ROADWAY SHALLOW WATER FLOW MODELING BY VELOCITY DISTRIBUTION

by

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ABSTRACT

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Manning's equation is a widely used method for determining flow discharge in a channel with unconfined gravity flow. The roughness value, n-value, is a critical factor for Manning's equation to obtain the accurate amount of flow. A precise estimation of Manning "n" is difficult to obtain and varies by investigator justification and experience. Flow on a roadway is a type of open channel flow normally determined by Manning's equation. To ensure reliability and highway safety, the hydraulic geometry dimensions such as spread, depth and discharge must be accurately estimated.

A Texas Department of Transportation Manning's n-value research project collected data on surface roughness and estimate n-value of four different types of

roadway sections; asphalt, asphalt treatment, smooth (worn) concrete and TxDOT's standard concrete surface. This research used full scale roadway sections with the varied flows and longitudinal and transverse slopes. This study focused on estimating n-values for the entire roadway flow width.

A velocity distribution method is used as an alternative method to study the flow characteristic and estimate n-values of each roadway cross-section. The velocity distribution equations use basic geometry data from the TxDOT research. The data for the four types of roadways from TxDOT Manning's n-value research were used as input for the velocity distribution modeling.

The percent accuracy of model simulation is estimated from a comparison of result, discharge and n-value, between the velocity method result and the original TxDOT research data. The modeling utilizes theoretical survey, statistical-analysis, numerical-analysis and flow methods to simulate roadway flow. Statistical analysis such as normality, data cleaning, and outlier detection, were used to improve results.

The results indicate velocity distribution equations are potentially a good method for estimating discharge and n-values for a roadway section. It shows comparable discharge volumes and average n-values to the original TxDOT laboratory result with an acceptable percent of error.

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CHAPTER 1

INTRODUCTION

1.1 Background

Manning's equation has been used for a number of years. It is used in hydraulics to estimate channel discharge. Manning's equation can be used to estimate discharge accurately if the correct roughness, n-value, is used. Innumerable researches have studied channels with the intention to determine exact n-values. Manning's n-values are obtained from roughly estimating channel bottom surfaces and local channel geometry. For natural channels, a bottom surface roughness is estimated through observation of the bed material. Bottom surface roughness is difficult to estimate and often inaccurate due to the vast variable geometric condition of natural channels. Increasing the number of bed material samples can help improve the accuracy of roughness estimation, but increases cost.

A roadway is considered a type of channel flow. It's designed to remove water from the roadway surface. Because of public safety and reliability, a roadway needs to be designed to have adequate discharge capacity. The flow capacity of a roadway depends on both Manning's n-value and the cross-section geometry. An incorrect n-value leads to either under or over estimation of roadway geometry and flow capacity.

Changing longitudinal and transverse slopes significantly change the roadway discharge capacity. In order to achieve sufficient flow capacity, a roadway should be designed with as accurate n-value and factors of safety as possible.

1.2 Flow Simulation with Velocity Distribution Method

The velocity distribution method is found to be very useful to obtain a stream velocity without numerous physical measurements. It is used to calculate average discharges of a channel. This method considers many geometry conditions such as longitudinal slope, surface roughness, hydraulic depth, and cross-section area of a channel. The velocity distribution method is capable of simulating flow distributions in any shape of channel such as triangular, rectangular, and trapezoidal, including symmetric and non-symmetric cross-section channels. It uses average surface roughness height to calculate flow in channels. Since the velocity distribution technique requires many conditional parameters such as friction velocity, average roughness height, and critical roughness, it can provide accurate discharge estimations.

This research expands upon the TxDOT roadway roughness project. The TxDOT project studied flow over roadway roughness surfaces and evaluated a single Manning's n-value for each roadway surface. The TxDOT project was constructed in a hydraulic laboratory at the University of Texas at Arlington. It was composed of two standard full-scale roadway lanes with an overall size of 64 feet by 17 feet, as shown in Figure 1.1. The roadway slopes varied, and were set and checked by survey methods. The slopes were adjustable in the longitudinal and transverse axis. Two 60 horse-power centrifugal pumps provided constant discharge, ranging from 1-11cfs for the roadway. Flow geometry data, spread and depth, was collected and used to compute Manning's n-values. The TxDOT project studied four types of roadway surfaces: smooth (worn) concrete, TxDOT concrete, asphalt, and asphalt treatment surfaces as shown in Figure 1.2–1.5. The curb and roadway surfaces were built according to TxDOT roadway standards.

Figure 1.1 TxDOT roadway roughness research study

Figure 1.2 Asphalt roadway surface (longitudinal cross-section)

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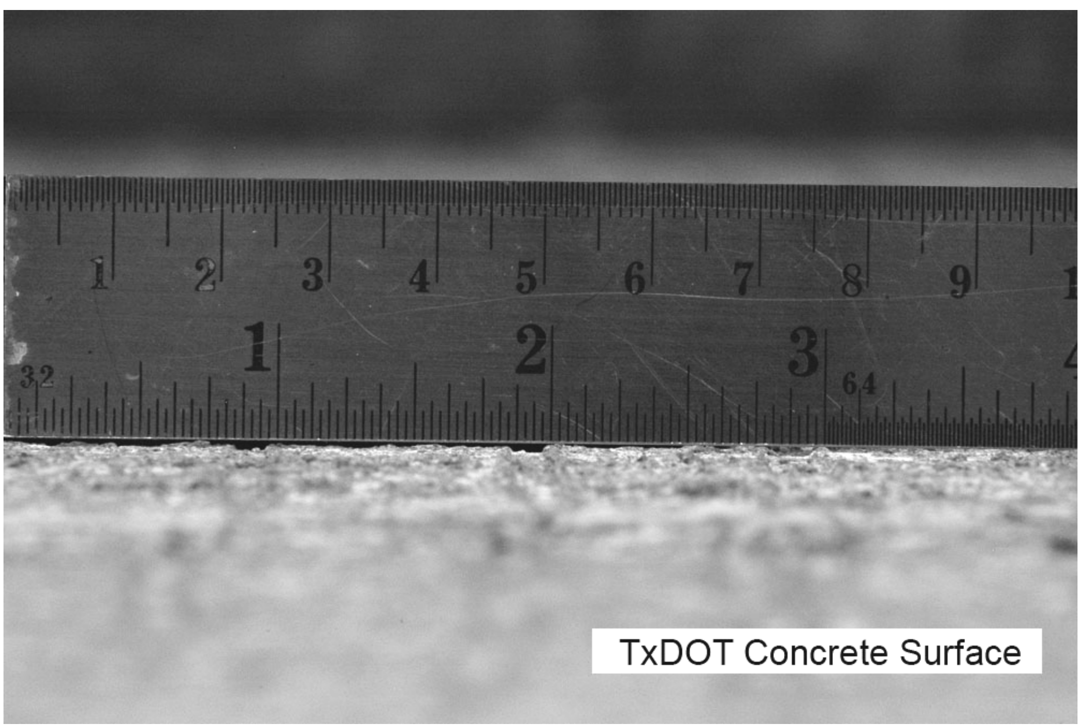


Figure 1.3 TxDOT concrete roadway surface (longitudinal cross-section)

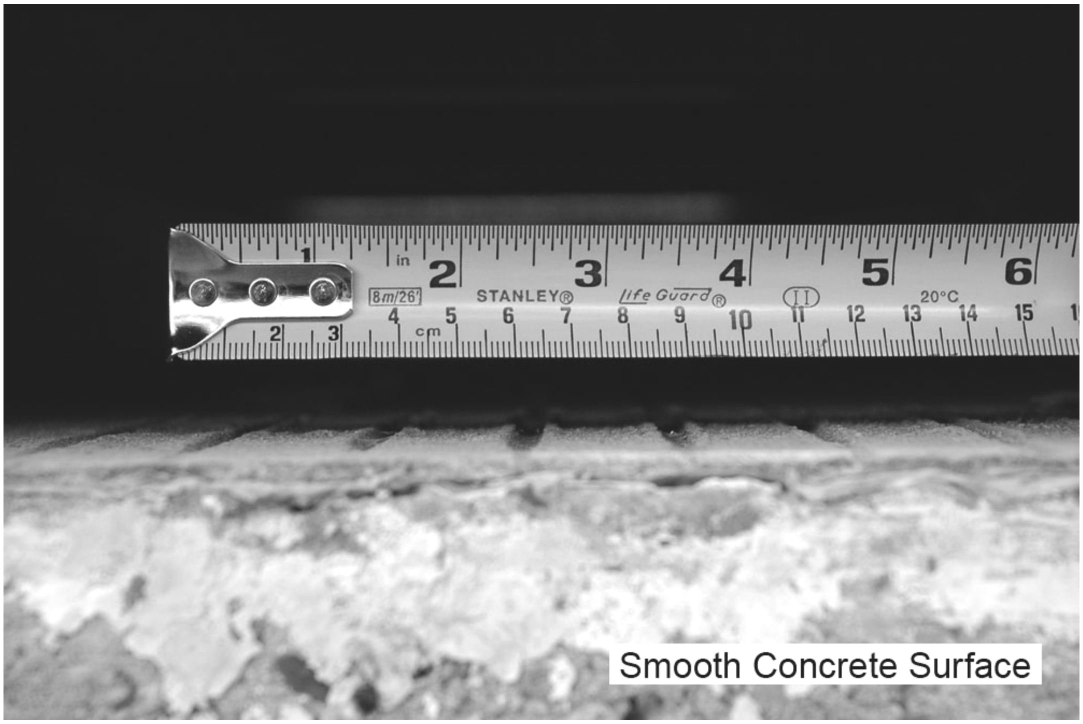


Figure 1.4 Smooth concrete roadway surface (longitudinal cross-section)

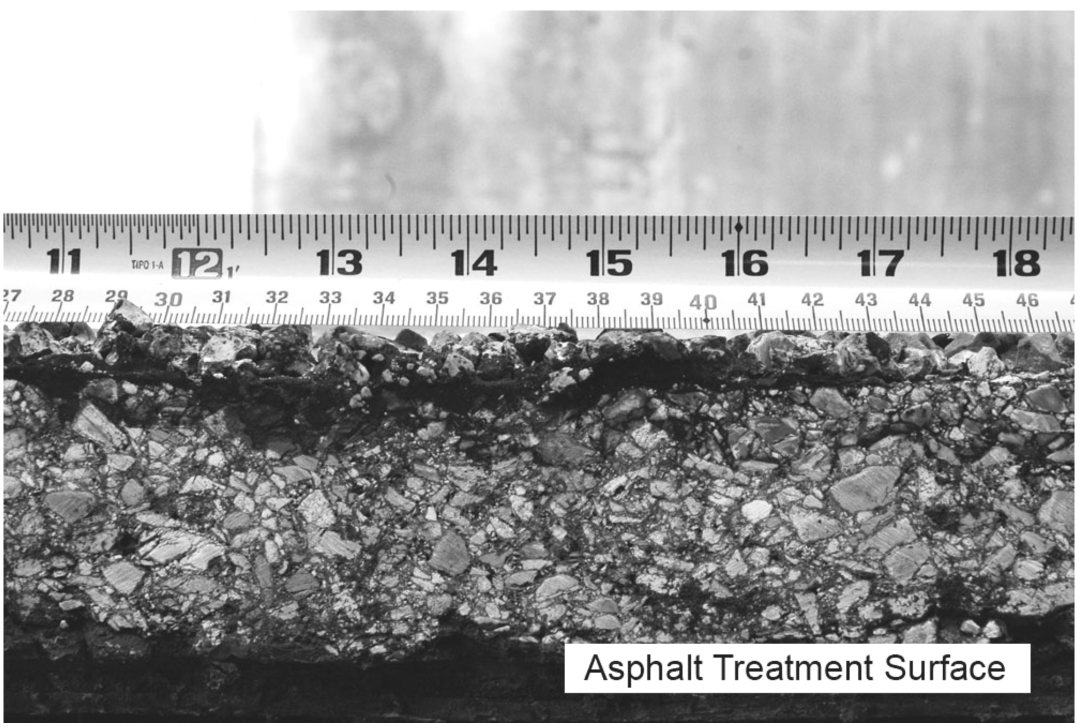


Figure 1.5 Asphalt treatment roadway surface (longitudinal cross-section)

In this research project, roadway and flow geometry data are taken from the TxDOT study. The data consists of roadway cross-section geometries such as depth, spread, longitudinal slope and transverse slopes, along with flows and determined n-values. The TxDOT concrete roadway was also tested with a rainfall simulator to determine the impact of rainfall on Manning's n-value. The rainfall simulator provided rainfall equivalents of one, three and six inches per hour over the roadway.

1.3 Statement of the Problem

Manning's equation is used in roadway design and has been for many years. Manning's n-values have been assigned to past roadway surfaces as a constant value. Present methods of roadway construction including material, equipment, technique, and environment have improved and changed as the result of new technologies and higher standard requirements. These improvements can alter roadway n-values. As roadway surfaces age they change n-values. Roadway designs are based on new surface standards.

The velocity distribution method is an alternative method for calculating discharges. This method uses the same basic geometry data as the Manning's equation. The roughness estimation is determined differently. Instead of using Manning's n-value for surface roughness value, the velocity distribution method utilizes actual roughness height (k) in measurable units. The actual roughness dimension (k) is obtained directly from vertical roughness dimension of a roadway longitudinal cross-section. The roughness dimension (k) of the velocity distribution method can be transformed to a Manning's n-value.

This research proposes to compare total discharges and average n-values from the velocity distribution method to the original TxDOT roadway data for difference and reliability.

1.4 Objective of the Study

Prandtl-von Karman velocity distribution method is used to simulate vertical velocity profiles of flow in a roadway channel. These velocity profiles can be used to estimate an average velocity and a total cross-section flow of a roadway channel.

A roadway channel is considered to be an irregular channel. It is made up of small non-symmetric sub-sections adjacent to each other throughout the entire cross-section. An entire roadway cross-section profile is established from a theoretical survey calculation. This study focuses on using an estimated roughness dimension (k) for velocity distribution equations. The roughness value (k) is estimated directly from channel bed material. It is converted to Manning's n-value by theoretical equation conversion. The converted n-value can be used to estimate the average cross-section n-value of a roadway channel.

Unlike Manning's n-value, the roughness value (k) is limited to physical measuring of the actual bottom roughness dimension on roadway surfaces. The roughness value (k) is considered to be uniform and constant for the entire surface and highly affects the flow. It's not a variable due to changing of cross-section geometries or flow environments. On the contrary, Manning's n-value can be changed by flow environments such as states of flow, geometry dimensions, and slopes. Theoretically, Manning's n-value is a constant average index value of an individual roughness surface.

This research is designed to find affects of flow environments to Manning's n-value. It's possible that Manning's n-value can be changed due to variation of flow stages from laminar to turbulent flow. For constant discharge and bottom surface roughness, velocity and depth of flow are varied by roadway longitudinal and transverse slopes. The validation of n-value variation is determined by comparison of roughness value (k) to Manning's n-value and discharge comparison.

Another study topic is the Manning's n-value cross-section averaging method. Averaging methods of n-values are significant factors and highly affect the outcome of the average cross-section n-value. Weighting parameters such as, area, depth, wetted-perimeter, hydraulic-radius, discharge, and velocity for each sub-section are key factors in determining averaging methods effect. In order to justify the specific methods of average, various discharge and n-value comparisons are considered.

1.5 Approach

The proposed simulation will be performed in the following steps:

1. Collect necessary geometry data such as depth, spread, slopes, and discharge from the TxDOT roadway study and use as input to a velocity distribution method for flow calculations.

2. Develop a roadway geometric model to simulate flow calculation. Perform discharge and n-value calculations using this model.

3. Using both sets of discharge and n-value results, perform statistical analysis and display the result comparison of the two methods.

CHAPTER 2

LITERATURE REVIEW

2.1 Manning's n-value

Manning's n-value represents roughness a value of channel bottom material. This value is used with Manning's equation as shown in equation 2.1. The main purpose of Manning's equation is to estimate channel velocity and thus flow discharge. The Manning's equation consists of n-value, longitudinal slope (S), and hydraulic radius (R) in order to find average velocity (V) of a channel. An n-value can be obtained by carefully determining the bottom roughness material of a channel.

$$V = \frac{1.486}{n} S^{1/2} R^{2/3} \quad \text{Manning's equation (Sturm, 2001)} \qquad \text{eq.2.1}$$

V = velocity

n = Manning's n-value

S = slope

R = hydraulic radius

A number of researchers have written about Manning's n-values. It has been a research topic for many years. Often the purpose was to estimate the most precise n-value for a particular channel. Much of the literatures is about natural and man made channels with various bottom materials. Some are about artificial channels, specially constructed for research purposes. The approach of each is very specific depending on its particular geometries and the bottom surface material. Because each location presents unique basic geometry and surface conditions, n-values are estimated based on the unique conditions to achieve acceptable accuracy.

Boyer is one of the early n-value researchers. He purposes an equation for solving n-value in natural channels by using a velocity ratio as shown in equation 2.2. His estimation is based on natural river data. The equation contains no physical roughness parameter of the channel's bottom material. Since Boyer's equation was derived based on a velocity distribution equation, n-values can be similar to the Prandtl-von Karman estimation.

$$n = \frac{(x-1)y^{1/2}}{6.78(x+0.95)}$$ (Boyer, 1954), Mississippi river eq.2.2

Where x $=u_{0.2}/u_{0.8}$; y = depth of water,

$u_{0.2}$, $u_{0.8}$ = velocity at 20% and 80% of the depth from the surface of water.

Many researches suggest an n-value estimated from dimensions of channel bottom material, depth or hydraulic radius. These n-value equations are derived from experimental natural channel data. Equations 2.2-2.13 show various equations of n-value estimation based on empirical natural river data.

$n = 0.034\ d_{50}^{1/6}$ (Strickler, 1923): Gravel-bed river in Switzerland eq.2.3

where $d_{50,75 \text{ and } 90}$ = mean grain size of bed material which correspond to 50%, 75% and 90% finer respectively.

$n = 0.032\ d_{90}^{1/6}$ Meyer-Peter, (Mueller, 1948): Sand mixtures in flumes eq.2.4

$n = 0.039\ d_{75}^{1/6}$ (Lane-Carlson, 1953): Canals lined with cobbles eq.2.5

$$n = 0.104\ R^{1/6} \left(\frac{R^{-0.297}}{d_{50}} \right) \left(\frac{P^{-1.03}}{R} \right) \qquad \text{eq.2.6}$$

(Griffiths, 1981): Gravel and cobble bed rivers in USA, Canada, New Zealand, and England.

where P = wetted-perimeter, and

R = hydraulic radius.

$n = 0.048\ d_{50}^{0.179}$ (Bray, 1979): Gravel-bed river in Alberta, Canada eq.2.7

$n = 0.126\ R^{1/6} \left(\frac{R^{-0.281}}{d_{50}} \right)$ (Bray, 1979): Gravel-bed river in Alberta, Canada eq.2.8

$n = \dfrac{0.0927\, R^{1/6}}{0.248 + 2.36\ \log_{10}\left(\dfrac{R}{d_{50}} \right)}$ (Bray, 1979): Gravel-bed rivers in Alberta, Canada eq.2.9

$n = \dfrac{0.0927\ R^{1/6}}{0.76 + 1.98\ \log_{10}\left(\dfrac{R}{d_{50}} \right)}$ (Griffiths, 1981) eq.2.10

Gravel and cobble bed rivers in USA, Canada, New Zealand and England

$n = \dfrac{0.0927\ R^{1/6}}{0.035 + 2.03\ \log_{10}\left(\dfrac{R}{d_{50}} \right)}$ (Limerinos, 1970): Gravel-bed river in California eq.2.11

$n = 0.39\ S^{0.38}\ R^{-0.16}$ (Jarrett, 1983) eq.2.12

Steep streams in CO with cobble sand small boulders

$$n = 0.245\ R^{0.14}\left(\frac{R^{-0.44}}{d_{50}}\right)\left(\frac{T^{-0.3}}{R}\right) \text{ (Froehlich, 1978)} \qquad \text{eq.2.13}$$

Gravel and cobble bed rivers in USA.

where T = top spread width

In natural channels, channel geometry conditions are difficult to determine. Due to various geometry conditions, non-symmetrical shape of natural channels, bottom materials, average slopes, and obstructions, an average velocity can be difficult to simulate. Water flow distribution within a channel comes from unequal velocity distribution as a result of the local bottom material and geometries. An average velocity is considered the best representation of flow. It is often used to estimate the total cross-section discharge.

A roadway represents a specific type of an artificial channel. It consists of a uniform consistent slope and roughness through out the entire cross-section area. Roadway slopes are designed as a function of the drainage required, reliability desired and safety required. Because of these limiting conditions, roadway Manning's n-values must be estimated more precisely than natural channels. A roadway cross-section is unlike other channel types in that they are a shallow non-symmetry triangular channel. Flow over a roadway is intentionally shallow to improve the traffic handling and reduce drainage safety issue such as hydroplaning.

2.2 Velocity Distribution

Velocity distribution method has been used for a number of years for non roadway channel. A number of researches have worked on this methodology. The velocity distribution is a very useful method for measuring and determining flow velocities in an open channel. This method is an alternative for determining a flow rate in channel without using Manning's n-value. Many roughness equations have been proposed in the literatures for natural rivers as shown in equations 2.15, 2.17, 2.20, 2.24 and 2.26. These equations can be rearranged in to the form of the velocity distribution equation as shown in equation 2.14. The transformations of roughness equations such as Bathurst (1985), Bray (1979), Griffiths (1981), Hey (1979), Limerinos (1970) and Keulegan (1938) into flow resistance equations are shown in equation 2.16, 2.19, 2.21, 2.23, 2.25 and 2.27 by Bettess (2002). These flow resistance equations are based on experimental studies of natural channels. The derivations are based on the logarithm function and friction velocity of channel bed material. After the transformation, every equation is in the similar velocity distribution equation form, eq.2.14. Most flow resistance equations produce similar velocity profiles depends upon the equation parameters. Comparisons of discharge with various velocity distribution equations are provided in chapter 4.

The general flow resistance equation form is

$$V = \sqrt{\alpha\, g\, R\, S}\,\log\left(\frac{\beta\, d}{k}\right) \quad \text{or} \quad V = \sqrt{\alpha\, g\, R\, S}\,\log\left(\frac{\beta\, R}{k}\right) \qquad \text{eq.2.14}$$

where α and β = estimated parameters,

k = roughness dimension,

V = flow velocity,

g = gravity,

S = longitudinal slope, and

Hydraulic radius (R) = depth (d) for broad wide channel and infinitesimal differential area.

2.2.1 Flow Resistance Equation Transformation

The following is an example of roughness equation to be transformed into a velocity distribution equation.

Limerinos (1970) roughness equation is

$$n = \frac{0.113\,d^{1/6}}{1.16 + 2.00\log_{10}\left(\frac{d}{D_{84}}\right)}$$. (Limerinos, 1970), Gravel-bed river eq.2.15

Roughness is considered to approximate a function of the diameter of grain size used to define the bed roughness as seen in eq.2.15.

$k \approx 3D_{50,\ 84\ \text{or}\ 90}$

$D_{50,\ 84\ \text{or}\ 90}$ = estimated bed material diameter, and

K = average roughness height.

From Manning's equation $V = \frac{1}{n} d^{2/3} S^{1/2}$ (SI-units)

$$\frac{d^{2/3} S^{1/2}}{V} = \frac{0.113\,d^{1/6}}{1.16 + 2.00\ \log_{10}\left(\frac{d}{D_{84}}\right)},$$

$$V = \frac{d^{2/3} S^{1/2}}{0.113 d^{1/6}} \left(1.16 + 2.00 \log_{10}\left(\frac{3d}{k}\right)\right),$$

$$V = 8.84 d^{1/2} S^{1/2} 2\left(0.58 + \log_{10}\left(\frac{3d}{k}\right)\right),$$

$$V = 17.699 d^{1/2} S^{1/2} \left(\log_{10}(3.80) + \log_{10}\left(\frac{3d}{k}\right)\right),$$

$V = \sqrt{31.93 g d S} \log_{10}\left(\frac{11.4 d}{k}\right)$ Based on Limerinos's (1970) equation. eq.2.16

Brays's (1979) roughness equation is shown below.

$$\frac{1}{\sqrt{f}} = 1.26 + 2.16 \log_{10}\left(\frac{d}{D_{90}}\right) \quad \text{eq.2.17}$$

f = roughness value

Literature (Sturm, 2002) shows that the friction value (f) can be expressed as an equation below.

where $f = \frac{8 g R S}{V^2}$, (Sturm, 2002) eq.2.18

g = gravity,

R = hydraulic radius,

V = velocity, and

S = slope.

After transforming Bray's roughness equation, eq.2.17, the flow resistance equation is shown below as, eq.2.19.

Bray's transformed equation is

$$V = \sqrt{37.32\, g\, R\, S}\, \log_{10}\left(\frac{11.49\, d}{k}\right). \qquad \text{eq.2.19}$$

Griffiths's (1981) roughness equation is

$$\frac{1}{\sqrt{f}} = 0.760 + 1.98 \log_{10}\left(\frac{R}{D_{90}}\right). \qquad \text{eq.2.20}$$

Griffith's transformed equation is

$$V = \sqrt{31.36\, g\, R\, S}\, \log_{10}\left(\frac{9.68\, R}{k}\right). \qquad \text{eq.2.21}$$

Keulegan's (1938) velocity equation is

$$V = \sqrt{g\, d\, S}\left[6.25 + 5.75 \log_{10}\left(\frac{d}{k}\right)\right]. \qquad \text{eq.2.22}$$

Keulegan's transformed equation is

$$V = \sqrt{33.06\, g\, d\, S}\, \log_{10}\left(\frac{12.22\, d}{k}\right). \qquad \text{eq.2.23}$$

Hey's (1979) roughness equation is

$$\frac{1}{\sqrt{f}} = 2.03 \log_{10}\left(\frac{a\, R}{3.5\, D_{84}}\right). \qquad \text{eq.2.24}$$

Where $12.95 < a < 15.70$ depends on shape of channel.

Hey's transformed equation is

$$V = \sqrt{32.97\, g\, R\, S}\, \log_{10}\left(\frac{a\, R}{k}\right). \qquad \text{eq.2.25}$$

Bathurst's (1985) roughness equation is

$$\sqrt{\frac{8}{f}} = 5.62 \log_{10}\left(\frac{d}{D_{84}}\right) + 4 . \qquad \text{eq.2.26}$$

Bathrust's transformed equation is

$$V = \sqrt{31.6\, g\, R\, S}\, \log_{10}\left(\frac{15.44\, d}{k}\right) . \qquad \text{eq.2.27}$$

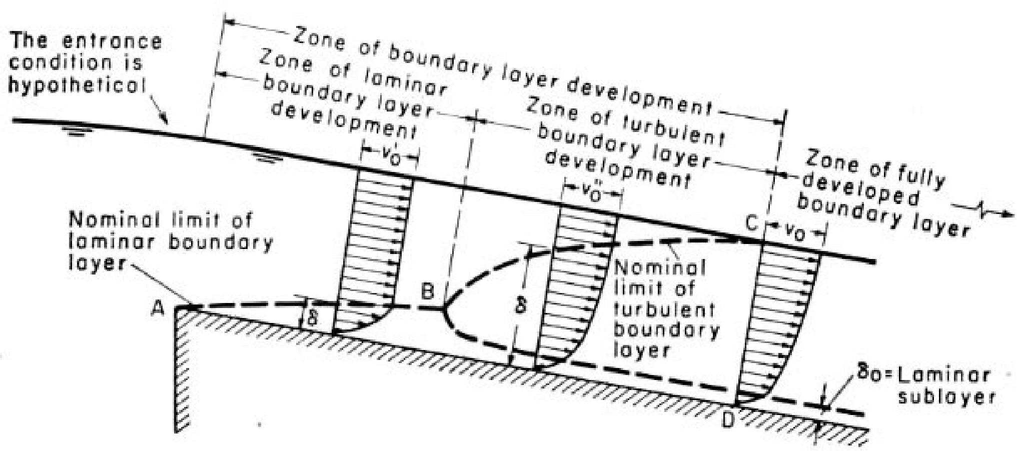
Colebrook's (1939) velocity equation is

$$V = \sqrt{32\ g\, R\, S}\, \log_{10}\left(\frac{14.8\, R}{k}\right) . \qquad \text{eq.2.28}$$

In this research, Prandtl-von Karman (1989) velocity distribution equations, equation 2.35 and 2.36, were selected based on consistency and accuracy of the discharge calculation. The results, discharges and n-values, comparison are discussed in chapter 4.

