Leeds Clean Air Zones Modelling

Local Model Validation Report:

Highway Assignment Transport Model

Car, LGV and HGV

Prepared by: ..... Checked by: .....
Rob Dziurla Stuart Dalgleish
Consultant Regional Director

Approved by: .....
Stuart Dalgleish
Regional Director

Leeds Transport Model – CAZ Validation

Rev No	Comments	Checked by	Approved by	Date
1	Draft issued to client	SD	SD	07/08/17
2	Final updated with revised model update	SD	SD	25/04/18

5th Floor, 2 City Walk, Leeds, LS11 9AR
Telephone: 0113 391 6800 Website: http://www.aecom.com

Job No 60274233 Reference M050 Date Created April 2018

Table of Contents

1 Introduction

1.1 Purpose of Report

AECOM has been appointed by Leeds City Council (LCC) to provide a transport modelling evaluation of a Clean Air Zone (CAZ) within Leeds, using the recently updated 2015 Leeds Transport Model (LTM) as the basis of appraisal.

The aim of this report is to present the level of calibration and validation achieved in the 2015 version of the Leeds Transport Model with a particular, focus on HGVs & LGVs as these are the vehicle types within the model which will be affected by the CAZ.

This report should be read in conjunction with the 2015 Leeds Highway Model Local Model Validation Report.

This report supersedes the version dated August 2017 and contains results of some updates that were made to the base year highway model to provide better calibration around some of the other transport schemes that Leeds City Council are pursuing.

1.2 Background

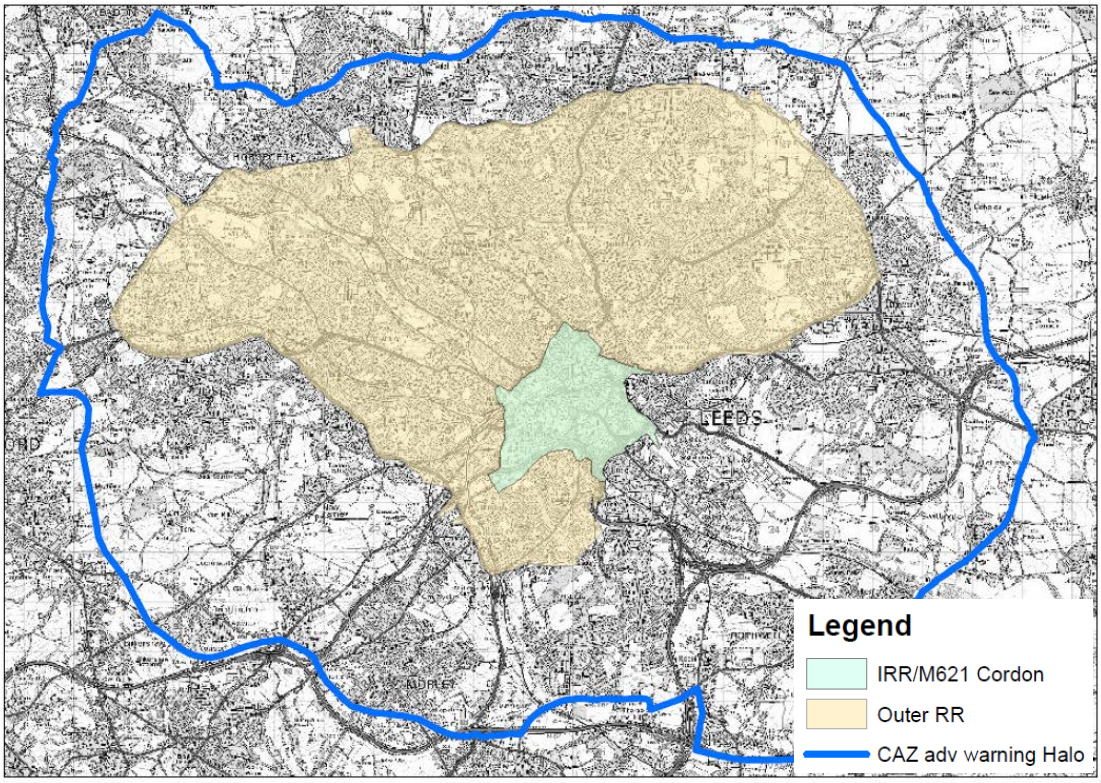
In December 2015 the Government announced plans to introduce Clean Air Zones (CAZ) in Birmingham, Leeds, Nottingham, Derby and Southampton by 2020. These Zones will see the most polluting vehicles, like old buses, taxis, coaches and lorries, discouraged from driving within the zone through charges. A further announcement was made in 2017 which involved a much larger number of cities which may need to introduce varying schemes as part of a CAZ.

The Clean Air Zones will be targeted at areas of each city where the air quality problem is most serious. These Zones aim to reduce the pollution in city centres and encourage the replacement of older, more polluting vehicles with modern, cleaner vehicles.

Within Leeds a number of boundaries are being investigated. One is based on Leeds Outer Ring Road with a secondary option of an inner ring road boundary also being considered. These are shown in Figure 1 below. Any non-compliant vehicles inside of this will be subject to a daily charge. Goods vehicles (as well as taxis and buses) are likely to be part of the scheme. It is possible cars may also need to be included if sufficient reductions in air pollution cannot be achieved without them.

As the plan is to use the LTM to assess these schemes it is necessary to show how well the model validates against observed data in the area influenced by the schemes. This report sets out the level of validation achieved in these areas.

Figure 1 – Potential CAZ Boundaries



1.3 Implications for Leeds Transport Model

As part of the evaluation of the CAZ, the structure of the Leeds Transport Model (LTM) will need to be modified. The modifications will cover changes to the Base model matrices to create new user classes covering compliant and non-compliant cars, LGVs and HGVs. The splitting of the car, LGV and HGV base year matrices will use the same factors across all OD cells as no evidence exists to show variation across Leeds or the wider model area. Separate factors will however be applied by vehicle type. In the base year, routing of vehicle will not change within the CAZ version of LTM and therefore the results from the non CAZ base year model are still applicable. It is these results that are presented in this report.

1.4 Structure of the Report

The remainder of this report sets out the following:

Chapter 2: Proposed use of the model in respect of the CAZ scheme

Chapter 3: Validation of the Trip Matrices

Chapter 4: Validation of the Assigned Flows

Chapter 5: Conclusions

Appendix A presents some scatter plots of observed and modelled flows at a screenline level.

2 Proposed Uses of the Model

2.1 Introduction

The 2015 LMVR for the full model outlines the original proposed use of the model and associated appraisal techniques. In general, the model is required to provide the necessary output to conduct Value for Money appraisals and produce major scheme business cases for Transport Improvement schemes through the West Yorkshire Plus Transport Fund (WY+TF). The CAZ assessment represents a new requirement for the model.

2.2 CAZ

The proposed approach for modelling and appraising criteria for the CAZ has been set out by DfT/Defra and LCC. This includes the requirement of a Transport model review documentation relating to the model that is to be adapted to assess the CAZ scheme.

Although the LTM Highway Model LMVR covers WebTAG requirements, there is little requirement to present analysis and comparison between observed and modelled flows of LGV and HGV within the study area. These are generally only reported as part of the total flow.

This document provides reporting of the LGV and HGVs using the same screenlines and cordons as the car and total flows in the main LMVR. This is done across the Leeds fully modelled area.

The expected responses from the CAZ scheme are set out in Table 1 below.

Table 1: CAZ Responses and Modelling Approach

CAZ Response	Modelling Approach
Fleet replacement – the charge may cause some vehicle owners and operators to replace a non-compliant vehicle with a compliant one, particularly if they are regular users of the roads within the designated area. The number of operators doing this will be a function of the size of the charge, the area covered and the stage each vehicle is in the normal replacement cycle. For example an owner or operator may not wish to replace a vehicle that has just recently been purchased. Some larger operators may have the opportunity to swap vehicles between depots or routes so that the non-compliant vehicles do not operate within the CAZ.	To be considered outside of LTM and input as a set of factors which will move trips from the non-compliant matrices to the compliant matrices.
Re-routing – some non-compliant vehicles which are currently passing through the CAZ without an origin or destination in the zone may re-route around the edge of the zone in order to avoid paying the charge. The number re-routing will depend on the size of the zone, the scale of the charge and the level of congestion on the alternative routes.	This will be modelled by applying a charge to links and centroid connectors around edge and within the CAZ area. The re-routing responses in the existing model will be sufficient for the CAZ response.
Re-distribution of trips – some non-compliant vehicles may stop servicing clients within the CAZ and serve clients in other areas. We expect that if this was to happen then those clients will still have requirements and these will be served by operators who have compliant vehicles. Overall the number of trips may not change but there will be a switching of the vehicle type used, both inside and outside of the zone.	The existing redistribution responses within LTM will enable an approximation of this CAZ response to be reflected.
Mode choice – some car trips could change mode to public transport or active modes in order to avoid the charge.	The existing mode choice within LTM will enable this response to be estimated.
External Schemes – some form of Park and Ride or freight logistics centre or transhipment depot could be set up outside the zone to transfer goods from non-compliant vehicles into compliant ones for delivery within the zone.	Usage of Park and Ride can be estimated within LTM for car based trips however LTM does not have the functionality to model the responses to a freight transhipment scheme.

LTM no longer has income segmentation therefore the car responses are not as precise as they could otherwise be.

Capabilities on project:
Transportation

In order to show that the model is suitable for the intended use it is necessary to consider its performance against four criteria:

- Does the model have the required functionality to assess the scheme.
- How well do the modelled screenline flows compare against observed data across the whole of the modelled area and within the City centre. This should be reported by vehicle type and across all modelled time periods. The purpose of this check is to understand whether there is the correct amount of traffic in the model and that it is split between vehicle types appropriately.
- How well do modelled flows compare with observed data at an individual link level across the whole of the modelled area and within the City centre. This should also be reported by vehicle type and across all modelled time periods. The purpose of this check is to understand whether traffic is routing correctly through the network.
- How well do modelled journey times compare with observed data. This should be reported by individual time periods. The purpose of this check is to show that travel costs are being estimated sensibly in the model.

The original version of LTM does not have all the functionality required to assess the CAZ scheme however changes have been made so that an assessment of the impacts set out in Table 1 can be estimated.

The results of the flow and journey time tests are set out in the following sections.

3 Trip Matrix Calibration and Validation

3.1 Introduction

The purpose of this Chapter is to show that the calibration of the travel demand matrices in the updated Leeds Highway Model is sufficient to meet the needs of the CAZ scheme within Leeds.

