and static weights;

$Z_{\alpha/2}$ = the critical value from the standard normal distribution associated with the level of confidence α;

S_A = the standard deviation of A;

n = the number of observations.

The level of confidence generally employed is 95%. If the calculated interval around the mean accuracy includes the value zero, it can be concluded that the scale is accurate.

An important issue for weight enforcement is that while a WIM scale may be capable of providing an accurate estimate of weight for a sample of trucks or axles, in general, it will not perform very well for individual trucks or axles when the variance of equation 1 is large. In other words, the scale may be accurate but imprecise. The precision of the statistic given in equation 1 may be defined as the range within which a specific percentage of all observations can be expected to fall, which is represented as follows:

$$A \pm Z_{\alpha/2} * S_A \tag{3}$$

The precision of a WIM scale corresponds to its ability to consistently measure given dynamic forces. Precision is affected by vehicle, roadway, and operating factors that jointly determine the dynamic force placed on the WIM scale and the scale's inherent ability to measure that force. Actions that can reduce dynamic load variation contribute directly to WIM precision improvements. Among the controllable factors contributing to dynamic load variation (after optimizing the scale site for flatness, roughness, etc.), reducing vehicle speed produces a substantial reduction in load variation (Izadmehr and Lee, 1987b; Moore et al., 1989; van Niekerk and Visser, 1993; Papagiannakis et al., 1995; Sebaaly and Tabatabaee, 1993). Also, redundancy in the WIM system from the use of "double threshold" scales has been shown to improve precision substantially (Krukar et al., 1996).

2.1 MEASUREMENT ERROR

In equations 1, 2 and 3 it is assumed that static weights are known weights with zero variance. In practice, these weights must be measured on static scales. Given that weighing procedures cannot be entirely controlled, it is unlikely that the variance of the weights taken from static scales is zero (Davies and Sommerville, 1987; Lee, 1988; Moore et al., 1989). The consequences of error in measuring static weights are best illustrated with respect to the inverse regression procedure commonly used to estimate static weights from WIM observations in determining calibration factors (Gillmann, 1992; Izadmehr and Lee, 1987b; Papagiannakis, 1995). The first step in this procedure is to obtain observations on WIM and static weights to estimate the regression

$$\text{WIM} = \alpha_0 + \beta_1 * \text{Static} + e \qquad \text{where} \tag{4}$$

WIM	=	the response or dependent variable;
Static	=	the predictor or independent variable;
α_0	=	the estimated intercept parameter;
β_1	=	the estimated slope parameter;
e	=	a random error term.

Given the estimated regression it is then possible to infer an unobserved static weight from an observed WIM weight as follows:

$$\text{Static}_i = [(\text{WIM}_i - \alpha_0)/\beta_1] \tag{5}$$

The reason that this two-step inverse regression procedure is employed is that it is acknowledged that WIM weights are measured with error. The alternative regression of static weight on WIM weight would thus result in a downward-biased estimate of β (Maddala, 1977). Estimation bias is avoided in the inverse regression approach *if* static weights are measured without error. While it is clear that static weight measurement is less subject to error than WIM weight measurement (given that dynamic force variation is, by definition, absent in the former case), it is now recognized that error is potentially present in static weight measures and should therefore be evaluated (Davies and Sommerville, 1987; Lee, 1988; Papagiannakis et al., 1995). The Appendix reports the findings from attempts to identify sources of static scale measurement error in the present project.

3.0 WIM SYSTEMS AND PERFORMANCE STANDARDS

WIM scales differ according to the choice of technology to capture an axle or vehicle's dynamic weight. Two types of technology are most commonly employed, but others also exist and development is occurring at a fairly rapid pace. In terms of the number of units deployed, the most common technology is based on piezo-electric sensors that produce a voltage in proportion to the applied stress, from which dynamic loads can be calculated. The other predominant technology uses bending plates to measure strain. Less common are load cells, which measure weight via hydraulic pressure change. Finally, there are two new technologies, with one just emerging and the other still in development. The former is based on quartz sensors, while the latter is based on fiber-optic sensors that measure weight through light interruption.

Curnow (1998) summarizes the distinctions among different WIM technologies in terms of initial and maintenance costs, as well as the level of accuracy (see Figure 1). Load cells have experienced the greatest accuracy and their relatively long life span (10-20 years) contributes to low maintenance cost. Initial outlays for load cells are much greater than the outlays for the other WIM technologies. Bending plate systems have not tended to be as accurate as load cells. While their initial costs are lower, their 3-5 year expected lives contribute to relatively higher maintenance costs. Piezo-electric systems require relatively small initial outlays. However, fairly extensive experience with piezo-electric technology indicates that these systems are not likely to achieve the levels of accuracy and precision needed for enforcement applications. Quartz crystal technology was introduced to the market in 1997, and its performance and operating cost experience is thus limited. It does appear to be capable of achieving the accuracy and precision of bending plate systems at somewhat lower cost. Fiber-optic systems are not yet available commercially, but research indicates that this technology is potentially capable of achieving high levels of accuracy and precision a moderate cost.

FIGURE 1

GENERAL COST AND PERFORMANCE CHARACTERISTICS OF ALTERNATIVE WIM TECHNOLOGIES

Technology	Initial Cost	Maintenance Cost	Accuracy
Load Cell	High	Low	High
Bending Plate	Moderate	Moderate	Moderate
Piezo-electric	Low	High	Low
Quartz Sensor	Low	Low-Moderate	Moderate
Fiber-optic	Likely Moderate	Likely High	Likely High

Although the NIST has not adopted accuracy standards for WIM systems, the ASTM has developed a standard specification for four alternative applications of WIM technology (ASTM, 1994). The ASTM E 1318-94 standard specification includes procedures for testing the accuracy of WIM systems, and it identifies precision standards for alternative uses. The ASTM specification is intended to provide WIM system users with performance characteristics to allow them to design systems that are capable of meeting intended applications. However, the ASTM standard specification does not provide a legal basis for enforcement applications of WIM systems. That responsibility resides with the NIST.

The classification and performance aspects of WIM systems addressed in the ASTM standard specification are summarized in Figure 2. Four types of systems are identified, but a major distinction can be made between systems that are configured for traffic data collection (Types I and II) and systems that are configured for screening and direct enforcement (Types III and IV). Type III screening applications of WIM technology provide a means to increase the effective vehicle handling capacity of weigh stations by identifying potential weight violators at moderate speeds (15-50 mph) and directing them to the static scales. In this application, ASTM precision standards of ± 6, 10 and 15% are specified for vehicles, axle groups and individual axles, respectively.

The standards for Type IV WIM systems are directly relevant to the present project. For enforcement applications, the ASTM standard specification limits speed to 10 mph or less and sets threshold precision levels at ± 4.2, 4.8 and 4.2% for vehicles, axle groups and individual axles. At the maximum allowable weight for single and tandem axles in Oregon (20, 000 and 34,000 pounds, as stated in ORS 818.010), the precision levels are ± 2.5 and 3.5%, respectively.

FIGURE 2

ASTM CLASSIFICATION AND PERFORMANCE SPECIFICATION FOR WIM SYSTEMS

WIM System Type	Purpose	Speed	Precision (at 95% confidence level)	
Type I	Traffic Data Collection	10-70 mph	Axle Load Axle Group Load Gross Vehicle Weight	± 20% ± 15 ± 10
Type II	Traffic Data Collection	10-70 mph	Axle Load Axle Group Load Gross Vehicle Weight	± 30% ± 20 ±15
Type III	Identification of Vehicles Suspected of Weight-Limit and Load-Limit Violations ("Screening")	15-50 mph	Axle Load Axle Group Load Gross Vehicle Weight	± 15% ± 10 ± 6
Type IV	Detection of Weight-Limit or Load Limit Violations at Weight-Enforcement Stations ("Enforcement")	0-10 mph	Axle Load Axle Group Load Gross Vehicle Weight	± 2.5 - 4.2% ± 3.5 - 4.8 ± 3.1 - 4.2

* The ASTM tolerances for Type IV WIM Systems are specified in pounds, with corresponding threshold weight values set for each axle configuration category. The percentage values at the larger end of the ranges shown above were calculated at threshold weight levels of 12,000 (axle), 25,000 (axle group) and 60,000 (vehicle) pounds. The values at the smaller end were calculated at Oregon's limits of 20,000, 34,000 and 80,000 pounds.

4.0 REVIEW OF WIM PRECISION STUDIES

A limited number of field studies provide evidence of WIM system precision in measuring vehicle and axle weights at slow speeds. Some findings are based on scale calibration data and thus may not be representative of vehicles in the traffic stream nor invariant to potentially relevant dynamic conditions (e.g., weather, instrument drift, etc.). Nevertheless, the studies provide a general indication of the levels of performance that WIM systems have achieved. Accuracy is not addressed here, although a number of studies report these findings as well. Generally, as a result of the development of standard procedures for calibrating WIM systems, the scales have been found to be capable of providing accurate weighings (i.e., well within a range of ±1%).

Figure 3 summarizes the levels of precision for axle and vehicle weight reported in eight studies. Precision of ± 10% for gross vehicle weight has been fairly consistently achieved at speeds under 10 mph, although about half the studies are based on calibration data. Only two studies -- Castle Rock Consultants (1989) and Izadmehr and Lee (1987b) -- recorded precision levels on gross vehicle weight under ± 5%. Moreover, the precision recorded in the Castle Rock study for gross vehicle weight clearly bettered the ASTM IV standard.

The precision achieved for axle weights is consistently worse than it is for gross vehicle weight. Aside from the Castle Rock precision findings, which ranged from 2.74 to 3.25% in three test periods, none of the studies reporting on axle weights in Figure 3 achieved a precision level below ± 10% at the axle or axle group level. Thus the precision achieved by WIM systems to date have generally not been adequate for direct enforcement of axle weight limits, even with respect to the more liberal ASTM standard.

FIGURE 3

SUMMARY OF WIM PRECISION STUDY FINDINGS

Reference	**Speed**	**Vehicle Weight**	**Axle Weight**	**Comments**
Castle Rock Consultants (1989)	2.5 mph	95% within ± 1.18-1.92%	95% within ± 2.74-3.25%	Arizona I-10 traffic stream weighings
Faghri et al. (1995)	N.R.*	28-46% within ± 5%	N.R.	Field test of 10 WIM systems on I-95
Gillmann (1992)	N.R.	95% within ± 10%	N.R.	Calibration data from Kansas WIM system
Izadmehr & Lee (1987a)	<10 mph	95% within ± 6.2%	95% within ± 13%	Weights on 86 trucks following calibration
Izadmehr & Lee (1987b)	<10 mph	95% within ± 4-6.5%	95% within ± 11.8-13.3%	Findings from multiple calibrations
Jacob et al. (1993)	25-50 mph	95% within ± 10%	95% within ± 10%	Tolerances for French "Category B" WIM facilities**
Lee & Machemehl (1985)	"Slow & Steady"	95% within ± 6.3%	95% within ± 13.2%	Texas I-10 traffic stream weighings
Moore et al. (1989)	10-50 mph	95% within ± 26%	95% within ± 39%	Test of 6 WIM systems in UK

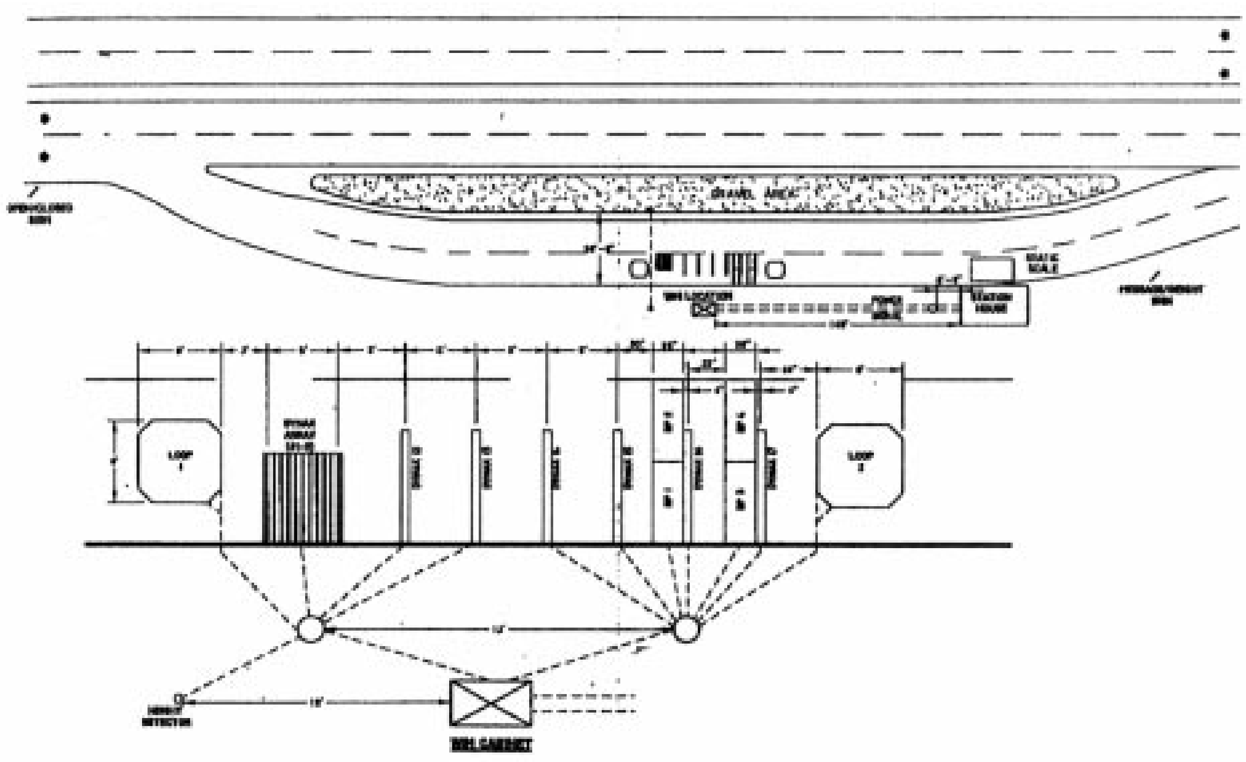
* Not reported.

** WIM systems in this category are subject to requirements that are comparable to ASTM E 1318 - 94 Type III systems in the US.

5.0 WYETH WIM TEST SITE

The WIM test facility is located at the Wyeth Weigh Station on I-84 westbound at mile post 55, about 10 miles east of the Cascade Locks Port of Entry (P.O.E.) and 50 miles east of Portland. The weigh station has been equipped with a static scale and is operated on a random basis. The WIM system consists of four bending plate scales arrayed in two rows (i.e., a "double threshold" configuration), loops fore and aft, and Dynax Array with six Dynax Sensors (see Figure 4). The system was manufactured by International Road Dynamics, Inc. It was installed and initially calibrated in late 1994. The user requirements identified in the ASTM standard specification for WIM systems were followed in the installation of the system.

FIGURE 4
CONFIGURATION OF WYETH WIM SYSTEM



A photograph of the test facility is shown in Figure 4. The truck in the middle of the photo is passing over the WIM scales. The Dynax Array is the dark space between the latter two trucks. To the right, partially concealed by the speed sign, is the WIM cabinet, containing a hard drive for data storage and a telephone link to ODOT's mainframe computer. The station house, where the static scale is located, is visible in the background. The distance between the WIM and static scales is about 120 feet. The weight recorded by the WIM scale is displayed in a monitor in the station house. For a vehicle traveling at 5 mph, about 15 seconds elapses between the WIM and static scale locations. In normal operation, the large volume of traffic has led to allowing trucks to pass over the static scale at a slow roll, and under these conditions the WIM scale has served effectively as a screening device in weight enforcement.