In one dimensional flow, a velocity profile represents logarithm vertical flow velocity distribution in one-dimension parallel to the flow direction. Velocity distribution equations or so called flow resisting equations are based on shear forces emanating at the bottom surface of channel. These equations can be used with an open channel or a gravity flow. With no restriction of geometry conditions, velocity profiles can be used for any type of channel with a known bottom roughness value. In a small sub-section of a channel, a velocity profile starts from channel bottom and progress upward to the water surface.

Figure 2.1 shows various stages of gravity flow behavior in a channel. At the beginning point, water starts entering a channel assumed to be laminar and uniform velocity. At this point, a small laminar layer starts developing a long the channel bottom. This laminar layer is shown in region from point A to B. This zone is called "laminar boundary layer". The velocity distribution in this layer (below A to B to C) is assumed to be parabolic. The flow distribution above line ABC is constant.



Development of the boundary layer in an open channel with an ideal entrance condition.

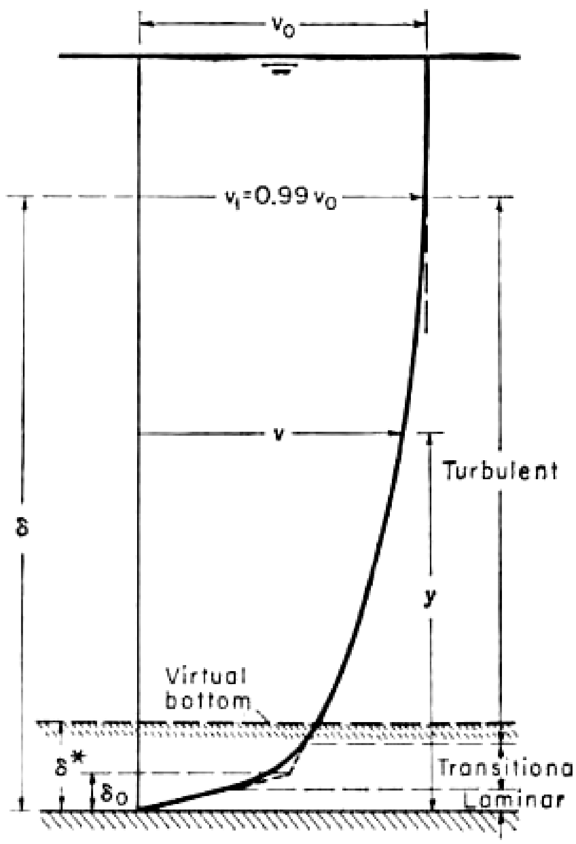
Figure 2.1 Development of the boundary layer (Chow, 1959)

From the channel entrance, the effect of bottom surface roughness on flow distribution is shown under the line ABC. Flow under the line ABC is called the "boundary layer" of δ height.

After the stream reaches a certain velocity, a turbulent zone starts developed from point B to C. In this zone, a very thin laminar layer can developed at the channel bottom due to a smooth bottom roughness surface. This bottom layer is called "laminar sub-layer", δ^* or δ_o. Velocity in this zone (below B to C) is approximate as logarithmic.

If flow in a channel becomes uniform, a fully developed turbulent zone is assumed to occurred, after point C. (Chow, 1959)

The velocity profile (Figure 2.2) shows various states of flow from laminar, transition, and turbulent. A laminar layer is a bottom layer of a flow. It represents a very thin layer relative to the whole depth of flow. A velocity at this level is highly resisted by bottom roughness.



Distribution of velocity over a smooth channel surface (not in scale).

Figure 2.2 Velocity profile of flow (Chow, 1959) where v_o = water surface velocity

v_1 = velocity at boundary layer ($v_1 = 0.99v_o$)

δ = boundary layer

δ^* = displacement thickness

δ_o = laminar sub-layer

The next level of velocity is the transition zone or diverting zone. In every turbulent flow, the transition zone is a turning point of velocity profile. Flow in this transition zone is still under a great influence from bottom roughness. In this zone, the laminar zone and turbulent zone can be separated approximately by both top and bottom boundaries of this layer.

The top layer of a fully developed turbulent flow is a turbulent zone. The turbulent zone is defined by relationship of both roughness and flow conditions. Slopes of a bottom surface also have a great influence on flow in this zone. Turbulent flow develops from under a virtual bottom zone same as other layers. The reason that it dominates a flow is because of a greater flow layer. In fully turbulent flow, the turbulent layer contains more than 90 percent of flow discharge.

"The effect of boundary layer on the flow is equivalent to a fractious upward displacement of the channel bottom to a virtual position by an amount equal to the so called "displacement thickness", δ^*, (Chow, 1959) as shown in Figure 2.2.

Water flows from a higher level to a lower level as a function of gravitation. Surface roughness and slopes of a channel affect a flow as a function of the earth's gravity. In open channel flow, surface roughness and slopes of a channel have significant effects on the flow velocity. Roughness dimension and slopes of channel are normally constant for a channel. Hydraulic depth is a key identifier of the flow conditions. For gravitation flow, velocity is a function of roughness, slope and hydraulic depth. Flow velocity increases as depth increases from the bottom of the channel. This is possible only at the point that bottom roughness doesn't disturb the flow anymore, after that velocity will be a function of slope and gravity.

Three parts of the velocity profile, turbulent, transition, and laminar are developed in the channel as shown in Figure 2.2. These layers of flow define characteristics of fluid flow in three different stages. When water begins entering the channel, it also starts to increase velocity. The velocity develops over a period of time up to a definite speed. The velocity of flow depends on conditions of channel such as, a longitudinal slope and roughness.

Some literature suggests resistance force between air and the top water surface is also present. As water flows in a channel, air is flowing above the water. Friction force can be created between these two flowable materials. This phenomenal could create a convex velocity curve at the surface of water. Especially for a steady gravitation flow layer, where roughness and a slope are constant, air particle resistance could have an effect on water flow. Water flow over a roadway is a very shallow water flow type. Unless the air has significant velocity, the air would have a minimal effect to this type of flow.

2.2.2 Friction Velocity

The friction velocity, V_f, is a result of resistance force created between the liquid and surface friction at the channel bottom. The geometries of roadway, such as longitudinal slope and hydraulic radius, have significant effects on friction velocity. For a roadway surface, a cross-section is divided in to small vertical sub-sections beginning with the curb to the end of water on the roadway surface. In this situation, the hydraulic radius is equal to the water depth at each location.

Friction velocity varies with basic geometries of channel such as longitudinal slope, bottom surface roughness, side surface roughness, and hydraulic depth. Transverse slope has an indirect effect to friction velocity. Changing the transverse slope changes the hydraulic depth by changing flow spread. Different types of surface roughness provide different vertical velocity profiles. Surface roughness is estimated by bed material, such as average grain size for natural channels and roughness height for streets and artificial channels. The derivation of friction velocity is shown in the next topic.

2.2.3 Prandtl-von Karman Velocity Distribution Equation

The vertical velocity distribution is a result of local geometry conditions such as depth, hydraulic radius, slopes and surface roughness. Turbulence in the liquid takes a role in justifying distributions of velocity profile. Prandtl-von Karman (1926) derived flow resistance equation based on shear stress of bottom surface roughness. Prandtl introduced a shear stress for turbulent flow as follow.

Shear stress in flow equation

$$\tau = \rho l^2 (\frac{dv}{dy})^2 \text{ (Prandtl-von Karman, 1926)} \qquad \text{eq.2.29}$$

where τ = Shear stress,

p = Mass density = w/g,

w = Unit weight of the fluid,

g = Gravity,

l = Mixing length, and

$\frac{dv}{dy}$ = Velocity gradient at depth (y) from water surface.

"Assume the mixing length is proportional to depth and that the shear stress is constant, $\tau = \tau_o$" (Prandtl, 1926). Equation 2.29 can be rewritten as follow.

$$du = \frac{1}{k}\sqrt{\frac{\tau_o}{\rho}}\frac{dy}{y} \qquad \text{eq.2.30}$$

Where k is a constant that varies with mixing length and depth, then

$$V = 2.5\sqrt{\frac{\tau_0}{\rho}}\ln\left(\frac{y}{y_0}\right), \qquad \text{eq.2.31}$$

By using $\sqrt{\frac{\tau_0}{\rho}} = \sqrt{gRS} = V_f$, (Chow, 1959) eq.2.32

where Vf = friction velocity,

R = hydraulic radius,

d = hydraulic depth, and

S = slope.

it can be shown that:

$$V = 2.5\, V_f \ln\left(\frac{y}{y_0}\right). \qquad \text{eq.2.33}$$

For a broad channel, hydraulic radius (R) can be assumed equivalent to depth (d). Then equation 2.32 can be shown as;

$$\sqrt{\frac{\tau_0}{\rho}} = \sqrt{g\, d\, S} = \sqrt{g\, R\, S} = V_f\,. \qquad \text{eq.2.32}$$

The vertical velocity profile equation is divided into two types, roughness surface and smooth surfaces. These two types are result of roughness, viscosity and turbulent in individual channel. Roughness and channel slopes play a critical role in determining the type of vertical velocity profile. Because each individual channel has its own unique slope and roughness, vertical velocity profile must be individually determined.

"When surface is smooth, y_o is depended on the friction velocity and kinematic viscosity" (Chow, 1959). In equation 2.33, y_o is a constant defined as follow;

$$y_0 = \frac{mv}{V_f}, \qquad \text{eq.2.34}$$

where m = constant value; "equal to 1/9 for smooth surface and 1/30 for rough surface", (Chow, 1959)

v = kinematic viscosity, and

V_f = friction velocity.

After inputting $y_0 = \frac{mv}{V_f}$, the equation can be shown below.

Flow velocity in smooth surface,

$$V = 5.75\,V_f \log\left(\frac{9\,y\,V_f}{v}\right). \text{ (Prandtl-von Karman, 1926)} \qquad \text{eq.2.35}$$

For a rough surface, y_o mainly depends on texture height,

$y_0 = mk$

where k = average surface roughness.

Inputting y_o, gets the flow velocity in rough surface as shown below.

$$V = 5.75\,V_f \log\left(\frac{30\,y}{k}\right), \text{ (Prandtl-von Karman, 1926)} \qquad \text{eq.2.36}$$

Prandtl introduced velocity distribution equations based on the shear stress equation in turbulent flow as shown in equation 2.35 and 2.36. These two equations are used to calculate velocity distribution base on geometry conditions and roughness.

2.3 Roughness Dimension

Roughness dimension is the key to define uniform types of surface. It has a direct affect on flow in a channel. There are three types of surface roughness, rough, wavy and smooth surface conditions. In the velocity distribution method, the surface roughness condition is defined through comparison of an actual roughness (k) to a critical roughness (k_c). The critical roughness is described as a layer of roughness magnitude influence. The actual roughness (k) will have an influence beyond the laminar layer if the critical roughness height (k_c) is less than the roughness height (k) (Chow, 1959). Schlichting (1923) defines the smooth flow condition (eq.2.37) from his experiment in pipe flow for smooth flow condition as below.

$$\frac{V_f k}{\nu} < 5 \quad \text{or} \quad k < \frac{5\nu}{V_f}, \text{ (Schlichting, 1923)} \qquad \text{eq.2.37}$$

where V_f = friction velocity

ν = kinematic viscosity, and

k = Roughness value.

Schlichting gives estimation of the critical roughness to be $k_c = 100\ \nu/V$,

Inputting Chezy's equation to transformed equation 2.37, a critical roughness equation can be shown as.

Critical roughness with Chezy's C. is

$$k_c = \frac{5\nu}{V_f} = \frac{5\nu}{\sqrt{gRS}} = \frac{5\nu C}{\sqrt{g}\,V} \text{ (Chow, 1959)} \qquad \text{eq.2.38}$$

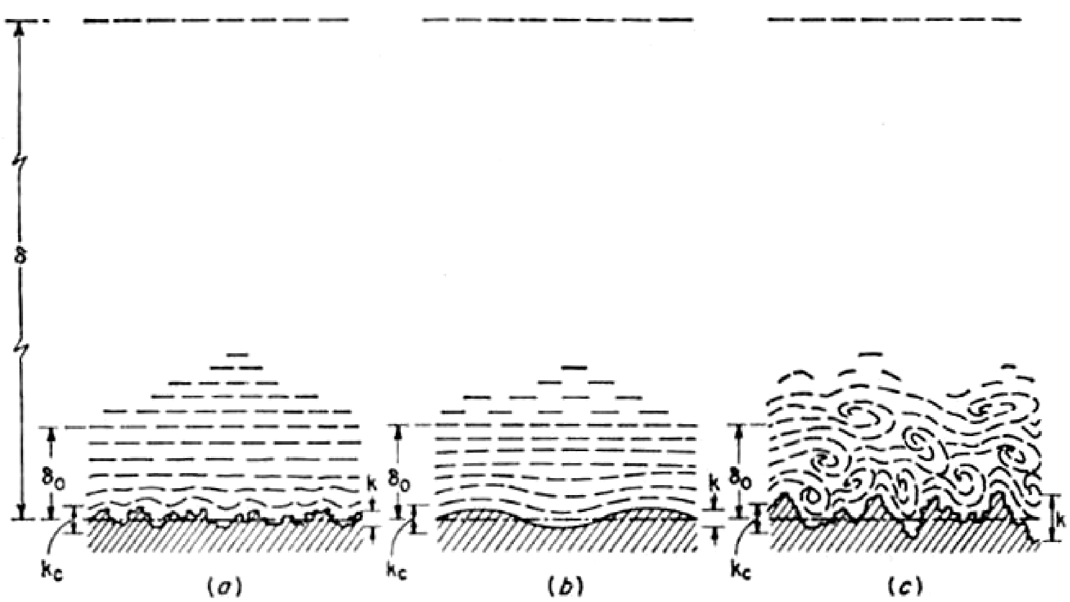
where C = Chezy's C, ($u = C\sqrt{RS}$),

v = kinematic viscosity,

V = average velocity,

g = gravity, and

k_c = critical roughness.



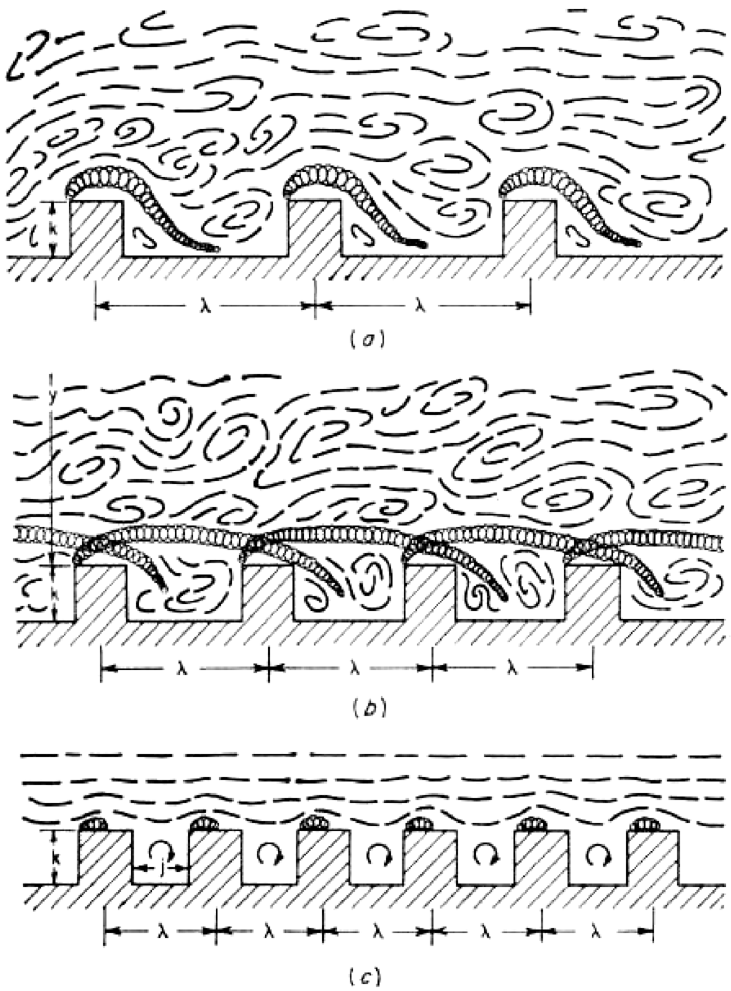
Nature of surface roughness. (*a*) Smooth; (*b*) wavy; (*c*) rough.

Figure 2.3 Projections of roughness value k, k_c in different conditions (Chow, 1959)

Three types of roughness are shown in Figure 2.3. The relationships between a critical roughness (k_c), a roughness height (k) and laminar layer (δ^* or δ_o) explain conditions of surface roughness. When the roughness height (k) is in the boundary of a critical roughness (k_c), a smooth surface is presented. From equation 2.38, a critical roughness (k_c) is a function of Chezy's C, kinematic viscosity, average velocity and gravity. With a constant critical roughness, surface roughness height is sufficient to identify types of roughness. In smooth surface, flow shows minimal influences due to the bottom surface roughness as shown in Figure 2.3a.

A wavy roughness condition shows almost equivalent height between a roughness height and a critical roughness as shown in Figure 2.3b. The surface roughness influences the flow but is still under the laminar sub-layer. The last type of surface, Figure 2.3c, is a rough surface. It shows a fully disturbed influence of roughness through out the bottom layer of a flow. In this type of surface, the roughness height is higher than a critical roughness.

Longitudinal spacing of roughness, λ, is an important consideration to determine types of flow. Chow, V. T. defines spacing of roughness as three types. These types of roughness are assumed to have equivalent roughness height (k) with three different spacing. The first type, Figure 2.4a, is an iso-lated roughness. In this type, roughness spacing is so far from each others. Influence of roughness height is less than an average spacing. Therefore, a ratio of k/λ will take place to account the effect as shown. The second type of roughness is a wake-interference flow as shown in Figure 2.4b. Spacing of roughness is close together. The roughness creates great effect to turbulent flow. Quasi-smooth flow is the last type of roughness spacing, Figure 2.4c. The roughness spacing is so close together, that it causes minimal effect to the flow.



Sketches showing concept of three basic types of rough-surface flow: (*a*) isolated-roughness flow; (*b*) wake-interference flow; (*c*) quasi-smooth flow.

Figure 2.4 Three basic types of rough surface flow (Chow, 1959)

2.4 Method of Estimating Average Manning's n-value

A total roadway cross-section average n-value can be estimated by averaging the sub-section n-values. Each sub-section n-value represents a local surface roughness of a sub-section. A sub-section n-value is the result of the unique physical flow condition of each individual sub-section. In determining an average n-value of the entire cross-section, the method of evaluation has a significantly impact on the overall n-value.

An estimation of the total cross-section roughness can be calculated from a weighting n-value with the geometry parameters for example depth, area, wetted-perimeter, discharge, velocity, or hydraulic radius across the entire roadway cross-section. Weighting parameters are as significant as methods of estimation. It shows significant effects on the outcome of the resulting n-value. The values of weighting parameter are varied from the curb to the end of roadway water. The variation of weighting parameters is caused by changing the basic geometry inputs such as depth and wetted-perimeter along the transverse slope. Hydraulic depth and wetted-perimeter are the basic geometry inputs of a channel calculation. Other parameters, hydraulic radius and area, are calculated from these basic geometry inputs.

Several methods of estimation are observed in literature. Most literature considered basic parameters such as depth and wetted-perimeter of local sections along with their conceptual assumptions. These assumptions are made to improve the compatibility of the geometry conditions. There are also equations used to estimate n-values of composite bottom channels. These equations are based on each individual conclusion.

2.4.1 Horton and Einstein's Equation

Horton and Einstein (1933) suggested an equation to evaluate cross-section n-value as shown in equation 2.39. This equation is based on an assumption that velocity of each sub-section is equivalent. This method uses only wetted-perimeter as a weighting parameter.

$$n_{Average} = \left[\frac{\sum_{1}^{N} (P_i \, n_i^{1.5})}{P} \right]^{2/3} = \frac{(P_1 \, n_1^{1.5} + P_2 \, n_2^{1.5} + ... + P_N \, n_N^{1.5})^{2/3}}{P^{2/3}} \qquad \text{eq.2.39}$$

(Horton and Einstein, 1933)

2.4.2 Pavlovski, Muhlhofer, Einstein and Banks's Equation

Equation 2.40 is based on assumption that the total resisting force is equal to sum of the resisting force each sub-section. It was introduced by Pavlovski, Muhlhofer, Einstein and Banks (1931). The total resisting force of channel is as follows.

$$n_{Average} = \left[\frac{\sum_{1}^{N} (P_i \, n_i^{2})}{P^{1/2}} \right]^{1/2} = \frac{(P_1 \, n_1^{2} + P_2 \, n_2^{2} + ... + P_N \, n_N^{2})^{1/2}}{P^{1/2}} \qquad \text{eq.2.40}$$

(Pavlovski, Muhlhofer, Einstein and Banks, 1931)

2.4.3 Lotter's Equation

By considering only discharges of a channel, Lotter (1933) suggested equation 2.41 for equivalent roughness. This equation is based on the assumption that the total discharge is equal to sum of the sub-section discharges. This method considers two parameter, wetted-perimeter and hydraulic-radius.

$$n_{Average} = \frac{P R^{5/3}}{\sum_{1}^{N}\left(\frac{P_i R_i^{5/3}}{n_i}\right)} = \frac{P R^{5/3}}{\frac{P_1 R_1^{5/3}}{n_1} + \frac{P_2 R_2^{5/3}}{n_2} + \ldots + \frac{P_N R_N^{5/3}}{n_N}} \quad \text{(Lotter, 1933)} \qquad \text{eq.2.41}$$

2.4.4 Krishnamurthy and Christensen's Equation

Krishnamurthy and Christensen (1972) introduced another equation for averaging n-value in 1972. An equation is based on the logarithmic velocity distribution as shown in equation 2.42. Two significant parameters, wetted perimeter and depth are used in a weighting process. As far as velocity distribution equation

$$\ln\left(n_{Average}\right) = \frac{\sum_{1}^{N}(P_i\, y_i^{3/2} \ln(n_i))}{\sum_{i=1}^{N} P_i\, y_i^{3/2}}$$

$$= \frac{P_1\, y_1^{3/2} \ln(n_1) + P_2\, y_2^{3/2} \ln(n_2) + \ldots + P_N\, y_N^{3/2} \ln(n_N)}{P\, y^{3/2}} \qquad \text{eq.2.42}$$

(Krishnamurthy and Christensen, 1972)

2.4.5 Other Methods of Averaging n-values

Area weighted n-value; $n_{Area-weight} = \frac{\sum_{1}^{N} n_i A_i}{\sum_{1}^{N} A_i}$ eq.2.43

Depths weighted n-value; $n_{Depth-weight} = \dfrac{\sum_1^N n_i \, d_i}{\sum_1^N d_i}$ eq.2.44

Wetted-perimeter weighted n-value; $n_{Wetted\text{-}perimeter\ weighted} = \dfrac{\sum_1^N n_i \, P_i}{\sum_1^N P_i}$ eq.2.45

Velocity weighted n-value; $n_{Velocity-weight} = \dfrac{\sum_1^N n_i \, u_i}{\sum_1^N u_i}$ eq.2.46

Discharge weighted n-value; $n_{Discharge-weight} = \dfrac{\sum_1^N n_i \, q_i}{\sum_1^N q_i}$ eq.2.47

Hydraulic radius weighted n-value; $n_{Hydraulic\text{-}radius-weight} = \dfrac{\sum_1^N n_i \, R_i}{\sum_1^N R_i}$ eq.2.48

Numerical average n-value; $n_{Numerical\ average} = \dfrac{\sum_1^N n_i}{N}$ eq.2.49

Manning’s equation average n-value using the actual discharge;

$$n_{Manning\ equation\ with\ measured\ discharge} = \frac{1.486\, S^{1/2}\ R^{2/3}}{\left(\dfrac{Q_{measured}}{A_{total\ cross-section}}\right)} \qquad \text{eq.2.50}$$

Manning's equation average n-value using velocity estimated discharge;

$$n_{\text{Manning equation with velocity estimated discharge}} = \frac{1.486\,S^{1/2}\,R^{2/3}}{\left(\dfrac{Q_{\text{estimated}}}{A_{\text{total cross-section}}}\right)} \qquad \text{eq.2.51}$$

Most of these equations provide very similar results. The impacts and comparisons of averaging methods will be discussed in chapter 4.

2.5 Statistical Analysis

Generally, data taken from field or laboratory contains error. The sources of error are from factors such as human and equipments. Mostly human error is caused by insufficient experience. Error such as incorrect reading and measurement are varies by person.

Another type of error is from measuring-equipment. The measuring-equipment error is caused by variation or limitation of equipment accuracy. The equipment accuracy is a result the equipment design. It also caused by the equipment age. Therefore, the measuring-equipment should be maintained and calibrated to minimize possible error.

Some sources of error can be observed shown in a data plot as unrelated points or outliers. Typically, the data error can be analyzed and identified by mathematic statistical analysis. The statistical analysis such as histogram, normality distribution (Q-Q plot) and scatter plots are useful to analyze the normal distribution of a data set.

2.5.1 Histogram Plot

The histogram plot is data groups plotted in intervals. The plot shows data frequency within the interval ranges. The normal distribution of a data set can be seen when the plot appear as a convex and symmetric shape with the maximum at a median point as shown in Figure 2.5. (Montgomery, Runger and Hubele, 2004)

2.5.2 Normality Distribution Plot (Q-Q Plot)

A normality distribution plot (Q-Q plot) is a special plot used to determine the statistic normality. The Q-Q plot is composed of pairs of observed data and standard quantiles. The normal probability plot indicates normality distribution of a data set. Equal probability ($P_{(j)}$) of every data point in Q-Q plot reveals the data relationship, consistency and outliers. A straight line and equal spacing between points are indications of a normal distribution. The outliers are normally seen on the ends of the Q-Q plot. Normal distribution and standard quantiles are related by equation 2.52. (Johnson, 2002)

$$P[Z \le q_{(j)}] = \int_{-\infty}^{q(j)} \frac{1}{\sqrt{2\pi}} e^{\frac{-z^2}{2}} dz = P_{(j)} = \frac{j - \frac{1}{2}}{n} \text{ (Johnson, 2002)} \qquad \text{eq.2.52}$$

where $P_{(j)}$ = probability level

$q_{(j)}$ = standard quantiles

j = 1, 2, 3, ….., n

n = Total numbers of sample

2.5.3 Scatter Plots

Scatter plots represent plots of multiple data series. The plots are related pairs from data sets plotted side by side and arranged in a matrix n by n (n = numbers of data set). Outliers of a single data set can be easily identified by examination of the unrelated points. In order to construct scatter plots, data sets should have the same sample number and data range.

2.5.4 Outlier Detection

The data error points or outliers are unusual points created by many different factors. Most laboratory data sets contain a minimal percent of error. A data set with a significantly large percent of error is unusual. Elimination of the outliers is a significant process to achieve the normality distribution and accurate statistical analysis. Outliers can be recognized by the unusually large or small magnitude of the number, and unrelated variance from the majority data in the plots. Several methods can be used to identify outliers in addition to the histogram plot, a normal probability plot and scatter plots. (discussed in section 2.5.3)

2.5.5 Correlation Coefficient

The straightness of a normal probability plot (Q-Q plot) can be determined by the correlation coefficient (r_Q). The correlation coefficient of data set can be calculated by equation 2.53. The critical point of normality distribution is defined as a critical correlation coefficient as shown in table 2.1. The critical correlation coefficient varies by number of samples and significant level (α). Therefore normality can be checked be comparison between the correlation coefficient (r_Q) and the critical correlation coefficient. (Johnson, 2002)

$$r_Q = \frac{\sum_{j=1}^{n} (x_{(j)} - \bar{x})(q_{(j)} - \bar{q})}{\sqrt{\sum_{j=1}^{n} (x_{(j)} - \bar{x})^2} \sqrt{\sum_{j=1}^{n} (q_{(j)} - \bar{q})^2}} \quad \text{(Filliben, 1975)} \qquad \text{eq.2.53}$$

where r_Q = correlation coefficient,

x = data point,

$\bar{x}$ = numerical average of data,

$q_{(j)}$ = standard quantiles,

$\bar{q}$ = numerical average of standard quantiles,

j = 1, 2, 3, ….., n, and

n = total number of samples.