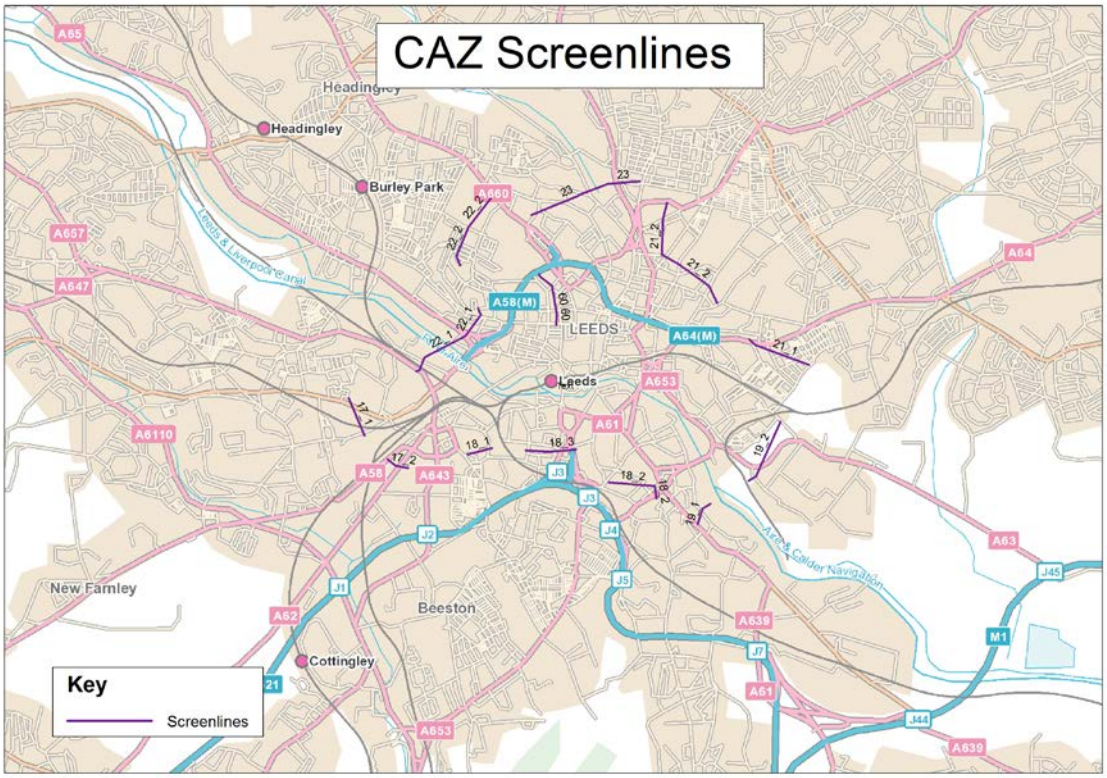
This Chapter should be read in conjunction with Chapter 10 of the 2015 LTM LMVR.

The matrix estimation process was undertaken in a two stage process. Firstly, estimation was applied using only the calibration screenlines. Following the completion of that process a second estimation run was undertaken. This used all screenlines (calibration and validation). The reasoning behind this was to make maximum use of the available data to improve the quality of the model providing the inclusion of the additional data did not distort the demand matrices in an unreasonable way. The 2015 LTM LMVR sets this out in more detail and presents the results of the tests undertaken to examine the impact that this had on the matrix. The conclusion was that the change was acceptable and it led to a more accurate comparison against observed data therefore the version of the model with all screenlines has been taken forward and used as the base year model.

3.2 Screenlines

For the purposes of assessing the quality of matrices in relation to the CAZ scheme we have considered all the screenlines within or close to the ORR. In addition we have reported a sub set of these that are close to or within the IRR see Figure 2. Statistics on the performance of the whole modelled area are reported the 2015 LMVR with selected information reproduced below.

Figure 2: City Centre Screen-lines used in LTM calibration and validation



3.3 LGV & HGV Matrix Assigned Flows and Observed Flows at Screenline Level

The WebTAG acceptability guidelines state that the modelled flow crossing all or nearly all screenlines should be within 5% of the observed flows. WebTAG specifies that this criterion applies to All Vehicles and Cars, not however for LGVs and HGVs. For the purpose of this report and the review of modelled LGVs and HGVs across the screenlines, the 5% pass criterion is still used. However, due to the low level of flow across many of the screenlines for LGVs and HGVs, small total difference amplify percentage differences significantly causing many screenline with low flows to fail, therefore a GEH criterion is also used at a screenline, incorporating both relative and absolute errors, defined as the following:

$$GEH = \sqrt{\frac{(M-C)^2}{(M+C)/2}}$$

Old versions of WebTAG suggested an acceptability criterion of 4 for screenlines. This has been used to provide an alternative assessment of the LGV and HGV validation.

For the percentage passing criterion a “graduated criterion”, reflecting the number of count sites per screenline was used in the 2015 LMVR. This assumes that the fewer counts making up a screenline, the greater the variability in the sum of the counts. It was assumed that if the screenline consisted of only one count, then an individual count criterion would apply i.e. within 15%. For screenlines up to 5 counts we have set the value of the criteria on a pro rata basis as set out in **Table 2**. This approach has also been applied to the values in this report.

Table 2: Acceptability Criteria for Short Screenlines

Number of counts in Screenline	Acceptability Criteria
5	5% (as per WebTAG)
4	7.5%
3	10%
2	12.5%
1	15%

Table 3 to Table 6 below show screenline performance summarised at model area for all individual time periods and all periods combined using two indicators; the standard WebTAG one and the alternative based on GEH as discussed above.

Table 3: Screenlines Meeting WebTAG Criteria – Whole Model

	700	800	900	IP	1600	1700	1800	All Periods
Cars	98%	97%	98%	99%	97%	96%	99%	98%
LGVs	86%	84%	89%	93%	89%	85%	87%	88%
HGVs	57%	68%	67%	71%	54%	47%	46%	59%
All Vehicles	97%	97%	98%	99%	97%	93%	98%	97%

Table 4: Screenlines Meeting WebTAG Criteria – City Centre

	700	800	900	IP	1600	1700	1800	All Periods
Cars	100%	94%	91%	100%	94%	91%	97%	95%
LGVs	85%	88%	92%	100%	88%	81%	88%	89%
HGVs	77%	85%	92%	92%	69%	65%	73%	79%
All Vehicles	100%	97%	91%	100%	97%	88%	97%	96%

Table 5: Screenlines Meeting Alternative Criteria (GEH < 4) – Whole Model

	700	800	900	IP	1600	1700	1800	All Periods
Cars	97%	98%	95%	98%	95%	94%	98%	96%
LGVs	92%	93%	94%	95%	94%	92%	93%	93%
HGVs	78%	80%	78%	81%	78%	80%	73%	78%
All Vehicles	95%	98%	96%	98%	94%	93%	96%	96%

Table 6: Screenlines Meeting Alternative Criteria (GEH < 4) – City Centre

	700	800	900	IP	1600	1700	1800	All Periods
Cars	100%	100%	91%	100%	91%	94%	97%	96%
LGVs	96%	96%	100%	100%	100%	100%	100%	99%
HGVs	100%	100%	92%	100%	100%	96%	100%	98%
All Vehicles	100%	100%	91%	100%	91%	91%	97%	96%

Comparing results in Table 3 and Table 4 there is no significant difference between the City Centre and the whole of the model area however, there is an evident difference in the proportion of screenlines passing between the different vehicle types. As noted above this is a result of the generally lower flows for LGVs and HGVs. The criterion used in this test is not considered to be as appropriate for these vehicle types as it is for cars. The value for cars is always above 90% and in many cases it is above 95%.

With the GEH criterion Table 5 and Table 6 we see a significant improvement in the results for LGVs and HGVs. These are in line with the values for cars, particularly in the City Centre and would be considered to be equally acceptable. Furthermore, scatter plots within the attached appendix highlight a good correlation between modelled and observed LGV and HGV screenline flows.

3.4 Model Stability and Convergence

Following the final run of matrix estimation a check of the convergence statistics in the model was carried out, all model and convergence statistic including LGV and HGV statistics have been summarised in section 10.5 of the 2015 LMVR

3.5 Impact of Matrix Estimation on the Prior Matrix

As advised by WebTAG Unit M3.1, the changes brought about by matrix estimation should be carefully monitored to demonstrate that matrix estimation does not significantly alter the character of the matrix. All matrix estimation impact statistics can be found in the 2015 LMVR, Section 10.6, which includes the following

- matrix zonal cell values;
- trip end totals by origin and destination zone;
- trip length distributions; and
- sector to sector movements.

All of these checks have been carried out separately for each modelled time period and each vehicle type. As mentioned within the full LMVR, the impact of Matrix Estimation has produced some statistical differences between prior and post matrices for the HGV user class. This is due to the estimation process including a number of counts external to Leeds on the motorway network. This is outside the fully observed area of the matrix (i.e. was not covered by RSI surveys in the development of the prior matrix during preparation of 2008 model) meaning that the volume of HGVs on the motorway network was originally understated in the prior. So although there is statistical difference between the post and prior HGV user class, the estimation process has aided in producing a more accurate HGV flow profile in the external areas of the model. All of which has only a negligible impact on the CAZ study area.

3.6 Summary and Conclusions

This section has shown that the comparison between observed and modelled flows at a screenline level in the model is acceptable across all three vehicle types and across all time periods for the model to be used for assessing a CAZ scheme which is applied at the IRR or ORR boundaries.

4 Assignment Calibration and Validation

4.1 Introduction

Having established that the demand matrices are of a suitable standard for use in the CAZ work it is necessary to check that the assignment of these to the road network uses sensible paths. In order to judge this it is necessary to look at the flows on individual links and compare these against observed data. This section looks at the base year model on completion of the calibration process.

4.2 WebTAG Criteria

WebTAG sets out different criteria for individual count locations. These are dependent of the level of flow at the location as set out below:

- Flows less than 700 per hour should be within 100 of the observed value;
- Flows between 700 and 2700 should be within 15% of the observed value; and
- Flows above 2700 should be within 400 of the observed value.

4.3 Assignment Validation Post Estimation

The assignment validation of the model has been undertaken against a set of traffic counts at individual locations. The comparison of the modelled flows is presented in Table 7 and Table 8 for the whole of the model area and the City Centre respectively. Values are reported by modelled time period and vehicle type.

Table 7: Individual Sites Meeting WebTAG Criteria – Whole Model

Time Period	Car	LGV	HGV	Total Vehicle
0700	80%	97%	93%	76%
0800	75%	98%	95%	73%
0900	79%	98%	93%	82%
IP	87%	98%	95%	85%
1600	82%	96%	94%	80%
1700	73%	97%	95%	73%
1800	82%	99%	96%	83%
All Day	80%	98%	94%	79%

Table 8: Individual Sites Meeting WebTAG Criteria – City Centre

Time Period	Car	LGV	HGV	Total Vehicle
0700	83%	100%	100%	84%
0800	76%	100%	99%	76%
0900	90%	100%	100%	86%
IP	93%	100%	100%	95%
1600	91%	100%	100%	89%
1700	77%	100%	100%	79%
1800	93%	100%	100%	94%
All Day	86%	100%	100%	86%

These results show that there is a slightly higher level of validation in the city centre compared with the whole model. The whole model values are generally over 75% which is good for a model of this size and complexity. In the city centre the values are always above 75%, with the average over all time periods being above 85%. Values for LGVs and HGVs are generally higher than those for cars.

While the level of flow validation in the city centre generally meets the recommended level in WebTAG (85%) the same is less true for the model as a whole. However, the level of validation achieved across the whole model is still considered acceptable as the CAZ charges will only be applied at an area level and not on single roads.

4.4 Journey Time Validation

Journey Time validation for LGVs and HGVs are assumed to be the same as Cars. Although in some instances journey time for HGVs in particular are considered to be on average longer than car trips, especially on motorways and road with national speed limits, the majority of Journey time routes within the LTM are within urban areas, hence journey times are assumed to be comparable. Full Journey time validation results can be found in section 11.5 of the 2015 LMVR. A summary is provided in Table 9 below. These are for the whole model area. Many of the journey time routes start and end in the city centre and therefore separate results are not provided for the city centre. As mentioned in the LMVR, the overall proportion of routes passing indicates a good level of network calibration for all vehicles although it is recognised that in the 0700, 0800 and 1700 hours the model does not achieve the recommended level in WebTAG (85%).