FIGURE 5
WYETH FACILITY AND WIM SYSTEM

6.0 DATA RECOVERY

In the initial stage of the project a sampling plan for data recovery was developed, based on both the error variance observed in the WIM scale calibration data as well as the error variance observed in the composition of the vehicle fleet traveling that segment of I-84 (Strathman and Fountain, 1996). The capability of automated data recovery and storage for both the WIM and static scales existed on site, and it was hoped that a fairly large number of weighings could be obtained under a variety of conditions over approximately a six month period. Originally, the project's time line set the initiation of the data recovery phase in August 1994.

Actual field experience revealed a variety of challenges that the research team had not anticipated. These challenges included equipment failure and site related problems, as well as operational and procedural difficulties.

With regard to operational and procedural problems, the large volume of truck traffic in this section of I-84 effectively prevented systematic sampling. Even in normal enforcement conditions, when trucks were allowed to roll at slow speed over the static scale, queues frequently formed and extended back the relatively short distance (approximately 600 feet) from the WIM scale to the freeway. When this occurred, trucks were allowed to bypass the scales. Queuing also contributed to data recovery problems on the WIM scale. Trucks in the queue often came to a stop on the WIM scale (as is the case with the truck in the center of the photo in Figure 5), invalidating the weighing, and tail-gating made it impossible for the WIM system to recognize axle configurations and thereby classify vehicles.

FIGURE 6

VEHICLE ACTIVITY AT THE WYETH WIM SITE

The large volume of trucks prevented automatic data recovery and necessitated developing a procedure for manual data recovery. It was concluded that two-person teams would be required, with one positioned outside the station house directing vehicles over the static scale and the other inside recording data from the scale monitors. A graduate assistant was teamed with a Motor Carrier Enforcement Officer and the procedure they followed for weighing vehicles was as follows:

1. An enforcement officer selects a vehicle when no queuing is occurring and stops the vehicle after it has passed over the WIM scale, but prior to the static scale.

2. The graduate assistant records WIM system data from the monitor in the station house.

3. The officer informs the driver that the vehicle has been selected to be a part of a scale accuracy study, and that each axle and axle group will need to be weighed with all brakes off and with the vehicle out of gear.

4. The officer positions the axles on the scale and the graduate assistant records the weights from the monitor in the station house.

The shift to manual data recovery also lead to extending the time frame for data recovery. Given the decline in the sampling rate associated with the manual weighing procedure, it was decided to extend the data recovery period from six to thirteen months in an effort to recover a reasonably large sample.

Another operational challenge was associated with the weather. The Wyeth site was selected in part because of its location in the Columbia River Gorge. This area is known for producing some of the most varied weather conditions in the Northwest, with periods of relatively high wind year-round, winters frequently characterized by sub-freezing temperatures accompanied by sleet and icy conditions, and temperatures regularly exceeding 90F in the months of July and August. While there was an interest in assessing the effects of weather on WIM system performance, when adverse conditions actually materialized, particularly in winter time, it proved too hazardous either to travel to or operate the weigh station.

Possibly related to the weather, equipment failure was also problematic. WIM scale units failed on several occasions, as did several Dynax sensors and the WIM monitor located in the station house. With each scale replacement, the system was re-calibrated.

By June 1997 the procedural, operational and technical issues had been resolved and data collection began. Data was periodically recovered over the following thirteen months, during which time no technical problems were encountered. Overall, 775 axles/axle groups and 272 vehicles were weighed, as shown in Table 1. Weather varied with respect to precipitation and wind, but no weighings were recovered in sub-freezing temperatures.

Analysis of the initial data revealed a problem with the effort to recover the weights of individual axles within tandem axle groups (Swope and Strathman, 1998; see the Appendix). While the WIM scales were easily capable of recovering the weights of individual axles within axle groups, the static scale's much larger deck required "splitting" tandems in several alternative ways depending on the configuration of the vehicle. It was determined that the procedures used to split tandem axles introduced measurement error in the static weighings. As a result, all non-steering axle observations for the first four dates in Table 1 were deleted. Following this, no attempt was made to split tandem axle weights on the static scale.

TABLE 1

DATA COLLECTION SUMMARY

Date	Vehicles	Axles	Weather
June 6, 1997	15	15*	Clear
June 9	5	5*	Clear
June 18	25	25*	Clear
July 8	9	9*	Clear
July 23	20	60	Clear
November 17	21	70	Rain
December 2	21	68	Windy and Clear
January 20, 1998	17	56	Rain
March 26	40	134	Rain
April 7	21	67	Clear then Rain
April 17	30	110	Clear
June 9	31	97	Clear
June 25	17	59	Clear
Total	272	775	

* All observations for June 6, 9, 18 and July 8 are for steering axles only. Observations on the other axles for these dates were deleted after it was determined that the procedure used to recover individual static axle weights from tandem axle groups was subject to measurement error.

A final issue in data recovery concerns speed. The ASTM standard specification for Type IV WIM systems recommends that WIM scale weighings be recorded at speeds of 10 mph or less. The Wyeth WIM data includes 24 axle/axle group (8 vehicle) observations at speeds exceeding 10 mph. These excess speed observations were deleted to conform to the ASTM standard specification.

7.0 DATA ANALYSIS

7.1 NOMINAL ACCURACY AND PRECISION

Table 2 reports statistics on the accuracy and precision of the WIM scale for the sample data. The observations are divided into five categories for subsequent analysis. The broadest distinction made is between the axle and vehicle level. Among axles, distinctions are also made for steering, tandem, and others. The latter category includes single axles that could be either drive or trailer units, depending on the vehicle.

The mean percentage error between the WIM and static scale weights is well under 1% for all but the "Other Axles" category. The greatest accuracy is achieved at the vehicle level, where the mean error was just under one-tenth of one percent. At the axle level, steering units were found to be the most accurate, with SWIM weights averaging within .16% of the static scale weights, followed fairly closely by tandem units, with an average error of .21%. The average error of "Other" units, at 1.25%, is over five times greater than the results for tandem units.

TABLE 2

ACCURACY AND PRECISION OF OBSERVED WIM DATA

Category	Sample Size	Mean Error	SD	Bias?*	Precision at 95% Confidence
All Axles	751	.221%	3.99%	No	± 7.82%
Steering Axles	261	-.159	4.50	No	± 8.82
Tandem Axles	390	.212	3.30	No	± 6.47
Other Axles	100	1.252	4.80	Yes	± 9.41
Gross Vehicle Wt.	210	.098	2.85	No	± 5.59

* The test for bias addresses the null hypothesis that the mean errors are equal to zero for the given sample sizes and the chosen significance level (95 percent).

Tests for the presence of systematic error, based on the 95% confidence interval around the mean errors, supported the presence of positive bias in the WIM scale measurement of "Other Axle" weights.

Regarding the precision of the WIM scale weights, the product of the standard deviation and the corresponding critical value from the standard normal distribution indicates that 95% of WIM scale vehicle weights fall within 5.6% of the static scale weight. At the axle level, tandem units yielded the most precise results, with the SWIM scale weights of 95% of these units falling with a range of 6.5% of the respective static scale weights. Thus, while steering axles were weighed somewhat more accurately than tandems, the precision of the latter is somewhat better than the former. This could reflect the relatively greater effects that acceleration and deceleration tend to have on the dynamic weights of steering axles. The overall precision of the SWIM scale weights at the axle level, $\pm$7.8%, represents and error range that is nearly 40% larger than the error range calculated at the vehicle level. This is consistent with previous studies' finding of greater precision at the vehicle level, although the relative difference between vehicle and axle level precision observed in the present student is smaller than the relative difference reported in the earlier studies.

With respect to controls for speed, four of the studies reviewed earlier provide the most direct basis for comparison of the precision findings in the present study. These include the studies by Castle Rock (1989), Izadmehr and Lee (1987a; 1987b), and Lee and Machemehl (1985). The mean precision at the vehicle and axle levels among these studies, based on the best performance reported at each level, is $\pm$4.42% (vehicle) and $\pm$10.18% (axle). By comparison, the present study is less precise at the vehicle level, with an error range that exceeds the earlier studies by 26.5%, and more precise at the axle level, with an error range that is, across all axles, 23.2% narrower.

7.2 REGRESSION ANALYSIS

From previous research, factors influencing systematic and random error can be identified. The consequence of controlling for their effects will be to reduce the error components and therefore improve the accuracy and precision levels over those reported in Table 2. The regression model serving this purpose can be generally specified as follows:

$$\text{WIM} = f(\text{Static, Time, Rain, Wind, Type, Speed}), \text{ where} \qquad (6)$$

WIM	=	Weigh-in-motion scale weight;
Static	=	Static scale weight;
Time	=	A variable indicating the month the weight was recovered;
Rain	=	A dummy variable equaling one if it was raining when the weight was recovered, and zero otherwise;
Wind	=	A dummy variable equaling one if the weight was recovered in high wind conditions, and zero otherwise;
Type	=	A dummy variable equaling one if the vehicle was a 3S2 unit, and zero otherwise;
Speed	=	The speed at which the axle was traveling over the weigh-in-motion scale when the weight was recovered.

Equation 6 is commonly referred to as an inverse regression model because it specifies the WIM weight rather than the static scale weight on the left-hand side. Although the purpose of the regression is to estimate parameters that can be used as correction factors in converting WIM weights to static weights (which would normally result in specifying the static weight on the left-hand-side), it is recognized that observations on WIM weights are subject to measurement error. If the WIM variable were specified on the right-hand-side, the parameter estimate associated with it would be downward-biased (Maddala, 1977). Bias problems are avoided when the WIM variable is specified on the left hand side. In this form, the only consequence of WIM measurement error is a reduction in the estimation efficiency of the regression. Of course, the inverse regression specification presumes that static weights are measured without error. With regard to both the regression model and the measures of accuracy and precision, it is important that this presumption hold true. A separate analysis established the conditions under which static weights are measured without error (see the Appendix).

The logic supporting the specification of the inverse regression model is as follows. The time variable was included to capture any temporal measurement drift in the weights recorded by the WIM scales. The dummy variable for rain was included to determine whether the relationship between WIM and static weights might be influenced by a wet (and thus heavier) static scale deck. A negative parameter estimate with this variable would be consistent with the hypothesis that a wet static scale deck would weigh heavier than a dry one, other things being equal. A 1/8" film of water on a 12' x 30' surface, for example, would weigh about 235 pounds.

The area of the Columbia River Gorge in which the Wyeth Weigh Station is located is characterized by generally windy conditions. However, on one of the dates (December 2), especially strong winds prevailed, and a dummy variable was included to test for any effect this might have had on the weights recovered.

Type 3S2 units represent about 70% of the truck traffic on I-84 in the study area. A dummy variable representing this type was specified to test whether its associated axle and vehicle weight determinant effects could be distinguished from those of the remaining vehicle types.

The speed passing over the WIM scale is the final variable in the regression model. Although all observations were at 10 mph or less, speed variations within this range may still have an effect. If so, this would lead to an anticipated negative parameter estimate, given that dynamic weight increases with speed.

As stated earlier, it was also hypothesized that temperature might be inversely related to the rigidity of the WIM scale plate, suggesting that WIM weights would be greater at higher temperatures. Given the shift to manual data collection, however, it was not possible to investigate this question.

The inverse regression equation was estimated at the axle-axle group level and at the vehicle level. Among the axle level models, separate regressions were estimated for Steering Axles, Tandem Axles, and others. The "Other" category is comprised of axles that fall into neither the "Steering" nor "Tandem" categories. They are thus single axles and could be either drive or trailer units.

The parameter estimates for the various models are reported in Table 3. Given the linear specification of the regression equation, the interpretation of the parameter estimates is straightforward. For the continuously measured variables (such as Static Weight, Time and Speed) the parameter is interpreted as the estimated change in WIM scale weight resulting from a unit change in the associated variable. For the dichotomous variables (i.e., Rain, Wind, Type 3S2), the parameter is interpreted as the estimated change in WIM scale weight associated with the existence of the defined condition.

With one exception, the estimated time parameter is significant at both the axle and vehicle levels. The "All Axles" regression estimates that WIM weights trended upward at a rate of 80 pounds per month. Among the significant time parameters, the rate of increase varied from 30 (Steering Axles) to 350 (Gross Vehicle Weight) pounds per month.

The differences in the estimated trend rates partly reflects differences in the relative weights analyzed in the alternative models. For example, the mean WIM scale weight in the Steering Axle equation is 11,076 pounds, while the corresponding mean for the Gross Vehicle Weight equation is 71,571 pounds. Evaluating the estimated trend effects in percentage terms at the respective means yields an increase of .72% per month for steering axles and .49% per month for vehicles.[1]

TABLE 3
WIM REGRESSION RESULTS
(Dependent Variable = WIM Weight)

	Axle-Level Models				
Variable	**All Axles**	**Steering**	**Tandem**	**Others**	**Gross Veh. Wt.**
Intercept (t-value)	-.70 (-6.72)*	-.44 (-1.59)	-1.36 (-5.92)*	1.05 (2.21)*	-3.70 (-5.19)*
Static Weight	.99 (412.3)*	1.00 (43.56)*	1.00 (191.5)*	.97 (82.29)*	1.00 (171.9)*
Time	.08 (11.67)*	.03 (4.19)*	.15 (12.75)*	-.06 (-1.55)	.35 (9.98)
Rain	-.36 (-7.04)*	-.21 (-3.44)*	-.43 (-5.35)*	-.35 (-2.50)*	-1.04 (-4.58)*
Wind	.11 (1.18)	-.13 (-1.19)	.42 (2.89)*	-.44 (-1.68)	.85 (2.10)*
Type 3S2	-.001 (-.01)	.01 (.08)	-.05 (-.54)	.18 (1.33)	-.08 (-.32)
Speed	.06 (5.52)*	.06 (5.35)*	.06 (4.00)*	.03 (1.41)	.20 (4.32)*
R^2	.99	.88	.99	.99	.99
Std. Error of Est.	.67	.46	.74	.49	1.54
Sum of Sqd. Errors	335.0	53.8	211.0	22.3	479.3
n	751	261	390	100	210

* Significant at the .05 level.

Rain is estimated to have a fairly substantial negative effect in all of the equations, ranging from minus 210 pounds for steering axles to just over minus 1,000 pounds at the vehicle level. As with the time effect, these estimates reflect the relative weight differences between the models. The estimated "rain effect" probably reflects the performance of the static scale, not the WIM scale. What the estimate says, using steering axles as an example, is that the WIM scale weighs steering axles 210 pounds lighter than the static scale when it is raining compared to when it is dry. There doesn't appear to be a plausible reason why the WIM scale should be affected by rain, but there does appear to be a reason (i.e., a large deck surface) why rain might affect the performance of the static scale.

Strong winds were estimated to have a significant positive effect on weighings at the tandem and vehicle levels, either increasing WIM scale or reducing static scale weights by 420 and 850 pounds, respectively.

The dummy variable for Type 3S2 units was not significant in any of the equations, indicating that this simple distinction in axle configuration had no effect on weighings.