Table 2.1 Critical points for the Q-Q plot correlation coefficient test for normality (Johnson, 2002)

Sample size n	Significance levels α .01	.05	.10
5	.8299	.8788	.9032
10	.8801	.9198	.9351
15	.9126	.9389	.9503
20	.9269	.9508	.9604
25	.9410	.9591	.9665
30	.9479	.9652	.9715
35	.9538	.9682	.9740
40	.9599	.9726	.9771
45	.9632	.9749	.9792
50	.9671	.9768	.9809
55	.9695	.9787	.9822
60	.9720	.9801	.9836
75	.9771	.9838	.9866
100	.9822	.9873	.9895
150	.9879	.9913	.9928
200	.9905	.9931	.9942
300	.9935	.9953	.9960

2.5.6 Transformation to Near Normality

The transformation to near normality is an alternative method of data treatment. It is a way to treat non-normal distribution data. Figures 2.5 and 2.6 demonstrate the histogram plots of normality and non-normality distribution of n-values. Methods of transformation are depended on type of distribution and character of outliers. For non-normality distribution data, changing a unit of the data set may change the data distribution. The data sets can be changed by a power transformation with a parameter λ. For example if $\lambda = -1$, then $x^{\lambda} = x^{-1}$. The power transformation either shrinks the large value or increases the large value of data. The proper weighted parameter (λ) may help transform the data distribution. Methods of transformation are shown below.

$......., X^{-1}, \ln X, X^{1/4}, X^{1/2}$ Shrink large values of data

$X^2, X^3,..$ Increase large values of data

After a transformation, data set may show normal distribution and be suitable for statistical analysis. Since methods of transformation affect data units, the statistical analysis of transformed data can not be compared with data in the original units. Therefore the method of transformation is not used in this project.

Outliers can be identified and should be removed only from normal distribution data sets. For non-normal distribution data sets, numerical average ($\bar{x}$) are calculated with no transformation treated. The numerical average ($\bar{x}$) from a non-normal distribution data set is the only statistic which should be compared. Other statistics of non-normal distribution are not valid.

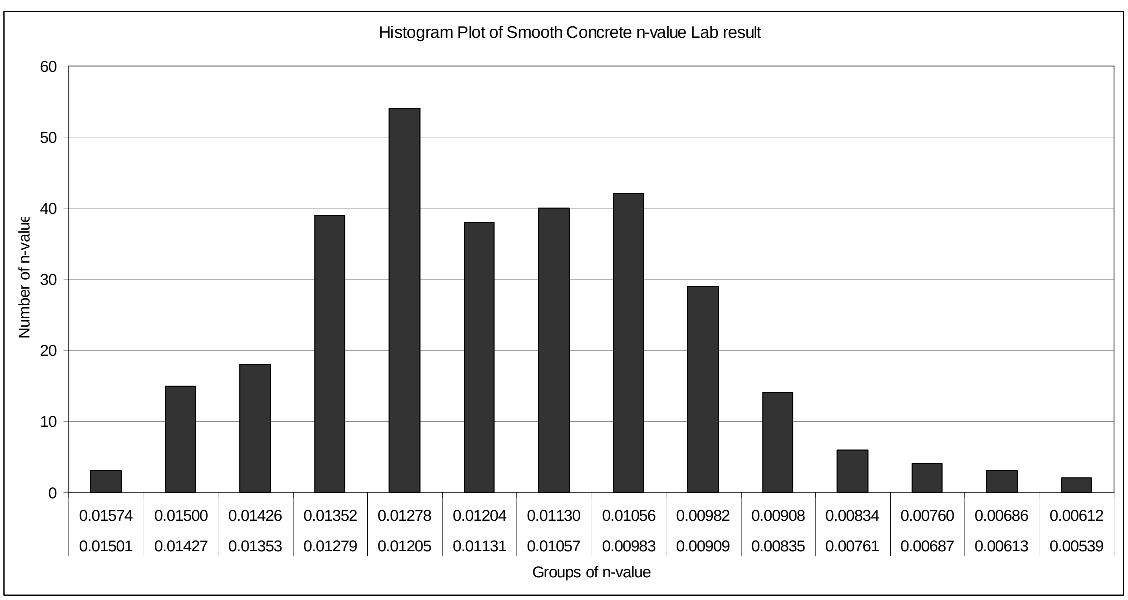


Figure 2.5 Histogram plot of smooth concrete n-value (lab result)

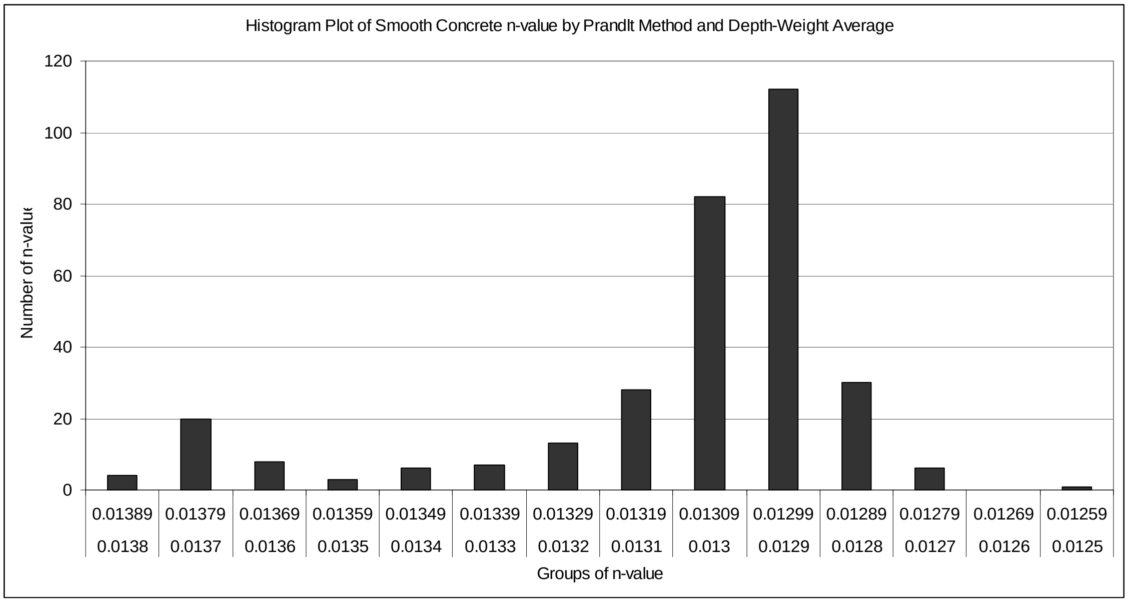


Figure 2.6 Histogram plot of smooth concrete n-value (Prandtl-von Karman velocity method and depth-weight averaging method)

CHAPTER 3

METHODOLOGY

3.1 Data Collection and Preparation

This project studies four types of roadway surfaces, TxDOT standard concrete, smooth (worn) concrete, asphalt, and asphalt treatment surface experiments. Each roadway surface represents one data set for analysis and inputs to this study. All data for this research was obtained from a TxDOT roadway roughness simulation project. The raw data included roadway basic geometry, discharge values, and flow cross-sections, which originally obtained by physical measurement.

Actual discharge values were obtained from ultrasonic meter readings. The ultrasonic meters were adjusted and calibrated by volumetric flow rate measurement. The meters provide flow rates measurements with minimum percent of error (<3.0%). Flow rate readings were acquired after establishing uniform and steady flow. Uniform flows on roadway were observed a short time after flow initiation. Time to achieve steady uniform flow varies as a result of slopes of roadway, flow rates, and pump stability. This data is used to study and verify the velocity distribution model approach.

All the data was analyzed for numerical averages and errors. Outlier detection and date cleaning were part of the statistical analysis. Inputs, discharges and n-values, were processed to achieve the maximum accuracy. Statistical analysis can indicate percentage of normality and data consistency. Resulting analysis showed some deviation of data. These irregular points could lead to erroneous future analysis. Therefore outliers were processed and removed. The normality of this data set is controlled by percent acceptability within a significant level (α) of 0.05. After cleaning the data set, results should noticeably improve in terms of accuracy and consistency.

Ultimate outputs of the velocity distribution model from this project, such as n-values and discharge, will be compared to original TxDOT project results for verification and analysis.

3.2 Calculation Process and Modeling

The simulation of flow on each roadway surface was performed in several steps. The process is shown in Figure 3.1. These steps are performed using Microsoft Excel spread-sheets.

In the flow calculation, there are two methods to estimate roadway cross-section n-values and discharges. The first method calculates average velocity and area by velocity distribution method and laboratory geometries. The n-values and discharges are calculated from each average velocity and area. The entire roadway cross-section n-value is estimated from various averaging methods as shown in chapter 2. The total roadway cross-section discharge is sum of sub-section discharges.

The second method, a total discharge is a constant input. The entire roadway cross-section geometries, depths and spreads, are estimated by trial and error according to the total discharge. Each average velocity is calculated by velocity distribution method according to estimated sub-section depths. The sub-section n-values are calculated from the estimated sub-section geometries. The total cross-section n-value is calculated from various averaging methods as shown in chapter 2.

The first method is the only method used this research due to accurate discharges and n-values compared to the original TxDOT project result.

Velocity Distribution Calculation Process

3.2.1. Obtain Geometry Data

3.2.2. Estimate Average Roughness (k) Over Total Surface

3.2.3. Calculate Total Cross-Section (A_t) and Sub-Section

3.2.4. Calculate Friction Velocity (V_f)

3.2.5. Calculate Critical Roughness Height (k_c)

3.2.6. Assign a Roughness Condition

3.2.7. Calculate Sub-Section Velocity Profiles

3.2.8. Calculate Average Sub-Section Velocities

3.2.9. Calculate Sub-Section' Manning N-values

3.2.10. Calculate sub-section discharges

3.2.11. Calculate Total Cross-Section Discharge and Average N-value

Figure 3.1 Velocity distribution calculation process

3.2.1. Obtain Geometry Data

Basic geometry data in this project is obtained from TxDOT roadway roughness study. All TxDOT geometry data is shown in Appendix B. In TxDOT study, geometric data is a basic input for calculating area of cross-section, height of roughness, and slopes. Original cross-section geometries were surveyed with an accuracy of 0.01 foot.

A measuring procedure was developed and constantly used to take consistent data reading. Since flow is a shallow water flow over a roadway. Water waves were developed by the affect of surface roughness across the roadway cross-section. The flow geometric readings of depth and spread are affected by these waves. A procedure of taking minimum and maximum readings was used to estimate an average flow reading. Flow and geometry data was repeatedly taken several times for each single setting of flow and roadway slopes to achieve the maximum accuracy.

Additionally, rainfall data was physically simulated on the TxDOT concrete surface. A rainfall simulator was used to simulate rainfall over this roadway. The rainfall simulator consists of special sprinklers distributing simulation over the roadway area. The rainfall rate and amounts are estimated from roadway area and time period of rainfall. Rainfall rate investigated were one, three, and six inches per hour.

In TxDOT research, results are analyzed from basic data consisting of depth, spread, and discharge. Flow cross-section area was obtained from basic geometric data. By inputting area, slope, discharge, and hydraulic radius data into Manning's equation (eq.2.1), the average Manning's n-value for the total cross-section can be obtained as follow.

$$\text{Manning n-value} = \frac{1.486}{Q} S^{\frac{1}{2}} R^{\frac{2}{3}} A \quad \text{Manning's Equation (Sturm, 2001)} \qquad \text{eq.3.1}$$

Q = velocity,

n = Manning's n-value,

S = longitudinal slope,

R = hydraulic radius, and

A = area.

The second method used to approach Manning's n-value determination is to use the Prandtl-von Karman velocity distribution method. This method is based on shear force between the liquid and the surface roughness of the roadway cross-section. The result from the TxDOT study and this Prandtl method calculation can then be compared in term of the total cross-section discharge.

3.2.2. Surface Roughness Estimation

Surface roughness plays a significant role in open channel flow estimation. It dramatically changes in energy dissipation through turbulence. Roughness estimation is always a tricky part of open channel design. It's an important part of many flow equations. Each channel requires study of roughness for accurate estimation.

Roadway flow design is considered to be open channel flow with uniform geometric conditions. A good estimate of some roadway surface roughness such as asphalt treatment, and smooth concrete surfaces can be difficult. Surface roughness value (k) is a direct physical measure of an actual height of surface roughness. The roughness value is often estimated from an average gain size of sand diameter in the channel or pipe bottom. The roadway surface roughness were estimated according to average uniform distribute of roughness through out the channel bottom. Roughness uniformity greatly affects the roughness value. Since the entire roadway surface was made at the same time the roughness is considered to be uniform roughness. For uniform roadway surfaces, roughness is divided in to two cases, sequence and non-sequence.

A uniform non-sequence roughness surface can be found in asphalt, asphalt treatment and TxDOT concrete surfaces. These surface roughness values can be calculated from an actual average height of roughness found in the direct measure of a surface cross-section image. (Figure 3.2, 3.3 and 3.5)

The other type of roughness is uniform sequence roughness (Figure3.4). It is found in the smooth (worn) concrete surface. This surface may contain one or two types of roughness, smooth or rough. For this type of surface, roughness height (k) can be estimated by visually observing the overall average height of longitudinal roughness from the lowest to the highest point.

A range of roughness values are pre-selected from visual inspection of roughness dimension. The maximum, minimum and average values of dimension are determined from vertical distance of roughness dimension as shown in Figure 3.2-3.5. These figures are actual longitudinal cross-sections of the roadway profile taken from the actual footage photography of roadway cross-sections.

The longitudinal surface profile presents the surface of roadway. For Figure 3.2, 3.3, and 3.4, the TxDOT concrete, asphalt, and smooth concrete surface, the surface profile represents projection of roughness from the bottom to the top. In these types of a roadway surface, roughness heights are projections of difference in vertical distances of a surface profile.

In Figure 3.5, treatment roadway profiles show projections of bottom surface profiles and top roughness profiles. Dash lines between the bottom surface and the top roughness profile show estimated projections of material in between levels.

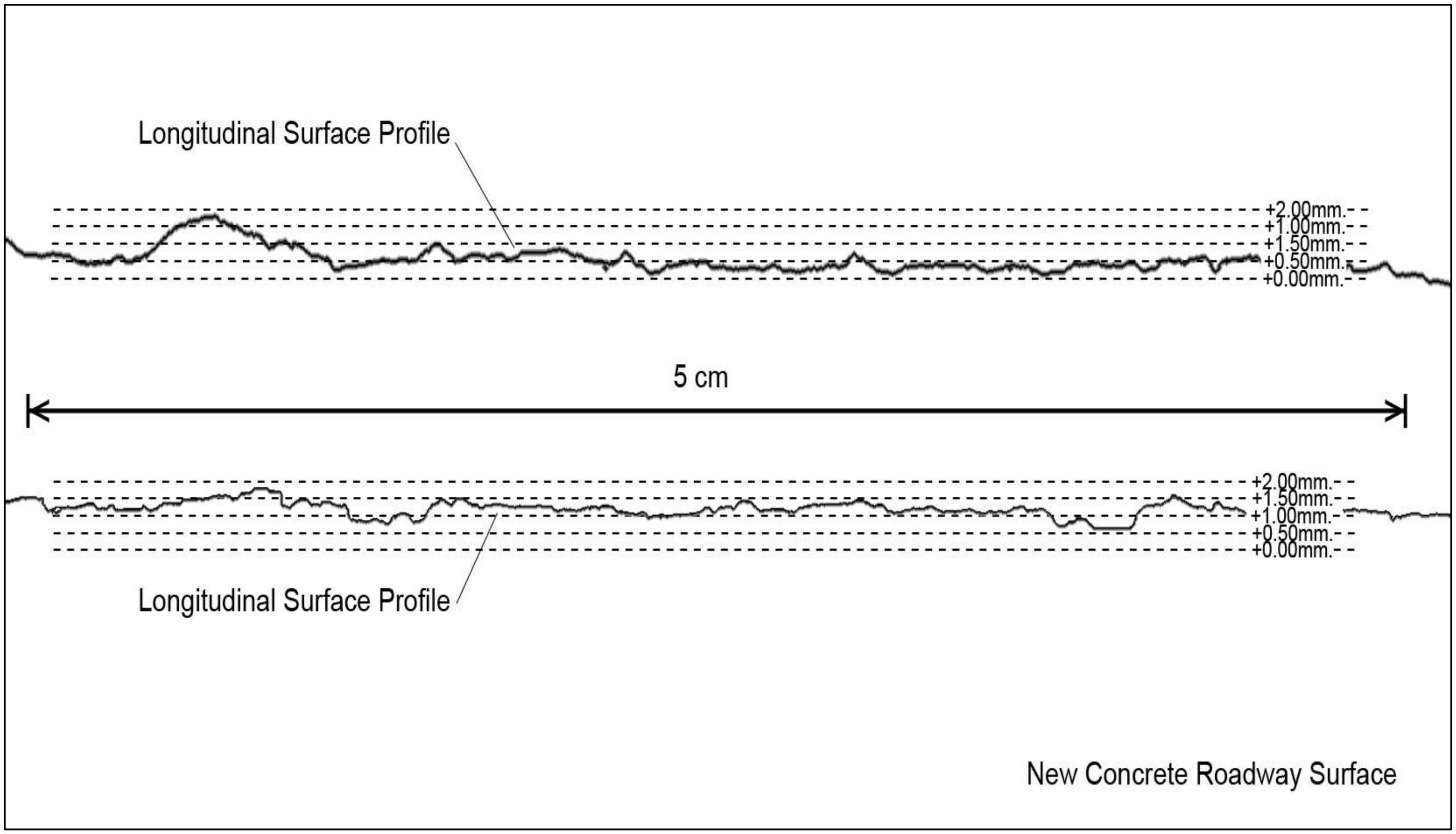


Figure 3.2 Longitudinal TxDOT concrete roadway surface profiles

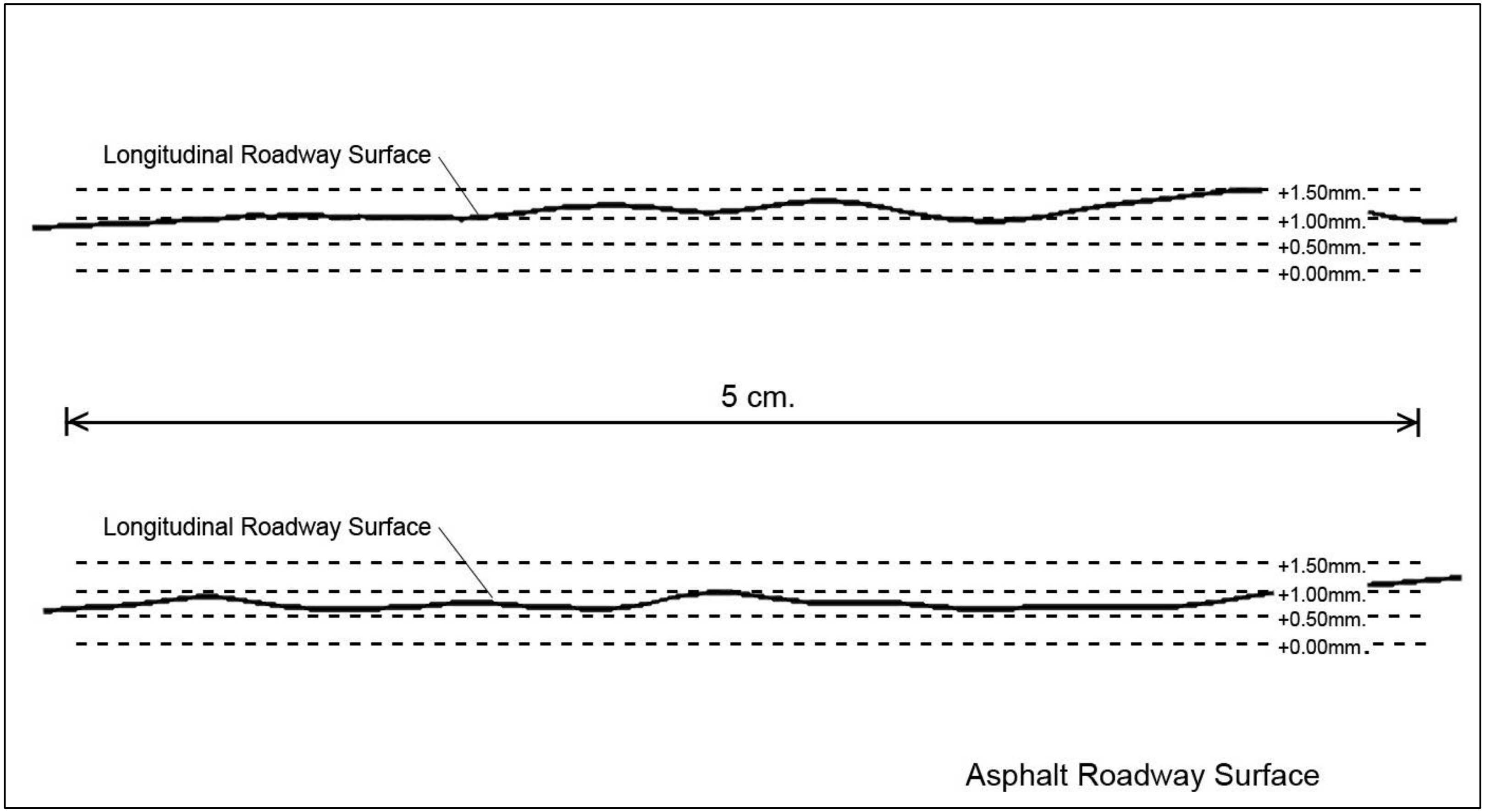


Figure 3.3 Longitudinal asphalt roadway surface profiles

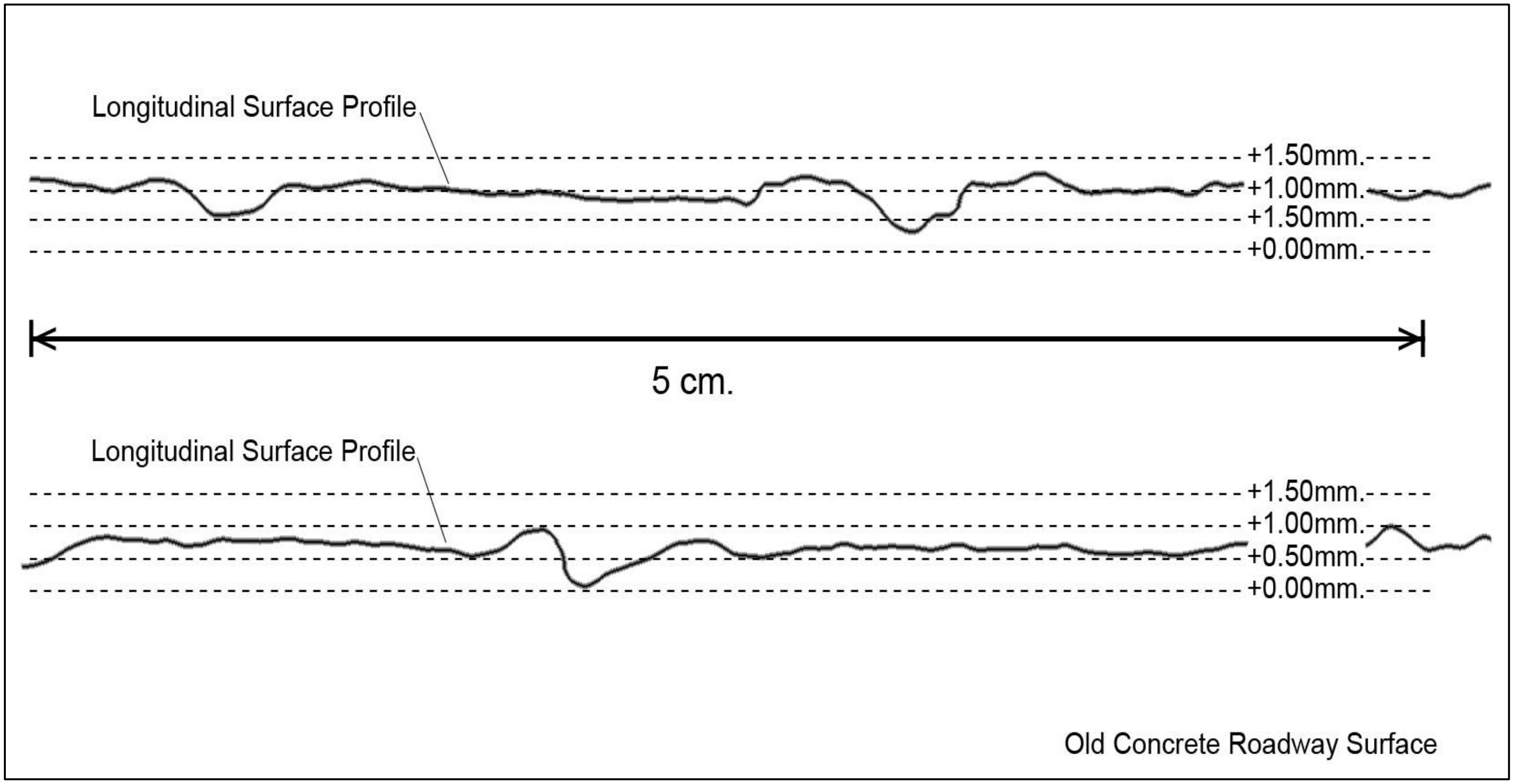


Figure 3.4 Longitudinal smooth concrete roadway surface profiles

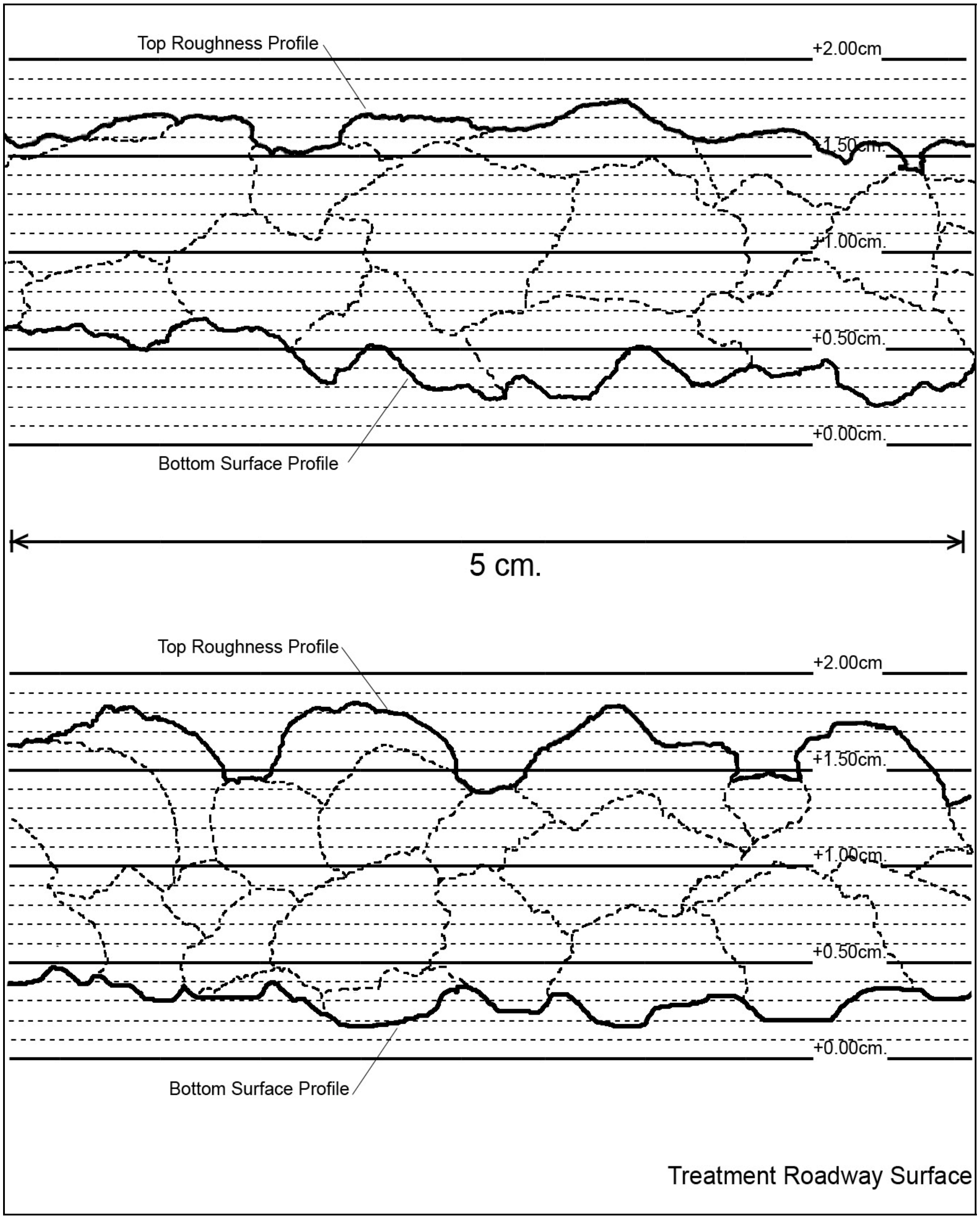


Figure 3.5 Longitudinal asphalt treatment roadway surface profiles

3.2.3 Calculate Roadway Cross-Section and Sub-Section Areas

For a steady state flow, no increase or decrease in velocity, depth, and discharge, occurs. A single cross-section is used to calculate discharge. The total cross-section area is a product of hydraulic depth and total spread. Discharge is the product of total average cross-section velocity multiple by total cross-section area.