Table 9: Journey Time Validation

Time Period	0700	0800	0900	IP	1600	1700	1800	All Day
Proportion Passing	80%	78%	87%	94%	98%	78%	93%	87%

5 Conclusions

It is proposed to use the 2015 version of the Leeds Transport Model (LTM) to model the proposed Leeds Clean Air Zone (CAZ). This model will have to be amended slightly in order to do this but none of these changes make a change to the validation of the base year highway model.

The existing validation of the base year model therefore needs to be understood in relation to the three vehicle types (Car, LGV and HGV) which could be affected by the CAZ scheme.

These are not always explicitly reported in the original Local Model Validation Report (LMVR) but have been reported here so that a judgment can be made on whether the model is likely to be a good starting point for assessing the CAZ scheme.

Four checks have been made:

- Trip Matrices (total screen line flows)
- The impact of matrix estimation
- Assignment routes (flows on individual links)
- Journey Times

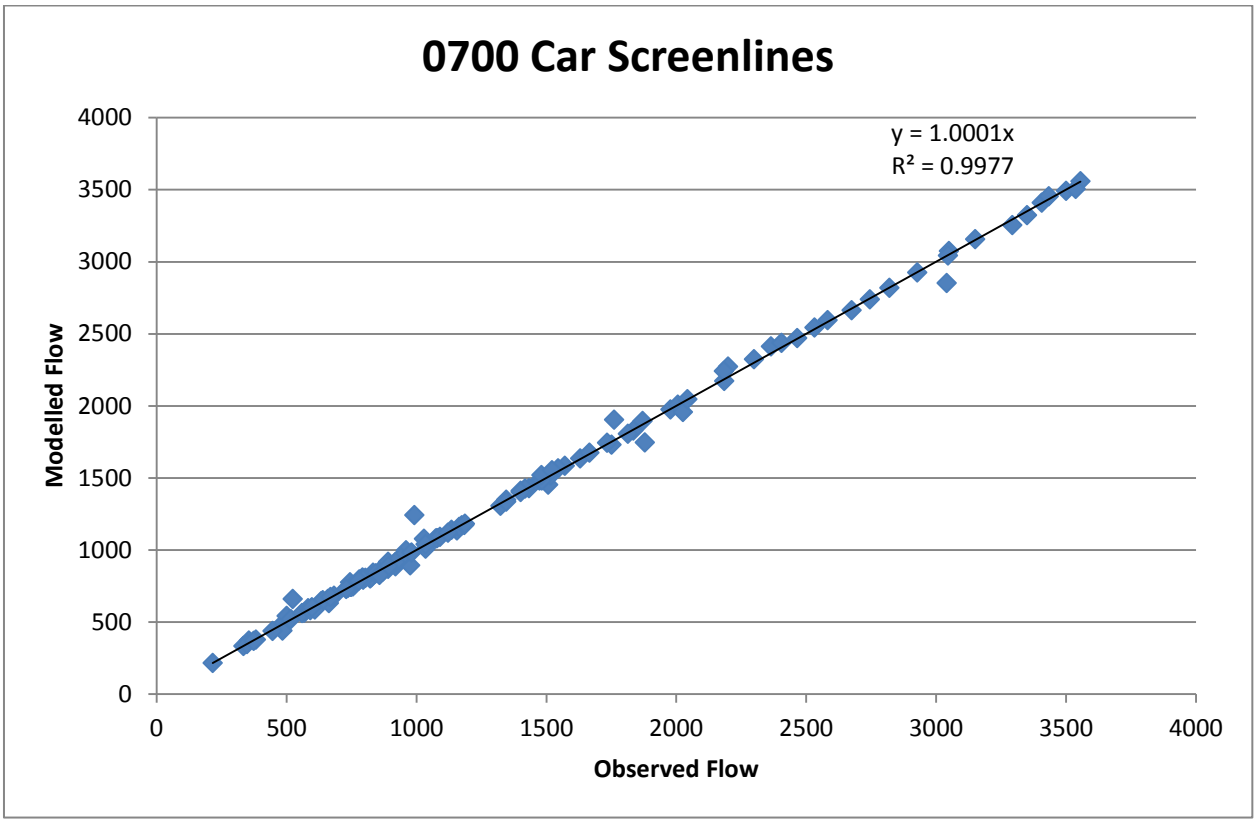
In most cases the acceptability criteria in WebTAG are based on car flows or total flows. It is not always appropriate to apply these directly to LGV or HGV flows as they are generally much smaller volumes. We have however reported against the standard criteria and, where practical, also against alternative criteria.

Taking into account the nature of the CAZ scheme and the level of validation achieved, we consider that the model is an acceptable representation of observed and therefore the model should be a realistic starting point for the CAZ assessment.

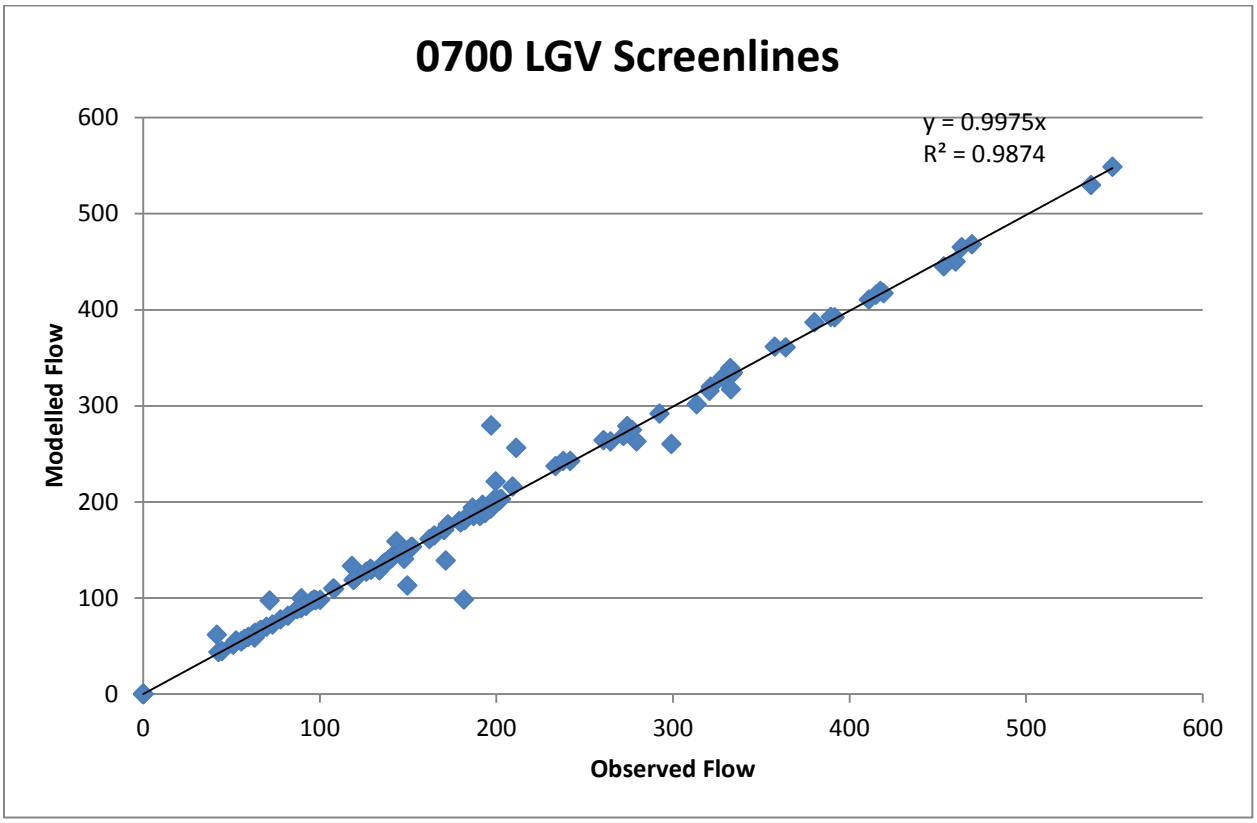
Appendices

Appendix A – Car, LGV & HGV Model vs Observed Screenline Scatter Plots

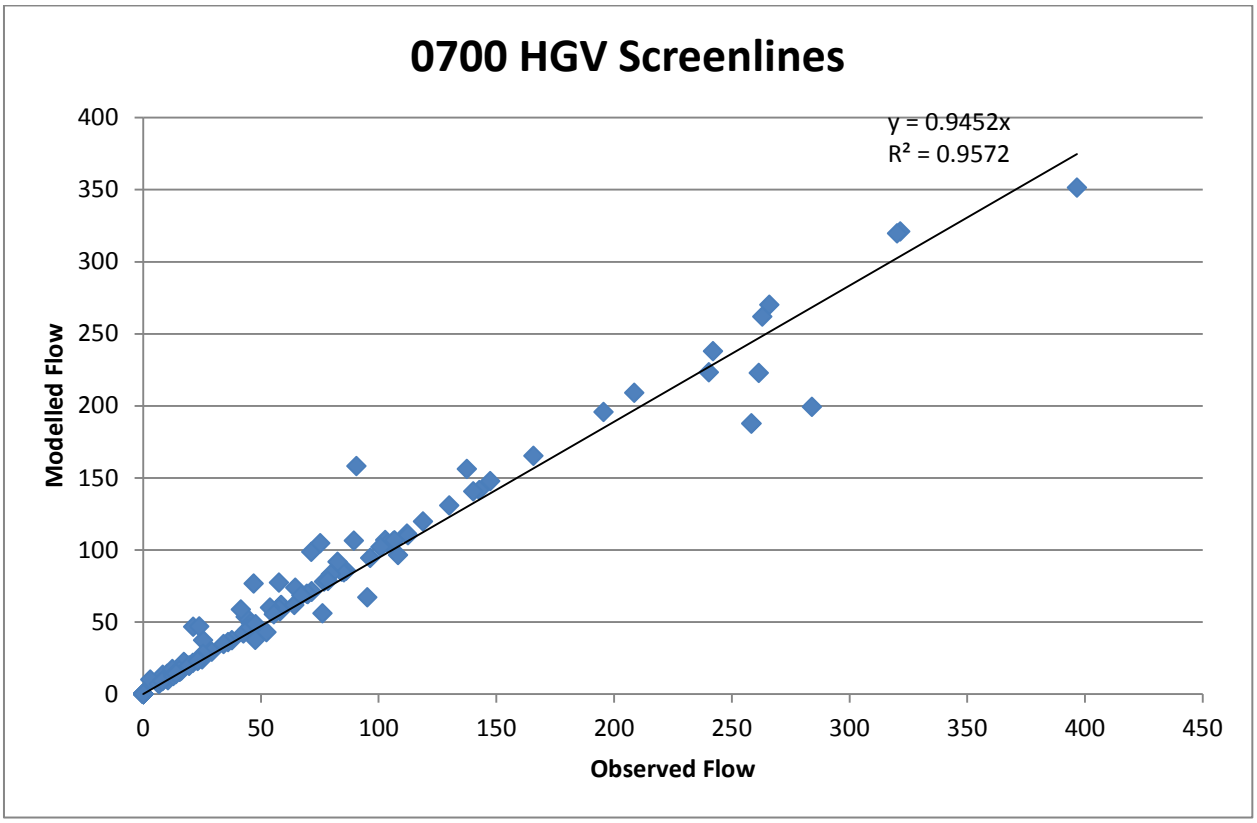
This appendix provides a complete output of screenline results for Car, LGV and HGV Modelled Vs Observed total flows for all time periods, post estimation. Overall, modelled screenlines have a strong positive correlation to observed counts, throughout all time periods.