Despite the fact that all WIM scale weighings were recovered at speeds of 10 mph or less, speed was nevertheless estimated to have a significant positive WIM scale effect in four of the five equations. Speeds averaged a little over 4 mph, and a 1 mph increase from this level was estimated to produce increases in the WIM scale weights of 60 pounds at the axle (All Axles, Steering, and Tandems) level and 200 pounds at the vehicle level.

The breakdown of the axle-level observations into separate equations for Steering, Tandem, and Other types result in parameter estimates that vary by axle type for most of the specified variables. It is possible to test whether the coefficient sets vary significantly across these equations. The test, based on the F distribution, was first proposed by Chow (1960) and is specified in the present context as follows:

$$F = [(SS_a - SS_s - SS_t - SS_o) / (k+1)] \;/\; [(SS_s+SS_t+SS_o)/ (n_s+n_t+n_o-3k-3)] \qquad (7)$$

where,

- SS_a = The sum of the squared residuals from the "All Axles" regression;
- SS_s = The sum of the squared residuals from the "Steering Axles" regression;
- SS_t = The sum of the squared residuals from the "Tandem Axles" regression;
- SS_o = The sum of the squared residuals from the "Other Axles" regression;
- k = The number of regressors in each of the equations;
- n_s = The number of observations in the "Steering Axles" regression;
- n_t = The number of observations in the "Tandem Axles" regression;
- n_o = The number of observations in the "Other Axles" regression.

The degrees of freedom with this test statistic are $k+1$ and $n_s+n_t+n_o-3k-3$. The information reported in Table 3 yields the following F value:

$$\begin{aligned} F &= [\,(335.0 - 53.8 - 211.0 - 22.3) / 7\,] \;/\; [\,287.1 / (751-18-3)\,] \\ &= (47.9 / 7) / (287.1 / 730) \\ &= 6.84 / .39 \\ &= 17.54 \end{aligned}$$

This F value is significant beyond the .001 level, indicating that the disaggregation of the axle level observations into the three distinct regression models resulted in a significant reduction in residual errors.

7.3 ACCURACY AND PRECISION OF CORRECTED DATA

The generally good performance of the regression models implies that improvements in WIM scale accuracy and precision can be obtained by using the parameters estimated in these models as correction factors. For any of the subgroups identified in Table 3, we can derive a predicted static weight for any given observation as follows:

$$\text{Predicted Static Weight}_i = [\, \text{WIM Weight}_i - (\alpha_0 + \Sigma_j \beta_j X_{ij}) \,] / \beta_s \text{ , where} \qquad (8)$$

WIM Weight_i	=	The recorded WIM scale weight for the "i"th observation;
α_0	=	The estimated intercept term from the regression;
β_j	=	The estimated parameter associated with variable "j";
X_{ij}	=	The "i" th observation of variable "j";
β_s	=	The estimated static weight parameter from the regression.

Predicted static weights were calculated for all of the axle and vehicle level observations in the data base. These weights were then substituted for the WIM scale observations used previously, and the accuracy and precision statistics were calculated again. The resulting reduction in error and improvement in precision are quite apparent visually in Figure 6. The improvement in precision is concentrated in the range extending from -2% to +2%. Among the observed data 392 of 751 axle weighings fell within this range, while after correction, 510 weighings reside within this range.

FIGURE 7
FREQUENCY DISTRIBUTION OF ERROR FOR OBSERVED AND REGRESSION-CORRECTED AXLE WEIGHT DATA

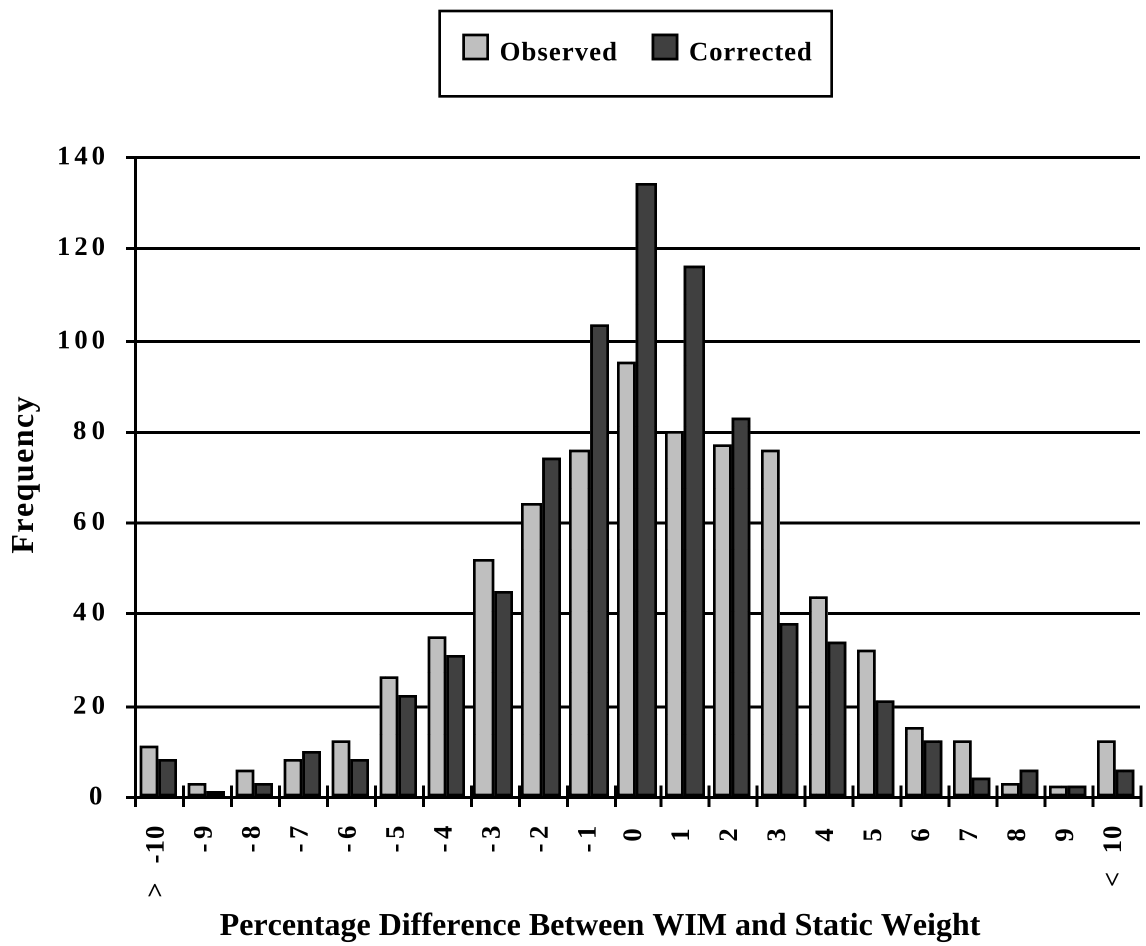


Table 4 reports accuracy and precision results for the regression-corrected data, and the changes from the counterpart statistics contained in Table 2. With respect to accuracy, the corrections result in substantial reductions in systematic error in four of the five categories. Reductions in mean absolute error range from 53% for vehicle weights to over 79% among all axles. Conversely, for tandem axles the systematic error increased by about 20%.

TABLE 4

ERROR COMPONENTS OF REGRESSION-CORRECTED WIM DATA

Category	Mean Error	Change*	SD	Bias?	ASTM IV Standard*	Precision at 95% Conf.	Change*
All Axles	-.046%	-79.2%	3.48%	No	--	±6.82%	-12.8%
Steering Axles	.045	-71.0	4.12	No	±2.5	±8.08	-8.4
Tandem Axles	-.255	20.3	2.66	No	±3.5	±5.21	-19.5
Other Axles	.533	-57.4	4.33	No	±2.5	±8.49	-9.8
Gross Veh. Wt.	.046	-53.1	2.23	No	±3.1	±4.37	-22.0

* The columns titled "Change" report the percentage differences between the systematic and random error values reported in this table and their counterparts reported in Table 2. The ASTM IV precision standards are calculated at the maximum allowable weights in each category.

The general reductions in systematic error were also accompanied by declines in their associated standard deviations. A t test was again performed and in no instance was the null hypothesis of systematic error equaling zero rejected. Thus the corrections eliminated the bias that was found earlier in the "Other Axle" category.

The reductions in the standard deviations of the errors are more modest than the declines in the mean errors. Nevertheless, the improvements in precision across the categories in Table 4 are noteworthy. For steering axles, 95% of the observations are estimated to fall within an error range of ±8.08%, a reduction of 8.4% from the ±8.82% range obtained with the uncorrected data. The improvement in precision is greatest at the vehicle level, where the 95% error range of ±4.37% is 22% narrower than the range obtained with the uncorrected data.

The precision results at the vehicle level approach the ASTM standard of ±4.2% for Type IV WIM Systems, exceeding the standard by only 4%. The precision levels obtained for tandems is also quite good, exceeding the ASTM standard of ±4.8% by only 8.5%. The ranges for Steering and Other axles, however, are about twice that of the ASTM standard.

It should be noted that the approach used here in applying correction factors to the weight data differs in several important ways from what might be developed to provide corrections in real time. First, a year-long trend correction is used here, and it is expected that if WIM systems were actually dedicated to weight enforcement they would need to be regularly re-calibrated. Second, the rain correction used here addresses what is thought to be a measurement problem with the static scale, not the WIM scale. Since neither of the parameters used in making these corrections were estimated with zero variance, it can be concluded that the corrected accuracy and precision results in Table 4 are conservative. That is, it is likely that the true accuracy and precision of the WIM scales are somewhat better than what is reported here.

8.0 CONCLUSIONS

This report presents accuracy and precision findings from a year-long field test of a slow-speed weigh-in-motion system (SWIM). Analysis of nominal weight data indicates that the SWIM system was, on average, accurate to within two-tenths of one percent at the axle level and one-tenth of one percent at the vehicle level. With respect to precision, it was found that 95 percent of all SWIM-recorded weights were within 7.8 percent of the corresponding static scale weights at the axle level, and within 5.6 percent at the vehicle level.

Regression analysis was employed to estimate the effects of time, weather and vehicle speed on SWIM accuracy and precision. Considerable improvements in accuracy and precision were achieved by correcting for these effects. Following correction, accuracy improved to one-half of one percent at both the axle and vehicle levels. Also following correction, 95 percent of the observations were within 6.8 percent of the static scale weight at the axle level. At the vehicle level, precision improved to a range of 4.4 percent. The precision of the corrected data for vehicles and tandem axles approaches the levels stated by the ASTM in its standard specification for Type IV (enforcement applications) WIM systems.

The standards adopted by NIST in *Handbook 44* for scales and weighers do not distinguish between accuracy and precision, except to state that all observations on weight should fall within the stated tolerance. By this definition, the WIM system weights analyzed here clearly fail to achieve the acceptance tolerance of one percent and maintenance tolerance of two percent error that NIST requires of portable weighers. However, even static scales that were certified as capable of achieving even stricter NIST accuracy tolerances using standard test weights were found in the present study to be subject to error as a result of procedural effects. As Lee (1988: 16) noted, "(a)ccurate equipment can be used in a way that produces erroneous results."

With respect to enforcement, precision is important because the measured weight serving as the basis of a citation must be capable of withstanding legal challenges. Knowledge of the precision of a WIM scale can be used to calculate "deductions" from measured WIM scale weights to minimize the likelihood of an inappropriate citation. Both Scheuter (1997) and Izadmehr and Lee (1987a) offer examples of this approach. For example, given the standard deviation reported in Table 4 for vehicle weight error and information from the standard normal distribution, we can calculate a deduction factor of 7.05% and conclude that in only one case in a thousand will a WIM scale weight, minus this deduction, exceed the "true" underlying weight. Should the level of confidence be relaxed to one in five hundred, the deduction would shrink to 5.84%, and for the case of one in one hundred, the deduction would be 5.26%.

There is a cost to ensuring against the possibility of erroneously citing a vehicle that is operating within the legal weight limit. If large deduction factors are needed for enforcement applications of WIM systems, then only large violations of weight limits will be identified and penalized. Consequently, there is an economic dimension to WIM scale precision. The larger number of weighings that are feasible with WIM systems increase the chances that weight violators will be identified, but at the same time the deductions guarantee that some violators will go uncited, while others who are cited are in reality operating at heavier true weights than what is recorded.

8.1 SUGGESTIONS FOR FURTHER RESEARCH

WIM scales already make an important contribution to improving the cost effectiveness of weight enforcement by screening potential violators from the traffic stream. As the relatively wide ASTM III precision standards indicate, however, many of the diverted vehicles will tend to be found to be operating below the maximum allowable weight. Thus, improvements in the precision of weight estimates in screening applications of WIM technology will result in cost savings. Given that the regression analysis in this project found speed variations to have a significant effect on WIM scale weights, even at speeds less than 10 mph, it is likely that similar analysis at screening speeds (10-50 mph) would yield speed correction factors and proportionately greater improvements in precision. This could be investigated at fairly low cost, given that the data needed to assess the potential for precision improvements in this context have already been collected by ODOT.

Beyond this, further improvement depends on eliminating the redundancy involved in requiring static scale weighings to cite weight violators. Presently, the most common WIM technology, including the system tested in this project, cannot achieve the precision that is required of static scales. WIM enforcement application will thus await technological improvements or changes in the NIST's interpretation of the conditions by which accuracy is determined.

9.0 FOOTNOTES

1. The presumption in the interpretation of the time variable in the regression is that measurement drift is confined to the WIM scale. The possibility that measurement drift also occurred in the static weight measures was also explored for the sub-sample of steering axles by regressing the static weight on time. The results of that regression are as follows (with t scores in parentheses):

$$\text{Static Weight} = \underset{(74.5)}{11.011} + \underset{(.44)}{.0073} * \text{Time}$$

$$n = 261 \quad \text{SEE} = 1.18 \quad R^2 = .0007$$

As the regression indicates, there is no significant time trend in the static weight of steering axles, which reinforces a conclusion that measurement drift was confined to the WIM scale.

10.0 REFERENCES

American Society for Testing and Materials. 1994. "Standard Specification for Highway Weigh-in-Motion (WIM) Systems with User Requirements and Test Method," *ASTM E 1318-94.*.

Castle Rock Consultants. 1989. *Port of Entry Weigh-in-Motion Feasibility Study*, Report No. FHWA-AZ89-702, Arizona Department of Transportation, Phoenix, Arizona.

Chow, G.C. 1960. "Tests of Equality Between Sets of Coefficients in Two Linear Regressions," *Econometrica*, 28, 591-605.

Curnow, A. 1998. "States of Weight: Developments in Weigh-in-Motion Applications," *Traffic Technology International*, United Kingdom: UK & International Press, 108-114.

Davies, P. and F. Sommerville. 1987. Calibration and Accuracy Testing of Weigh-in-Motion Systems," *Transportation Research Record 1123*, 122-126.

Faghri, A., R.R. Buddharaju and R. Nanda. 1995. "Statistical Accuracy Analysis for the I-95 Multi-State Traffic Monitoring Evaluation Project," paper presented at the 74th Annual Meeting of the Transportation Research Board, Washington, D.C.

Gillmann, R. 1992. "Calibration and Adjustment of Weigh-in-Motion Data," *Transportation Research Record 1364*, 186-192.

Hajek, J.J., G. Kennepohl and J.R. Billing. 1992. "Applications of Weigh-in-Motion Data in Transportation Planning," *Transportation Research Record 1364*, 169-178.

Izadmehr, I. and C.E. Lee. 1987a. "On-Site Calibration of Weigh-in-Motion Systems," *Transportation Research Record 1123*, 136-144.