The spread can be determined by two methods, depth or spread method, see Figure 3.6. Using the depth-method, total spread is estimated from the product of depth and measured transverse slope. Using the spread-method the total spread is obtained from an actual laboratory measurement as shown in Figure 3.6. The different methods can produce results that vary some what.

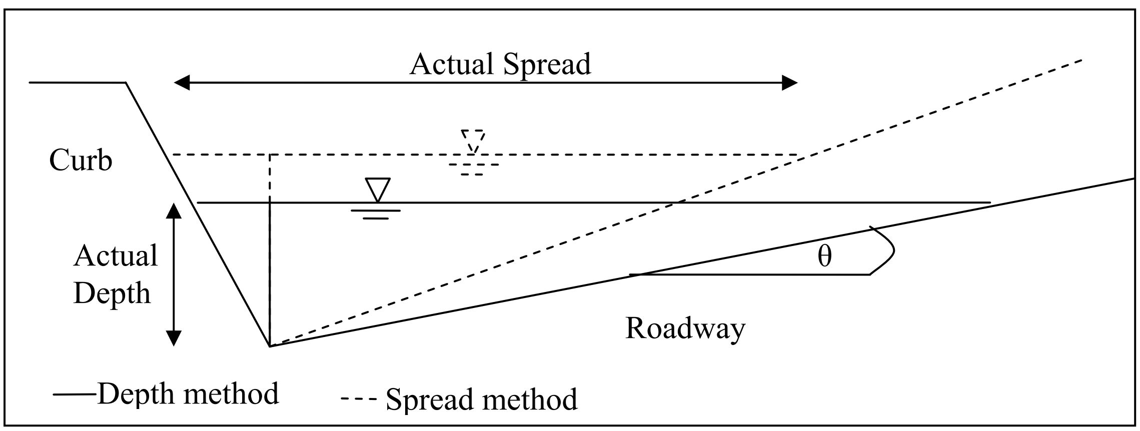


Figure 3.6 Methods of cross-section area estimation

In this research, the total roadway cross-section is divided into small vertical slices having an interval of 1 ft width in the roadway cross-section's transverse direction as shown in Figure 3.7. The sub-section area adjacent to the curb is calculated by the summation of two parts, the triangular and the trapezoidal areas, which are shown in Figure 3.8.

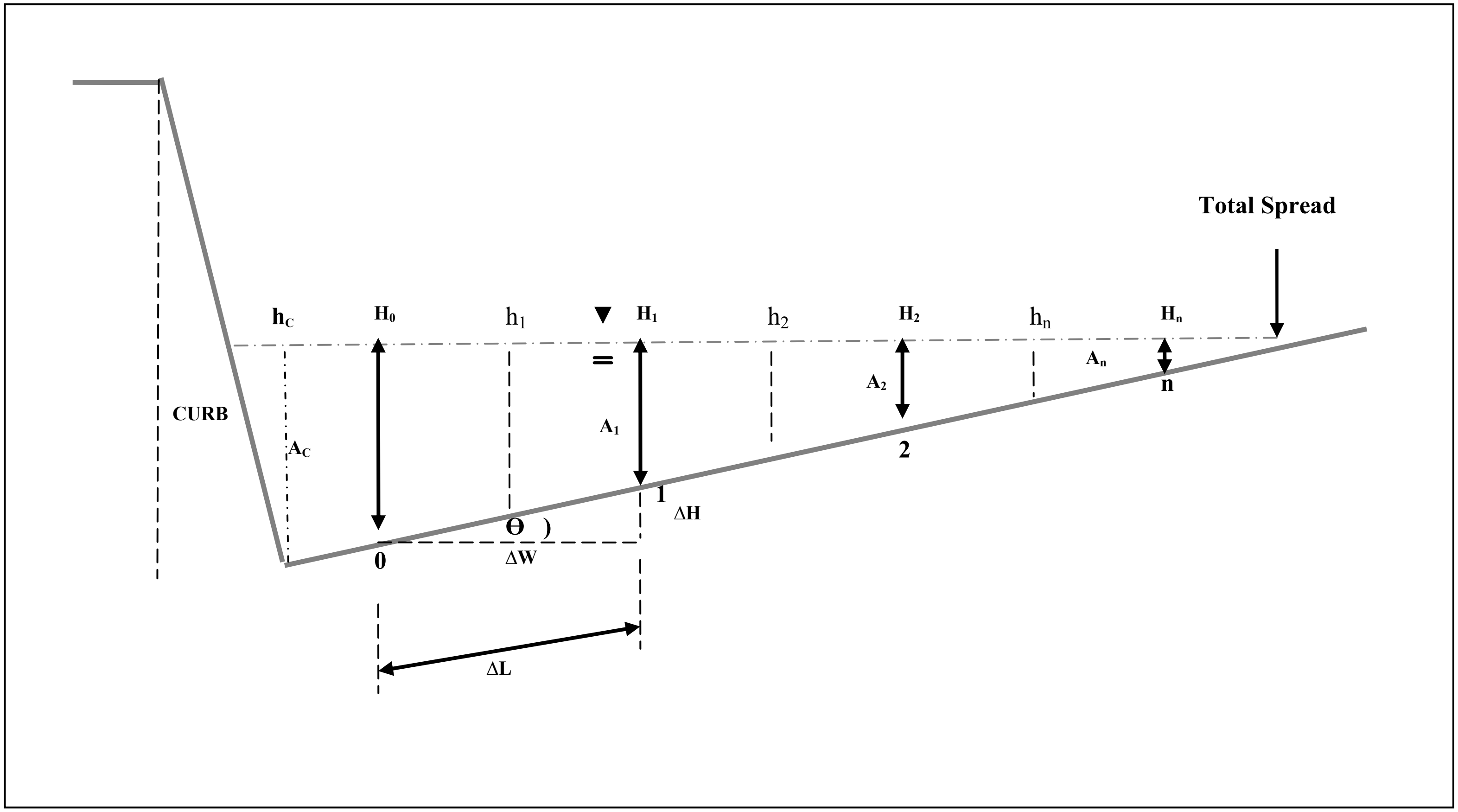


Figure 3.7 Total cross-section, sub section areas, heights, widths, and water elevation of the roadway cross-section

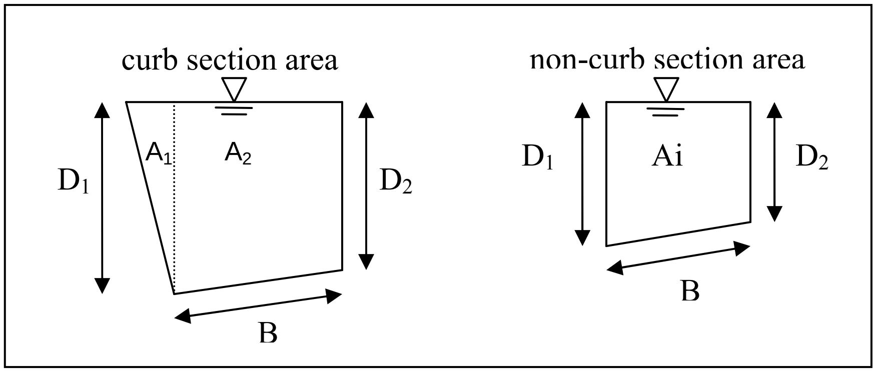


Figure 3.8 Roadway sub-section area dimensions

Figure 3.9 shows dimension of the TxDOT standard roadway curb.

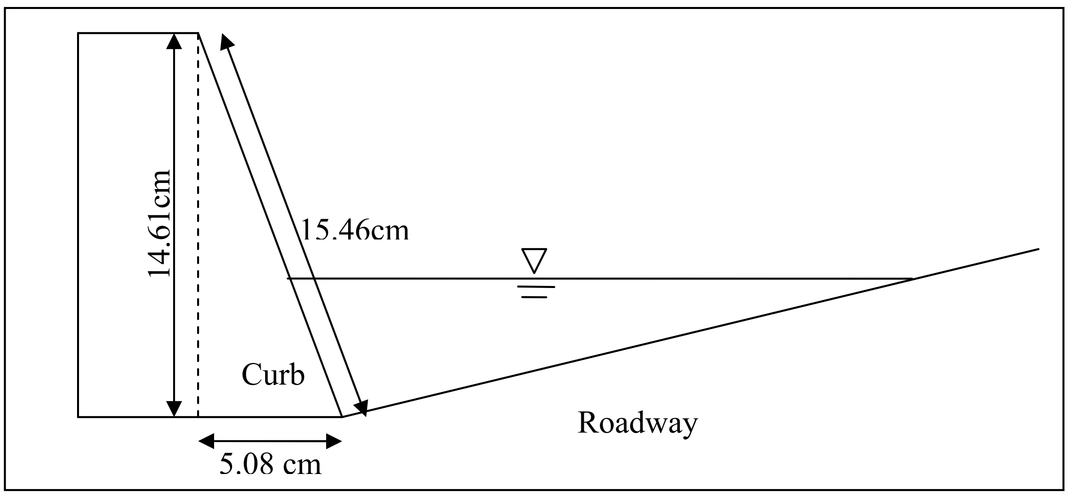


Figure 3.9 Roadway curb-section dimensions

The curb-area calculation is shown below.

curb-area (A_c) $= A_1 + A_2$ eq.3.2

where $A_1 = 0.5\ D_1 (D_1 \dfrac{5.08\text{ cm}}{14.61\text{ cm}}) = 0.1738\ D_1^{\ 2}$, eq.3.3

$A_2 = \dfrac{(D_1 + D_2)}{2} B$, eq.3.4

B = length of bottom surface, and

D_1, D_2 = hydraulic depth on left and right sides of section.

For other vertical sub-sections, areas are the product of average depth on both sides of section multiple by bottom length of section. For small transverse angles, the horizontal length between depths is similar to the bottom roadway surface length.

non-curb section area $A = \frac{(D_1 + D_2)}{2} B$ eq.3.5

The geometry data obtained from laboratory use depth (Y) in vertical distances. The conversion of vertical depth to hydraulic depth is shown below.

Hydraulic depth is $D = Y\cos(\theta)$.

where $\theta = \left[\tan^{-1}\frac{H}{100}\right]$, eq.3.6

D = hydraulic depth,

Y = vertical depth of water,

θ = degree slope angle, and

H = percent longitudinal slope; $\text{percent slope} = \frac{H\ (\text{ft})}{100\ (\text{ft})}$.

Figure 3.10 shows relationship between a vertical water depth, hydraulic depth and roadway longitudinal slope.

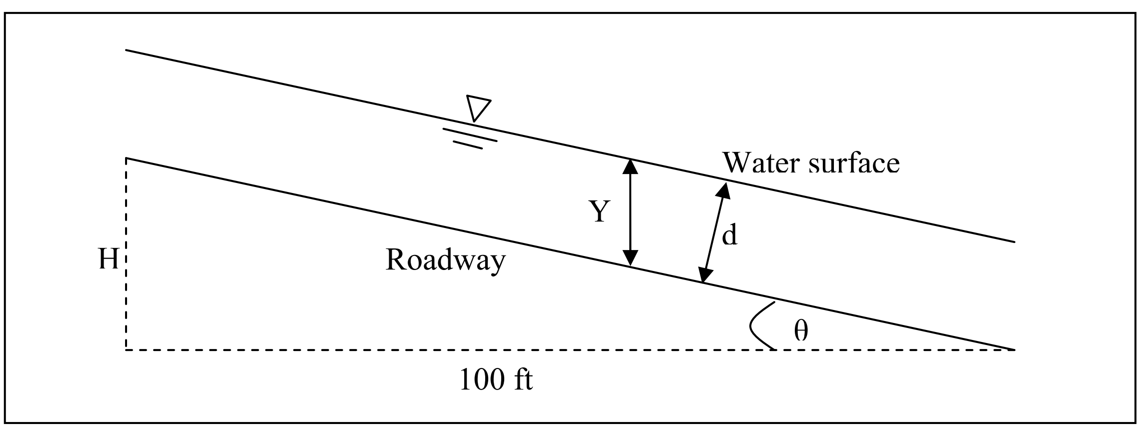


Figure 3.10 Roadway longitudinal slope calculation

3.2.3.1 Water Surface

There are two techniques of calculating surface water level in this project. Both techniques use the cross-section depth measurements obtained in the TxDOT roadway project.

For asphalt, asphalt treatment and smooth concrete roadway surface one water depth measurement was made. It was located adjacent to the curb at the deepest point of the channel. For the TxDOT concrete roadway surface, multiple water depths were taken along the transverse slope.

Additionally, all cross-sectional roadway surfaces were surveyed at several locations along the transverse direction from the curb. This survey data allows the development of a representative transverse slope for the entire cross-section or a sub-section.

The spread was measured for all roadway surfaces. The depth at the curb when convoluted with the transverse slope did not always equal to the measured spread. This is a result of the minor wave action, surface variation in the transverse slope and the shallower flow as distance progressed from the curb. Figure 3.13 shows this phenomenon in that the water surface profile does not connect with the roadway.

3.2.4 Friction Velocity

The friction velocity is described in a chapter 2. Equation 2.32 presents friction velocity.

$$\sqrt{\frac{\tau_0}{\rho}} = \sqrt{g\,R\,S} = \sqrt{g\,d\,S} = V_f \quad \text{Friction velocity (Chow, 1959)} \qquad \text{eq.2.32}$$

where hydraulic radius (R) = depth (d) for a broad channel,

R = hydraulic radius,

d = hydraulic depth,

S = slope,

ρ = mass density = w/g,

w = unit weight of fluid, and

g = gravity.

3.2.5 Critical Roughness Height

Critical roughness height is a function of roughness value, kinematic viscosity, gravity, and average velocity. It represents a unique condition of flow in channel. The critical roughness height is described in chapter 2. The critical roughness equation is presented in equation 2.38.

$$k_c = \frac{5C\nu}{\sqrt{g}V} \text{ (Chow, 1959)} \qquad \text{eq.2.38}$$

where C = Chezy's C,

ν = kinematic viscosity,

V = average velocity,

g = gravity, and

k_c = critical roughness.

3.2.6 Surface Roughness Condition

Surface roughness can be separated in to two types, a rough and smooth condition. In the velocity distribution method, the surface roughness condition can be defined through comparison of the critical roughness (k_c) and the roughness height (k). The following equation (eq.2.37) indicates the surface condition, a smooth condition and rough condition.

$$\frac{V_f k}{v} < 5 \quad \text{or} \quad k < \frac{5v}{V_f} \quad \text{Smooth flow condition, (Schlichting, 1923)} \qquad \text{eq.2.37}$$

where k = roughness height,

ν = kinematic viscosity, and

V_f = friction velocity.

If the value of the term $\frac{V_f\ k}{v}$ is less than 5, the surface is in smooth condition.

If the value of the term $\frac{V_f\ k}{v}$ is more than 5 a surface is in rough condition.

Since k is almost constant in a particular channel section and ν minimally changes, friction velocity has the greatest effect to define the surface roughness conditions. (Chow, 1959)

3.2.7 Vertical Velocity Profile

Vertical velocity distributions are flow resistance equations, which represent the relationship of velocity and roughness. They are the direct result of channel geometry conditions. Local sub-section flow and geometry such as depth, kinetic viscosity and surface roughness are used to evaluate the velocity profile. The local geometries of each roadway sub-section vary section by section due to the non-symmetric triangular shape of the roadway. The vertical velocity profile equation is divided into two types, roughness surface and smooth surface. Two types of flow equation used in this project are shown in equation 2.35 (smooth surface condition) and 2.36 (rough surface condition). These two types are result from different roughness, viscosity and turbulence in an individual channel. The velocity profile methodology is explained in chapter 2. Figure 3.11 demonstrates vertical velocity profiles of every sub-section across the roadway.

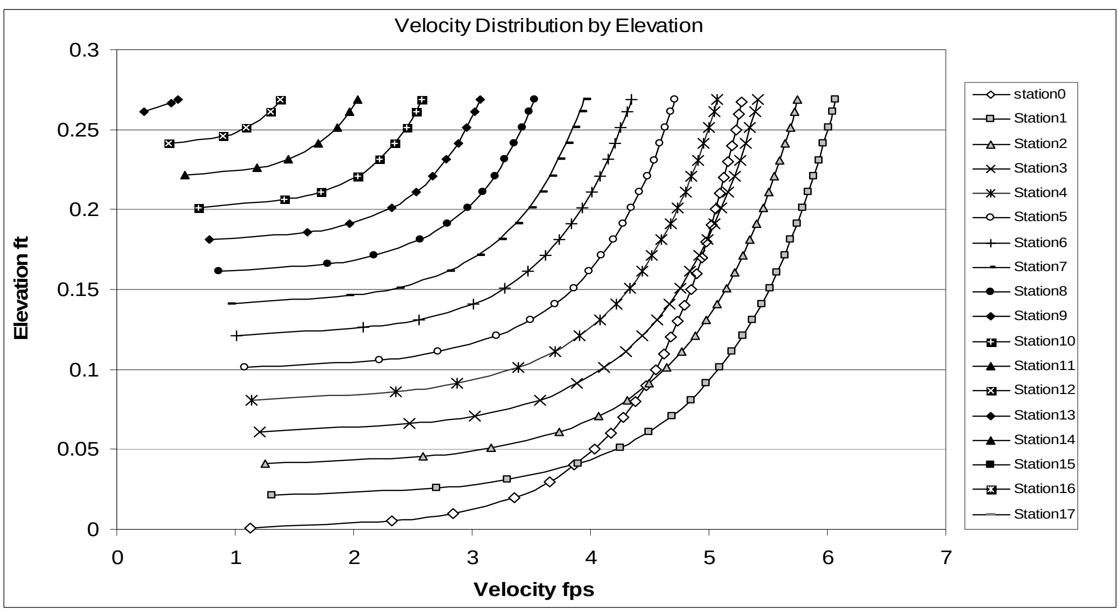


Figure 3.11 Vertical velocity profiles across the roadway cross-section

The velocity profile starting approximately at elevation 0 ft is nearest to the curb. Elevation represents the height on a profile above the channel lowest point near the curb where a velocity can be found. Each additional profile stat at the next elevation is located further out along the transverse slope.

$$V = 5.75\,V_f \log\left(\frac{9\,y\,V_f}{v}\right) \text{ for smooth surface (Prandtl-von Karman, 1926)} \qquad \text{eq.2.35}$$

$$V = 5.75\,V_f \log\left(\frac{30\,y}{k}\right) \text{ for rough surface (Prandtl-von Karman, 1926)} \qquad \text{eq.2.36}$$

3.2.8 Calculate Sub-Section Average Velocity

A roadway cross-section is a non-symmetric triangular channel. Each vertical velocity profile is individually calculated from the station depth. The USGS recommended average velocity method (Wahl, Thomas and Hirsh, 1995) is used in this research. The average velocity can be obtained by taking the velocity at 0.6 of the depth or an average of the 0.2 and 0.8 of the depth from the surface of water.

Another method for averaging velocity is an integration of vertical velocity profile. Integration will give the total area of vertical velocity curve, which when divided by the total depth estimated the average velocity. An average velocity can be obtained from equation 3.7. This method gives a very close estimation to the USGS method.

$$\text{Average sub-section velocity} = \frac{\int_0^d V\,dy}{d_i} \qquad \text{eq.3.7}$$

Figure 3.12 shows sub-section average velocities across the roadway cross-section. The average velocity at the curb-section is dropped due to the increasing wetted-perimeter at the curb-section. The section next to the curb shows the highest average velocity. Sub-section average velocities decrease along the transverse slope due to the decreasing of water depth.

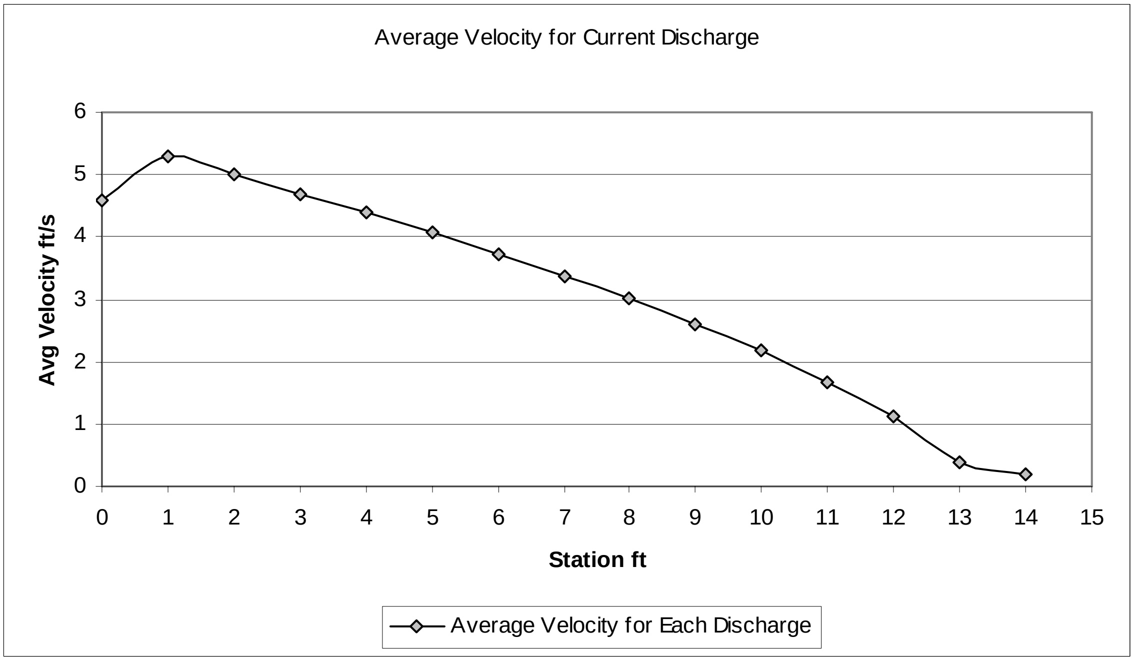


Figure 3.12 Plan view of average velocity in each station from curb on left hand side to the end of water on right hand side of roadway cross-section

3.2.8.1 Total Cross-Section Velocity Distribution

A cross-section velocity distribution can be display by plotting local geometries of roadway such as elevation, transverse slope and sub-section vertical velocity profiles as shown in Figure 3.13. The roadway cross-section velocity distribution demonstrates details of isolated-velocity, depth of flow and water surface across the entire cross-section. It also shows location of super-critical, critical (Froude number = 1), and sub-critical state of flow.

Froude number = $F = \frac{V}{(g\,d/\alpha)^{1/2}}$ (Sturm, 2001) eq.3.8

where F = Froude number,

V = velocity,

g = gravity,

d = depth, and

α = specific gravity.

In Figure 3.13, the water surface varies with the depth measurement. The fitted equation best represents the water surface. It also indicates potential shallow flow area that could easily be missed during measurement. Notice that the Froude number in this diagram can be representation of super and sub-critical flow location.

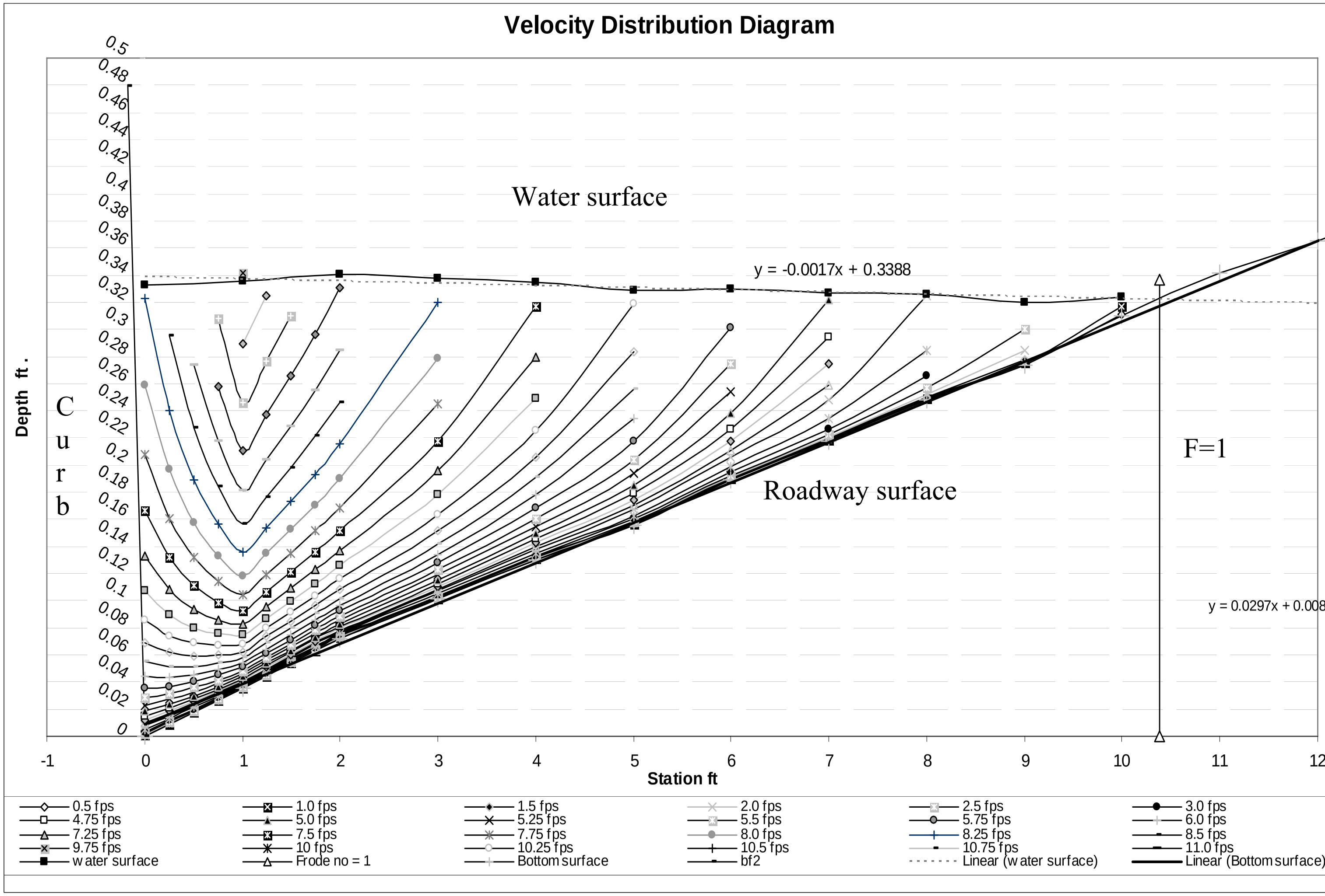


Figure 3.13 Velocity distributions across a roadway cross-section

3.2.9. Sub-Section Manning's n-value Calculation

In every sub-section, n-value is separately calculated based on local geometries of sub-section. The local geometries consist of water depth, surface elevation, surface area, longitudinal, and transverse slopes. The sub-section n-value is estimated from the Prandtl-von Karman velocity equations. The transformations of velocity and Manning's equations are shown below. The equation 3.9 shows the calculation of sub-section n-value based on Prandtl-von Karman velocity distribution equations.

Manning's equation (eq.2.1) can be used to calculate an average sub-section velocity (V_i) by inputting sub-section geometries as shown below.

$$V_i = \frac{1.486}{n_i} S^{1/2} R_i^{2/3} \text{ (Sturm, 2001)} \qquad \text{eq.3.9}$$

where V_i = sub-section velocity

n_i = sub-section Manning's n-value

S = longitudinal slope

R_i = sub-section hydraulic radius

The average sub-section velocity also can be estimated from Prandtl-von Karman velocity equation (equation 2.35 and 2.36).

By assuming an average velocity is located at 0.4 of depth from the bottom surface (y = 0.4d), equation 2.36 can be rewritten in eq.3.10.