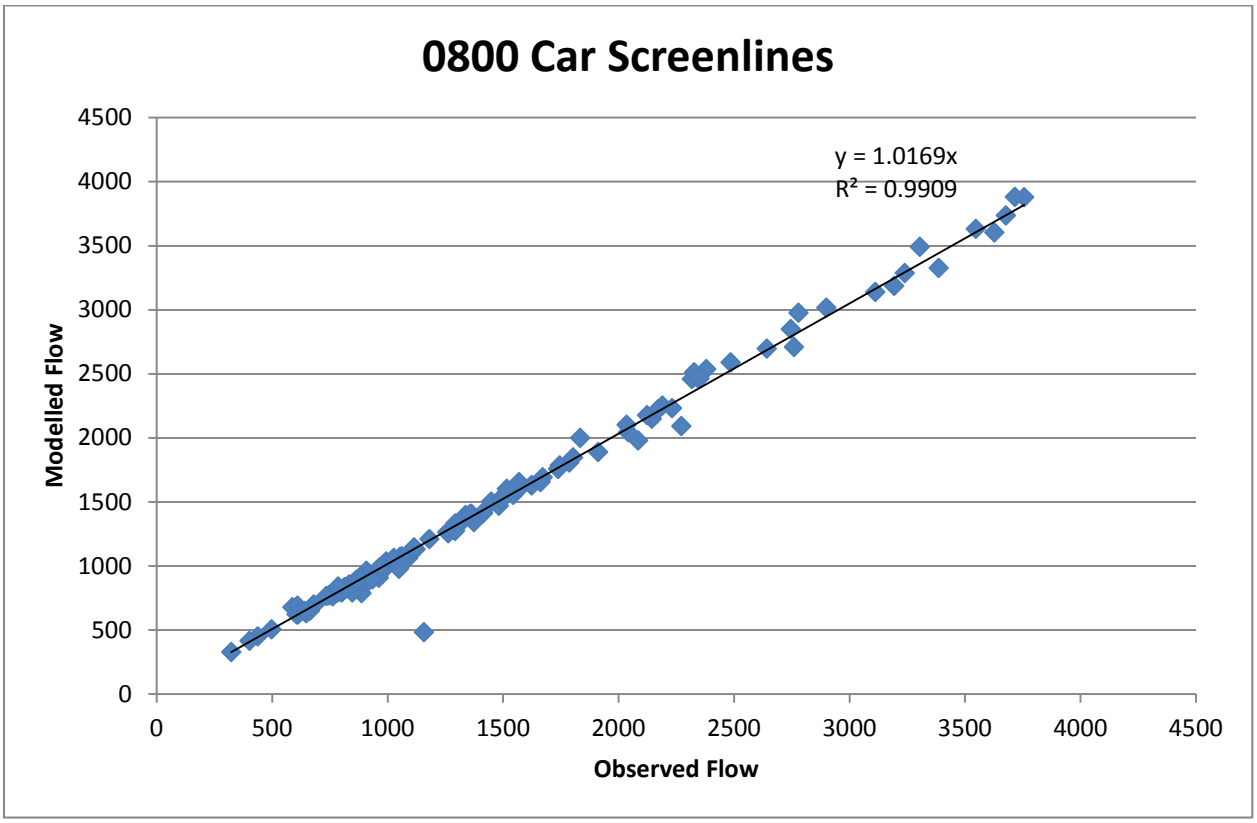
Capabilities on project:
Transportation



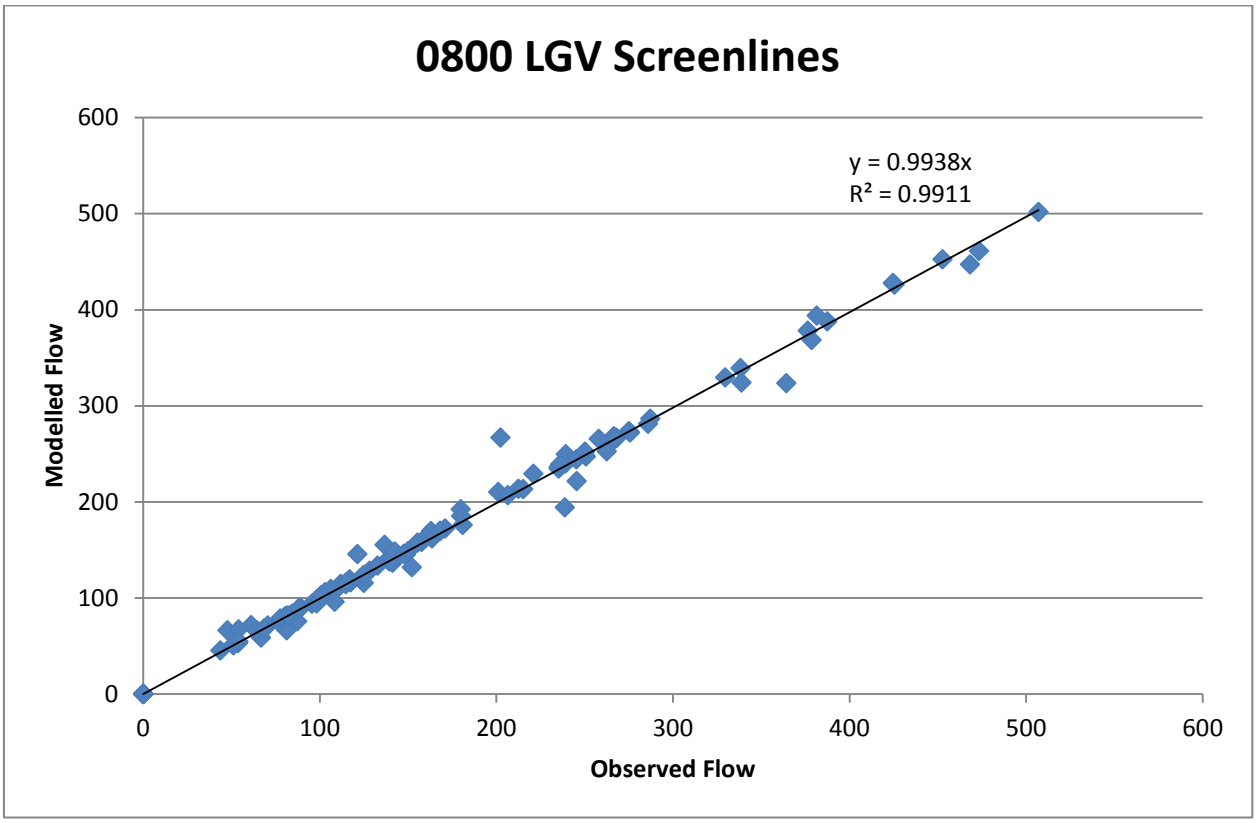
Capabilities on project:
Transportation



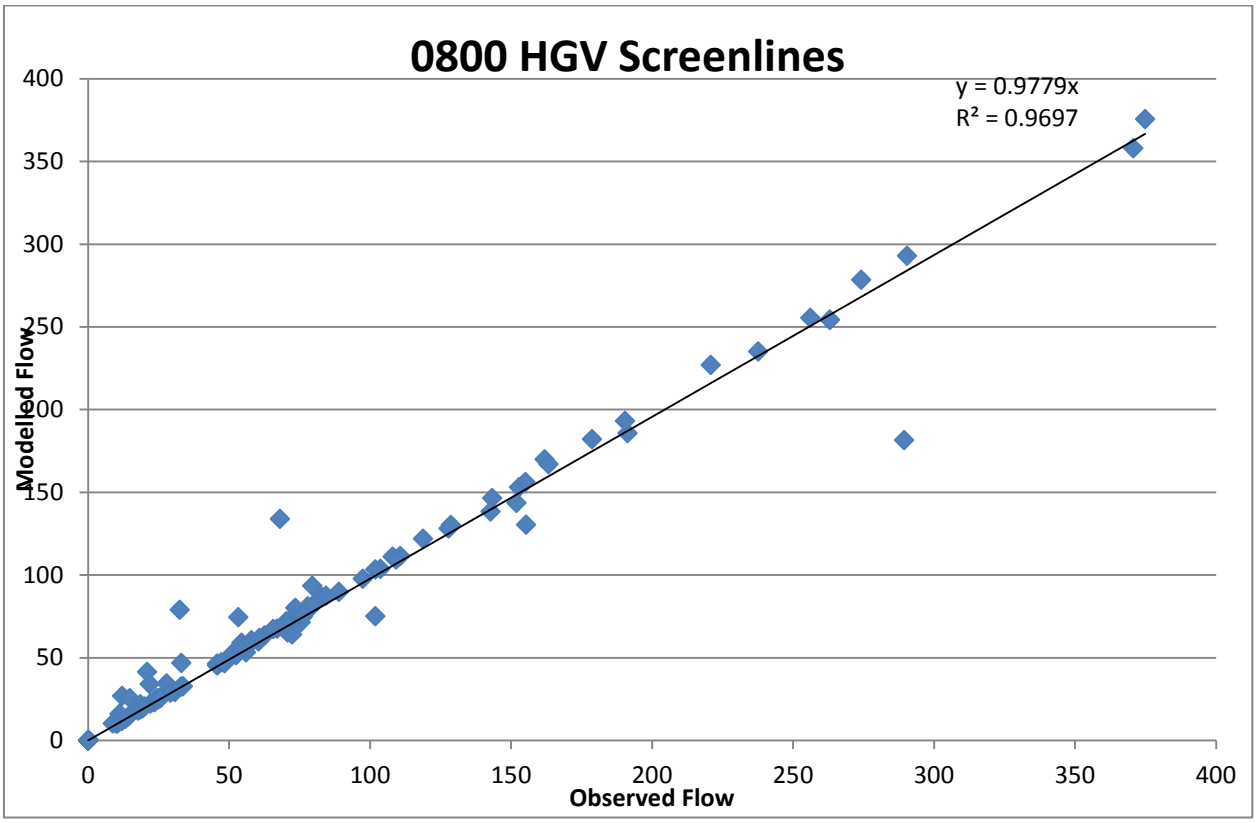
Capabilities on project:
Transportation



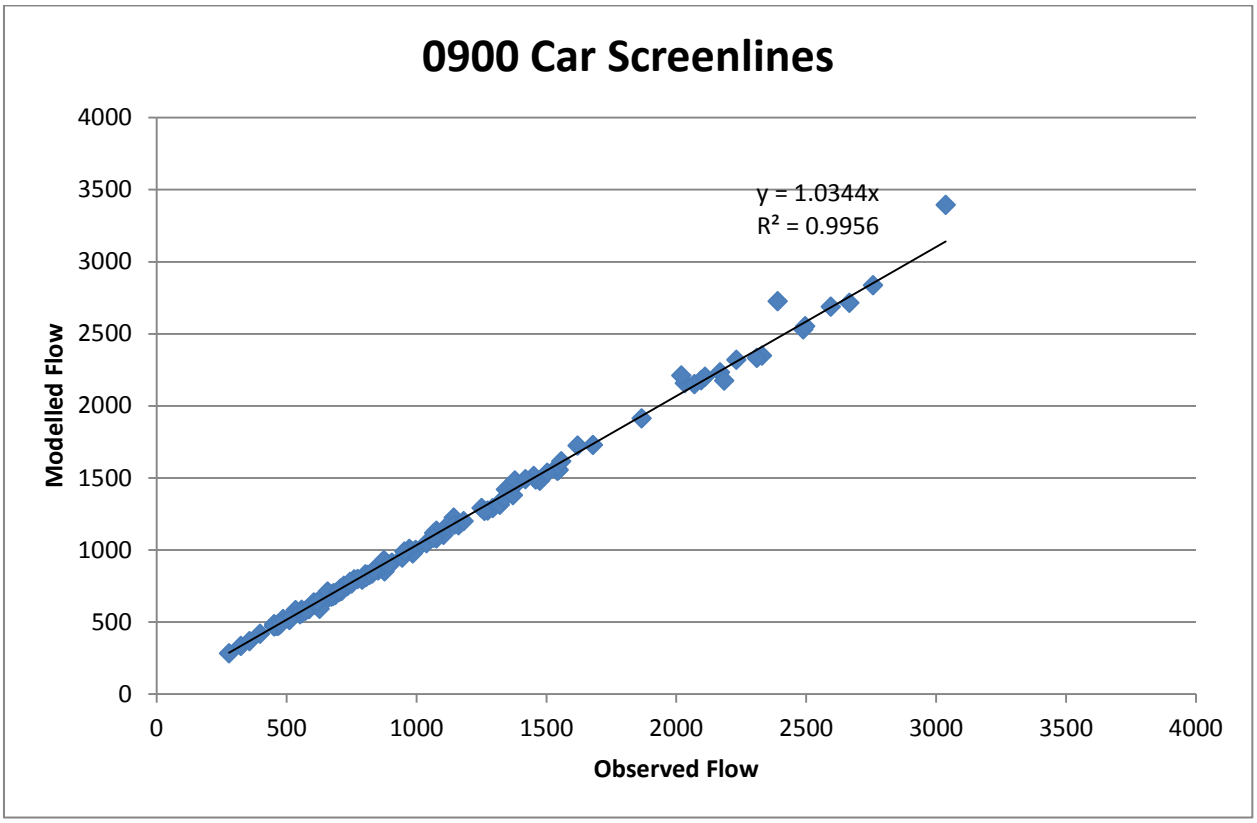
Capabilities on project:
Transportation



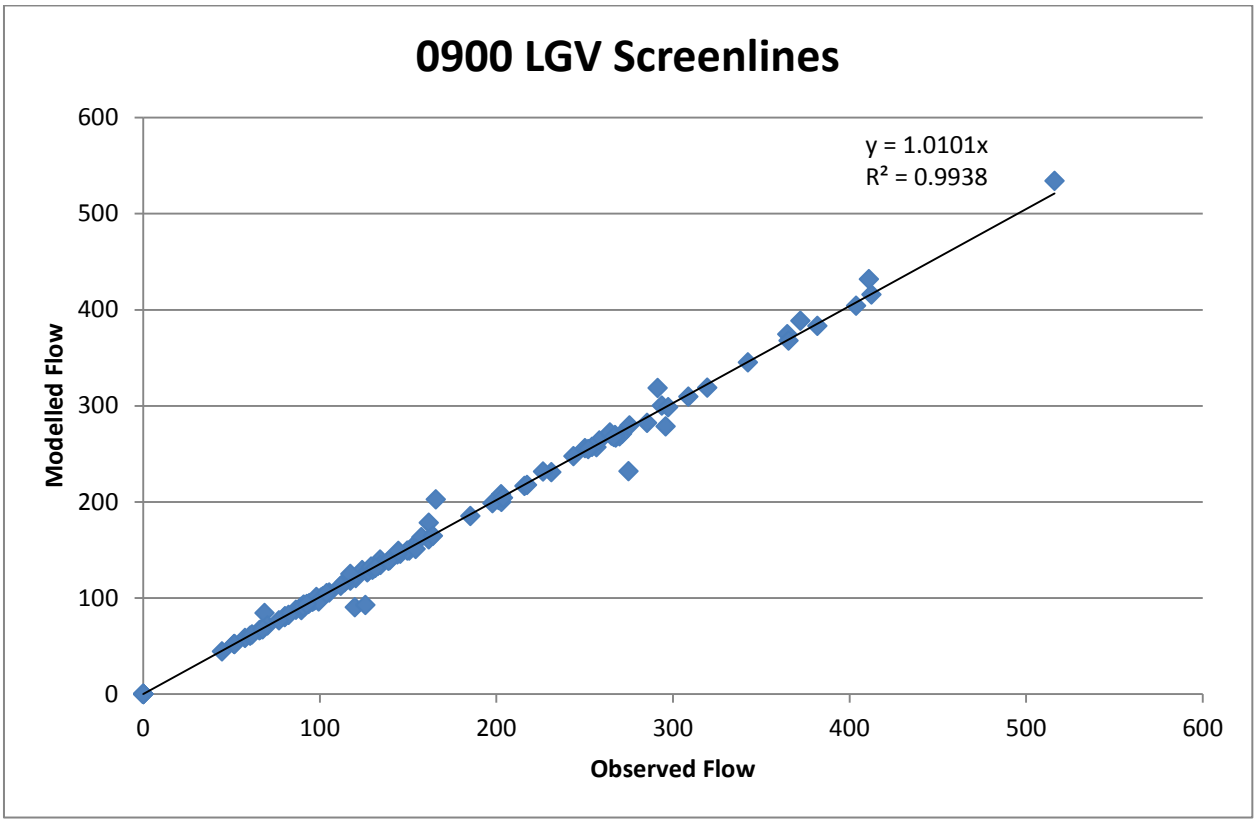
Capabilities on project:
Transportation



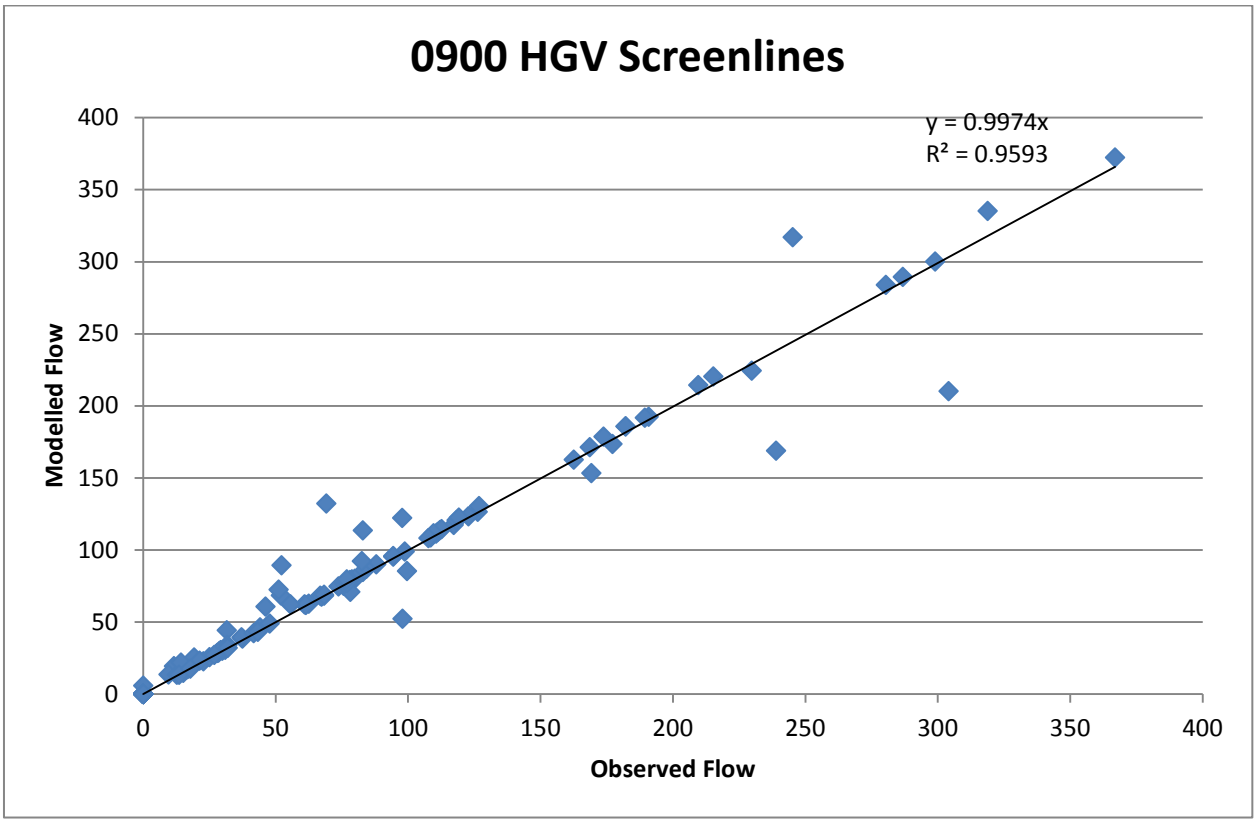
Capabilities on project:
Transportation



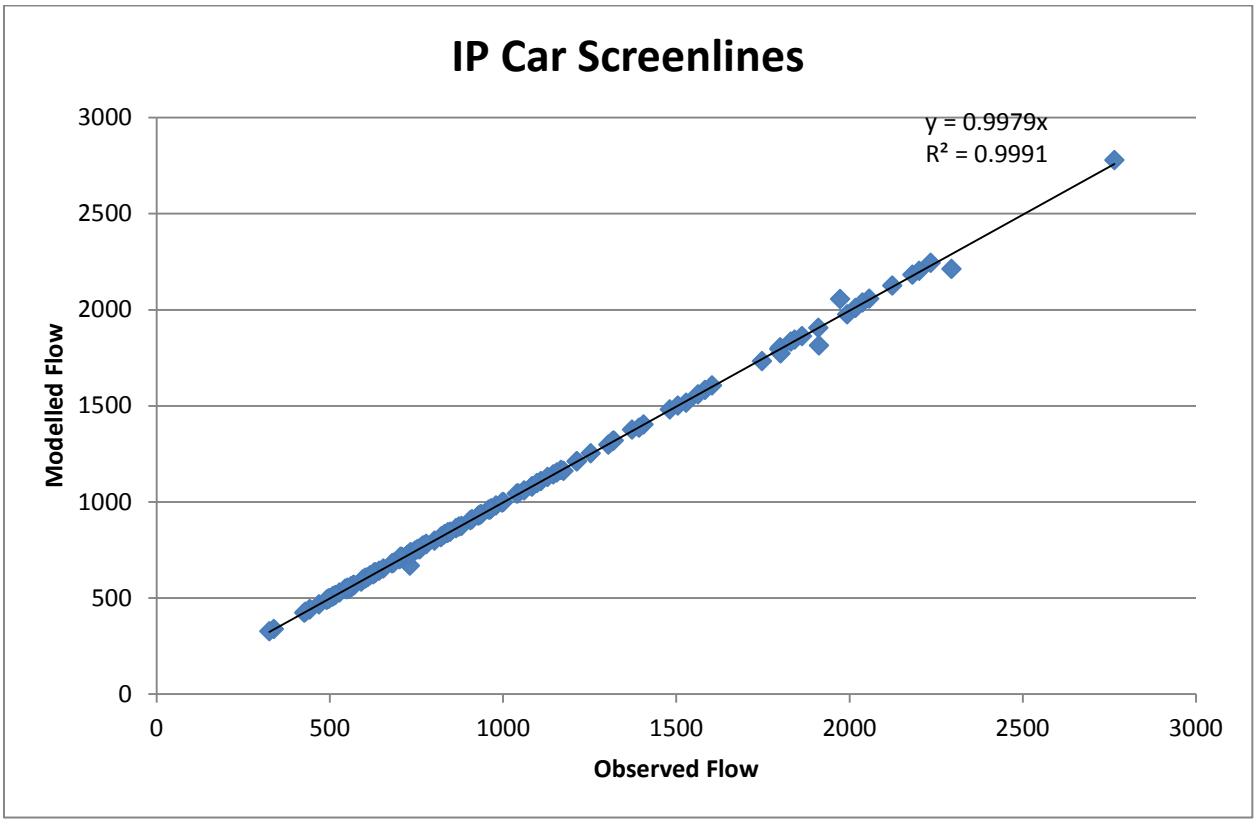
Capabilities on project:
Transportation



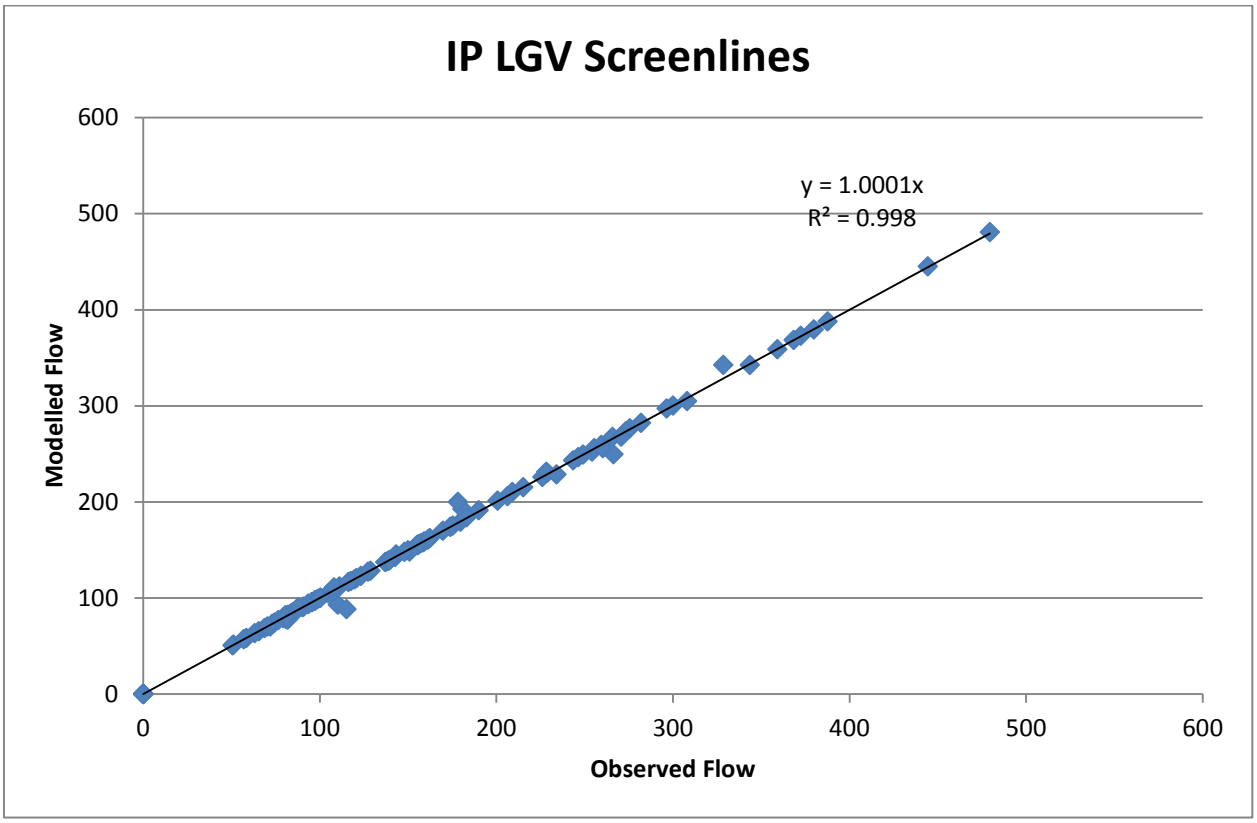