Izadmehr, I. and C.E. Lee. 1987b. "Accuracy and Tolerances of Weigh-in-Motion Systems," *Transportation Research Record 1123*, 127-135.

Jacob, B., C. Maeder, L.A. George and M. Gaillac. 1993. "Results of Weigh-in-Motion Project in France: 1989-1992," *Transportation Research Record 1410,* 115-122.

Krukar, M. and K. Evert. 1990. "Integrated Tactical Enforcement Network (Automated Enforcement Facilities in Oregon)," *Proceedings*, National Traffic Data Acquisition Technologies Conference, Austin, Texas.

Krukar, M., K. Evert and H. Laylor. 1996. "Double Threshold Weigh-in-Motion Scales: Preliminary Accuracy Test Results From the PASS Project," paper presented at the National Traffic Data Acquisition Conference, Albuquerque, New Mexico, May 5-9.

Lee, C.E. 1988. "Factors That Affect the Accuracy of WIM Systems," *Proceedings*, Third National Conference on Weigh-in-Motion, St. Paul, Minnesota.

Lee, C.E. and R.B. Machemehl. 1985. "Weighing Trucks on Axle-Load and Weigh-in-Motion Scales," *Transportation Research Record 1048,* 74-82.

Maddala, G.S. 1977. *Econometrics*, London: McGraw-Hill International.

Moore, R.C., B.G. Stoneman and J. Prudhoe. 1989. "Dynamic Axle and Vehicle Weight Measurements: Weigh-in-Motion Equipment Trials," *Traffic Engineering and Control*, 30:1, 10-18.

National Institute of Standards and Technology. 1998. *Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices, Handbook 44*, Washington, D.C: US Government Printing Office.

Papagiannakis, A.T. 1995. Paper presented at the 14th International Weights and Dimensions Conference, Ann Arbor, Michigan.

Papagiannakis, A.T., K. Senn and A.T. Bergan. 1995. "WIM System Evaluation/ Calibration: Progress of NCHRP Study 3-39(2)," paper presented at the 75th Annual Meeting of the Transportation Research Board, Washington, D.C.

Scheuter, F. 1997. "Sources of Error in Dynamic Weight Measurement," Traffic *Technology International*, United Kingdom: UK & International Press, 289-291.

Sebaaly, P.E. and N. Tabatabaee. 1993. "Influence of Vehicle Speed on Dynamic Loads and Pavement Response," *Transportation Research Record 1410*, 107-114.

Strathman, J.G. and R. Fountain. 1996. "The Oregon DOT Slow-Speed Weigh-in-Motion Project: Calibration Stage Accuracy and Precision Analysis," Center for Urban Studies, Portland State University.

Swope, T. and J. G. Strathman. 1998. "Oregon DOT Slow-Speed Weigh-in-Motion Project: Preliminary Report on Initial Weight Data." Center for Urban Studies, Portland State University.

van Niekerk, P.E. and A.T. Visser. 1993. "Vehicle Configuration Influences on Weigh-in-Motion Response," *Transportation Research Record 1410,* 100-106.

11.0 APPENDIX A

EVALUATION OF STATIC SCALE MEASUREMENT ERROR

The methodology for determining the accuracy and precision of the Wyeth WIM system assumes that static scale weights (the benchmark comparators for the WIM weights) are measured without error. This assumption was evaluated in two ways. The first involved replicated weighings of the ODOT scale calibration truck (a 3 axle truck), while the second assessed the procedure used to weigh individual axles comprising tandem axle groups.

The replicated weighings of the ODOT truck were completed in June 1996. A total of 160 vehicle weighings were obtained, with the truck loaded to three different weights: 52,800 lbs (n=60), 46,900 lbs (n=47), and 40,800 lbs (n=53). Three axle weighings were obtained with each replication, thus producing 180, 141, and 159 axle-level observations at the respective weight levels. In each of the three instances the variance of the recorded axle weights was zero, indicating the absence of measurement error.

In the second case the procedure used to measure individual axle weights within tandem axle groups was evaluated. Although standards for axle groups are defined by ASTM, the WIM scale's capability of recovering individual axle weights led to the initial decision to "split" tandem axle groups on the static scale and recover corresponding single axle weights.

There are two procedures that can be used to split tandem axles, and both were evaluated. In the first procedure the truck first stops with the lead axle on the front of the scale and then pulls ahead and stops with the trailing axle on the back of the scale. The accuracy of these axle weights can then be calculated as follows:

$$\text{Accuracy}_1 = (((W_l + W_t) - W_c) / W_c) * 100\text{, where} \qquad \text{(A1)}$$

W_l = the weight of the leading axle;
Wt = the weight of the trailing axle;
W_c = the weight of the tandem axle group.

The second procedure determines the weight of one axle as the difference between the weight of the tandem and the weight of the other axle. With respect to the case in which the weight of the lead axle is determined in this fashion, accuracy can be calculated as follows:

$$\text{Accuracy}_{2l} = ((W_{lr} - W_l) / W_l) * 100\text{, where} \qquad \text{(A2)}$$

W_{lr} = the derived weight of the lead axle (Wc - Wt);
W_l = the weight of the lead axle as measure in the first procedure.

The second procedure provides the only means for splitting tandem axle weights for some types of vehicles (e.g., some 3 axle trucks and the drive axles of 3S2 units). Strictly speaking, however, the formula above will not determine accuracy if the reference weight, W_l, is measured with error. Thus, the validity of the second accuracy measure depends on a "no-error" finding of the first measure.

Weights were recovered at the Wyeth Weigh Station using the two procedures in July 1997 from a sample of 39 Type 3S-2 vehicles drawn from the traffic stream. The accuracy results are presented in the table below. The first procedure produced a substantial amount of random measurement error. The estimated precision at the 95% confidence level, $\pm$1.72%, indicates that the measurement error associated with this tandem-splitting procedure by itself would account for over 85% of the target precision standard of $\pm$2.0% for portable wheel load weighers. The precision of the second procedure is about half that of the first, reflecting the error embedded in the reference weight. These results indicate that tandems should be measured as axle groups.

TABLE A1

ERROR DISTRIBUTION FROM SPLITTING TANDEM AXLES

Measure	**Mean Error**	**SD**	**Precision at 95% Confidence**
Accuracy_1	.228%	.852%	$\pm$1.72%
Accuracy_{2l}	.486	1.72	$\pm$3.47

12.0 APPENDIX B

VEHICLE WEIGHT DATA

This appendix contains the vehicle data used in the SWIM study. The definition of the variables follows below.

Column	Label	Description
1	VID	Vehicle identification number
2	MO	Month in which the data was recovered, with June 1997=1 to June 1998=13
3	GWIM	Gross vehicle weight recorded by the WIM scale
4	GSTAT	Gross vehicle weight recorded by the static scale
5	RAIN	A dummy variable equaling one if it was raining when weight was recorded, and zero otherwise
6	WIND	A dummy variable equaling one if weight was recovered in high wind period, and zero otherwise
7	3S2	A dummy variable equaling one if vehicle was type 3, and zero otherwise
8	TYPE	Vehicle type, where 1 = Truck 2 = Log truck 3 = Tractor-trailer semi 4 = Truck with trailer 5 = Double trailer 6 = Triple trailer 7 = Dromedary 8 = Other
9	VAXL	The number of axles on the vehicle
10	VSPD	Vehicle speed (mph)
11	STR	A dummy variable equaling one for steering axles and zero otherwise
12	DRV	A dummy variable equalling one for drive axles and zero otherwise

VID	MO	GWIM	GSTAT	RAIN	WIND	3S2	TYPE	VAXL	VSPD	STR	DRV
158	10	129.6	137.5	1	0	0	8	8	2	1	0
205	11	78.5	78.5	0	0	0	7	5	3	1	0
234	13	81	78.7	0	0	0	7	5	2	1	0
153	10	69.6	69.2	1	0	0	6	6	8	1	0
174	11	87.2	86	1	0	0	6	8	3	1	0
200	11	75.5	72.7	0	0	0	6	7	3	1	0
217	11	80.9	80.5	0	0	0	6	7	4	1	0
84	6	102	102.9	1	0	0	5	8	8	1	0
87	6	103.8	101.5	1	0	0	5	7	4	1	0
91	6	99.1	98.3	1	0	0	5	8	7	1	0
94	6	96.8	97.6	1	0	0	5	7	2	1	0
101	7	51.2	49.9	0	1	0	5	8	7	1	0
125	8	100.6	101.6	1	0	0	5	7	2	1	0
128	8	100.8	101.5	1	0	0	5	8	4	1	0
156	10	79.4	78.7	1	0	0	5	6	6	1	0
160	10	105.3	107.8	1	0	0	5	7	4	1	0
163	10	76.3	78.2	1	0	0	5	7	2	1	0
172	10	99.9	100.1	1	0	0	5	8	4	1	0
173	10	96.9	96.9	1	0	0	5	9	2	1	0
183	11	69.8	68.4	1	0	0	5	8	4	1	0
195	11	70.4	71.2	0	0	0	5	6	3	1	0
197	11	107	103.5	0	0	0	5	7	6	1	0
209	11	54.2	51.7	0	0	0	5	8	4	1	0
211	11	99.7	96.6	0	0	0	5	8	3	1	0
212	11	83	83.6	0	0	0	5	5	3	1	0
213	11	59.9	59.5	0	0	0	5	5	4	1	0
215	11	103	102.3	0	0	0	5	7	4	1	0
242	13	90.2	88.2	0	0	0	5	7	4	1	0
251	13	106	105.3	0	0	0	5	8	2	1	0
265	13	84.1	81.3	0	0	0	5	7	3	1	0
269	13	105	104.5	0	0	0	5	7	3	1	0
271	13	89.6	88	0	0	0	5	8	6	1	0
98	7	60.5	62.7	0	1	0	4	5	0	1	0
110	7	84.9	86.6	0	1	0	4	6	1	1	0
140	10	98.3	99.5	1	0	0	4	8	5	1	0
169	10	104.7	103	1	0	0	4	8	4	1	0
189	11	57.8	58.1	0	0	0	4	5	4	1	0
199	11	107.9	104.5	0	0	0	4	8	7	1	0
224	11	40.7	39.3	0	0	0	4	5	3	1	0
267	13	78.9	79.2	0	0	0	4	6	6	1	0
97	7	87.1	87.1	0	1	1	3	7	2	1	0
55	2	70.2	72.3	0	0	1	3	5	6	1	0
56	2	76.6	79	0	0	1	3	5	2	1	0
57	2	75.4	78.1	0	0	1	3	5	9	1	0
58	2	76.6	78.6	0	0	1	3	5	3	1	0
59	2	76.6	78.4	0	0	1	3	5	3	1	0
60	2	61.7	63.7	0	0	1	3	5	7	1	0

61	2	74.3	76.1	0	0	1	3	5	3	1	0
62	2	76	78.9	0	0	1	3	5	8	1	0
63	2	78.6	79.5	0	0	1	3	5	6	1	0
64	2	65.6	67.7	0	0	1	3	5	3	1	0
65	2	55.5	56.7	0	0	1	3	5	8	1	0
66	2	75.5	77.7	0	0	1	3	5	3	1	0
67	2	65.2	67	0	0	1	3	5	4	1	0
68	2	69.7	71.8	0	0	1	3	5	8	1	0
69	2	75.1	77.2	0	0	1	3	5	7	1	0
70	2	75.8	78	0	0	1	3	5	6	1	0
71	2	77.3	79.3	0	0	1	3	5	7	1	0
72	2	68.9	70.6	0	0	1	3	5	3	1	0
73	2	60.2	61.5	0	0	1	3	5	4	1	0
74	2	83	85.7	0	0	1	3	5	3	1	0
75	6	76.2	78.3	1	0	1	3	5	3	1	0
76	6	76.5	77.9	1	0	1	3	5	8	1	0
77	6	49.5	54.8	1	0	1	3	5	2	1	0
78	6	49.5	54.8	1	0	1	3	5	3	1	0
79	6	37.7	38.3	1	0	1	3	5	3	1	0
80	6	75.5	78	1	0	1	3	5	3	1	0
81	6	91.6	92.4	1	0	1	3	7	9	1	0
82	6	72.6	78.7	1	0	1	3	5	2	1	0
83	6	75.5	75.1	1	0	1	3	5	7	1	0
85	6	94.5	95.2	1	0	1	3	7	6	1	0
86	6	78.3	77.1	1	0	1	3	5	9	1	0
88	6	67	68.4	1	0	1	3	5	9	1	0
89	6	68.6	71.2	1	0	1	3	5	6	1	0
90	6	73.2	73.3	1	0	1	3	5	8	1	0
93	6	78.2	79.8	1	0	1	3	5	5	1	0
95	6	65.9	66.7	1	0	1	3	5	2	1	0
96	7	34.2	33.7	0	1	1	3	5	1	1	0
99	7	71.3	71.2	0	1	1	3	5	3	1	0
100	7	39.9	38.8	0	1	1	3	5	8	1	0
102	7	79	79.7	0	1	1	3	5	1	1	0
103	7	34.3	33	0	1	1	3	5	3	1	0
104	7	76.9	76.5	0	1	1	3	5	6	1	0
105	7	75.6	75.2	0	1	1	3	5	3	1	0
107	7	74.2	72.5	0	1	1	3	5	9	1	0
108	7	94.8	93.7	0	1	1	3	7	1	1	0
109	7	43.5	44	0	1	1	3	3	2	1	0
111	7	34.7	34.8	0	1	1	3	5	3	1	0
112	7	44.6	43.9	0	1	1	3	5	4	1	0
113	7	76.6	76.2	0	1	1	3	5	5	1	0
114	7	58.3	58.4	0	1	1	3	5	1	1	0
115	7	44.7	45.1	0	1	1	3	5	1	1	0
116	7	47.7	46.8	0	1	1	3	5	3	1	0
117	8	61	60.9	1	0	1	3	5	2	1	0
118	8	61.6	61.1	1	0	1	3	5	6	1	0
119	8	78	77.9	1	0	1	3	5	9	1	0