Average velocity by velocity distribution equation (rough condition)

$$V_i = 5.75 V_{f\,i} \log \frac{30(0.4 d_i)}{k} \qquad \text{eq.3.10}$$

By substitute average velocity (V_i) in Manning's equation (eq.2.1) by Prandtl-von Karman average velocity equation (eq.3.10), the relationship of roughness value (k) and n-value can be shown in equation below.

$$\frac{1.486}{n_i} S^{1/2} R_i^{2/3} = 5.75 V_{f\,i} \log \frac{30(0.4 d_i)}{k} \qquad \text{eq.3.11}$$

Then solving for n-value

Manning's n-value by Prandtl's rough surface equation is

$$n_i = \frac{1.486 S^{1/2} R_i^{2/3}}{5.75 V_{f\,i} \log(\frac{30(0.4 d_i)}{k})} \qquad \text{eq.3.12}$$

The smooth surface condition (eq.2.35) can be similarly derived giving in equation 3.13, Manning's n-value by Prandtl's smooth surface equation is

$$n_i = \frac{1.486 S^{1/2} R_i^{2/3}}{5.75 V_{f.i} \log(\frac{9(0.4 d_i) V_{f.i}}{\nu})} \qquad \text{eq.3.13}$$

3.2.10. Sub-Section Discharges Calculation

The vertical velocity profile of sub-sections is estimated by Prandtl-von Karman velocity method. The average velocity and area of sub-section is shown in *"average velocity calculation*" and "*sub-section area calculation"* sections. Each sub-section discharge is obtained by multiplied average sub-section velocity by the sub-section area for each sub-section across the roadway cross-section. As shown below.

$$\text{Sub-section discharge}\ (q_i) = V_{i-\text{average}} * A_i \qquad \text{eq.3.14}$$

3.2.11 Total Cross-Section Discharge and Average Manning's n-value Calculation

Total cross-section discharge of a roadway can be obtained by sum of all sub-section discharge as shown below.

$$Total\ discharge\ (Q_{total}) = \sum_{1}^{n} Sub-section\ discharge \qquad \text{eq.3.15}$$

A sub-section n-value is multiplied by a local geometry such as depth, wetted-perimeter, hydraulic-radius, velocity, discharge and area in order to weight effects of local geometry in that section. These factors are parts of the local geometry inputs and calculation results. There are several methods to obtaining average n-value of the entire cross-section. The methods of averaging n-value are associated with local geometries of a roadway. Some literatures suggest using a depth or a wetted-perimeter for a weight-parameter in estimating a cross-section average n-value. Each method gives different results of an average n-value. All methods used for averaging cross-section n-value are discussed in the chapter 2.

3.3 Mathematic Statistical Analysis

Before any analysis, all TxDOT roadway and velocity distribution data sets, n-values and discharges, have to be analyzed statistically. The processes such as normality distribution, detect outliers, scatter plot, cleaning outliers, and normality evaluation were used to analyze data. The statistical analysis is a step to minimize errors in the results. The statistical analysis process steps are shown in Figure 3.14.

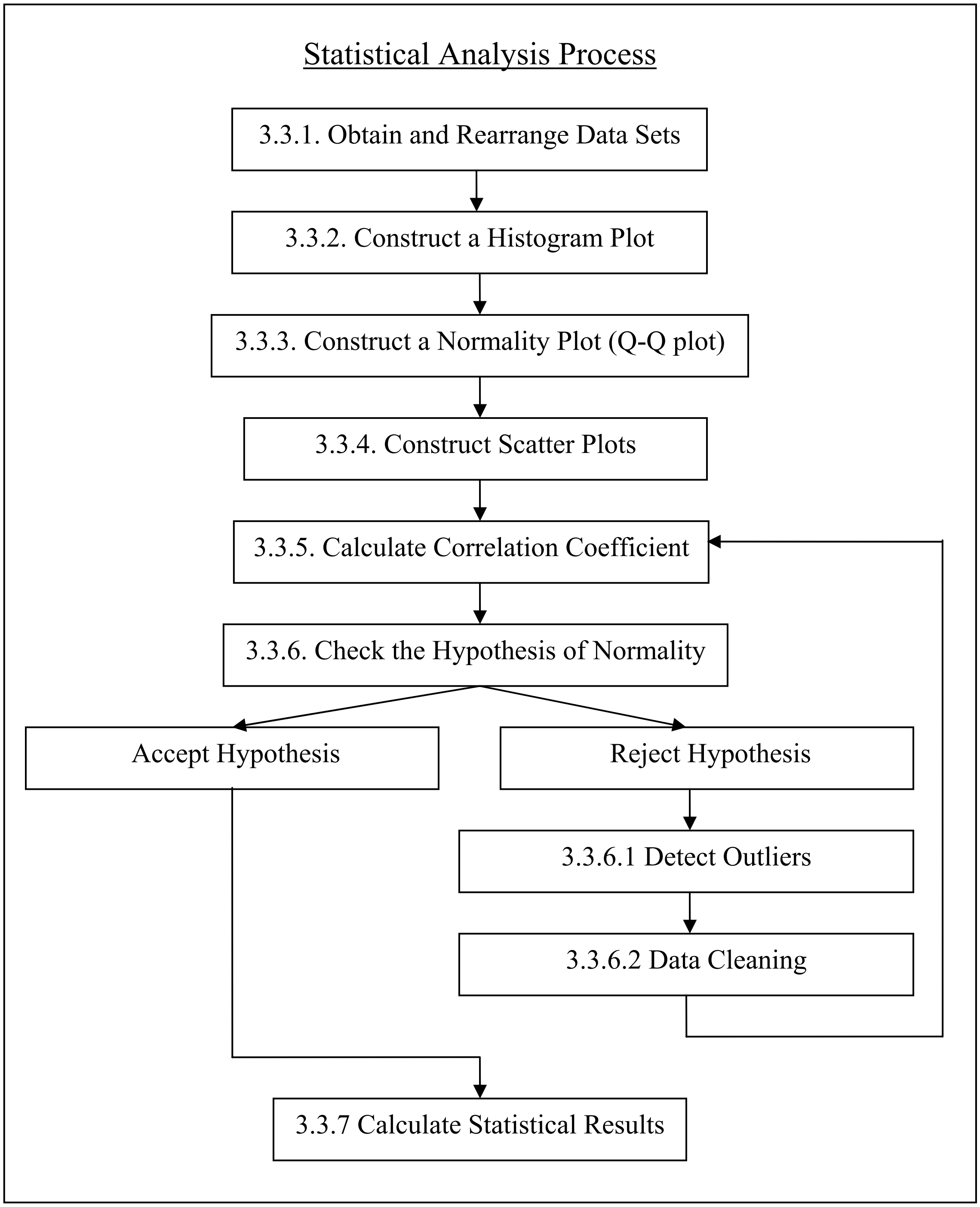


Figure 3.14 Process of statistical analysis

3.3.1 Obtain and Rearrange Data Sets

All series of average cross-section n-values and discharges from TxDOT laboratory and velocity distribution method are rearranged in order from low value to high value. Histogram and probability plots are developed from these data sets.

3.3.2 Construct Histogram Plot

In this research, the total cross-section n-values are used in histogram plots. The total range of n-value is based on the overall maximum and minimum n-value. The n-value interval is roughly estimated to be about 0.001. All the histogram plots of total roadway cross-section n-value indicate sign of normal distribution with some outliers. The highest column in the histogram plot shows the largest interval of n-value data frequency. An example histogram plot is shown in Figure 3.15 and Appendix E.

A histogram plot can be constructed as follow.

1. Divide the continuous range of data in to equal intervals. Too many or too few data intervals make it difficult to recognize normality distribution.

2. Group data into the interval ranges. The number of data in each interval range represents the data frequency.

3. Plot a bar graph between numbers of data and the interval ranges in y and x coordinates respectively. Montgomery, (Runger and Hubele, 2004)

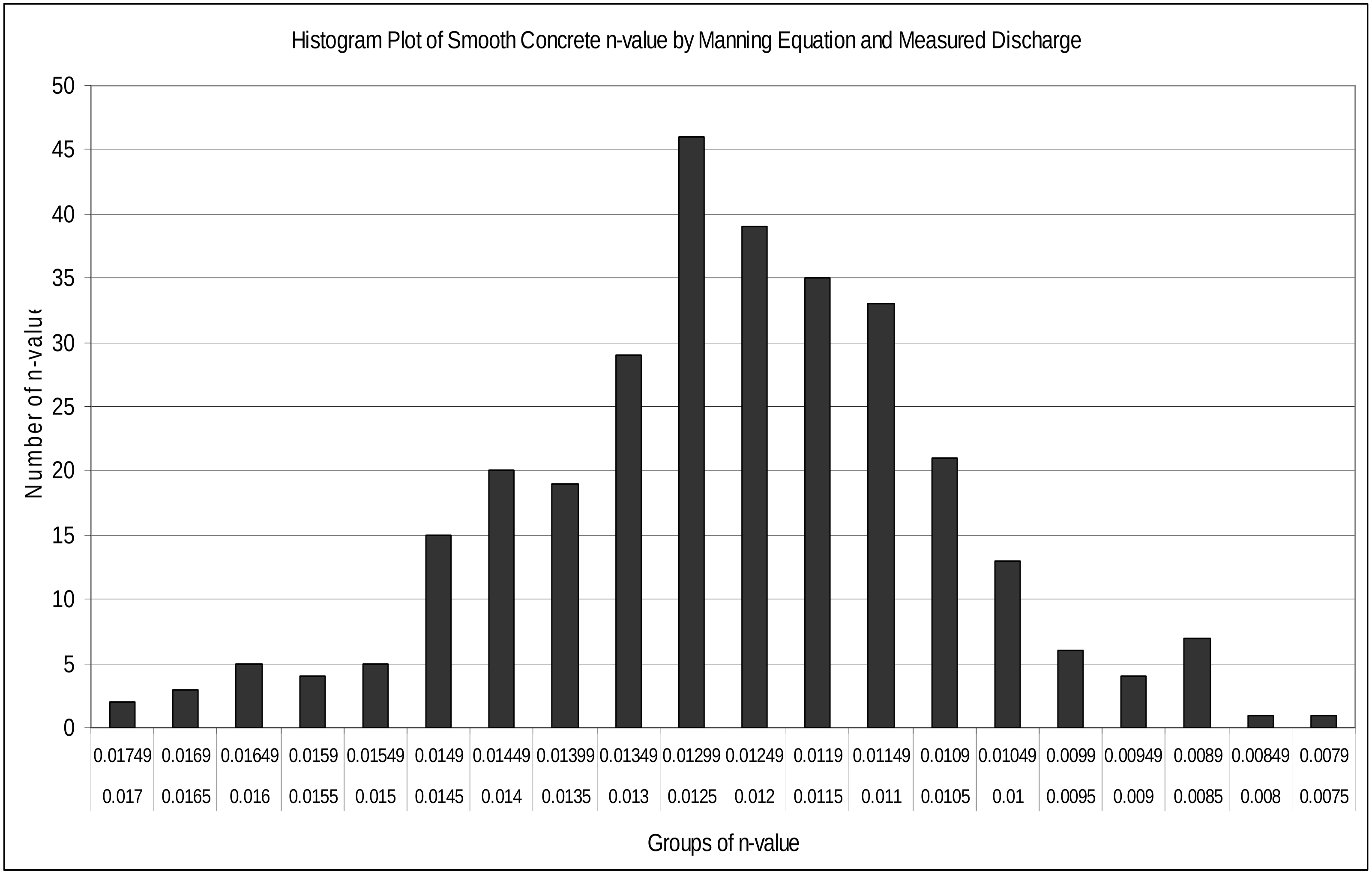


Figure 3.15 Histogram plot of smooth concrete n-value by Manning's equation and measure discharge

3.3.3 Construct a Normal Probability Plot (Q-Q Plot)

In this research, normality plots of n-value and discharge are developed for all sets of roadway data. Example plots of normal probability are shown in Figures 3.16 (before cleaning data) and Figure 3.17 (after cleaning data). The normality plot is constructed by the following steps.

1. Order the original observations to get $x_{(1)}$, $x_{(2)}$, …..$x_{(n)}$ and their corresponding probability values (1-1/2)/n, (2-1/2)/n,…., (n-1/2)/n;
2. Calculate the standard normal quantiles $q_{(1)}$, $q_{(2)}$, ……, $q_{(n)}$
3. Plot the pairs of observations ($q_{(1)}$, $x_{(1)}$), ($q_{(2)}$, $x_{(2)}$), ……($q_{(n)}$, $x_{(n)}$), and examine the "straightness" of the outcome. (Johnson, 2002)

Probability level is related to standard quantiles as shown in equation 2.52.

$$P[Z \leq q_{(j)}] = \int_{-\infty}^{q(j)} \frac{1}{\sqrt{2\pi}} e^{-z^2/2}\, dz = P_{(j)} = \frac{j - \frac{1}{2}}{n} \text{ (Johnson, 2002)} \qquad \text{eq.2.52}$$

where $P_{(j)}$ = probability level,

$q_{(j)}$ = standard quantiles,

Z = probability,

j = 1, 2, 3, ….., n, and

n = total number of samples.

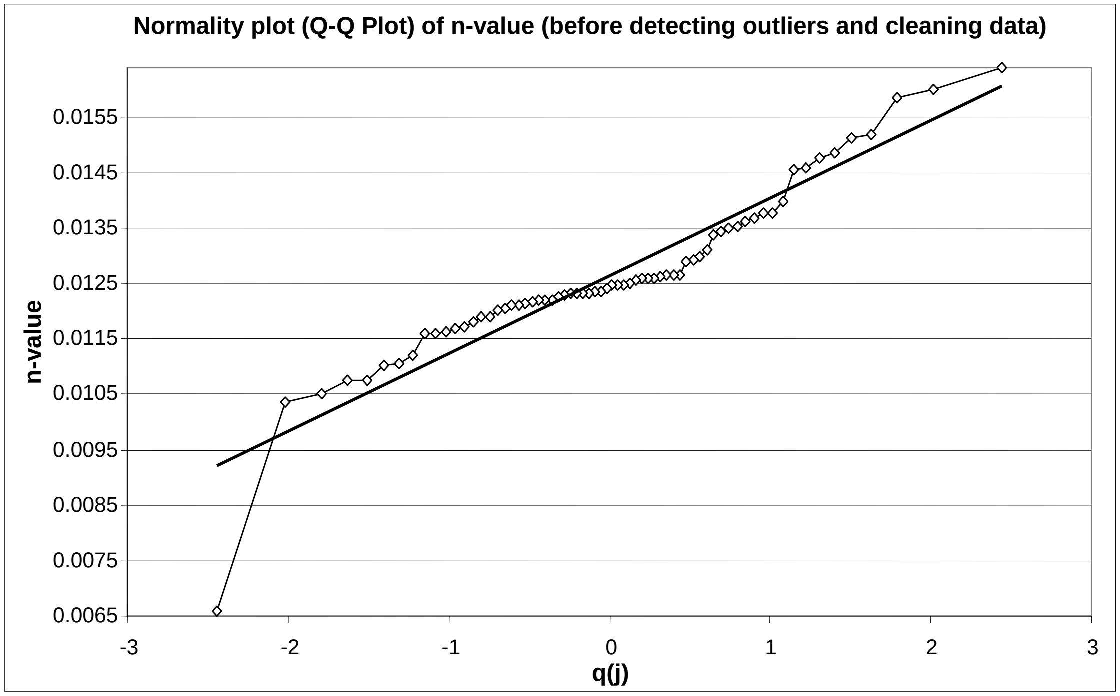


Figure 3.16 Normality plot (Q-Q plot) of n-values (before detecting outliers and cleaning data)

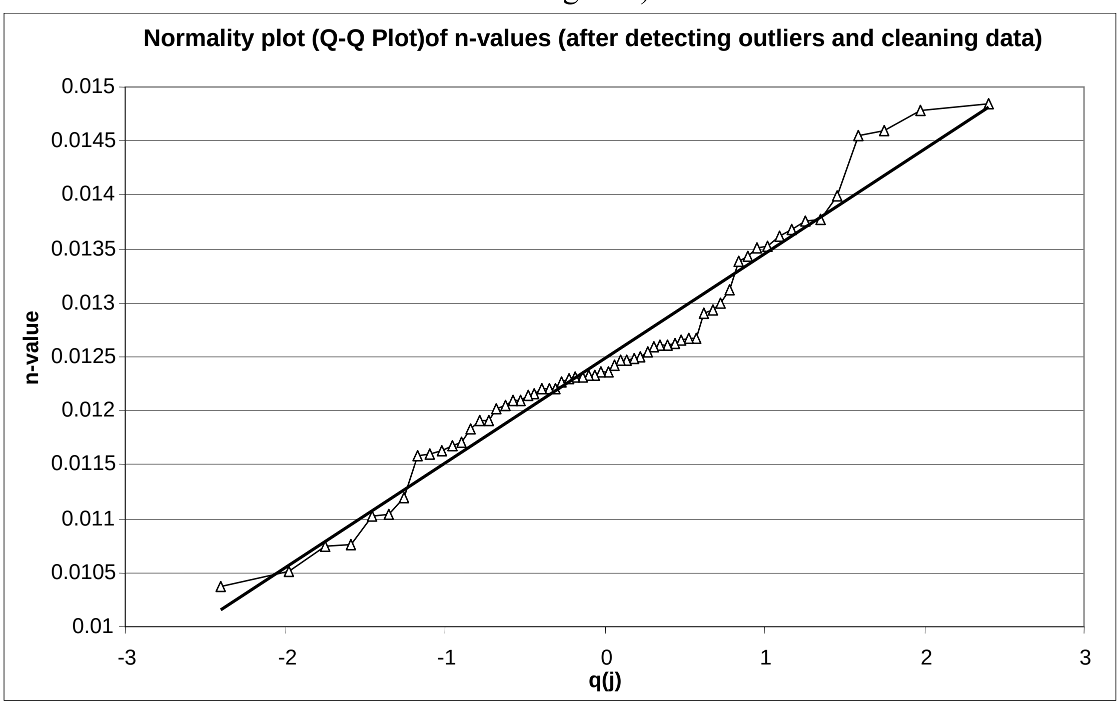


Figure 3.17 Normality plot (Q-Q plot) of n-values (after detecting outliers and cleaning data)

3.3.4 Construct Scatter Plots

A scatter plot compares one set of data with a second set of data taken under similar conditions. In this study, four similar sets of data existed for the TxDOT concrete roadway. The data sets differed only by the amount of rainfall each experiment. Each data set experiment only one of the following rainfall rates; 0, 1, 3 and 6 inches per hour. These four data sets were plotted one on one in scatter plots as shown in Figure 3.18.

X_1 is no-rainfall data plotted against no-rainfall data.

X_2 is 1-in/hr rainfall data plotted against 1-in/hr rainfall data.

X_3 is 3-in/hr rainfall data plotted against 3-in/hr rainfall data.

X_4 is 6-in/hr rainfall data plotted against 6-in/hr rainfall data.

The top row is X_1, no-rain vs 1-in/hr, no-rain vs 3-in/hr, no-rain vs 6-in/hr.

The left column is X_1, 1-in/hr vs no-rain, 3-in/hr vs no-rain, 6-in/hr vs no-rain.

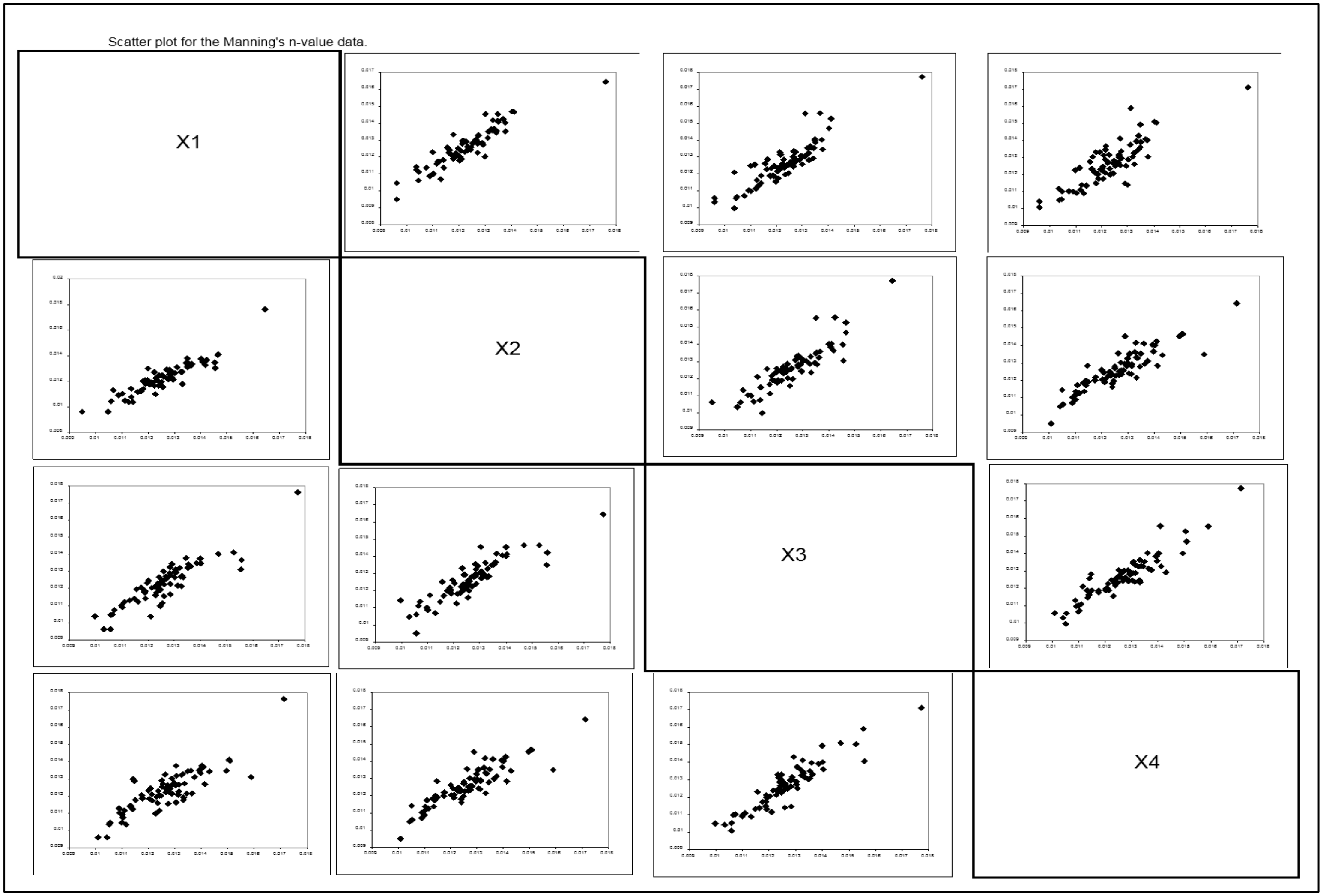


Figure 3.18 Scatter plots of TxDOT concrete roadway n-values with no-rain, 1-inch/hr, 3-inch/hr, and 6-inch/hr

3.3.5 Calculate Correlation Coefficient

The correlation coefficient is used to estimate normality distribution of data set before and after removing outliers. Correlation coefficient is a method used to calculate after most of outliers were taken out. An equation 2.53 provides a calculation of correlation coefficient of data set. Several of methods, such as histogram, normal probability plot, and scatter plots were used to identify and remove outliers. The process of removing outlier is described in topic 3.3.6.1. Table 3.1 shows correlation coefficient calculation samples.

$$r_Q = \frac{\sum_{j=1}^{n}(x_{(j)} - \bar{x})(q_{(j)} - \bar{q})}{\sqrt{\sum_{j=1}^{n}(x_{(j)} - \bar{x})^2}\sqrt{\sum_{j=1}^{n}(q_{(j)} - \bar{q})^2}} \quad \text{(Filliben, 1975)} \qquad \text{eq.2.53}$$

where r_Q = correlation coefficient,

x = data point,

$\bar{x}$ = numerical average of data,

$q_{(j)}$ = standard quantiles,

$\bar{q}$ = numerical average of standard quantiles,

j = 1, 2, 3… n, and

n = total number of samples.

Table 3.1 Correlation coefficient calculation table

no.	n-value	$(x_{(j)} - \bar{x})\, q_{(j)}$	$(x_{(j)} - \bar{x})^2$	$q_{(j)}$	$q^2_{(j)}$
1	0.010578	0.003476	0.000004	-1.827880	3.341145
2	0.010578	0.003178	0.000004	-1.671644	2.794393
3	0.010654	0.002826	0.000003	-1.548003	2.396313
4	0.010720	0.002541	0.000003	-1.444321	2.086064
5	0.010982	0.002028	0.000002	-1.354190	1.833831
6	0.011028	0.001849	0.000002	-1.273889	1.622794
7	0.011105	0.001651	0.000002	-1.201055	1.442534
8	0.011310	0.001327	0.000001	-1.134090	1.286160
9	0.011478	0.001073	0.000001	-1.071858	1.148880
10	0.011560	0.000932	0.000001	-1.013522	1.027227
11	0.011632	0.000812	0.000001	-0.958446	0.918619
12	0.011750	0.000661	0.000001	-0.906134	0.821079
	.	.	.	.	.
	.	.	.	.	.
	.	.	.	.	.
73	0.012101	0.000209	0.000000	-0.551806	0.304490
74	0.012150	0.000169	0.000000	-0.512776	0.262939
Σ		0.045037	0.000048		43.613574
correlation coefficient (r_q)=			0.968		
In table 3.1, at 74 samples and α = 0.05; critical point = 0.983					

3.3.6 Check Hypothesis of Normality

Hypothesis of normality is used to separate types of data series distribution. For a normal distributed data set, correlation coefficient value will be compared to a critical correlation coefficient value at significant level (α) of 0.05 for acceptation level. Table 3.2 shows critical points for correlation coefficient value with various significance levels (α) and sample sizes. For different sample size, the critical correlation coefficient is obtained by interpolation. In order to accept a data set, the correlation value has to be higher or equal to critical values in the table. Data sets with a lower correlation coefficient value than a critical value will need further data cleaning analysis or rejected as a non-normal distribution.

Table 3.2 Critical points for the Q-Q plot correlation coefficient test for normality (Johnson 2002)

Sample size	Significance levels α		
n	.01	.05	.10
5	.8299	.8788	.9032
10	.8801	.9198	.9351
15	.9126	.9389	.9503
20	.9269	.9508	.9604
25	.9410	.9591	.9665
30	.9479	.9652	.9715
35	.9538	.9682	.9740
40	.9599	.9726	.9771
45	.9632	.9749	.9792
50	.9671	.9768	.9809
55	.9695	.9787	.9822
60	.9720	.9801	.9836
75	.9771	.9838	.9866
100	.9822	.9873	.9895
150	.9879	.9913	.9928
200	.9905	.9931	.9942
300	.9935	.9953	.9960

3.3.6.1 Detect Outliers

Outliers are unusual data points that can be identified by histogram plot, probability plot, scatter plot, and chi-square plot. In the probability plot, outliers can be found on both ends of data sets as shown in Figure 3.16. Those unusual points greatly affect the outcome of analysis. The results are unpredictable with interruption sources. The only way to treat these unused points is carefully remove them out from the analysis. The unusual points can be found as uneven spacing or further out from a main line plot.

The following steps are for standardized and generalized distances calculation. They are used for detecting outliers in data sets with very similar data range. Therefore, these steps were used only TxDOT concrete roadway data with no-rain, 1-in/hr, 3-in/hr and 6-in/hr.

1. Make a dot plot for each variable.
2. Make a scatter plot for each pair of variables.
3. Calculate the standardized values $z_{jk}= (x_{jk} – x_k)/\text{sqrt}(s_{kk})$ for j = 1,2..n and each column k = 1,2,..p examine these standardized values for large or small values.
4. Calculate the generalized squared distances $d_j^2 = (x_{(j)} - \bar{x})' S^{-1} (x_{(j)} - \bar{x})$.

   Examine these distances for unusually large values. (Johnson, 2002)

Table 3.3 shows standardized, generalized distances and n-values of TxDOT roadway surface with no-rain, 1-in/hr, 3-in/hr, 6-in/hr.