Capabilities on project:
Transportation



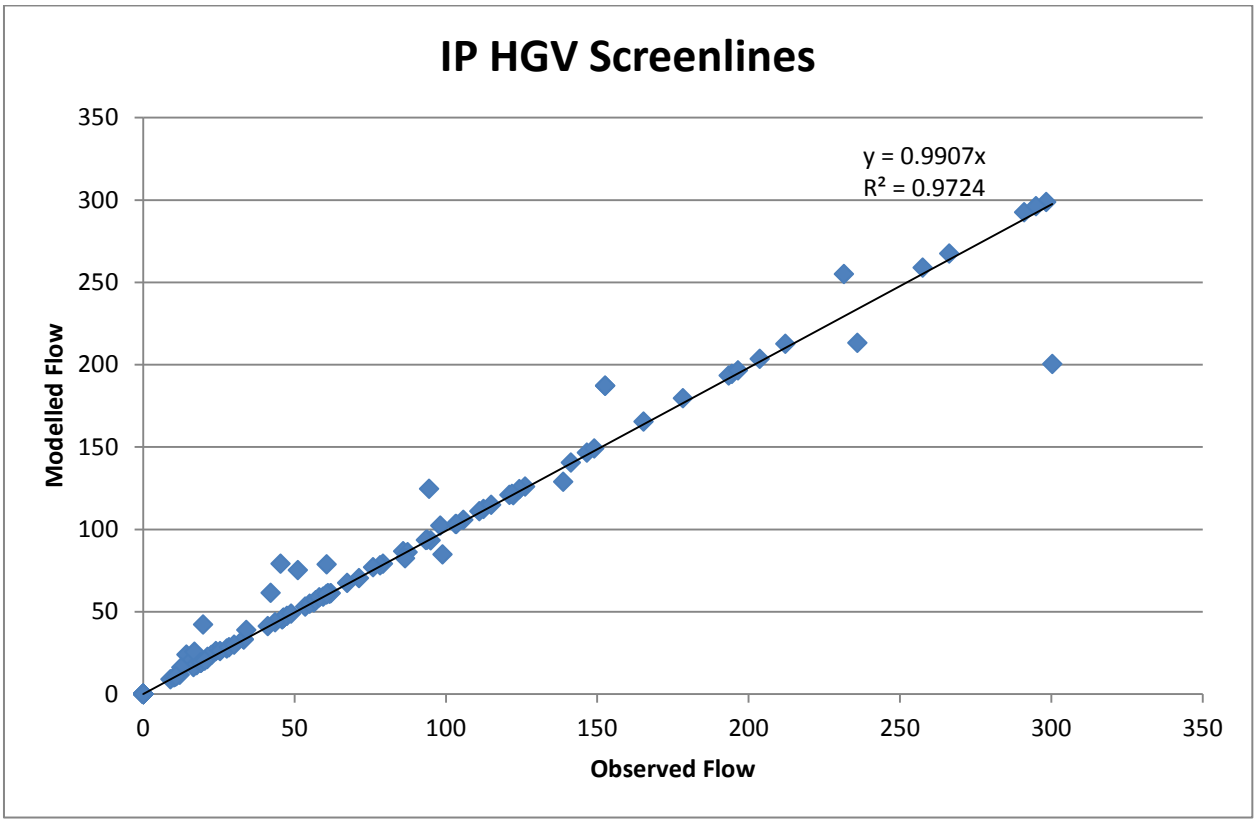
Capabilities on project:
Transportation



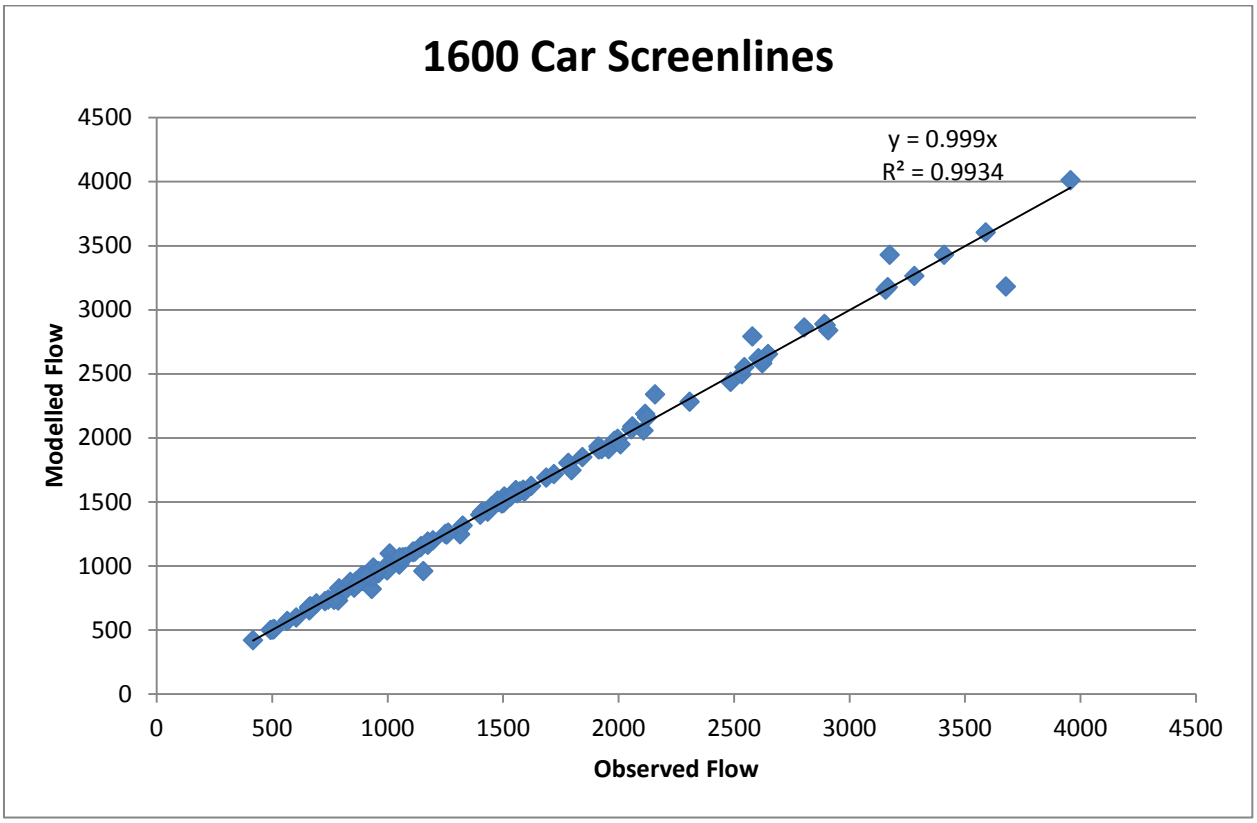
Capabilities on project:
Transportation



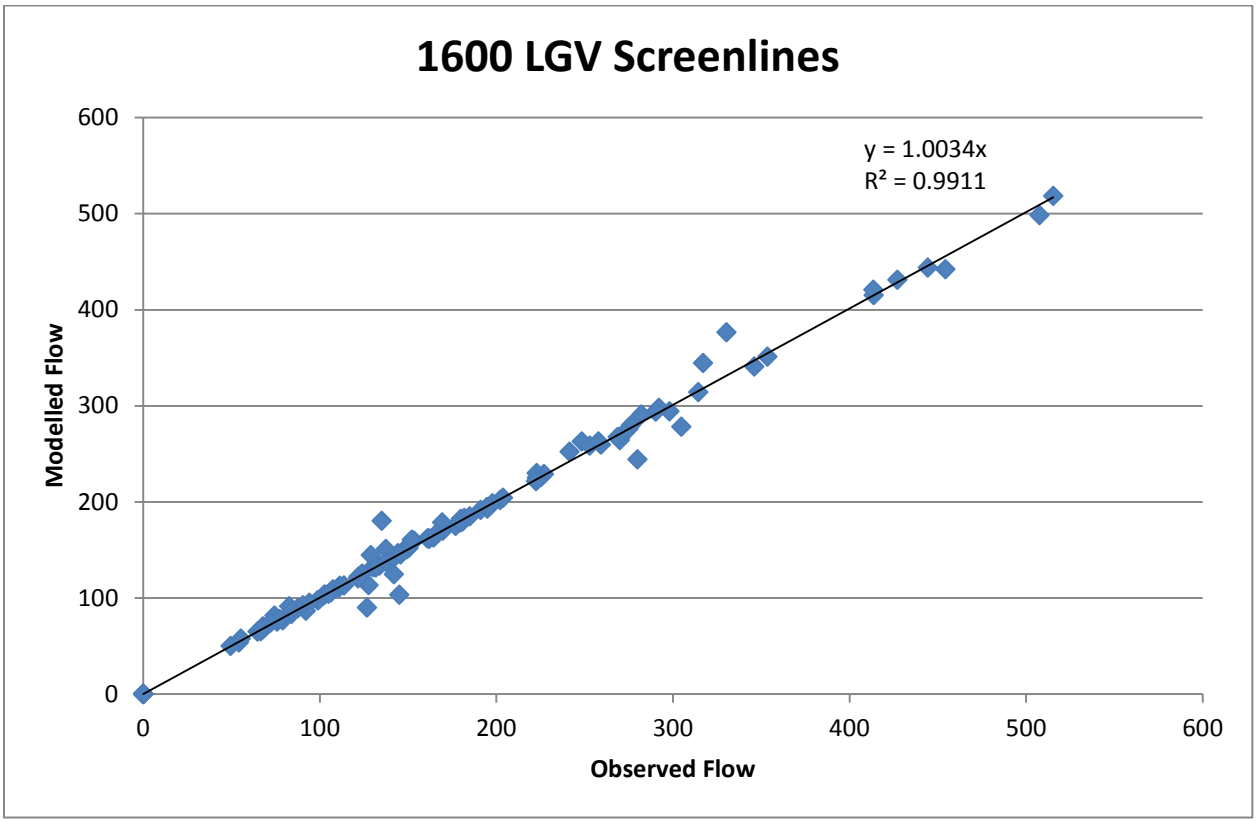
Capabilities on project:
Transportation