120	8	78.1	78.3	1	0	1	3	5	3	1	0
121	8	72.9	71.6	1	0	1	3	5	1	1	0
122	8	48	47.8	1	0	1	3	5	4	1	0
123	8	78	79.1	1	0	1	3	5	1	1	0
124	8	69.4	69.9	1	0	1	3	5	4	1	0
126	8	72.3	75.8	1	0	1	3	5	1	1	0
127	8	74.4	80.4	1	0	1	3	5	2	1	0
129	8	48.8	50.6	1	0	1	3	7	2	1	0
130	8	60.5	64.1	1	0	1	3	5	3	1	0
131	8	63.5	62.4	1	0	1	3	5	10	1	0
133	8	67.6	66.5	1	0	1	3	5	1	1	0
134	10	75.5	76.4	1	0	1	3	5	5	1	0
135	10	77.7	78.8	1	0	1	3	5	3	1	0
136	10	72.1	72.5	1	0	1	3	5	4	1	0
137	10	85.8	88.3	1	0	1	3	6	1	1	0
138	10	80.9	80.6	1	0	1	3	5	7	1	0
139	10	59.2	60.1	1	0	1	3	5	8	1	0
141	10	77.5	78.9	1	0	1	3	5	3	1	0
142	10	77.5	77	1	0	1	3	5	8	1	0
143	10	84.1	83.8	1	0	1	3	5	8	1	0
144	10	77.1	75.8	1	0	1	3	5	6	1	0
146	10	74.7	76.1	1	0	1	3	5	4	1	0
147	10	74.7	75.6	1	0	1	3	5	4	1	0
148	10	63.4	64.5	1	0	1	3	5	8	1	0
149	10	78.3	77.7	1	0	1	3	5	4	1	0
150	10	78.1	79.4	1	0	1	3	5	3	1	0
152	10	56.6	57.3	1	0	1	3	5	4	1	0
154	10	82.9	81.2	1	0	1	3	7	8	1	0
155	10	40.7	39.3	1	0	1	3	5	7	1	0
157	10	33.9	34.7	1	0	1	3	5	1	1	0
159	10	61.8	65.7	1	0	1	3	5	1	1	0
161	10	95.2	95.5	1	0	1	3	7	4	1	0
164	10	67	66.5	1	0	1	3	5	7	1	0
165	10	56.8	60.5	1	0	1	3	5	1	1	0
167	10	78	77.9	1	0	1	3	5	6	1	0
168	10	77.3	77.2	1	0	1	3	5	2	1	0
170	10	79.9	81.2	1	0	1	3	5	1	1	0
171	10	37.6	40.7	1	0	1	3	4	3	1	0
175	11	69.4	68.7	1	0	1	3	5	3	1	0
176	11	42.7	43	1	0	1	3	5	2	1	0
177	11	92.5	92	1	0	1	3	7	1	1	0
178	11	84.9	83.9	1	0	1	3	6	8	1	0
179	11	49.1	48.5	1	0	1	3	5	6	1	0
180	11	86.5	87.7	1	0	1	3	6	4	1	0
181	11	23.7	23.6	1	0	1	3	3	4	1	0
182	11	62.7	61.2	1	0	1	3	5	3	1	0
184	11	44	43.2	1	0	1	3	5	4	1	0
185	11	79.4	80.6	1	0	1	3	5	5	1	0
186	11	76.9	77.5	1	0	1	3	5	4	1	0

187	11	59.1	57.8	0	0	1	3	5	9	1	0
188	11	34.2	33.8	0	0	1	3	5	1	1	0
190	11	93.7	91.3	0	0	1	3	7	3	1	0
191	11	78.7	77.9	0	0	1	3	5	8	1	0
192	11	78.6	79.4	0	0	1	3	5	1	1	0
193	11	68.8	76	0	0	1	3	5	2	1	0
198	11	36.5	33.7	0	0	1	3	5	0	1	0
202	11	75.9	75.8	0	0	1	3	5	7	1	0
203	11	55	55.1	0	0	1	3	5	5	1	0
204	11	77.5	77.7	0	0	1	3	5	9	1	0
206	11	81.3	79.7	0	0	1	3	6	6	1	0
207	11	43.6	42.8	0	0	1	3	5	8	1	0
208	11	80.5	79.2	0	0	1	3	5	3	1	0
210	11	40.8	40.7	0	0	1	3	5	8	1	0
214	11	58.2	56.6	0	0	1	3	5	4	1	0
216	11	79.1	78.3	0	0	1	3	5	9	1	0
218	11	64.6	63.8	0	0	1	3	5	3	1	0
219	11	77.2	77.1	0	0	1	3	5	3	1	0
221	11	76.7	75.7	0	0	1	3	5	4	1	0
222	11	73.5	73.6	0	0	1	3	5	2	1	0
223	11	79.8	77.6	0	0	1	3	5	7	1	0
225	13	56	54.3	0	0	1	3	5	2	1	0
226	13	62.9	60.4	0	0	1	3	5	3	1	0
227	13	60.8	59.2	0	0	1	3	5	3	1	0
228	13	80.6	79.2	0	0	1	3	5	5	1	0
229	13	77.4	74.3	0	0	1	3	5	2	1	0
230	13	78.1	76.4	0	0	1	3	5	4	1	0
231	13	81.4	78.9	0	0	1	3	6	7	1	0
232	13	95.5	91.2	0	0	1	3	7	3	1	0
233	13	65	63.2	0	0	1	3	5	4	1	0
235	13	73.6	71.9	0	0	1	3	6	1	1	0
236	13	64.2	61.6	0	0	1	3	5	2	1	0
237	13	62.4	62.5	0	0	1	3	5	3	1	0
238	13	76.9	75	0	0	1	3	5	6	1	0
239	13	37.8	36.1	0	0	1	3	3	10	1	0
240	13	62.6	60.8	0	0	1	3	5	3	1	0
241	13	80	78.5	0	0	1	3	5	3	1	0
243	13	82.3	80.5	0	0	1	3	5	4	1	0
244	13	82.8	80.2	0	0	1	3	6	3	1	0
245	13	67	64.6	0	0	1	3	5	2	1	0
246	13	52	49.4	0	0	1	3	5	3	1	0
247	13	81.2	79.1	0	0	1	3	5	8	1	0
248	13	106	100.9	0	0	1	3	8	8	1	0
249	13	88.2	84.9	0	0	1	3	8	5	1	0
250	13	99.1	99.2	0	0	1	3	8	8	1	0
252	13	78.7	76.6	0	0	1	3	5	6	1	0
253	13	78	75.4	0	0	1	3	5	6	1	0
254	13	64.8	62.3	0	0	1	3	5	8	1	0
255	13	78.6	76.4	0	0	1	3	5	2	1	0

256	13	77.9	76.5	0	0	1	3	5	4	1	0
257	13	70.5	68.9	0	0	1	3	5	3	1	0
258	13	66	64.4	0	0	1	3	5	3	1	0
260	13	78.8	77.5	0	0	1	3	5	4	1	0
261	13	53.6	57.9	0	0	1	3	5	3	1	0
262	13	77	76	0	0	1	3	5	1	1	0
263	13	82.7	79.3	0	0	1	3	7	6	1	0
264	13	103.4	100.6	0	0	1	3	8	1	1	0
266	13	57.8	57	0	0	1	3	5	7	1	0
268	13	58.6	56.8	0	0	1	3	5	2	1	0
272	13	99.1	94.4	0	0	1	3	7	5	1	0
92	6	22.1	22.5	1	0	0	1	2	7	1	0
151	10	24.7	25	1	0	0	1	2	10	1	0
166	10	21.1	21	1	0	0	1	2	7	1	0
194	11	17.9	17.3	0	0	0	1	2	4	1	0
220	11	25.9	26	0	0	0	1	2	6	1	0

13.0 APPENDIX C

AXLE WEIGHT DATA

This appendix contains the axle data used in the SWIM study. The definition of the variables follows below.

Column	Label	Description
1	VID	Vehicle identification number
2	MO	Month in which the data was recovered, with June 1997=1 to June 1998=13
3	RAIN	A dummy variable equalling one if it was raining when weight was recorded, and zero otherwise
4	WIND	A dummy variable equalling one if weight was recovered in high wind period, and zero otherwise
5	3S2	A dummy variable equalling one if vehicle was type 3, and zero otherwise
6	TYPE	Vehicle type, where 1 = Truck 2 = Log truck 3 = Tractor-trailor semi 4 = Truck with trailor 5 = Double trailor 6 = Triple trailor 7 = Dromedary 8 = Other
7	VAXL	The number of axles on the vehicle
8	VSPD	Vehicle speed (mph)
9	TAND	A dummy variable equalling one for tandem axle groups and zero otherwise
10	WIM	Gross vehicle weight recorded by the WIM scale
11	STAT	Gross vehicle weight recorded by the static scale
12	STR	A dummy variable equalling one for steering axles and zero otherwise
13	DRV	A dummy variable equalling one for drive axles and zero otherwise

ID	MO	RAIN	WIND	3S2	TYPE	VAXL	VSPD	TAND	WIM	STAT	STR	DRV
97	7	0	1	1	3	7	2	1	17.5	17.5	0	0
158	10	1	0	0	8	8	2	1	36.9	39.1	0	0
158	10	1	0	0	8	8	2	1	31.3	33.1	0	1
158	10	1	0	0	8	8	2	1	38.3	40.1	0	0
205	11	0	0	0	7	5	3	1	33.4	33.3	0	0
205	11	0	0	0	7	5	3	1	33.9	33.7	0	1
234	13	0	0	0	7	5	2	1	33.9	33	0	1
234	13	0	0	0	7	5	2	1	33.7	32.5	0	0
174	11	1	0	0	6	8	3	1	19.1	18.8	0	1
84	6	1	0	0	5	8	8	1	27.4	28.9	0	0
160	10	1	0	0	5	7	4	1	25.3	26	0	0
91	6	1	0	0	5	8	7	1	22.1	22.7	0	0
163	10	1	0	0	5	7	2	1	22	22.5	0	0
101	7	0	1	0	5	8	7	1	9.5	9.7	0	0
94	6	1	0	0	5	7	2	1	30	30.6	0	0
125	8	1	0	0	5	7	2	1	31.8	32.4	0	0
94	6	1	0	0	5	7	2	1	30.3	30.8	0	1
128	8	1	0	0	5	8	4	1	23	23.3	0	0
125	8	1	0	0	5	7	2	1	32.7	33.1	0	1
84	6	1	0	0	5	8	8	1	32.9	33.3	0	1
160	10	1	0	0	5	7	4	1	33.5	33.9	0	1
156	10	1	0	0	5	6	6	1	20.7	20.9	0	1
128	8	1	0	0	5	8	4	1	22	22.2	0	0
215	11	0	0	0	5	7	4	1	32.6	32.8	0	0
251	13	0	0	0	5	8	2	1	19.3	19.4	0	0
128	8	1	0	0	5	8	4	1	29.2	29.3	0	1
163	10	1	0	0	5	7	2	1	23.1	23.1	0	1
173	10	1	0	0	5	9	2	1	17.8	17.8	0	0
195	11	0	0	0	5	6	3	1	22	22	0	1
271	13	0	0	0	5	8	6	1	29.9	29.8	0	1
172	10	1	0	0	5	8	4	1	28	27.9	0	0
91	6	1	0	0	5	8	7	1	23.4	23.3	0	1
172	10	1	0	0	5	8	4	1	17.3	17.2	0	0
269	13	0	0	0	5	7	3	1	33.4	33.2	0	1
172	10	1	0	0	5	8	4	1	31.9	31.7	0	1
251	13	0	0	0	5	8	2	1	31	30.8	0	1
173	10	1	0	0	5	9	2	1	29.7	29.5	0	1
87	6	1	0	0	5	7	4	1	29.3	29.1	0	0
215	11	0	0	0	5	7	4	1	32.9	32.6	0	1
197	11	0	0	0	5	7	6	1	32.9	32.5	0	1
101	7	0	1	0	5	8	7	1	13	12.8	0	1
183	11	1	0	0	5	8	4	1	25.3	24.9	0	0
271	13	0	0	0	5	8	6	1	18.5	18.2	0	0
271	13	0	0	0	5	8	6	1	12.2	12	0	0
87	6	1	0	0	5	7	4	1	31.8	31.1	0	1
251	13	0	0	0	5	8	2	1	30.8	30.1	0	0

269	13	0	0	0	5	7	3	1	25.9	25.3	0	0
265	13	0	0	0	5	7	3	1	34.3	33.4	0	1
183	11	1	0	0	5	8	4	1	26.3	25.6	0	1
173	10	1	0	0	5	9	2	1	26.2	25.5	0	0
211	11	0	0	0	5	8	3	1	22.3	21.7	0	0
242	13	0	0	0	5	7	4	1	28.9	28.1	0	1
183	11	1	0	0	5	8	4	1	7	6.8	0	0
84	6	1	0	0	5	8	8	1	30.3	29.2	0	0
211	11	0	0	0	5	8	3	1	24.7	23.8	0	1
101	7	0	1	0	5	8	7	1	10.8	10.4	0	0
197	11	0	0	0	5	7	6	1	32	30.8	0	0
211	11	0	0	0	5	8	3	1	24	23.1	0	0
265	13	0	0	0	5	7	3	1	28.2	27.1	0	0
242	13	0	0	0	5	7	4	1	18.2	17.3	0	0
209	11	0	0	0	5	8	4	1	9.1	8.6	0	0
209	11	0	0	0	5	8	4	1	9	8.5	0	0
91	6	1	0	0	5	8	7	1	23.3	22	0	0
209	11	0	0	0	5	8	4	1	15.2	13.8	0	1
140	10	1	0	0	4	8	5	1	18.9	19.9	0	0
98	7	0	1	0	4	5	0	1	21	22.1	0	1
140	10	1	0	0	4	8	5	1	27.3	27.9	0	0
110	7	0	1	0	4	6	1	1	35.8	36.4	0	1
98	7	0	1	0	4	5	0	1	28.6	28.9	0	0
267	13	0	0	0	4	6	6	1	23.2	23.4	0	1
140	10	1	0	0	4	8	5	1	30.2	30.2	0	1
169	10	1	0	0	4	8	4	1	39.6	39.6	0	1
267	13	0	0	0	4	6	6	1	24.7	24.5	0	0
199	11	0	0	0	4	8	7	1	51.6	50.7	0	0
189	11	0	0	0	4	5	4	1	30.1	29.5	0	1
169	10	1	0	0	4	8	4	1	50.7	49.6	0	0
224	11	0	0	0	4	5	3	1	19	18.5	0	1
199	11	0	0	0	4	8	7	1	41.3	40	0	1
193	11	0	0	1	3	5	2	1	30.1	35	0	1
77	6	1	0	1	3	5	2	1	20.1	22.6	0	0
78	6	1	0	1	3	5	3	1	20.1	22.6	0	0
89	6	1	0	1	3	5	6	1	27.3	30.4	0	0
261	13	0	0	1	3	5	3	1	20.4	22.6	0	1
127	8	1	0	1	3	5	2	1	31.3	34.1	0	1
171	10	1	0	1	3	4	3	1	16.9	18.3	0	1
82	6	1	0	1	3	5	2	1	29.5	31.9	0	0
82	6	1	0	1	3	5	2	1	31.5	34	0	1
127	8	1	0	1	3	5	2	1	32	34.3	0	0
261	13	0	0	1	3	5	3	1	22.8	24.3	0	0
165	10	1	0	1	3	5	1	1	22.2	23.6	0	0
159	10	1	0	1	3	5	1	1	24.3	25.8	0	0
159	10	1	0	1	3	5	1	1	28.3	30	0	1
76	6	1	0	1	3	5	8	1	31.9	33.8	0	0
62	2	0	0	1	3	5	8	1	32	33.9	0	0
88	6	1	0	1	3	5	9	1	27	28.5	0	0