Table 3.3 Standardized and generalized distance values for TxDOT concrete roadway surface with no-rain, 1-in/hr, 3-in/hr, 6-in/hr

no-rain	1-in/hr	3-in/hr	6-in/hr	no.					
X_1	X_2	X_3	X_4		Z_1	Z_2	Z_3	Z_4	dj^2
0.01411	0.01466	0.01527	0.0150	1	1.611	1.816	2.403	2.154	5.0424
0.01375	0.01401	0.01401	0.01401	2	1.288	1.235	1.253	1.223	3.2260
0.01178	0.01331	0.0123	0.01331	3	-0.474	0.617	-0.282	0.589	0.4360
0.01192	0.01214	0.01246	0.0133	4	-0.349	-0.428	-0.162	0.588	0.2362
0.01292	0.01271	0.01305	0.01250	5	0.548	0.078	0.382	-0.142	0.5837
0.01348	0.01411	0.01403	0.01359	6	1.046	1.326	1.271	0.848	2.1278
0.01266	0.01282	0.01334	0.01313	7	0.315	0.175	0.644	0.432	0.1928
0.01204	0.01196	0.01234	0.01246	8	-0.234	-0.588	-0.267	-0.176	0.1067
0.01164	0.01239	0.01285	0.01304	9	-0.592	-0.203	0.200	0.350	0.6820
0.01270	0.01224	0.01269	0.01254	10	0.354	-0.337	0.051	-0.105	0.2439
0.01271	0.01283	0.01325	0.01412	11	0.359	0.184	0.566	1.322	0.2501
0.01090	0.01088	0.01102	0.01000	12	-1.256	-1.555	-1.470	-1.504	3.0656
0.01115	0.01160	0.01255	0.01239	13	-1.035	-0.908	-0.075	-0.239	2.0833
0.01377	0.01349	0.01345	0.01304	14	1.311	0.772	0.749	0.344	3.3387
0.01322	0.0136	0.01322	0.01325	15	0.819	0.894	0.535	0.536	1.3024
0.01310	0.01349	0.0155	0.01588	16	0.713	0.772	2.658	2.922	0.9887
0.01368	0.01423	0.01558	0.01407	17	1.226	1.431	2.689	1.279	2.9205
0.01334	0.01366	0.01359	0.01396	18	0.924	0.922	0.870	1.182	1.6593
0.01216	0.01295	0.01314	0.01364	19	-0.132	0.294	0.460	0.895	0.0336
0.01347	0.01453	0.01399	0.01494	20	1.043	1.703	1.240	2.064	2.1133
0.01402	0.01465	0.01469	0.01508	21	1.528	1.808	1.877	2.191	4.5358
0.01223	0.01230	0.01242	0.01265	22	-0.069	-0.283	-0.198	-0.002	0.0093
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
0.01102	0.01101	0.01098	0.01090	69	-1.151	-1.435	-1.512	-1.591	2.5749
0.01130	0.01069	0.01131	0.01088	70	-0.902	-1.723	-1.213	-1.612	1.5798
0.01213	0.01277	0.01327	0.01343	71	-0.158	0.130	0.582	0.704	0.0487
0.01045	0.01060	0.01057	0.01053	72	-1.658	-1.801	-1.881	-1.926	5.3413
0.01762	0.01644	0.01772	0.01711	73	4.741	3.397	4.645	4.032	43.690
0.01299	0.01199	0.01258	0.01140	74	0.607	-0.560	-0.050	-1.134	0.7167
0.01231	0.01262	0.01263	0.01266	<= average n-value					

3.3.6.2 Data Cleaning

Normally, laboratory or field raw data contains unusual point as shown in detect outliers step. The methods to identify outliers such as detecting outliers and scatter plots show location of unrelated points. These unrelated points or outliers can be removed out of the data sets to improve the normality. Figure 3.16, 3.17, 3.19, 3.20 and 3.21 show plots of result, discharge and n-value, before and after data cleaning process.

3.3.7 Calculate Statistical Result

The statistical result of analyzed data shows improvement of normality distribution and minimal numbers of outliers. The percentage of error is reduced on account of the reduction of outliers in data series. Then the analyzed data sets are ready for display and numerical average calculation. An average n-value of each data set is calculated from numerical average. After an average n-value for each TxDOT study and velocity method data set are calculated, data comparison can be done. All data sets of n-value after removed outliers are plotted in normal scale graph and shown in Appendix C. The comparisons of discharge between measured and velocity method four types of the roadway surface are shown in Figure 3.19, 3.20 and Appendix D.

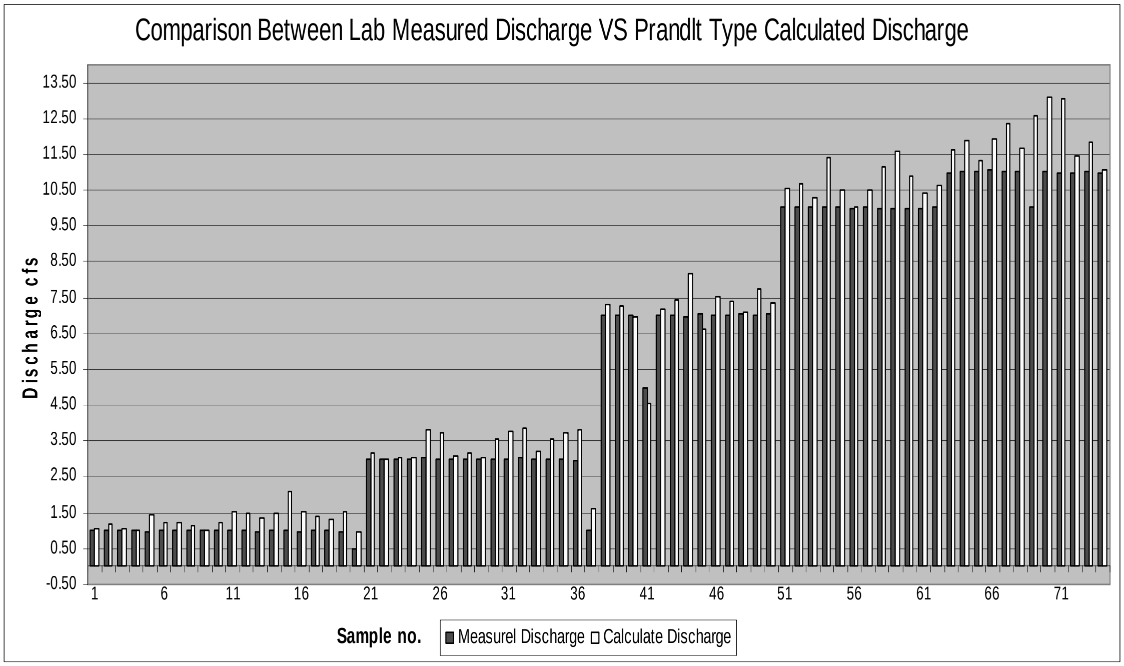


Figure 3.19 Result of TxDOT concrete discharge comparison before cleaning process

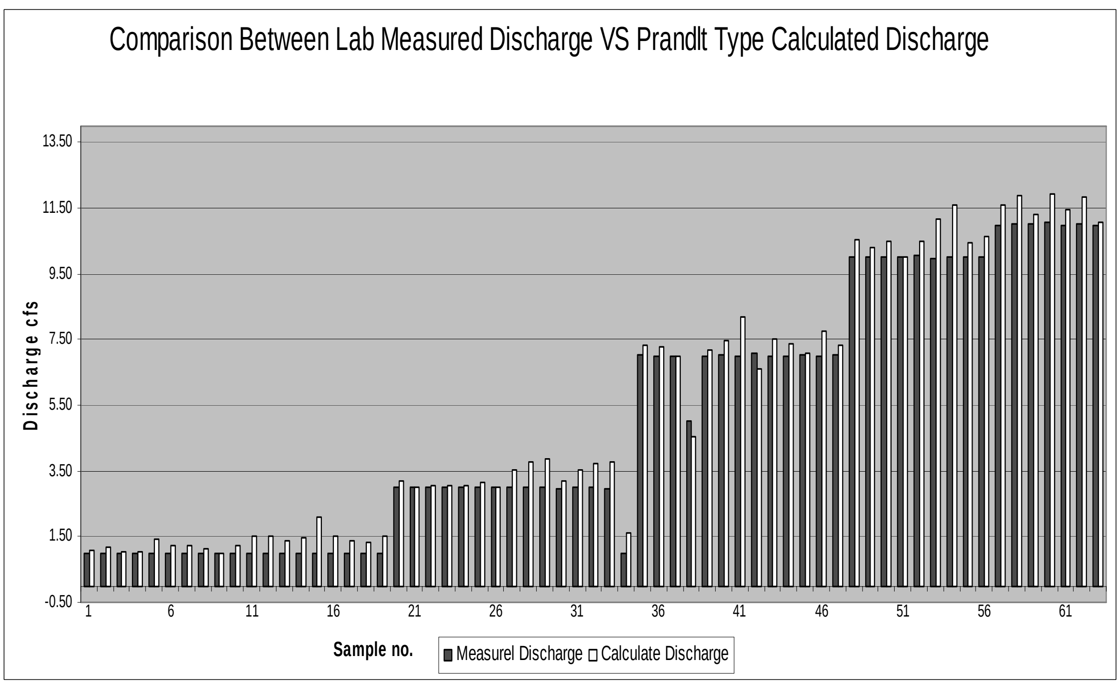


Figure 3.20 Result of TxDOT concrete discharge comparison after cleaning process

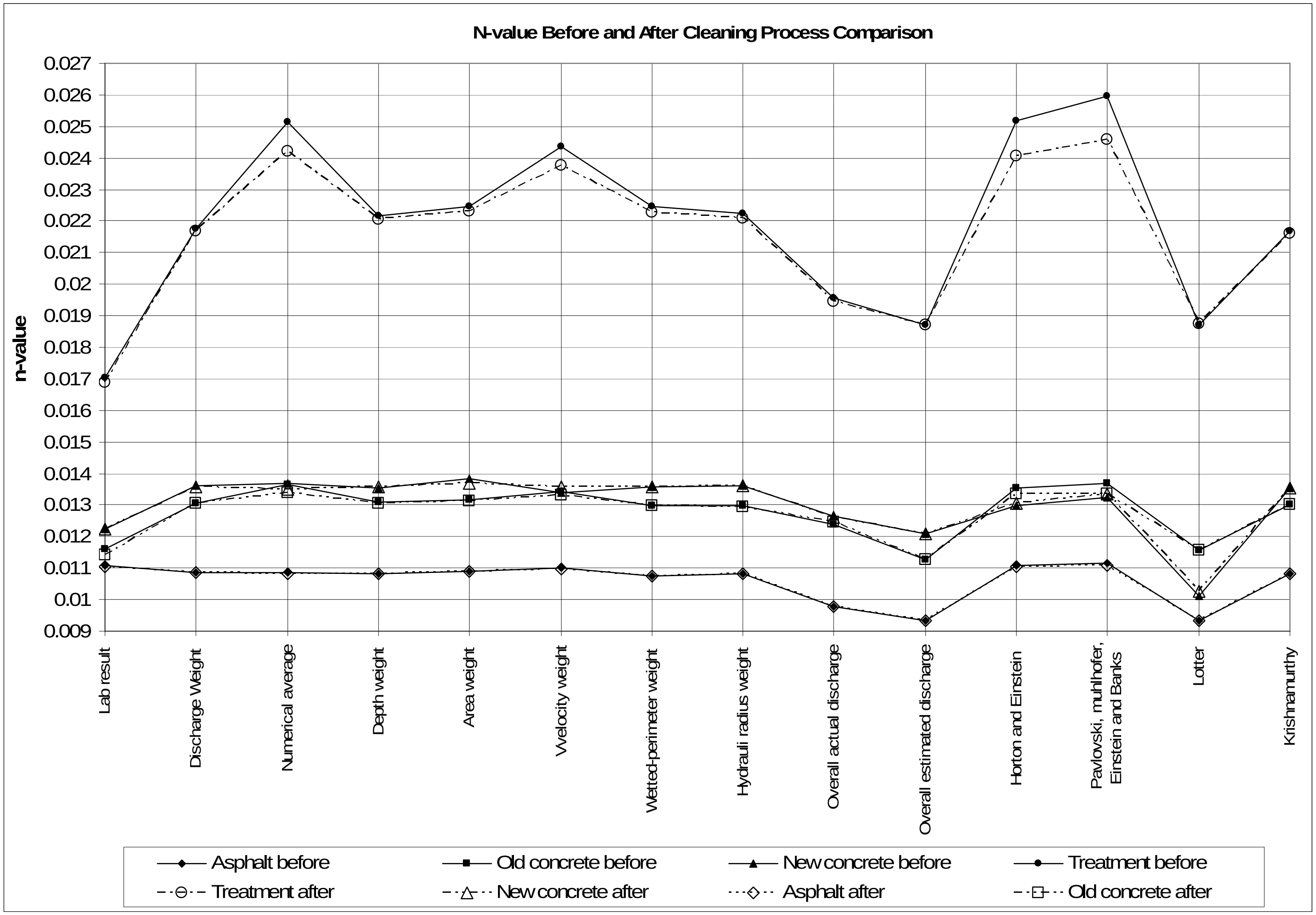


Figure 3.21 Comparison of average n-values by various averaging methods (before and after cleaning data)

CHAPTER 4

MODEL VERIFICATION AND RESULT ANALYSIS

4.1 Model Calibration and Verification

The TxDOT roadway roughness project geometry data for the roadway surfaces, new concrete, smooth concrete, asphalt, and asphalt treatment are used in the velocity distribution model. Geometry data is used for the Manning's roughness analysis. Two methods are used to estimate cross-section n-values and discharges.

The first method calculates average sub-section velocity by velocity distribution method. Calculate sub-section area by sub-section's geometry, depth and spread. The sub-section n-values and discharges are calculated from each average sub-section velocity and sub-section area. The entire roadway cross-section n-value is estimated from various averaging methods as shown in chapter 2. The total roadway cross-section discharge is sum of sub-section discharges.

The second method, a total discharge is a constant input. The entire roadway cross-section geometries, depths and spreads, are estimated by trial and error according to the total discharge. Each average velocity is calculated by velocity distribution method according to estimated sub-section depths. The sub-section n-values are calculated from the estimated sub-section geometries. The total cross-section n-value is calculated from various averaging methods as shown in chapter 2

The first method is the only method used this research. It provides accurate discharges and n-values compared to the original TxDOT project result.

In the TxDOT project, some geometry conditions such as curb surface roughness, actual transverse slope and the actual water surface were not used in the total cross-section n-value estimation. As a result, the TxDOT project's n-value is differ from the velocity distribution's n-value.

The laboratory result consists of two methods of total area calculation, depth-analysis and spread-analysis as shown in Figure 3.6. These methods have different assumptions to estimate the total cross-section geometries. Depth-analysis is based on a curb station depth and transverse slope. Then the total cross-section spread is calculated by dividing the curb-depth by the transverse slope. The total cross-sectional area is a one half product of the curb-depth and the spread width.

The second technique, spread-analysis, a total spread is estimated from average laboratory readings. The total cross-section area is calculated the same way as previous method. Figure 4.1 demonstrates the difference between two area estimation methods, depth-analysis and spread-analysis. These two techniques always show similar but different total cross-sectional areas. An average value from these methods might be a better estimation of the total area.

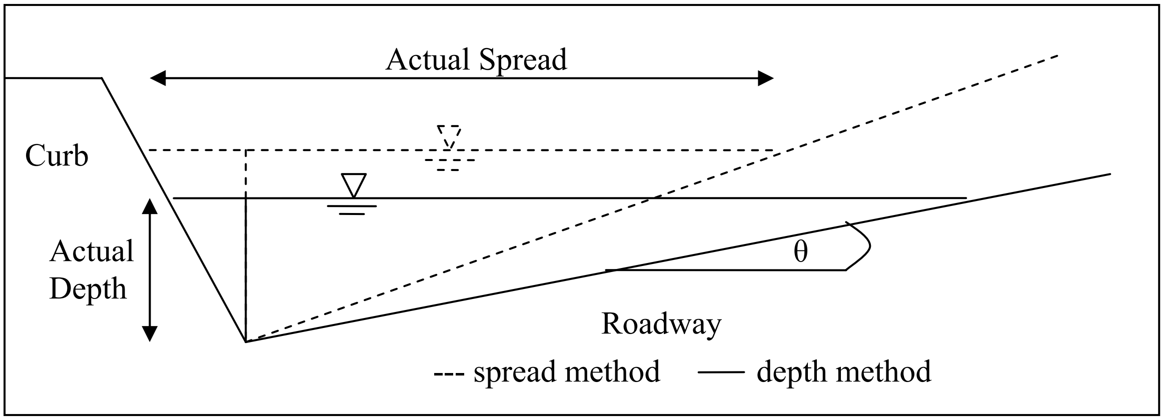


Figure 4.1 Cross-sectiona areas estimated by spread and depth methods

4.2 Theoretical Manning's n-value

Literature suggests several equations to estimate roughness n-value for all types of channels. Due to complexities of natural channel geometries, it is almost impossible to estimate accurately the actual n-value. Most purposed techniques for finding average n-values are based on empirical data as well as theoretical assumptions. The experimental field data helps improve accuracy of n-value estimations.

There are two types of theoretical equations for estimating n-values, variable and constant roughness equations. The constant roughness equation calculates n-value from the average grain size of bed material. Estimations of n-values by the constant roughness equations are shown in table 4.1. The roughness value (k) was obtained by estimating roadway roughness height as shown in chapter 3. The n-values are then calculated from equation 2.3, 2.4, 2.5, and 2.7. These equations are based on Strickler (1923), Meyer-Peter (1948), Lane (1953), and Bray (1979) assumptions respectively. These constant n-values do not vary as a function of channel geometry but vary a function of the average bed material diameter. Since bed material of roadways rarely changes quickly, the estimated n-values from the constant roughness equation remain constant.

Table 4.1 Estimated Manning's n-values

	Estimated n-value			
	Asphalt	Smooth concrete	TxDOT concrete	Treatment
Roughness value, k	0.5mm	1.6mm	2mm	17mm
Strickler (1923)	0.01168	0.01417	0.01471	0.02102
Meyer-Peter, Muller (1948)	0.01099	0.01334	0.01385	0.01978
Lane-Carlson (1953)	0.01339	0.01626	0.01687	0.02411
Bray (1979)	0.01523	0.01876	0.01952	0.02863

A second type of roughness equation exists, which contains more geometry information such as depth, hydraulic radius, and width of channel. Estimated n-values from these equations are more representative of the channel cross-section geometries. Some of these equations are not compatible with this research, such as the Jarret (1983) equation (assuming steep longitudinal slope) and the Forehlich (1975) equation (containing a special estimated parameter). Some of these variable n-value equations such as equation 2.6, 2.8, 2.9, 2.10 and 2.11 are more practicable to estimate n-values. Figure 4.2-4.5 show n-value estimation for four types of roadway surfaces. The Bray (1979), Limerinos (1970) and Griffiths (1981) equations show different n-value estimation. Limerinos (1970) equation shows higher n-values than Bray (1979) and Griffith (1981) equations. All equations show high estimated n-values at low discharge and vise versa.

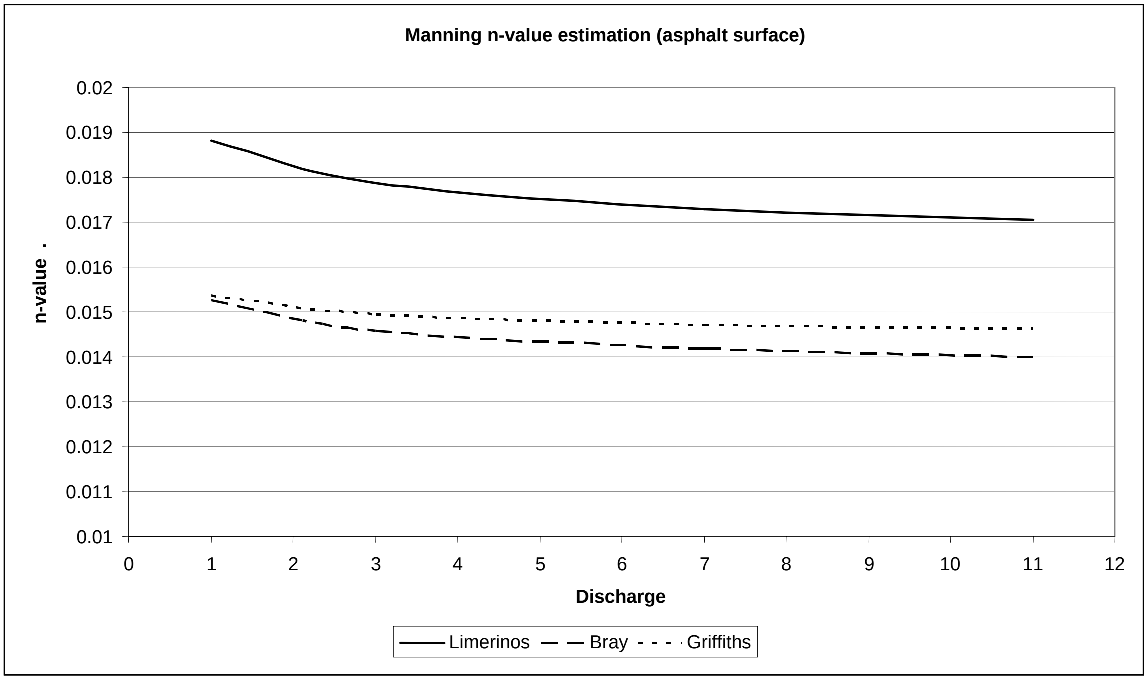


Figure 4.2 Estimated Manning's n-value for asphalt surface

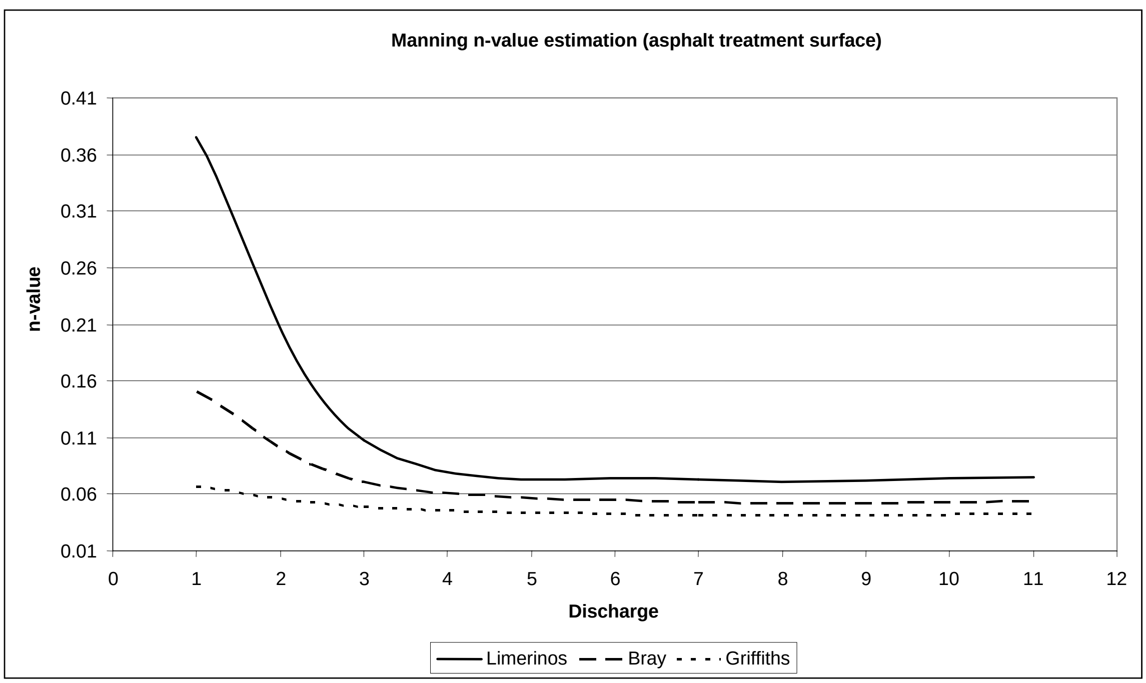


Figure 4.3 Estimated Manning's n-value for asphalt treatment surface

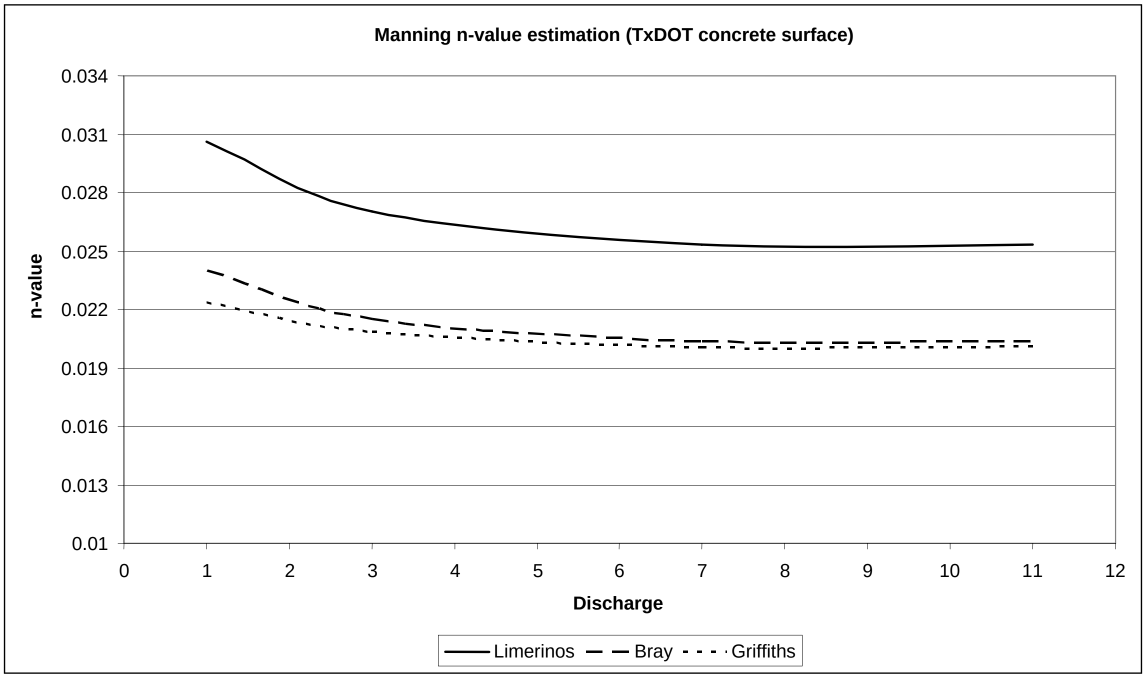


Figure 4.4 Estimated Manning's n-value for TxDOT concrete surface

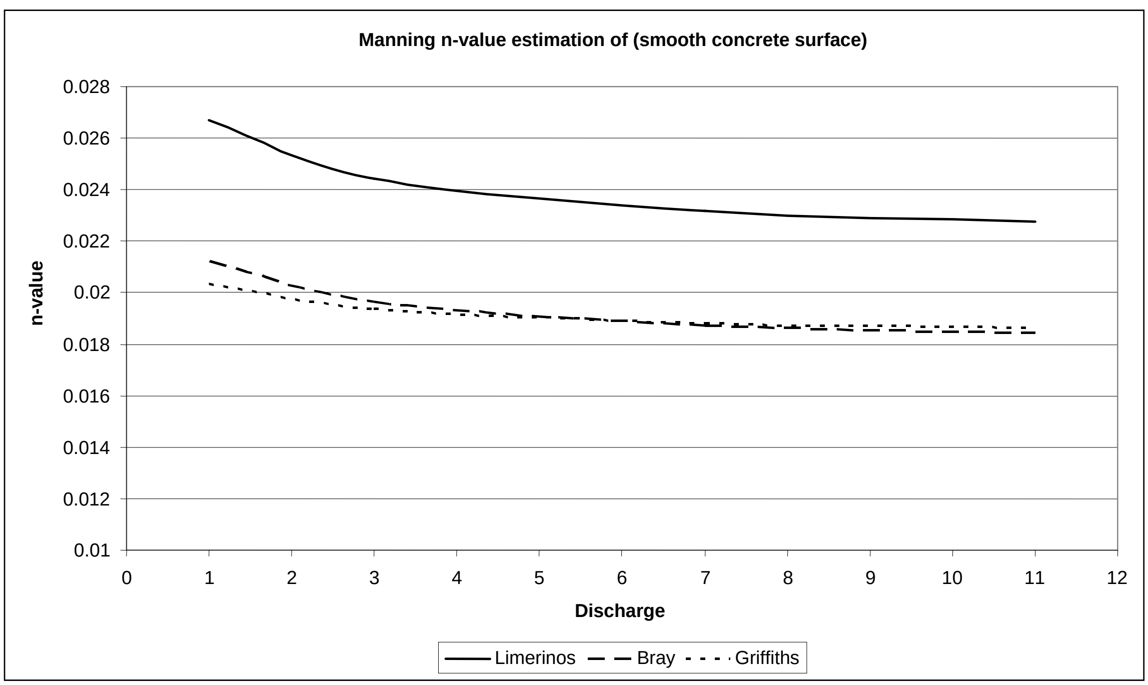


Figure 4.5 Estimated Manning's n-value for smooth concrete surface

4.3 Velocity Distribution Methods Comparison

All the flow resistance equations, equation 2.16, 2.19, 2.21, 2.23, 2.25, 2.27, 2.28, 2.35 and 2.36 from the chapter two were analyzed and compared by percent error of total estimated discharge. In order to estimate accuracy of velocity equations, flow of all four types of roadways, TxDOT concrete, smooth concrete, asphalt, and asphalt treatment were used in the comparison of these velocity equations. All the roadway data provide variety of roughness and geometry inputs to these velocity equations.