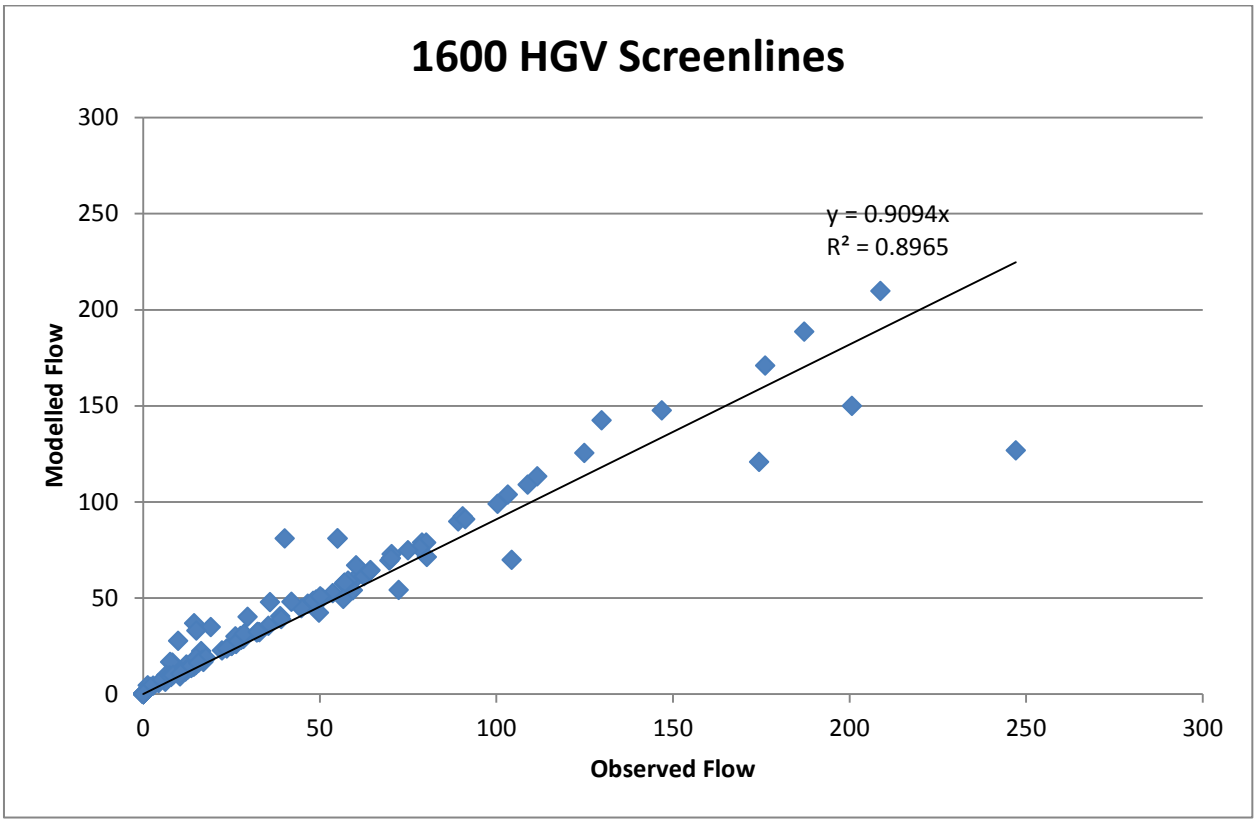
Capabilities on project:
Transportation



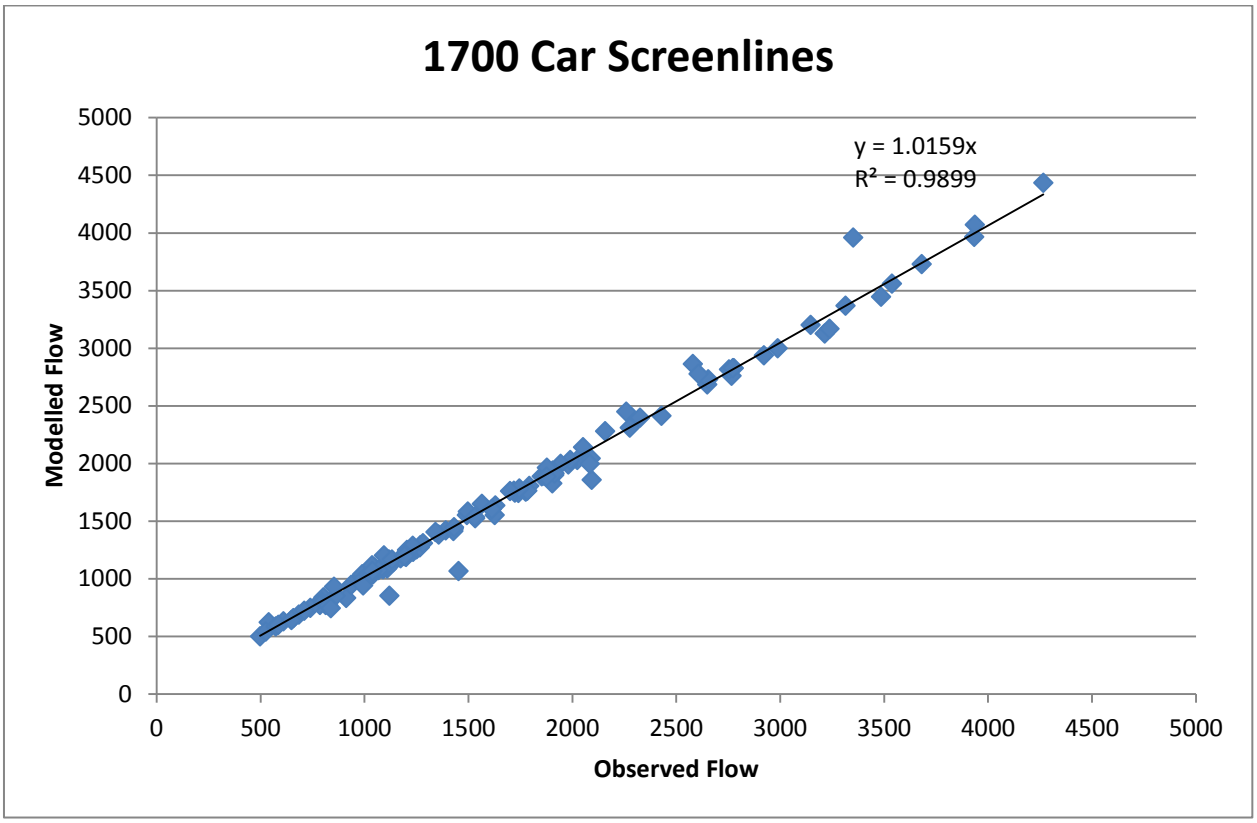
Capabilities on project:
Transportation



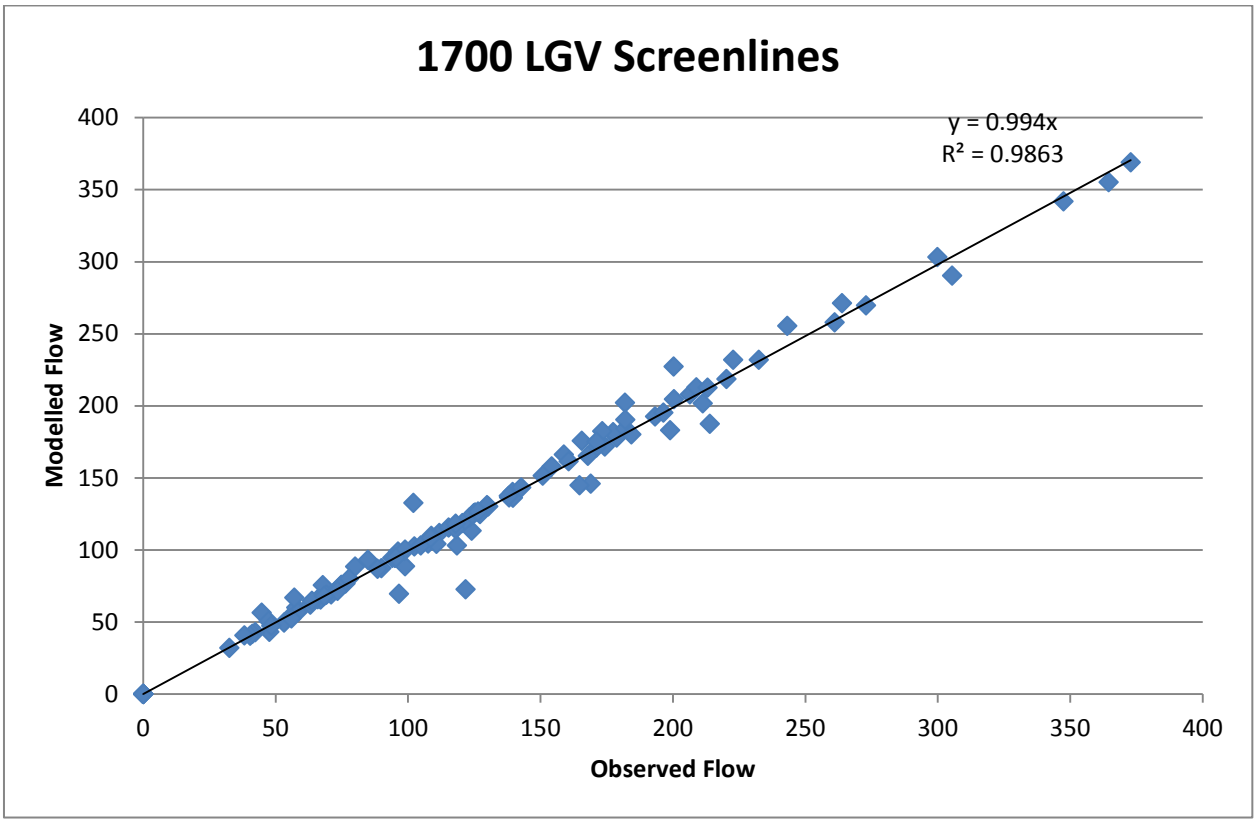
Capabilities on project:
Transportation



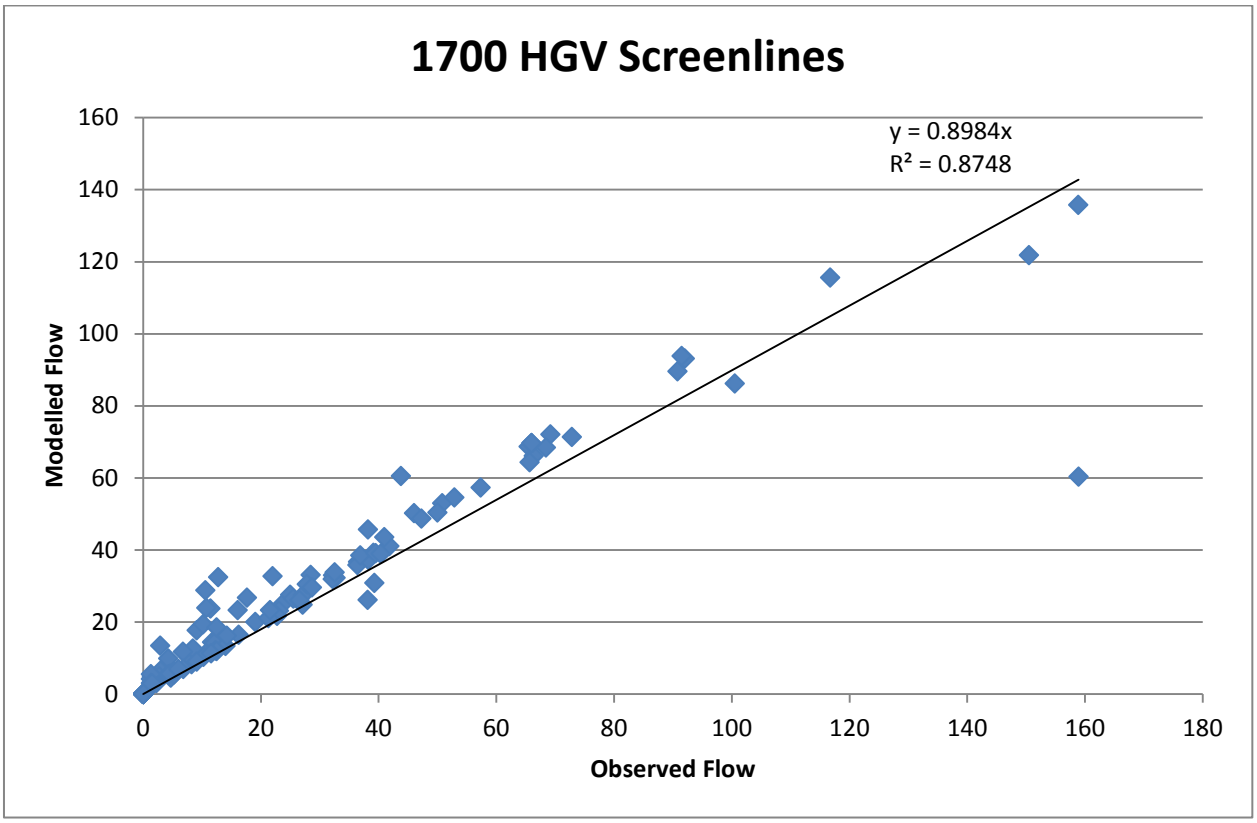
Capabilities on project:
Transportation



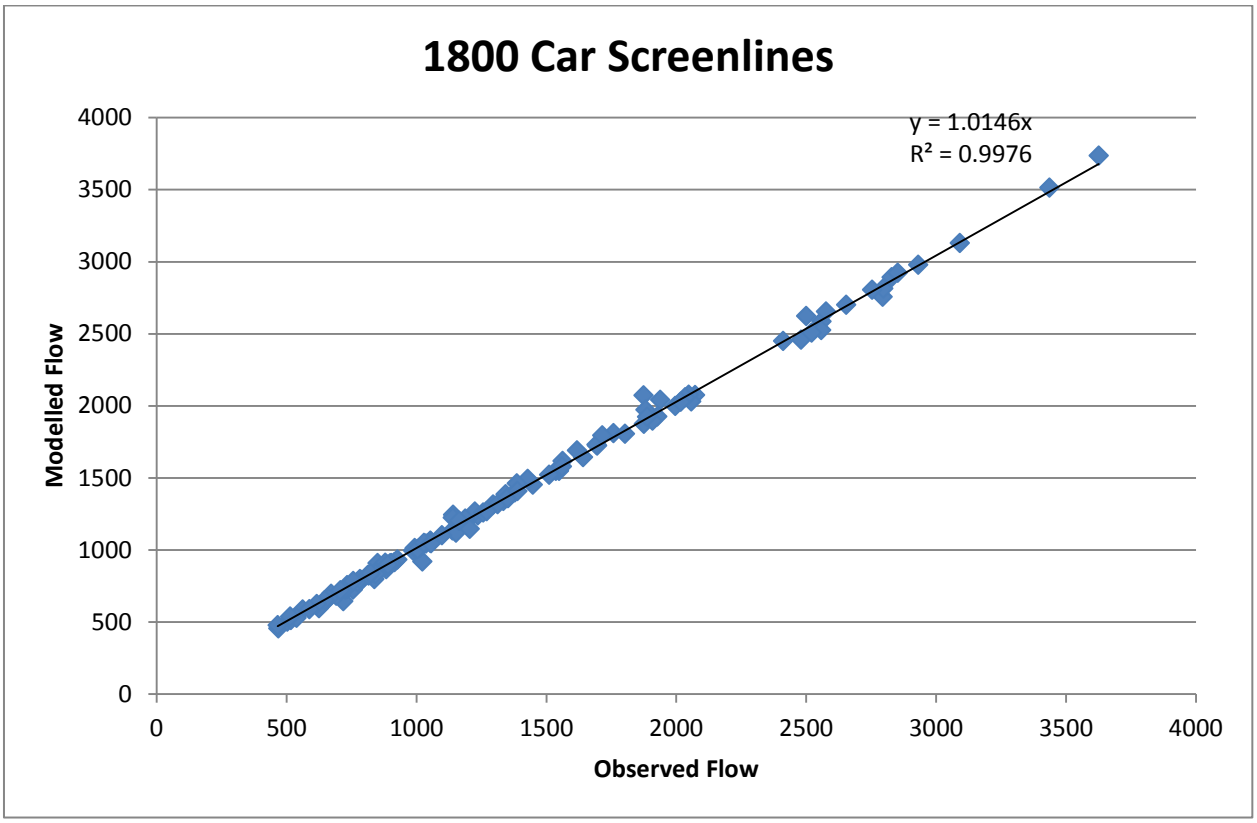
Capabilities on project:
Transportation



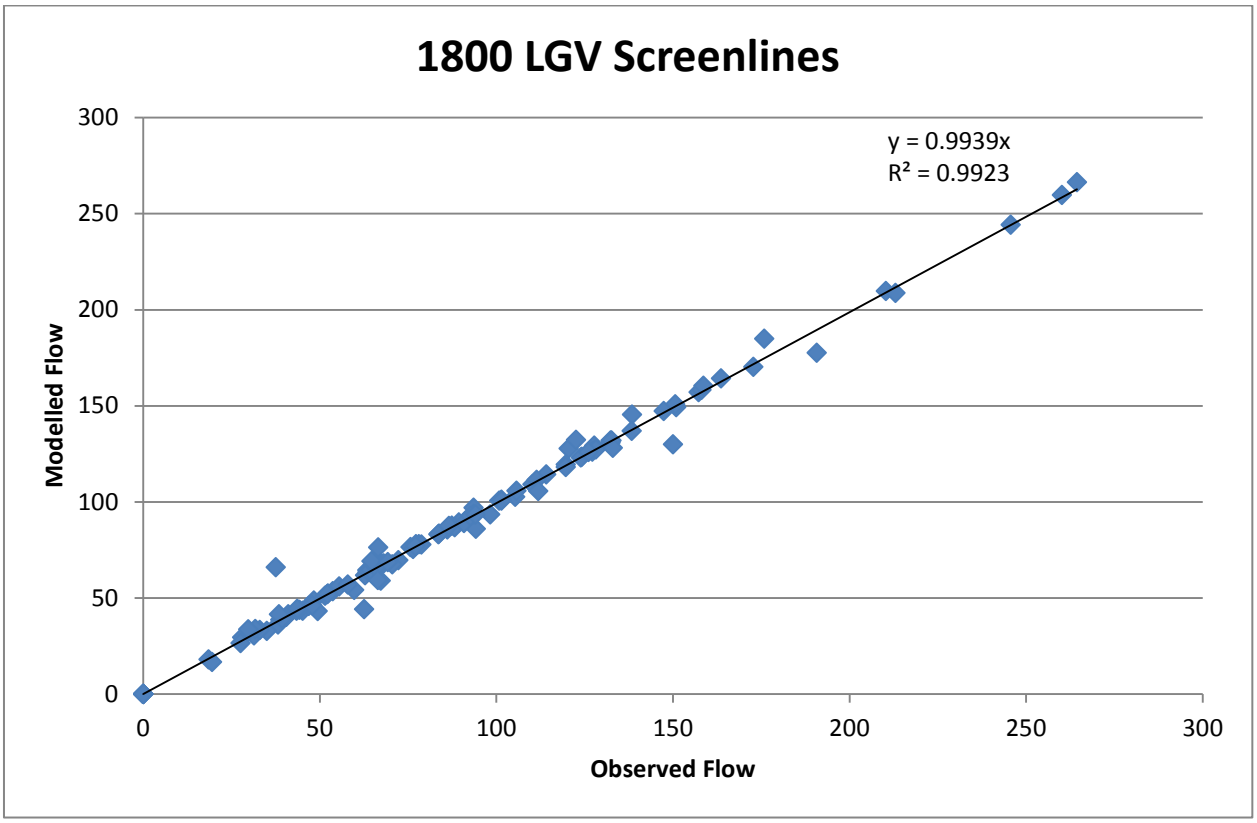
Capabilities on project:
Transportation



Capabilities on project:
Transportation



Capabilities on project:
Transportation



Capabilities on project:
Transportation