55	2	0	0	1	3	5	6	1	29.4	31	0	1
60	2	0	0	1	3	5	7	1	27.8	29.3	0	1
130	8	1	0	1	3	5	3	1	26	27.4	0	0
165	10	1	0	1	3	5	1	1	24.2	25.5	0	1
70	2	0	0	1	3	5	6	1	31.8	33.5	0	0
130	8	1	0	1	3	5	3	1	25.3	26.6	0	1
126	8	1	0	1	3	5	1	1	31.4	33	0	1
167	10	1	0	1	3	5	6	1	30.1	31.6	0	0
95	6	1	0	1	3	5	2	1	26.3	27.6	0	1
93	6	1	0	1	3	5	5	1	32.5	34.1	0	0
80	6	1	0	1	3	5	3	1	31.3	32.8	0	0
69	2	0	0	1	3	5	7	1	31.4	32.9	0	0
126	8	1	0	1	3	5	1	1	31	32.4	0	0
193	11	0	0	1	3	5	2	1	29.4	30.7	0	0
57	2	0	0	1	3	5	9	1	32.3	33.7	0	0
85	6	1	0	1	3	7	6	1	48.9	51	0	0
57	2	0	0	1	3	5	9	1	32.2	33.5	0	1
74	2	0	0	1	3	5	3	1	34.7	36.1	0	1
75	6	1	0	1	3	5	3	1	32.4	33.7	0	0
71	2	0	0	1	3	5	7	1	32.5	33.8	0	0
79	6	1	0	1	3	5	3	1	15	15.6	0	1
64	2	0	0	1	3	5	3	1	28.5	29.6	0	1
55	2	0	0	1	3	5	6	1	29.2	30.3	0	0
66	2	0	0	1	3	5	3	1	32.6	33.8	0	0
67	2	0	0	1	3	5	4	1	27.5	28.5	0	0
129	8	1	0	1	3	7	2	1	39	40.4	0	1
56	2	0	0	1	3	5	2	1	29	30	0	1
180	11	1	0	1	3	6	4	1	31.9	33	0	1
72	2	0	0	1	3	5	3	1	26.5	27.4	0	0
59	2	0	0	1	3	5	3	1	32.7	33.8	0	1
56	2	0	0	1	3	5	2	1	36.8	38	0	0
185	11	1	0	1	3	5	5	1	33.7	34.8	0	0
148	10	1	0	1	3	5	8	1	21.8	22.5	0	0
62	2	0	0	1	3	5	8	1	31.4	32.4	0	1
97	7	0	1	1	3	7	2	1	28.2	29.1	0	0
68	2	0	0	1	3	5	8	1	31.7	32.7	0	1
67	2	0	0	1	3	5	4	1	25.7	26.5	0	1
137	10	1	0	1	3	6	1	1	32.9	33.9	0	1
58	2	0	0	1	3	5	3	1	32.9	33.8	0	1
64	2	0	0	1	3	5	3	1	26.2	26.9	0	0
136	10	1	0	1	3	5	4	1	30.2	31	0	1
115	7	0	1	1	3	5	1	1	19.1	19.6	0	1
61	2	0	0	1	3	5	3	1	31.4	32.2	0	1
68	2	0	0	1	3	5	8	1	27.5	28.2	0	0
134	10	1	0	1	3	5	5	1	31.5	32.3	0	0
147	10	1	0	1	3	5	4	1	32	32.8	0	0
66	2	0	0	1	3	5	3	1	32.1	32.9	0	1
58	2	0	0	1	3	5	3	1	32.3	33.1	0	0
71	2	0	0	1	3	5	7	1	33.2	34	0	1

72	2	0	0	1	3	5	3	1	31.1	31.8	0	1
73	2	0	0	1	3	5	4	1	26.9	27.5	0	0
74	2	0	0	1	3	5	3	1	36.3	37.1	0	0
80	6	1	0	1	3	5	3	1	32.1	32.8	0	1
65	2	0	0	1	3	5	8	1	23.1	23.6	0	0
137	10	1	0	1	3	6	1	1	41.5	42.4	0	0
157	10	1	0	1	3	5	1	1	23.8	24.3	0	1
170	10	1	0	1	3	5	1	1	30.2	30.8	0	1
123	8	1	0	1	3	5	1	1	31.5	32.1	0	1
59	2	0	0	1	3	5	3	1	32	32.6	0	0
75	6	1	0	1	3	5	3	1	32.9	33.5	0	1
81	6	1	0	1	3	7	9	1	38.9	39.6	0	1
73	2	0	0	1	3	5	4	1	22.3	22.7	0	1
228	13	0	0	1	3	5	5	1	33.6	34.2	0	1
150	10	1	0	1	3	5	3	1	34.3	34.9	0	1
250	13	0	0	1	3	8	8	1	45.8	46.6	0	0
60	2	0	0	1	3	5	7	1	24.5	24.9	0	0
152	10	1	0	1	3	5	4	1	24.6	25	0	0
146	10	1	0	1	3	5	4	1	31.5	32	0	0
124	8	1	0	1	3	5	4	1	31.9	32.4	0	1
176	11	1	0	1	3	5	2	1	32.5	33	0	1
61	2	0	0	1	3	5	3	1	32.7	33.2	0	0
141	10	1	0	1	3	5	3	1	32.7	33.2	0	1
146	10	1	0	1	3	5	4	1	32.7	33.2	0	1
141	10	1	0	1	3	5	3	1	33.1	33.6	0	0
135	10	1	0	1	3	5	3	1	33.2	33.7	0	1
204	11	0	0	1	3	5	9	1	33.6	34.1	0	0
148	10	1	0	1	3	5	8	1	30.7	31.1	0	1
191	11	0	0	1	3	5	8	1	31.2	31.6	0	0
134	10	1	0	1	3	5	5	1	31.7	32.1	0	1
69	2	0	0	1	3	5	7	1	32.1	32.5	0	1
70	2	0	0	1	3	5	6	1	32.1	32.5	0	1
202	11	0	0	1	3	5	7	1	32.9	33.3	0	0
63	2	0	0	1	3	5	6	1	33.3	33.7	0	1
142	10	1	0	1	3	5	8	1	33.3	33.7	0	0
186	11	1	0	1	3	5	4	1	33.3	33.7	0	0
192	11	0	0	1	3	5	1	1	34	34.4	0	0
123	8	1	0	1	3	5	1	1	35.8	36.2	0	0
139	10	1	0	1	3	5	8	1	20.8	21	0	0
83	6	1	0	1	3	5	7	1	31.5	31.8	0	1
260	13	0	0	1	3	5	4	1	31.9	32.2	0	0
65	2	0	0	1	3	5	8	1	21.6	21.8	0	1
138	10	1	0	1	3	5	7	1	32.8	33.1	0	1
203	11	0	0	1	3	5	5	1	22.5	22.7	0	1
192	11	0	0	1	3	5	1	1	34	34.3	0	1
143	10	1	0	1	3	5	8	1	38.7	39	0	0
88	6	1	0	1	3	5	9	1	28.6	28.8	0	1
83	6	1	0	1	3	5	7	1	31.8	32	0	0
186	11	1	0	1	3	5	4	1	31.8	32	0	1

135	10	1	0	1	3	5	3	1	33.4	33.6	0	0
63	2	0	0	1	3	5	6	1	33.8	34	0	0
102	7	0	1	1	3	5	1	1	34.4	34.6	0	0
149	10	1	0	1	3	5	4	1	37.2	37.4	0	0
152	10	1	0	1	3	5	4	1	22	22.1	0	1
187	11	0	0	1	3	5	9	1	23.4	23.5	0	0
114	7	0	1	1	3	5	1	1	25.4	25.5	0	1
124	8	1	0	1	3	5	4	1	26.2	26.3	0	0
139	10	1	0	1	3	5	8	1	27	27.1	0	1
90	6	1	0	1	3	5	8	1	30.5	30.6	0	1
85	6	1	0	1	3	7	6	1	32.4	32.5	0	1
150	10	1	0	1	3	5	3	1	31.8	31.9	0	0
204	11	0	0	1	3	5	9	1	32.3	32.4	0	1
119	8	1	0	1	3	5	9	1	33.1	33.2	0	1
223	11	0	0	1	3	5	7	1	33	33.1	0	0
185	11	1	0	1	3	5	5	1	34.5	34.6	0	1
161	10	1	0	1	3	7	4	1	40.6	40.7	0	1
161	10	1	0	1	3	7	4	1	42.6	42.7	0	0
76	6	1	0	1	3	5	8	1	33.3	33.3	0	1
81	6	1	0	1	3	7	9	1	42.6	42.6	0	0
89	6	1	0	1	3	5	6	1	30.6	30.6	0	1
90	6	1	0	1	3	5	8	1	30.8	30.8	0	0
102	7	0	1	1	3	5	1	1	33	33	0	1
108	7	0	1	1	3	7	1	1	43	43	0	1
111	7	0	1	1	3	5	3	1	15.5	15.5	0	1
118	8	1	0	1	3	5	6	1	29.6	29.6	0	1
118	8	1	0	1	3	5	6	1	20.1	20.1	0	0
120	8	1	0	1	3	5	3	1	30.9	30.9	0	1
120	8	1	0	1	3	5	3	1	35.7	35.7	0	0
122	8	1	0	1	3	5	4	1	23.4	23.4	0	1
154	10	1	0	1	3	7	8	1	28.7	28.7	0	1
168	10	1	0	1	3	5	2	1	32.7	32.7	0	1
170	10	1	0	1	3	5	1	1	39.9	39.9	0	0
210	11	0	0	1	3	5	8	1	30.7	30.7	0	1
216	11	0	0	1	3	5	9	1	32.8	32.8	0	0
219	11	0	0	1	3	5	3	1	33.1	33.1	0	1
222	11	0	0	1	3	5	2	1	28.8	28.8	0	1
178	11	1	0	1	3	6	8	1	41.2	41.1	0	0
177	11	1	0	1	3	7	1	1	40	39.9	0	1
177	11	1	0	1	3	7	1	1	40.9	40.8	0	0
222	11	0	0	1	3	5	2	1	33	32.9	0	0
99	7	0	1	1	3	5	3	1	30.3	30.2	0	0
136	10	1	0	1	3	5	4	1	30.3	30.2	0	0
99	7	0	1	1	3	5	3	1	29.2	29.1	0	1
164	10	1	0	1	3	5	7	1	29.3	29.2	0	1
258	13	0	0	1	3	5	3	1	29.9	29.8	0	1
113	7	0	1	1	3	5	5	1	29	28.9	0	1
237	13	0	0	1	3	5	3	1	27.4	27.3	0	1
117	8	1	0	1	3	5	2	1	24.5	24.4	0	1

237	13	0	0	1	3	5	3	1	24	23.9	0	0
114	7	0	1	1	3	5	1	1	21.5	21.4	0	0
77	6	1	0	1	3	5	2	1	21.1	21	0	1
78	6	1	0	1	3	5	3	1	21.1	21	0	1
119	8	1	0	1	3	5	9	1	33.5	33.3	0	0
105	7	0	1	1	3	5	3	1	32.7	32.5	0	1
219	11	0	0	1	3	5	3	1	32.3	32.1	0	0
105	7	0	1	1	3	5	3	1	31.7	31.5	0	0
147	10	1	0	1	3	5	4	1	31.6	31.4	0	1
155	10	1	0	1	3	5	7	1	14.3	14.2	0	1
164	10	1	0	1	3	5	7	1	26	25.8	0	0
179	11	1	0	1	3	5	6	1	22.9	22.7	0	1
79	6	1	0	1	3	5	3	1	11.3	11.2	0	0
256	13	0	0	1	3	5	4	1	33.6	33.3	0	1
168	10	1	0	1	3	5	2	1	33.2	32.9	0	0
221	11	0	0	1	3	5	4	1	33.3	33	0	0
116	7	0	1	1	3	5	3	1	22	21.8	0	1
180	11	1	0	1	3	6	4	1	43.3	42.9	0	0
133	8	1	0	1	3	5	1	1	32.2	31.9	0	1
250	13	0	0	1	3	8	8	1	42.3	41.9	0	1
256	13	0	0	1	3	5	4	1	31.9	31.6	0	0
191	11	0	0	1	3	5	8	1	34.9	34.5	0	1
243	13	0	0	1	3	5	4	1	33.9	33.5	0	0
104	7	0	1	1	3	5	6	1	33.7	33.3	0	1
143	10	1	0	1	3	5	8	1	33.6	33.2	0	1
144	10	1	0	1	3	5	6	1	33.6	33.2	0	0
93	6	1	0	1	3	5	5	1	33.4	33	0	1
232	13	0	0	1	3	7	3	1	33.1	32.7	0	1
86	6	1	0	1	3	5	9	1	33	32.6	0	0
86	6	1	0	1	3	5	9	1	32.7	32.3	0	1
202	11	0	0	1	3	5	7	1	31.7	31.3	0	1
178	11	1	0	1	3	6	8	1	31.5	31.1	0	1
121	8	1	0	1	3	5	1	1	31	30.6	0	1
227	13	0	0	1	3	5	3	1	29.8	29.4	0	1
203	11	0	0	1	3	5	5	1	22.2	21.9	0	0
233	13	0	0	1	3	5	4	1	21.2	20.9	0	1
218	11	0	0	1	3	5	3	1	27.7	27.3	0	1
249	13	0	0	1	3	8	5	1	40.5	39.9	0	0
241	13	0	0	1	3	5	3	1	33.7	33.2	0	1
131	8	1	0	1	3	5	10	1	26.3	25.9	0	1
142	10	1	0	1	3	5	8	1	32.9	32.4	0	1
190	11	0	0	1	3	7	3	1	39.4	38.8	0	1
104	7	0	1	1	3	5	6	1	32.5	32	0	0
207	11	0	0	1	3	5	8	1	32.1	31.6	0	1
218	11	0	0	1	3	5	3	1	25.4	25	0	0
262	13	0	0	1	3	5	1	1	31.7	31.2	0	0
96	7	0	1	1	3	5	1	1	12.4	12.2	0	1
107	7	0	1	1	3	5	9	1	30.3	29.8	0	1
149	10	1	0	1	3	5	4	1	30	29.5	0	1

257	13	0	0	1	3	5	3	1	29.6	29.1	0	0
266	13	0	0	1	3	5	7	1	28.9	28.4	0	1
208	11	0	0	1	3	5	3	1	34.3	33.7	0	0
247	13	0	0	1	3	5	8	1	34.4	33.8	0	0
208	11	0	0	1	3	5	3	1	34.1	33.5	0	1
262	13	0	0	1	3	5	1	1	33.7	33.1	0	1
235	13	0	0	1	3	6	1	1	27.4	26.9	0	1
229	13	0	0	1	3	5	2	1	32.1	31.5	0	0
230	13	0	0	1	3	5	4	1	32.1	31.5	0	1
144	10	1	0	1	3	5	6	1	31.7	31.1	0	1
133	8	1	0	1	3	5	1	1	26.1	25.6	0	0
121	8	1	0	1	3	5	1	1	30.3	29.7	0	0
108	7	0	1	1	3	7	1	1	42.8	41.9	0	0
245	13	0	0	1	3	5	2	1	28.5	27.9	0	1
206	11	0	0	1	3	6	6	1	32.4	31.7	0	1
97	7	0	1	1	3	7	2	1	41.4	40.5	0	0
252	13	0	0	1	3	5	6	1	32.2	31.5	0	1
188	11	0	0	1	3	5	1	1	13.6	13.3	0	1
182	11	1	0	1	3	5	3	1	26	25.4	0	1
100	7	0	1	1	3	5	8	1	17.3	16.9	0	1
228	13	0	0	1	3	5	5	1	34.6	33.8	0	0
241	13	0	0	1	3	5	3	1	34.2	33.4	0	0
179	11	1	0	1	3	5	6	1	17	16.6	0	0
231	13	0	0	1	3	6	7	1	33.9	33.1	0	1
257	13	0	0	1	3	5	3	1	29.1	28.4	0	1
206	11	0	0	1	3	6	6	1	37.4	36.5	0	0
238	13	0	0	1	3	5	6	1	33.2	32.4	0	1
221	11	0	0	1	3	5	4	1	32.4	31.6	0	1
244	13	0	0	1	3	6	3	1	32.1	31.3	0	1
112	7	0	1	1	3	5	4	1	15.9	15.5	0	0
243	13	0	0	1	3	5	4	1	35.7	34.8	0	1
230	13	0	0	1	3	5	4	1	35.3	34.4	0	0
264	13	0	0	1	3	8	1	1	42.5	41.4	0	1
216	11	0	0	1	3	5	9	1	34.6	33.7	0	1
268	13	0	0	1	3	5	2	1	23.1	22.5	0	1
122	8	1	0	1	3	5	4	1	15.3	14.9	0	0
264	13	0	0	1	3	8	1	1	49	47.7	0	0
240	13	0	0	1	3	5	3	1	29.7	28.9	0	1
115	7	0	1	1	3	5	1	1	14.7	14.3	0	0
225	13	0	0	1	3	5	2	1	25.5	24.8	0	0
210	11	0	0	1	3	5	8	1	21.6	21	0	0
175	11	1	0	1	3	5	3	1	24.7	24	0	1
184	11	1	0	1	3	5	4	1	17.5	17	0	1
260	13	0	0	1	3	5	4	1	34.9	33.9	0	1
252	13	0	0	1	3	5	6	1	34.5	33.5	0	0
255	13	0	0	1	3	5	2	1	34.5	33.5	0	1
225	13	0	0	1	3	5	2	1	20.6	20	0	1
258	13	0	0	1	3	5	3	1	24	23.3	0	0
187	11	0	0	1	3	5	9	1	23.7	23	0	1