The flow resistance equations, eq.2.16, 2.19, 2.21, 2.23, 2.25, 2.27, 2.28, 2.35 and 2.36 are in a logarithmic form with two estimated variables α and β. The equation found from literature defined α and β as shown in eq.2.14. These parameters affect the outcome in different ways. Some flow equations use hydraulic-radius in stead of hydraulic-depth inside the logarithm term of the equation. These variances of α and β are a major cause of the velocity variation shown in Figure 4.6.

These equations simulate different velocity profiles with varied slopes and surface roughness with the same input parameters. Figure 4.6 shows plots of theoretical velocity profiles for all the methods investigated. In this specific figure, Griffiths's velocity equation produces the minimum velocity for a constant depth. Prandtl-von Karman velocity equation shows the maximum velocity profile. The rest of the velocity profiles are located between these curves. The velocity profiles shown in Figure 4.6 are not constant, since they vary with the geometry of the cross-section. The actual velocity distributions change with actual geometry conditions of the channels. Optimization of α and β could produce better flow estimations.

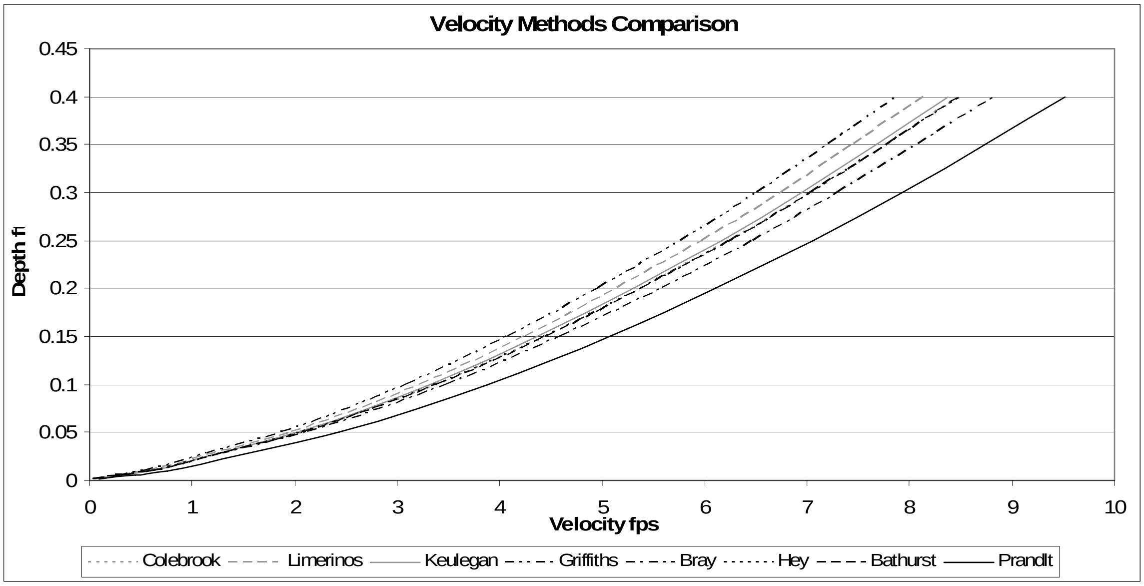


Figure 4.6 Comparison of velocity profiles by various flow resistance equations

Figure 4.7 shows the plots of eight velocity method estimated discharges for the TxDOT concrete surface. The negative and positive percent errors show over and under estimation of discharge respectively. All methods show both over and under estimated discharge. The trend lines of estimated error appear to align parallel to each other. This variance in flow appears to result from the variation of estimated parameters (α and β) in the velocity equations.

Most methods tend to under estimate at the lower flow rate and over estimated at the high flow rate. The calculated discharges by various velocity equations are compared to the actual discharge with average percent of error as shown in table 4.2. Plots of average percent error of all roadway surfaces are plotted in Figure 4.8. Each equation shows comparable results based on it parameters and functions.

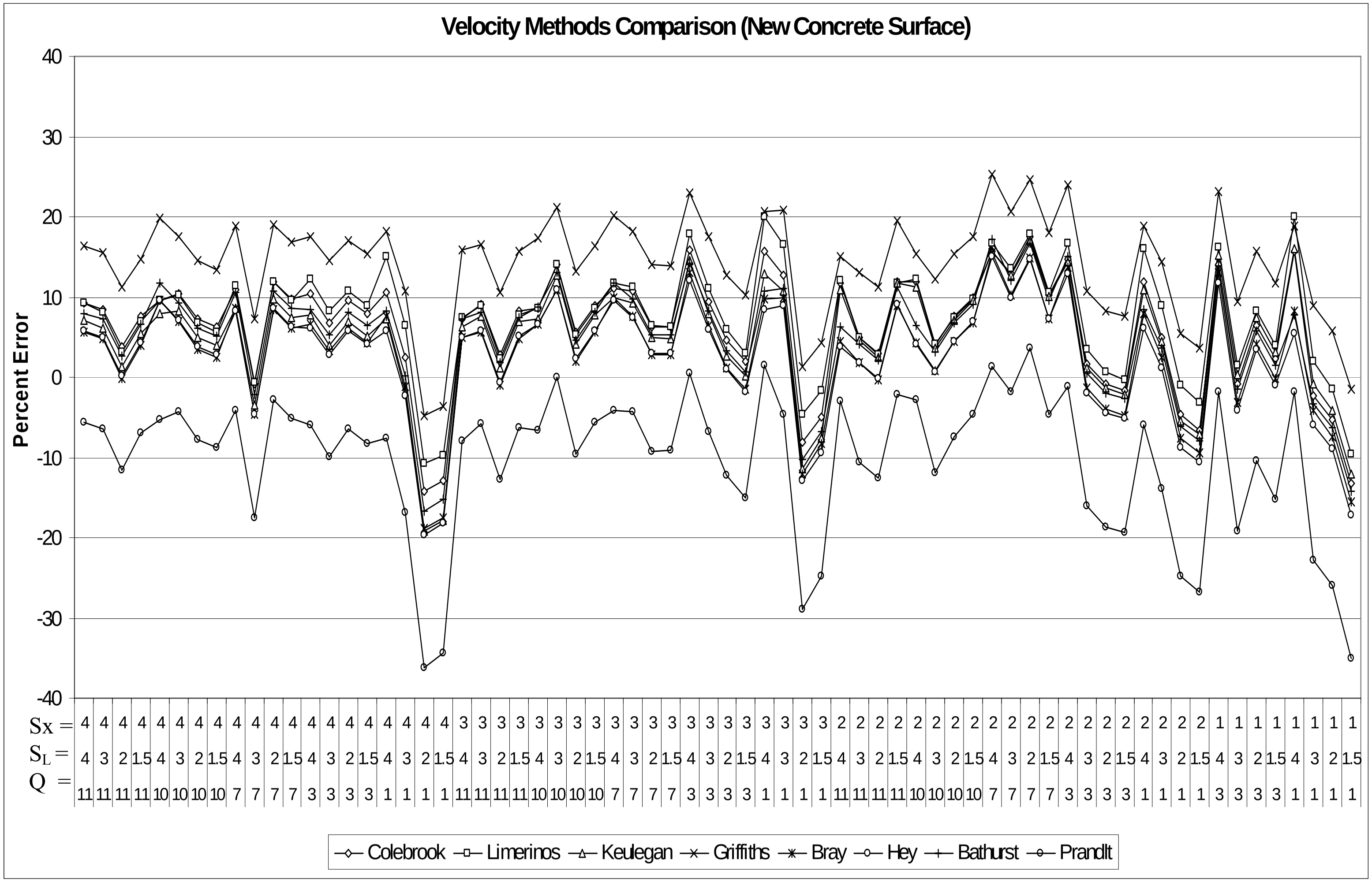


Figure 4.7 Discharge estimated by various flow resistance equations

Table 4.2 Average percent discharge errors from various velocity methods

	Average Percent Discharge Error							
Roadway type	Colebrook	Limerinos	Keulegan	Griffiths	Bray	Hey	Bathurst	Prandtl
Asphalt	14.06%	11.11%	11.08%	15.61%	11.11%	11.07%	11.30%	13.73%
Smooth Concrete	11.08%	10.81%	10.46%	16.15%	10.39%	10.44%	10.64%	13.69%
TxDOT Concrete	8.40%	8.70%	7.62%	14.51%	6.53%	6.53%	7.64%	10.48%
Asphalt Treatment	19.42%	24.00%	19.92%	31.99%	19.46%	16.84%	17.53%	10.43%
Average Percent Error	13.24%	13.66%	12.27%	19.56%	11.87%	11.22%	11.78%	12.08%

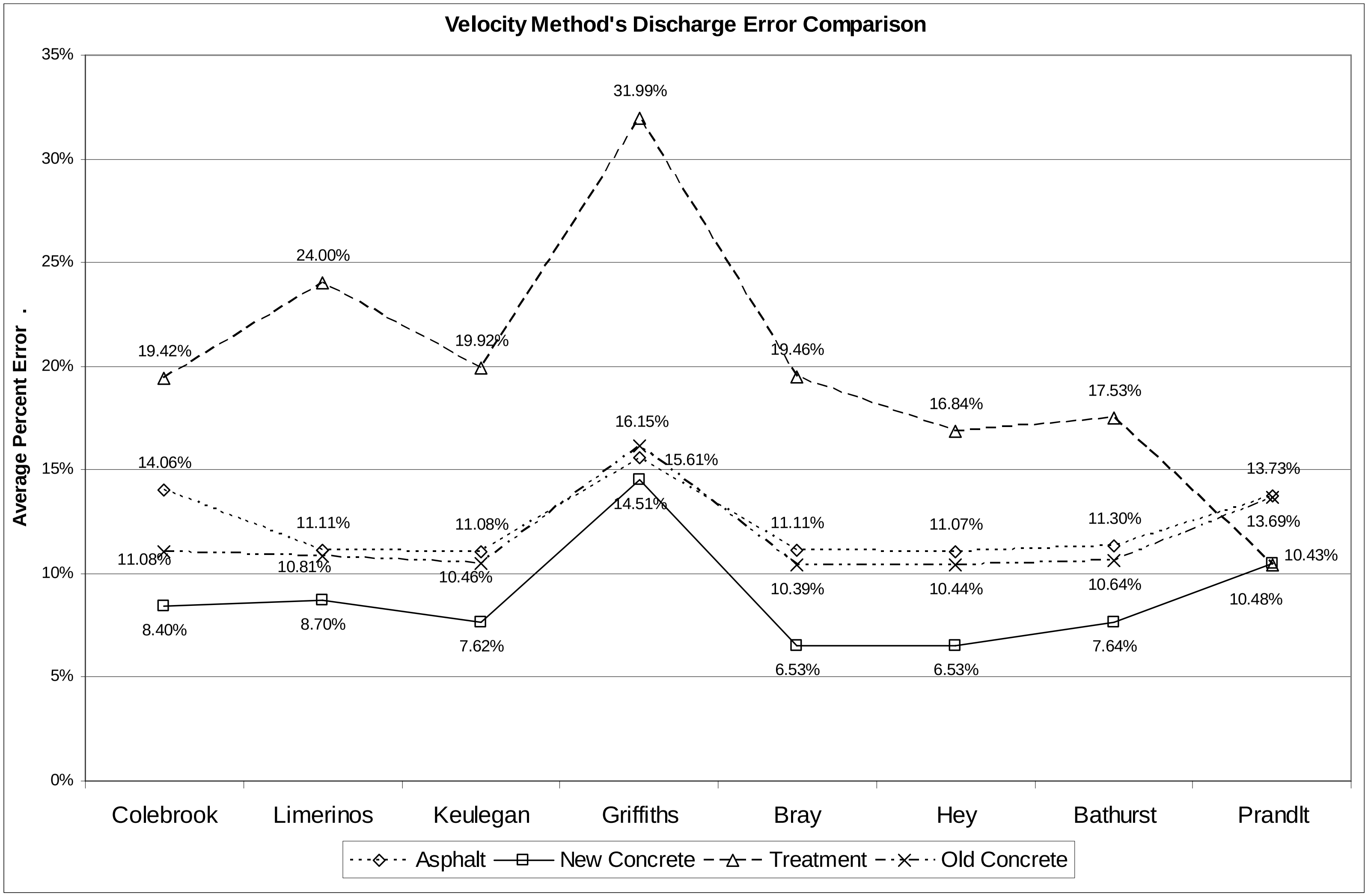


Figure 4.8 Average percent discharge error comparisons by various flow resistance equations

Table 4.2 and Figure 4.8 show average error of all methods ranges from about 6.5 to 32 percent. Some velocity equations are suitable only for low roughness value such as TxDOT concrete, asphalt and smooth concrete surfaces. Consequently, these equations show high error for higher roughness such as the asphalt treatment surface. In order to select the flow resistance method, justifications are determined not only from the overall accuracy but also from the most consistent estimated discharges.

Bray (1979) and Hey (1979) equations show the best result on the TxDOT concrete roadway. Their equations are among the best results shown for asphalt and smooth concrete surfaces. Nevertheless, these two equations are not used due to inconsistent results on the treatment surface. The same inconsistency scenario applied to most others such as Colebrook (1937), Limerinos (1970), Keulegan (1938), Griffiths and Bathurst (1985) equations.

Prandtl-von Karman velocity equation was selected for this research. The selection was made since they displayed the most consistency and accuracy of all the methods as shown in Figure 4.8. Even though this method produces a moderate overall accuracy result, the consistence is better than other methods. This velocity method shows average errors of about 10 to 14 percent for all the surfaces. Most errors for all surface types are related to over estimated discharge.

Figure 4.9, 4.10, 4.11, 4.12 and 4.13 are based on Prandtl-von Karman universal velocity method. The figures show effects of one variable condition to velocity profile with constant environment. Depths of velocity profile were estimated from velocity distribution program calculation in order to archive the same discharge. Average velocities are estimated at the depth of 0.6 (0.6d) from the surface of water. The average velocity line connects the average velocities of every velocity profile. The average velocity line is shown in a linear straight line across the velocity profiles.

Effect of variable bottom roughness heights to velocity profiles with constant discharge, transverse slope and longitudinal slope is shown in Figure 4.9. The velocity decreases according to increase of the channel bottom roughness. Water depth is increased by increase the channel bottom roughness.

Figure 4.10 and 4.11 shows affect of longitudinal and transverse slopes respectively. The velocity increases according to increase of the longitudinal or transverse slopes. In Figure 4.10, water depth is increased by decrease longitudinal slope. Depth of water is decreased by decrease transverse slope in Figure 4.11.

Figure 4.12 shows the effects of various roughness dimensions and longitudinal slopes at constant transverse slop and discharge. By increasing longitudinal slope, the surface velocity and the water depth remain the same by decreasing bottom roughness height. They were calculated from different roughness and longitudinal slopes. These velocity curves demonstrate the average velocities and velocity profiles could be different at the same depth and water surface velocity. This effect is created from roughness values and longitudinal slopes.

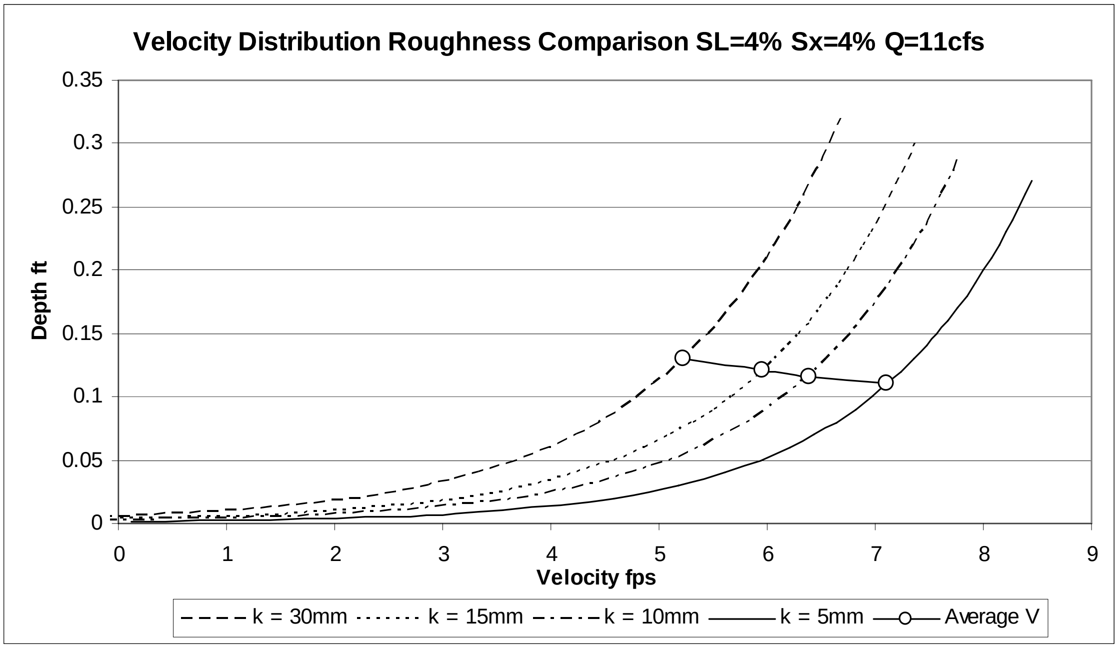


Figure 4.9 Vertical velocity profiles calculated by different roughness values (k)

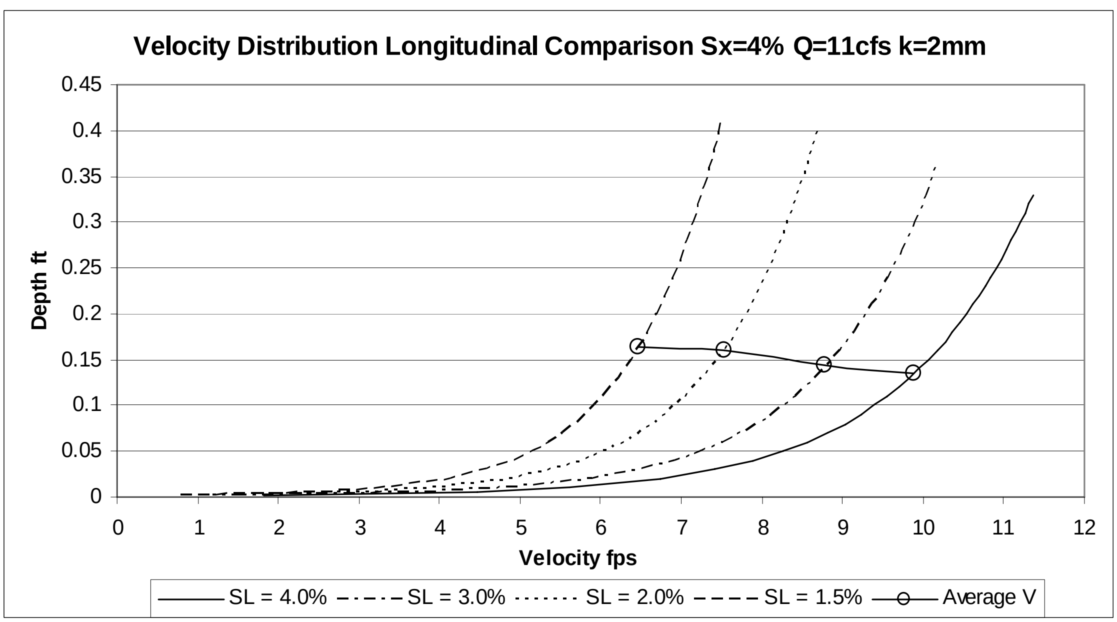


Figure 4.10 Vertical velocity profiles calculated by different longitudinal slopes

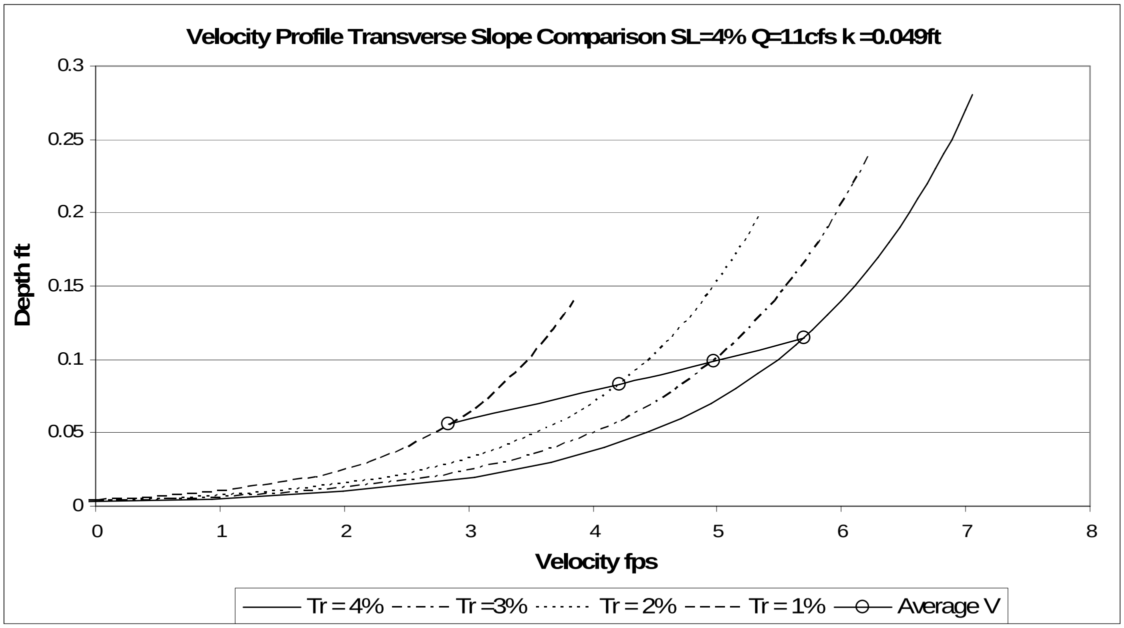


Figure 4.11 Vertical velocity profiles estimated by different transverse slopes

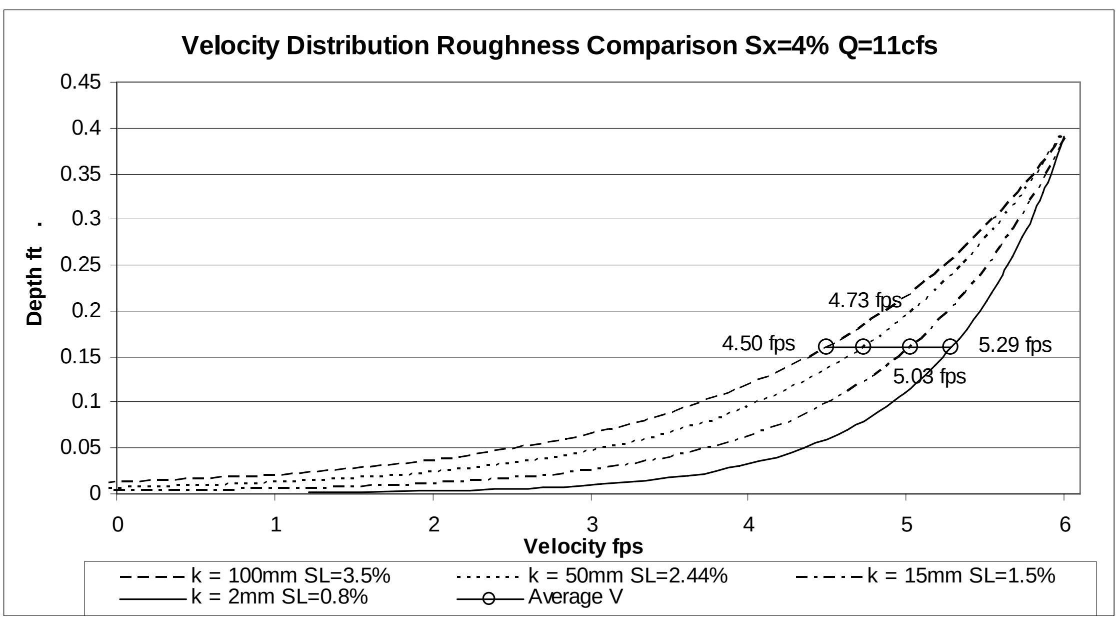


Figure 4.12 Vertical velocity profiles calculated by different roughness values (k) and longitudinal slopes

4.4 Manning's n-values Estimated by Various Averaging Methods

All methods for estimating the average cross-sectional n-value are shown in chapter 2 in equation 2.39 to 2.49. Some methods are suggested by literatures based on their empirical data and geometry assumptions. The averaging methods highly affect the outcome of average n-value. All averaging methods use the local geometry parameters of the sub-sections to calculate the total cross-section n-value. The relationships of local geometries and averaging methods are displayed in Figure 4.13. Wetted-perimeter and hydraulic depth are the basic geometry inputs. Sub-section geometries, such as velocity, discharge, hydraulic radius and area are calculated from the basic geometry. Average cross-section n-values are calculated by sub-section n-values and various sub-section geometries.

Results of average cross-section n-values estimated by Prandtl-von Karman (1926) velocity method and various averaging methods on the four roadway surface types are shown in table 4.3 and Figure 4.14.

Table 4.3 shows average cross-section n-values after cleaning process. The asphalt treatment n-value series shows the maximum variation and percent error from the lab result. Most averaging methods estimate n-value consistently higher than the lab result except the asphalt surface series.