214	11	0	0	1	3	5	4	1	22.8	22.1	0	0
182	11	1	0	1	3	5	3	1	25.9	25.1	0	0
231	13	0	0	1	3	6	7	1	35.6	34.5	0	0
167	10	1	0	1	3	5	6	1	35.2	34.1	0	1
253	13	0	0	1	3	5	6	1	33.8	32.7	0	1
103	7	0	1	1	3	5	3	1	12.1	11.7	0	1
255	13	0	0	1	3	5	2	1	33.3	32.2	0	0
266	13	0	0	1	3	5	7	1	18.1	17.5	0	0
107	7	0	1	1	3	5	9	1	33.1	32	0	0
244	13	0	0	1	3	6	3	1	39	37.7	0	0
214	11	0	0	1	3	5	4	1	23.6	22.8	0	1
238	13	0	0	1	3	5	6	1	32.3	31.2	0	0
247	13	0	0	1	3	5	8	1	35.2	34	0	1
248	13	0	0	1	3	8	8	1	50.7	48.9	0	0
263	13	0	0	1	3	7	6	1	36.4	35.1	0	1
235	13	0	0	1	3	6	1	1	36.1	34.8	0	0
96	7	0	1	1	3	5	1	1	11	10.6	0	0
190	11	0	0	1	3	7	3	1	43.7	42.1	0	0
112	7	0	1	1	3	5	4	1	18.2	17.5	0	1
116	7	0	1	1	3	5	3	1	15.4	14.8	0	0
154	10	1	0	1	3	7	8	1	37.6	36.1	0	0
268	13	0	0	1	3	5	2	1	25	24	0	0
188	11	0	0	1	3	5	1	1	9.8	9.4	0	0
245	13	0	0	1	3	5	2	1	26.7	25.6	0	0
254	13	0	0	1	3	5	8	1	23.7	22.7	0	1
184	11	1	0	1	3	5	4	1	16.3	15.6	0	0
254	13	0	0	1	3	5	8	1	29.6	28.3	0	0
226	13	0	0	1	3	5	3	1	29	27.7	0	0
253	13	0	0	1	3	5	6	1	33	31.5	0	0
240	13	0	0	1	3	5	3	1	21.7	20.7	0	0
263	13	0	0	1	3	7	6	1	34.4	32.8	0	0
227	13	0	0	1	3	5	3	1	19.3	18.4	0	0
248	13	0	0	1	3	8	8	1	42	40	0	1
236	13	0	0	1	3	5	2	1	29.2	27.8	0	1
233	13	0	0	1	3	5	4	1	32.7	31.1	0	0
226	13	0	0	1	3	5	3	1	22.4	21.3	0	1
272	13	0	0	1	3	7	5	1	42.4	40.3	0	1
236	13	0	0	1	3	5	2	1	24.2	23	0	0
272	13	0	0	1	3	7	5	1	45.8	43.5	0	0
100	7	0	1	1	3	5	8	1	11.8	11.2	0	0
155	10	1	0	1	3	5	7	1	15.5	14.7	0	0
249	13	0	0	1	3	8	5	1	36.8	34.8	0	1
246	13	0	0	1	3	5	3	1	19.4	18.3	0	0
229	13	0	0	1	3	5	2	1	33.2	31.3	0	1
246	13	0	0	1	3	5	3	1	21.6	20.3	0	1
223	11	0	0	1	3	5	7	1	34.1	31.9	0	1
232	13	0	0	1	3	7	3	1	50.6	47.3	0	0
103	7	0	1	1	3	5	3	1	12	11.1	0	0
198	11	0	0	1	3	5	0	1	12.8	11.7	0	1

198	11	0	0	1	3	5	0	1	12.9	11.6	0	0
158	10	1	0	0	8	8	2	0	9.4	10.4	1	0
40	1	0	0	0	8	7	3	0	12.4	12.7	1	0
205	11	0	0	0	7	5	3	0	11.2	11.5	1	0
9	1	0	0	0	7	5	3	0	8.3	8.3	1	0
234	13	0	0	0	7	5	2	0	13.4	13.2	1	0
200	11	0	0	0	6	7	3	0	10.2	10.4	1	0
217	11	0	0	0	6	7	4	0	11.4	11.2	1	0
153	10	1	0	0	6	6	8	0	10.8	10.5	1	0
174	11	1	0	0	6	8	3	0	10.9	9.7	1	0
163	10	1	0	0	5	7	2	0	11.4	12.4	1	0
172	10	1	0	0	5	8	4	0	10.5	11.4	1	0
91	6	1	0	0	5	8	7	0	11.3	12	1	0
94	6	1	0	0	5	7	2	0	10.9	11.4	1	0
242	13	0	0	0	5	7	4	0	11.1	11.6	1	0
173	10	1	0	0	5	9	2	0	9.3	9.7	1	0
251	13	0	0	0	5	8	2	0	11	11.4	1	0
195	11	0	0	0	5	6	3	0	9.3	9.6	1	0
32	1	0	0	0	5	5	3	0	10	10.3	1	0
49	2	1	0	0	5	7	6	0	12.2	12.5	1	0
212	11	0	0	0	5	5	3	0	10	10.1	1	0
215	11	0	0	0	5	7	4	0	10.1	10.2	1	0
209	11	0	0	0	5	8	4	0	10.2	10.3	1	0
125	8	1	0	0	5	7	2	0	10.8	10.9	1	0
84	6	1	0	0	5	8	8	0	11.4	11.5	1	0
19	1	0	0	0	5	5	2	0	10.9	10.9	1	0
28	1	0	0	0	5	5	6	0	10.7	10.7	1	0
160	10	1	0	0	5	7	4	0	12.9	12.9	1	0
183	11	1	0	0	5	8	4	0	11.2	11.1	1	0
16	1	0	0	0	5	5	5	0	10.9	10.8	1	0
213	11	0	0	0	5	5	4	0	10.7	10.6	1	0
211	11	0	0	0	5	8	3	0	9.8	9.7	1	0
18	1	0	0	0	5	5	9	0	8.2	8.1	1	0
128	8	1	0	0	5	8	4	0	10.7	10.5	1	0
156	10	1	0	0	5	6	6	0	11.6	11.3	1	0
265	13	0	0	0	5	7	3	0	11.1	10.8	1	0
269	13	0	0	0	5	7	3	0	12.4	12	1	0
101	7	0	1	0	5	8	7	0	10.3	9.9	1	0
271	13	0	0	0	5	8	6	0	12.5	12	1	0
26	1	0	0	0	5	7	6	0	12.5	11.9	1	0
87	6	1	0	0	5	7	4	0	12.5	11.7	1	0
197	11	0	0	0	5	7	6	0	12.4	11.6	1	0
98	7	0	1	0	4	5	0	0	10.9	11.7	1	0
110	7	0	1	0	4	6	1	0	13.2	13.9	1	0
267	13	0	0	0	4	6	6	0	15.7	16	1	0
224	11	0	0	0	4	5	3	0	11.9	12	1	0
3	1	0	0	0	4	5	4	0	12	12	1	0
189	11	0	0	0	4	5	4	0	11.7	11.6	1	0
140	10	1	0	0	4	8	5	0	11.5	11.4	1	0

169	10	1	0	0	4	8	4	0	14.4	13.8	1	0
199	11	0	0	0	4	8	7	0	15	13.8	1	0
77	6	1	0	1	3	5	2	0	8.3	11.2	1	0
78	6	1	0	1	3	5	3	0	8.3	11.2	1	0
171	10	1	0	1	3	4	3	0	6.2	7.3	1	0
193	11	0	0	1	3	5	2	0	9.3	10.3	1	0
82	6	1	0	1	3	5	2	0	11.6	12.8	1	0
130	8	1	0	1	3	5	3	0	9.2	10.1	1	0
165	10	1	0	1	3	5	1	0	10.4	11.4	1	0
127	8	1	0	1	3	5	2	0	11.1	12	1	0
159	10	1	0	1	3	5	1	0	9.2	9.9	1	0
13	1	0	0	1	3	3	3	0	8.2	8.8	1	0
170	10	1	0	1	3	5	1	0	9.8	10.5	1	0
261	13	0	0	1	3	5	3	0	10.4	11	1	0
137	10	1	0	1	3	6	1	0	11.4	12	1	0
139	10	1	0	1	3	5	8	0	11.4	12	1	0
126	8	1	0	1	3	5	1	0	9.9	10.4	1	0
150	10	1	0	1	3	5	3	0	12	12.6	1	0
61	2	0	0	1	3	5	3	0	10.2	10.7	1	0
104	7	0	1	1	3	5	6	0	10.7	11.2	1	0
65	2	0	0	1	3	5	8	0	10.8	11.3	1	0
180	11	1	0	1	3	6	4	0	11.3	11.8	1	0
102	7	0	1	1	3	5	1	0	11.6	12.1	1	0
111	7	0	1	1	3	5	3	0	9.5	9.9	1	0
74	2	0	0	1	3	5	3	0	12	12.5	1	0
53	2	1	0	1	3	5	6	0	9.8	10.2	1	0
129	8	1	0	1	3	7	2	0	9.8	10.2	1	0
184	11	1	0	1	3	5	4	0	10.2	10.6	1	0
68	2	0	0	1	3	5	8	0	10.5	10.9	1	0
112	7	0	1	1	3	5	4	0	10.5	10.9	1	0
146	10	1	0	1	3	5	4	0	10.5	10.9	1	0
135	10	1	0	1	3	5	3	0	11.1	11.5	1	0
22	1	0	0	1	3	5	4	0	11.3	11.7	1	0
141	10	1	0	1	3	5	3	0	11.7	12.1	1	0
93	6	1	0	1	3	5	5	0	12.3	12.7	1	0
17	1	0	0	1	3	3	4	0	9.6	9.9	1	0
157	10	1	0	1	3	5	1	0	10.1	10.4	1	0
109	7	0	1	1	3	3	2	0	6.8	7	1	0
181	11	1	0	1	3	3	4	0	6.9	7.1	1	0
34	1	0	0	1	3	5	8	0	10.6	10.9	1	0
188	11	0	0	1	3	5	1	0	10.8	11.1	1	0
266	13	0	0	1	3	5	7	0	10.8	11.1	1	0
64	2	0	0	1	3	5	3	0	10.9	11.2	1	0
115	7	0	1	1	3	5	1	0	10.9	11.2	1	0
44	1	0	0	1	3	3	8	0	7.3	7.5	1	0
73	2	0	0	1	3	5	4	0	11	11.3	1	0
237	13	0	0	1	3	5	3	0	11	11.3	1	0
147	10	1	0	1	3	5	4	0	11.1	11.4	1	0
21	1	0	0	1	3	5	6	0	11.3	11.6	1	0

23	1	0	0	1	3	5	6	0	11.3	11.6	1	0
43	1	0	0	1	3	5	2	0	11.4	11.7	1	0
58	2	0	0	1	3	5	3	0	11.4	11.7	1	0
63	2	0	0	1	3	5	6	0	11.5	11.8	1	0
95	6	1	0	1	3	5	2	0	11.6	11.9	1	0
35	1	0	0	1	3	5	8	0	11.8	12.1	1	0
80	6	1	0	1	3	5	3	0	12.1	12.4	1	0
122	8	1	0	1	3	5	4	0	9.3	9.5	1	0
33	1	0	0	1	3	6	5	0	9.8	10	1	0
152	10	1	0	1	3	5	4	0	10	10.2	1	0
117	8	1	0	1	3	5	2	0	10.3	10.5	1	0
203	11	0	0	1	3	5	5	0	10.3	10.5	1	0
37	1	0	0	1	3	5	10	0	10.6	10.8	1	0
56	2	0	0	1	3	5	2	0	10.8	11	1	0
66	2	0	0	1	3	5	3	0	10.8	11	1	0
75	6	1	0	1	3	5	3	0	10.9	11.1	1	0
14	1	0	0	1	3	5	2	0	11.3	11.5	1	0
168	10	1	0	1	3	5	2	0	11.4	11.6	1	0
120	8	1	0	1	3	5	3	0	11.5	11.7	1	0
69	2	0	0	1	3	5	7	0	11.6	11.8	1	0
222	11	0	0	1	3	5	2	0	11.7	11.9	1	0
51	2	1	0	1	3	3	3	0	7.3	7.4	1	0
25	1	0	0	1	3	5	8	0	9.3	9.4	1	0
60	2	0	0	1	3	5	7	0	9.4	9.5	1	0
175	11	1	0	1	3	5	3	0	10	10.1	1	0
81	6	1	0	1	3	7	9	0	10.1	10.2	1	0
235	13	0	0	1	3	6	1	0	10.1	10.2	1	0
123	8	1	0	1	3	5	1	0	10.7	10.8	1	0
192	11	0	0	1	3	5	1	0	10.6	10.7	1	0
96	7	0	1	1	3	5	1	0	10.8	10.9	1	0
221	11	0	0	1	3	5	4	0	11	11.1	1	0
1	1	0	0	1	3	5	3	0	11.1	11.2	1	0
45	1	0	0	1	3	5	3	0	11.1	11.2	1	0
233	13	0	0	1	3	5	4	0	11.1	11.2	1	0
47	2	1	0	1	3	5	4	0	11.2	11.3	1	0
72	2	0	0	1	3	5	3	0	11.3	11.4	1	0
79	6	1	0	1	3	5	3	0	11.4	11.5	1	0
114	7	0	1	1	3	5	1	0	11.4	11.5	1	0
50	2	1	0	1	3	5	3	0	11.5	11.6	1	0
216	11	0	0	1	3	5	9	0	11.7	11.8	1	0
262	13	0	0	1	3	5	1	0	11.6	11.7	1	0
99	7	0	1	1	3	5	3	0	11.8	11.9	1	0
219	11	0	0	1	3	5	3	0	11.8	11.9	1	0
48	2	1	0	1	3	5	3	0	11.9	12	1	0
59	2	0	0	1	3	5	3	0	11.9	12	1	0
70	2	0	0	1	3	5	6	0	11.9	12	1	0
161	10	1	0	1	3	7	4	0	12	12.1	1	0
8	1	0	0	1	3	5	2	0	10.4	10.4	1	0
10	1	0	0	1	3	5	4	0	11.6	11.6	1	0

29	1	0	0	1	3	6	4	0	13	13	1	0
41	1	0	0	1	3	7	4	0	10	10	1	0
57	2	0	0	1	3	5	9	0	10.9	10.9	1	0
62	2	0	0	1	3	5	8	0	12.6	12.6	1	0
67	2	0	0	1	3	5	4	0	12	12	1	0
90	6	1	0	1	3	5	8	0	11.9	11.9	1	0
103	7	0	1	1	3	5	3	0	10.2	10.2	1	0
105	7	0	1	1	3	5	3	0	11.2	11.2	1	0
113	7	0	1	1	3	5	5	0	10.2	10.2	1	0
119	8	1	0	1	3	5	9	0	11.4	11.4	1	0
138	10	1	0	1	3	5	7	0	12	12	1	0
148	10	1	0	1	3	5	8	0	10.9	10.9	1	0
179	11	1	0	1	3	5	6	0	9.2	9.2	1	0
185	11	1	0	1	3	5	5	0	11.2	11.2	1	0
186	11	1	0	1	3	5	4	0	11.8	11.8	1	0
206	11	0	0	1	3	6	6	0	11.5	11.5	1	0
218	11	0	0	1	3	5	3	0	11.5	11.5	1	0
236	13	0	0	1	3	5	2	0	10.8	10.8	1	0
238	13	0	0	1	3	5	6	0	11.4	11.4	1	0
240	13	0	0	1	3	5	3	0	11.2	11.2	1	0
253	13	0	0	1	3	5	6	0	11.2	11.2	1	0
223	11	0	0	1	3	5	7	0	12.7	12.6	1	0
208	11	0	0	1	3	5	3	0	12.1	12	1	0
15	1	0	0	1	3	5	4	0	12	11.9	1	0
214	11	0	0	1	3	5	4	0	11.8	11.7	1	0
7	1	0	0	1	3	5	1	0	11.6	11.5	1	0
71	2	0	0	1	3	5	7	0	11.6	11.5	1	0
154	10	1	0	1	3	7	8	0	11.4	11.3	1	0
226	13	0	0	1	3	5	3	0	11.5	11.4	1	0
124	8	1	0	1	3	5	4	0	11.3	11.2	1	0
202	11	0	0	1	3	5	7	0	11.3	11.2	1	0
131	8	1	0	1	3	5	10	0	11.2	11.1	1	0
100	7	0	1	1	3	5	8	0	10.8	10.7	1	0
107	7	0	1	1	3	5	9	0	10.8	10.7	1	0
182	11	1	0	1	3	5	3	0	10.8	10.7	1	0
255	13	0	0	1	3	5	2	0	10.8	10.7	1	0
116	7	0	1	1	3	5	3	0	10.3	10.2	1	0
210	11	0	0	1	3	5	8	0	10.1	10	1	0
5	1	0	0	1	3	4	10	0	9.1	9	1	0
42	1	0	0	1	3	5	7	0	12.4	12.2	1	0
241	13	0	0	1	3	5	3	0	12.1	11.9	1	0
143	10	1	0	1	3	5	8	0	11.8	11.6	1	0
164	10	1	0	1	3	5	7	0	11.7	11.5	1	0
254	13	0	0	1	3	5	8	0	11.5	11.3	1	0
246	13	0	0	1	3	5	3	0	11	10.8	1	0
36	1	0	0	1	3	5	6	0	10.8	10.6	1	0
38	1	0	0	1	3	5	8	0	10.7	10.5	1	0
230	13	0	0	1	3	5	4	0	10.7	10.5	1	0
190	11	0	0	1	3	7	3	0	10.6	10.4	1	0

268	13	0	0	1	3	5	2	0	10.5	10.3	1	0
176	11	1	0	1	3	5	2	0	10.2	10	1	0
108	7	0	1	1	3	7	1	0	9	8.8	1	0
12	1	0	0	1	3	5	3	0	12.3	12	1	0
134	10	1	0	1	3	5	5	0	12.3	12	1	0
144	10	1	0	1	3	5	6	0	11.8	11.5	1	0
227	13	0	0	1	3	5	3	0	11.7	11.4	1	0
121	8	1	0	1	3	5	1	0	11.6	11.3	1	0
136	10	1	0	1	3	5	4	0	11.6	11.3	1	0
177	11	1	0	1	3	7	1	0	11.6	11.3	1	0
247	13	0	0	1	3	5	8	0	11.6	11.3	1	0
207	11	0	0	1	3	5	8	0	11.5	11.2	1	0
88	6	1	0	1	3	5	9	0	11.4	11.1	1	0
149	10	1	0	1	3	5	4	0	11.1	10.8	1	0
250	13	0	0	1	3	8	8	0	11	10.7	1	0
272	13	0	0	1	3	7	5	0	10.9	10.6	1	0
86	6	1	0	1	3	5	9	0	12.6	12.2	1	0
133	8	1	0	1	3	5	1	0	9.3	9	1	0
252	13	0	0	1	3	5	6	0	12	11.6	1	0
264	13	0	0	1	3	8	1	0	11.9	11.5	1	0
257	13	0	0	1	3	5	3	0	11.8	11.4	1	0
4	1	0	0	1	3	5	9	0	11.7	11.3	1	0
52	2	1	0	1	3	5	5	0	11.6	11.2	1	0
204	11	0	0	1	3	5	9	0	11.6	11.2	1	0
46	2	1	0	1	3	5	8	0	11.3	10.9	1	0
142	10	1	0	1	3	5	8	0	11.3	10.9	1	0
198	11	0	0	1	3	5	0	0	10.8	10.4	1	0
167	10	1	0	1	3	5	6	0	12.7	12.2	1	0
243	13	0	0	1	3	5	4	0	12.7	12.2	1	0
225	13	0	0	1	3	5	2	0	9.9	9.5	1	0
178	11	1	0	1	3	6	8	0	12.2	11.7	1	0
118	8	1	0	1	3	5	6	0	11.9	11.4	1	0
263	13	0	0	1	3	7	6	0	11.9	11.4	1	0
244	13	0	0	1	3	6	3	0	11.7	11.2	1	0
76	6	1	0	1	3	5	8	0	11.3	10.8	1	0
155	10	1	0	1	3	5	7	0	10.9	10.4	1	0
89	6	1	0	1	3	5	6	0	10.7	10.2	1	0
229	13	0	0	1	3	5	2	0	12.1	11.5	1	0
260	13	0	0	1	3	5	4	0	12	11.4	1	0
231	13	0	0	1	3	6	7	0	11.9	11.3	1	0
232	13	0	0	1	3	7	3	0	11.8	11.2	1	0
55	2	0	0	1	3	5	6	0	11.6	11	1	0
6	1	0	0	1	3	5	7	0	11.5	10.9	1	0
187	11	0	0	1	3	5	9	0	12	11.3	1	0
245	13	0	0	1	3	5	2	0	11.8	11.1	1	0
239	13	0	0	1	3	3	10	0	9.7	9.1	1	0
191	11	0	0	1	3	5	8	0	12.6	11.8	1	0
249	13	0	0	1	3	8	5	0	10.9	10.2	1	0
256	13	0	0	1	3	5	4	0	12.4	11.6	1	0

258	13	0	0	1	3	5	3	0	12.1	11.3	1	0
83	6	1	0	1	3	5	7	0	12.2	11.3	1	0
228	13	0	0	1	3	5	5	0	12.4	11.2	1	0
248	13	0	0	1	3	8	8	0	13.3	12	1	0
11	1	0	0	1	3	5	1	0	13.4	11.9	1	0
85	6	1	0	1	3	7	6	0	13.2	11.7	1	0
24	1	0	0	0	2	5	4	0	10.8	11.3	1	0
30	1	0	0	0	2	5	2	0	12	12.5	1	0
39	1	0	0	0	2	5	7	0	11.3	11.5	1	0
20	1	0	0	0	1	2	6	0	9.6	9.9	1	0
151	10	1	0	0	1	2	10	0	11	11.1	1	0
54	2	1	0	0	1	2	3	0	7.5	7.5	1	0
2	1	0	0	0	1	3	8	0	15.6	15.5	1	0
194	11	0	0	0	1	2	4	0	8.8	8.6	1	0
166	10	1	0	0	1	2	7	0	7.3	7.1	1	0
220	11	0	0	0	1	2	6	0	10.3	10	1	0
92	6	1	0	0	1	2	7	0	8.8	8.3	1	0
158	10	1	0	0	8	8	2	0	13.7	14.8	0	0
217	11	0	0	0	6	7	4	0	8	9.4	0	0
174	11	1	0	0	6	8	3	0	12.8	13.7	0	0
153	10	1	0	0	6	6	8	0	9.2	9.5	0	0
153	10	1	0	0	6	6	8	0	16.2	16.6	0	1
174	11	1	0	0	6	8	3	0	11.8	12	0	0
217	11	0	0	0	6	7	4	0	10.2	10.2	0	0
217	11	0	0	0	6	7	4	0	11.6	11.6	0	0
200	11	0	0	0	6	7	3	0	16.8	16.7	0	1
153	10	1	0	0	6	6	8	0	13	12.9	0	0
217	11	0	0	0	6	7	4	0	14.6	14.4	0	1
174	11	1	0	0	6	8	3	0	16.8	16.5	0	0
200	11	0	0	0	6	7	3	0	10.5	10.2	0	0
174	11	1	0	0	6	8	3	0	6.5	6.3	0	0
174	11	1	0	0	6	8	3	0	9.3	9	0	0
153	10	1	0	0	6	6	8	0	3	2.9	0	0
153	10	1	0	0	6	6	8	0	17.4	16.8	0	0
200	11	0	0	0	6	7	3	0	14.8	14.2	0	0
217	11	0	0	0	6	7	4	0	12.5	11.9	0	0
200	11	0	0	0	6	7	3	0	11.3	10.7	0	0
217	11	0	0	0	6	7	4	0	12.6	11.8	0	0
200	11	0	0	0	6	7	3	0	5.6	5.2	0	0
200	11	0	0	0	6	7	3	0	6.3	5.3	0	0
163	10	1	0	0	5	7	2	0	11	11.6	0	0
160	10	1	0	0	5	7	4	0	16.2	17	0	0
156	10	1	0	0	5	6	6	0	14.9	15.5	0	0
269	13	0	0	0	5	7	3	0	15.2	15.8	0	0
173	10	1	0	0	5	9	2	0	13.9	14.4	0	0
160	10	1	0	0	5	7	4	0	17.4	18	0	0
94	6	1	0	0	5	7	2	0	12.6	13	0	0
213	11	0	0	0	5	5	4	0	11.7	12	0	0
128	8	1	0	0	5	8	4	0	15.9	16.2	0	0

195	11	0	0	0	5	6	3	0	11.9	12.1	0	0
212	11	0	0	0	5	5	3	0	19.8	20.1	0	1
125	8	1	0	0	5	7	2	0	14.3	14.5	0	0
195	11	0	0	0	5	6	3	0	14.6	14.8	0	0
212	11	0	0	0	5	5	3	0	18.4	18.6	0	0
195	11	0	0	0	5	6	3	0	12.6	12.7	0	0
269	13	0	0	0	5	7	3	0	18.1	18.2	0	0
212	11	0	0	0	5	5	3	0	19.5	19.6	0	0
213	11	0	0	0	5	5	4	0	12.5	12.5	0	0
215	11	0	0	0	5	7	4	0	15.8	15.7	0	0
212	11	0	0	0	5	5	3	0	15.3	15.2	0	0
87	6	1	0	0	5	7	4	0	15.2	15	0	0
197	11	0	0	0	5	7	6	0	14.4	14.2	0	0
156	10	1	0	0	5	6	6	0	17.3	17	0	0
209	11	0	0	0	5	8	4	0	10.7	10.5	0	0
213	11	0	0	0	5	5	4	0	10.2	10	0	0
251	13	0	0	0	5	8	2	0	13.9	13.6	0	0
163	10	1	0	0	5	7	2	0	8.8	8.6	0	0
242	13	0	0	0	5	7	4	0	20.8	20.3	0	0
172	10	1	0	0	5	8	4	0	12.2	11.9	0	0
87	6	1	0	0	5	7	4	0	15	14.6	0	0
242	13	0	0	0	5	7	4	0	11.2	10.9	0	0
213	11	0	0	0	5	5	4	0	14.8	14.4	0	1
125	8	1	0	0	5	7	2	0	11	10.7	0	0
271	13	0	0	0	5	8	6	0	16.5	16	0	0
211	11	0	0	0	5	8	3	0	18.9	18.3	0	0
91	6	1	0	0	5	8	7	0	19	18.3	0	0
265	13	0	0	0	5	7	3	0	4.3	4.1	0	0
265	13	0	0	0	5	7	3	0	6.2	5.9	0	0
215	11	0	0	0	5	7	4	0	11.6	11	0	0
197	11	0	0	0	5	7	6	0	15.3	14.4	0	0
156	10	1	0	0	5	6	6	0	14.9	14	0	0
101	7	0	1	0	5	8	7	0	7.6	7.1	0	0
94	6	1	0	0	5	7	2	0	13	11.8	0	0
189	11	0	0	0	4	5	4	0	16	17	0	0
110	7	0	1	0	4	6	1	0	17.1	17.3	0	0
110	7	0	1	0	4	6	1	0	18.8	19	0	0
267	13	0	0	0	4	6	6	0	15.3	15.3	0	0
140	10	1	0	0	4	8	5	0	10.4	10.1	0	0
224	11	0	0	0	4	5	3	0	4.7	4.4	0	0
224	11	0	0	0	4	5	3	0	5.1	4.4	0	0
111	7	0	1	1	3	5	3	0	4.8	5.1	0	0
95	6	1	0	1	3	5	2	0	12.9	13.7	0	0
171	10	1	0	1	3	4	3	0	14.5	15.1	0	0
138	10	1	0	1	3	5	7	0	17.6	17.9	0	0
109	7	0	1	1	3	3	2	0	19.3	19.5	0	1
109	7	0	1	1	3	3	2	0	17.4	17.5	0	0
113	7	0	1	1	3	5	5	0	19.3	19.4	0	0
175	11	1	0	1	3	5	3	0	17.1	17.1	0	0

181	11	1	0	1	3	3	4	0	10.5	10.5	0	1
175	11	1	0	1	3	5	3	0	17.6	17.5	0	0
117	8	1	0	1	3	5	2	0	13.2	13.1	0	0
117	8	1	0	1	3	5	2	0	13	12.9	0	0
131	8	1	0	1	3	5	10	0	13	12.9	0	0
154	10	1	0	1	3	7	8	0	5.2	5.1	0	0
113	7	0	1	1	3	5	5	0	18.1	17.7	0	0
239	13	0	0	1	3	3	10	0	13.5	13.2	0	1
131	8	1	0	1	3	5	10	0	13	12.5	0	0
181	11	1	0	1	3	3	4	0	6.3	6	0	0
138	10	1	0	1	3	5	7	0	18.5	17.6	0	0
239	13	0	0	1	3	3	10	0	14.6	13.8	0	0
95	6	1	0	1	3	5	2	0	15.1	13.5	0	0
111	7	0	1	1	3	5	3	0	4.9	4.3	0	0
92	6	1	0	0	1	2	7	0	13.3	14.2	0	1
220	11	0	0	0	1	2	6	0	15.6	16	0	1
151	10	1	0	0	1	2	10	0	13.7	13.9	0	1
166	10	1	0	0	1	2	7	0	13.8	13.9	0	1
194	11	0	0	0	1	2	4	0	9.1	8.7	0	1