Average cross-section n-values by averaging methods before and after cleaning data are shown in Figure 4.14. The decrease or increase value of Manning "n" is a result of the outlier reduction. Krishnamurthy (1972) averaging method is selected based on the accuracy and consistency of estimated discharges. (discussed in section 4.5)

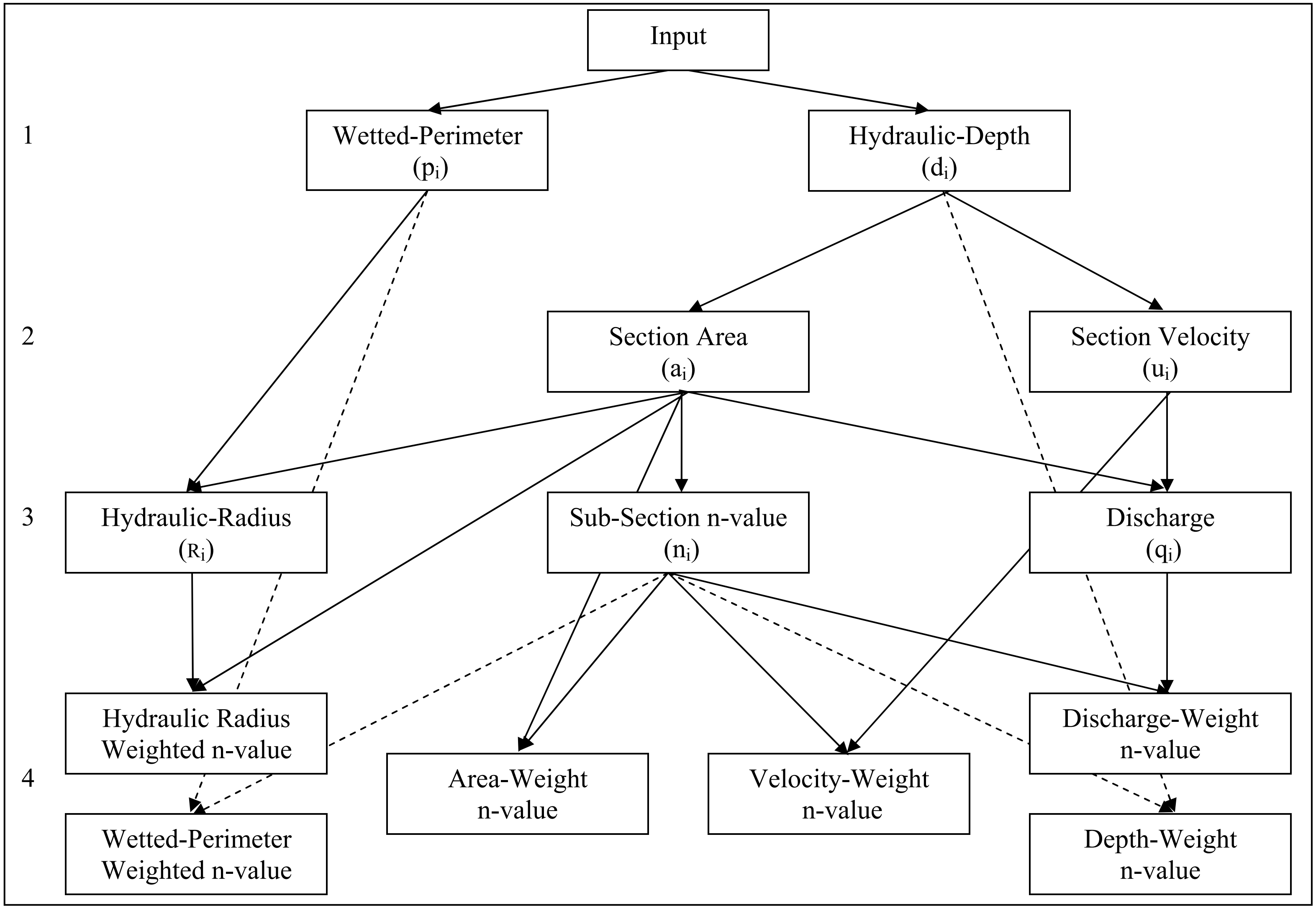


Figure 4.13 Relationships between local geometries and methods of averaging n-values

Table 4.3 Estimated average Manning's n-values for four types of roadway surfaces by Prandtl-von Karman velocity distribution and various averaging methods

	Asphalt surface		TxDOT Concrete surface		Smooth Concrete		Asphalt Treatment surface	
	n-value	% error from Lab result	n-value	% error from lab result	n-value	% error from lab result	n-value	%error from lab result
Lab result	0.01103		0.01222		0.01142		0.01687	
Discharge-weight	0.01086	1.52%	0.01359	11.19%	0.01306	14.30%	0.02169	28.60%
Numerical average	0.01084	1.70%	0.01351	10.59%	0.01338	17.11%	0.02421	43.55%
Depth-weight	0.01083	1.78%	0.01357	11.08%	0.01307	14.39%	0.02206	30.76%
Area-weight	0.01088	1.30%	0.01367	11.90%	0.01314	15.03%	0.02232	32.31%
Velocity-weight	0.01098	0.40%	0.01359	11.20%	0.01331	16.51%	0.02375	40.78%
Wetted-perimeter weighted	0.01075	2.48%	0.01358	11.13%	0.01296	13.45%	0.02229	32.15%
Hydraulic-radius weighted	0.01083	1.78%	0.01362	11.45%	0.01294	13.30%	0.02208	30.88%
Manning's equation and actual discharge	0.00976	11.46%	0.01262	3.26%	0.01245	8.95%	0.01946	15.34%
Manning's equation and estimated discharge	0.00933	15.38%	0.01210	0.97%	0.01126	1.47%	0.01871	10.95%
Horton and Einstein	0.01105	0.24%	0.01306	6.86%	0.01334	16.79%	0.02407	42.69%
Pavlovski, muhlhofer, Einstein and Banks	0.01105	0.23%	0.01334	9.12%	0.01335	16.89%	0.02457	45.65%
Lotter	0.00934	15.31%	0.01026	16.06%	0.01157	1.27%	0.01873	11.04%
Krishnamurthy	0.01082	1.84%	0.01353	10.68%	0.01300	13.82%	0.02161	28.12%
Average percent Of discharge error	13.73%		10.48%		13.69%		10.43%	

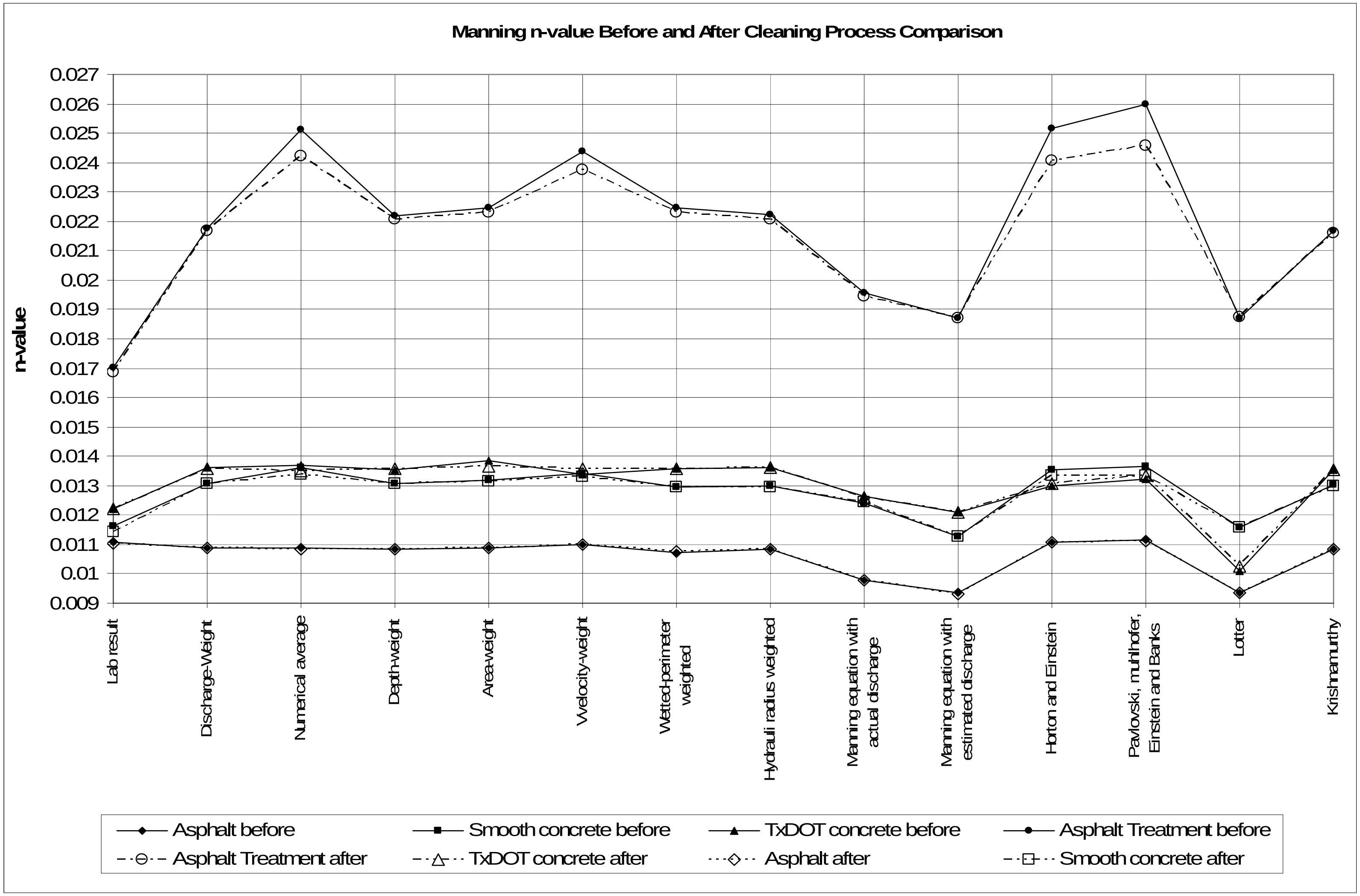


Figure 4.14 Average Manning's n-values by various averaging methods

Figure 4.15 shows the typical patterns of sub-section n-values across the entire roadway cross-section estimated by Prandtl-von Karman (1926) velocity distribution equation. The n-value at the curb section is significantly dropped because of an increasing of local wetted-perimeter in the curb sub-section. In other sections, n-values retain the same average. The n-values at the end of water are significantly increased. This phenomenon is caused by the logarithm depth term, i.e. the increasing shallow depth. As the depth is decreased then flow often changes from super-critical to sub-critical stage.

Since a depth of water decreases along the roadway lateral slope, the velocity tends to decrease noticeably as a logarithm function. Therefore the n-value increases according to decrease of velocity. Figure 4.16 shows example values of parameters across the cross-section. These values are used in methods of average n-value estimation. The parameter values across the roadway cross-section demonstrate the affect of geometry parameters to the average cross-section n-value.

Because the flow sections are divided in one-foot intervals, wetted-perimeters of sub-section are almost constant throughout the cross-section. In this case, results from the wetted-perimeter weight method and numerical average method would be close to each other. Other parameters vary from the curb to the end of water, because of hydraulic depth decrease along the transverse slope. Most parameters decrease as a function of depth.

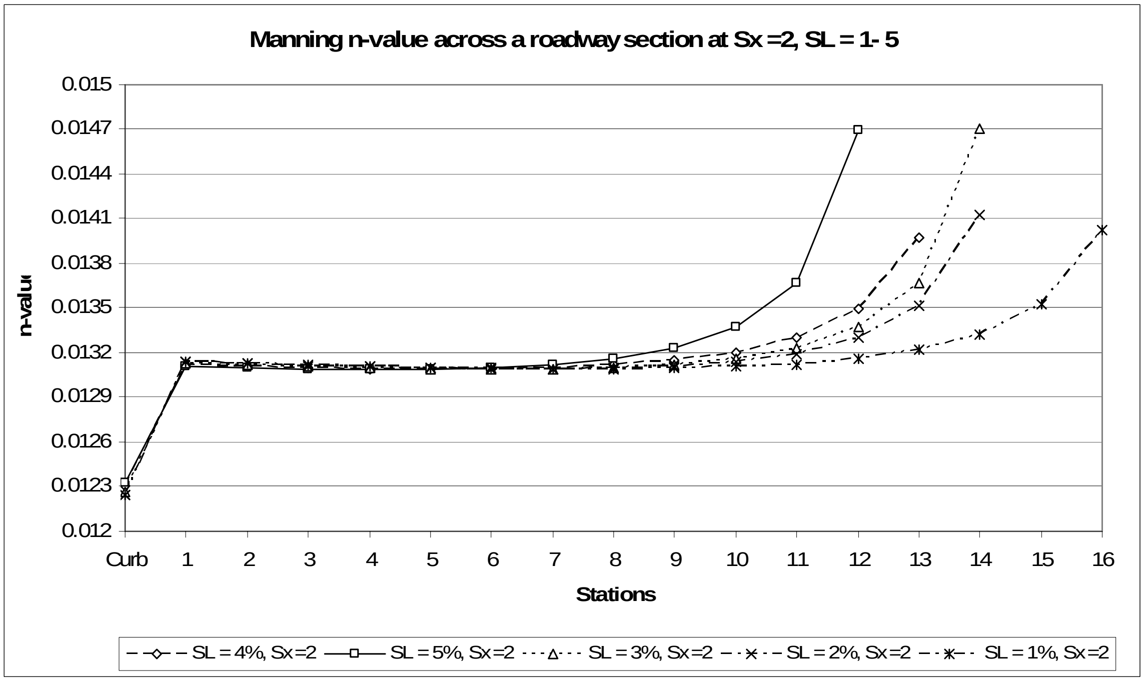


Figure 4.15 Example of sub-section n-values across the roadway cross-section by Prandtl-von Karman velocity distribution method

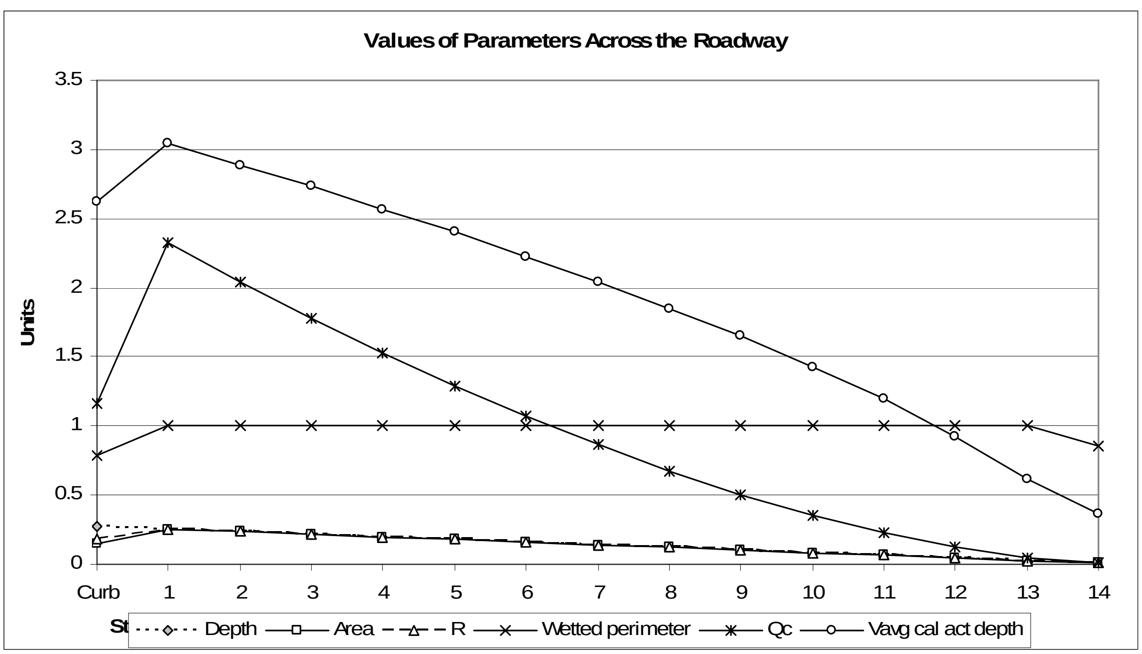


Figure 4.16 Example of averaging parameters across the entire roadway cross-section

4.5 Discharge Estimated by Velocity Distribution Methods'n-values

In the pervious section, various methods of averaging were used to estimating the average cross-section Manning's n-values. The type of estimation method considerably impacted the outcome of the average n-value. After the analysis, the overall average n-values (design n-values) by each method were determined. These overall average n-values were put back in to the Manning's equation to estimate discharges. A new discharge value is determined using the value of design n-values. The new discharges indicate the overall outcome of the estimated accuracy for that design n-value. The n-value estimated discharges of all roadway types are shown in Figure 4.17. The most accuracy can be obtained by the overall average n-value by actual discharge method. This method calculates n-values by directly inputting the actual discharge, total area, longitudinal slope and total wetted-perimeter in to Manning's equation. The result is the most accurate discharge possible. This estimation is comparable to a traditional design calculation. Where flow rate is calculated by average velocity of cross-section. Other methods are comparable with higher percent error.

According to Figure 4.17, most methods provide exceptional result of discharge. However, this research investigated performance of averaging system. Therefore the finest method for averaging shallow water flow over roadway was picked according to overall accuracy, consistency, and reliability. The averaging method by Krishnamurthy and Christensen was selected to be the finest method. Even though, this method provides moderate average result of all roadway types. It shows the most accuracy and consistency available.

Krishnamurthy-Christensen (1926) method was derived according to logarithm of the velocity distribution method. It shows more compatibility than other methods. Methods are limited by their empirical and basic assumptions, so they might not be suitable in this type of calculation. Some other methods such as discharge, depth, area, velocity and hydraulic-depth weights are consider good alternative for average n-value estimation. These methods provide good accuracy and consistency to the discharge result. The discharge results for four types of surfaces are shown in Appendix D.

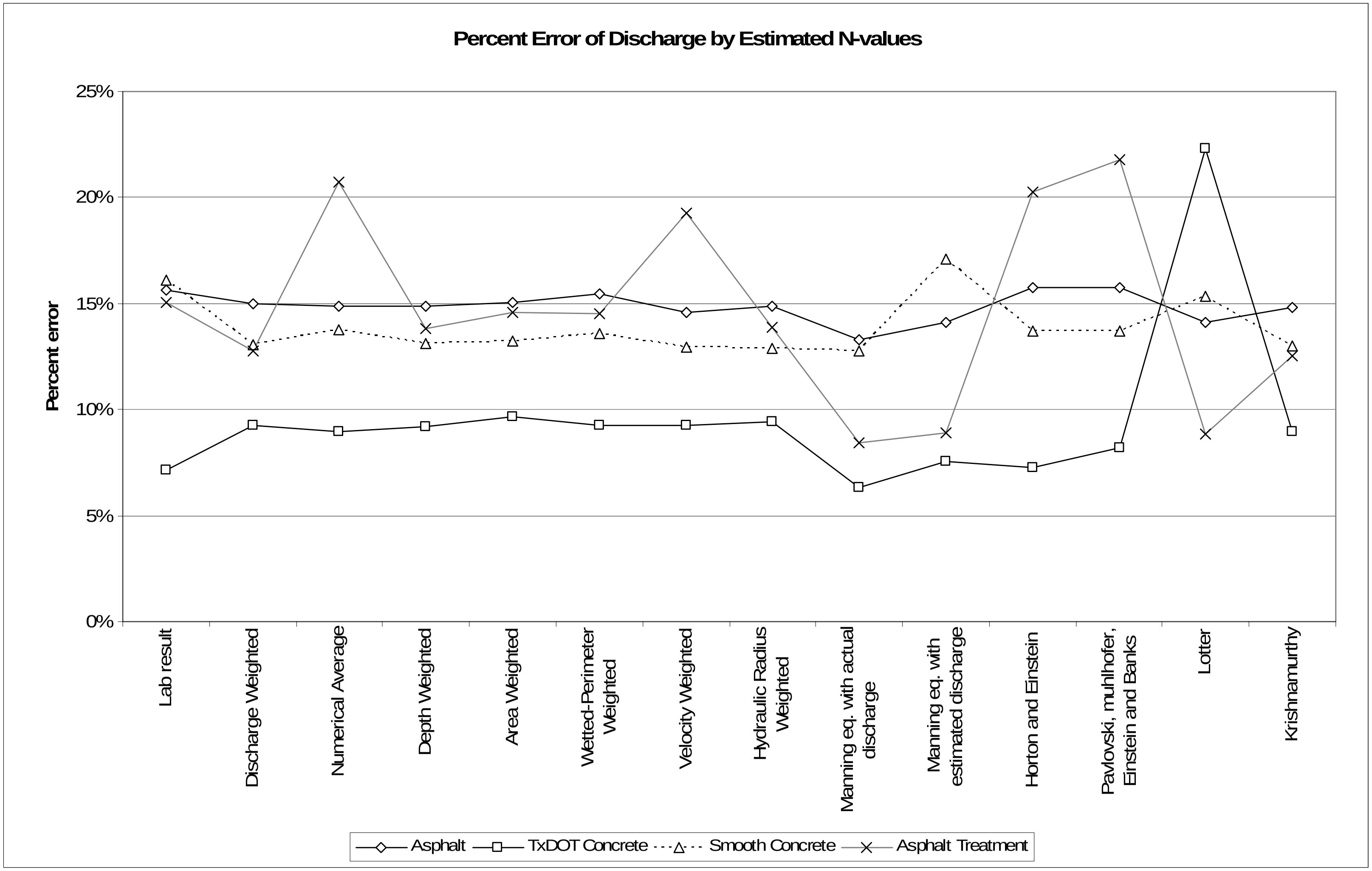


Figure 4.17 Percent discharge error by various methods of averaging n-value

There are two types of average n-values, constant and variable n-values. Figure 4.18 shows plots of n-values, the average constant n-value and the average variable n-values estimated by Prandtl-von Karman (1926) velocity method and Manning's equation with the actual discharge.

The constant n-value is estimated by numerical average of all n-values from each roadway surface. The actual numbers for constant n-value are shown in table 4.3. These constant n-values are not adapted to changing of discharge along the trend of n-value. In fact, it is constant throughout the range of flow. The logarithm trend line shows high-value at the low flow and low-value at the high flow compare to the constant n-value. Consequently, results should be an over estimated at the low flow and under estimated at high flows. This type of n-value is a practical case for most standard design purposes. This unchanged n-value provides simplicity and enough reliability to normal design method. Accuracy from constant n-value is in acceptable range of error.

Another type of n-value is variable value. The n-values in this set are variable by estimated logarithm function on average trend line as shown in Figure 4.18. The variable functions were determined by an average logarithm plot of n-values. An equation of n-values varies with discharge can be obtained from least-square fit of data distribution. This method of n-value adapted to the change of discharge from low flow to high flow rate.

The accuracy of n-values and calculated discharges are noticeable improved over the constant method as shown in Figure 4.19. The results of discharge error by constant and variable n-value methods for the TxDOT concrete surface are shown in

Figure 4.19. Most averaging methods with variable n-values show improvement over the constant n-values. The variable n-value method can easily be done by adding an estimated variable n-value equation to the Manning's equation.

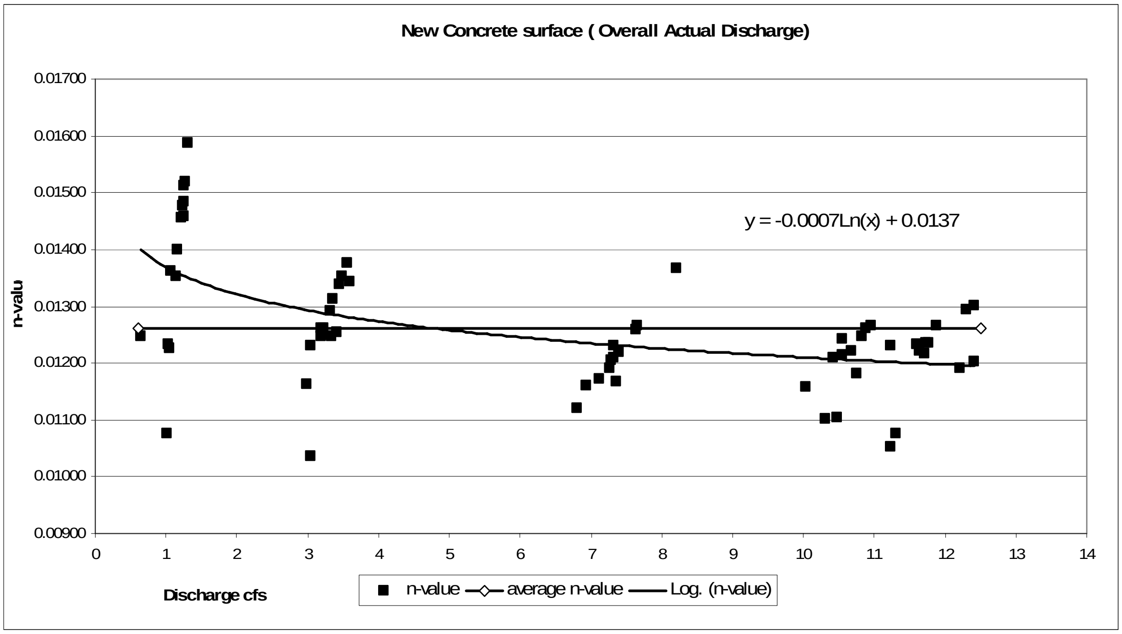


Figure 4.18 Plots of average variable and constant n-values

The variable n-value method is not a practical method for traditional design calculation. The improvement of discharge accuracy is so small and may not worth the complexity in the traditional design calculation.

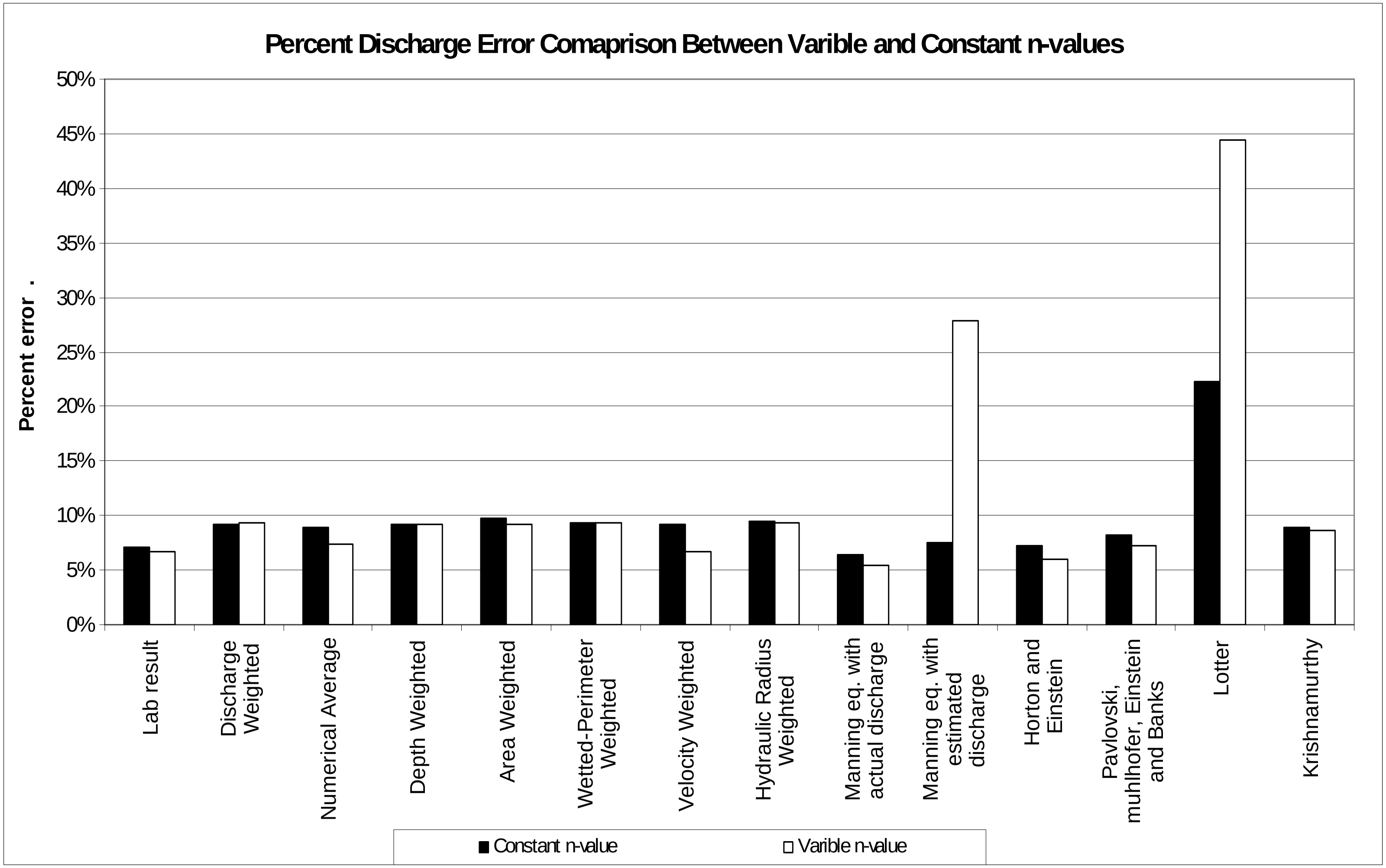


Figure 4.19 Comparison of percent error between variable and constant n-value by various averaging methods

4.6 Affect of Roadway Slopes

Longitudinal slope and surface roughness of a roadway are main parameters for flow equation. Both longitudinal and transverse slopes affect the results of discharge calculations. The roadway slopes are indirect area-affects that results in different depth of water. In this research, an average velocity is estimated by the velocity distribution method. This method tends to generate more errors for low velocity calculation. Transverse slope tends to change the depth of water more rapidly than longitudinal slope. This is due to the fact that a percent adjust of transverse slope likely changed the water depth more than the same percent adjust of longitudinal slope. With increases or decreases of the water depth, velocity profiles change as the slope increases or decreases.

Figure 4.20 and 4.21 show effect of changing transverse and longitudinal slopes to the flow cross-section. The hydraulic depth and flow velocity change as a result of changing cross-section area and longitudinal slope. Flow velocity is increased by increase the longitudinal or transverse slope. Water depth is increased by increase the transverse slope or decrease the longitudinal slope.

Calculated discharge plots for the design n-value for TxDOT roadway surface are shown in Figure 4.22-4.23 and Appendix A. The percent discharge errors are arranged in different transverse or longitudinal slopes. A change in transverse slope tends to have more variation in discharge estimations than a change of longitudinal slope. Low transverse slope tends to have more error fluctuation than high transverse slope.

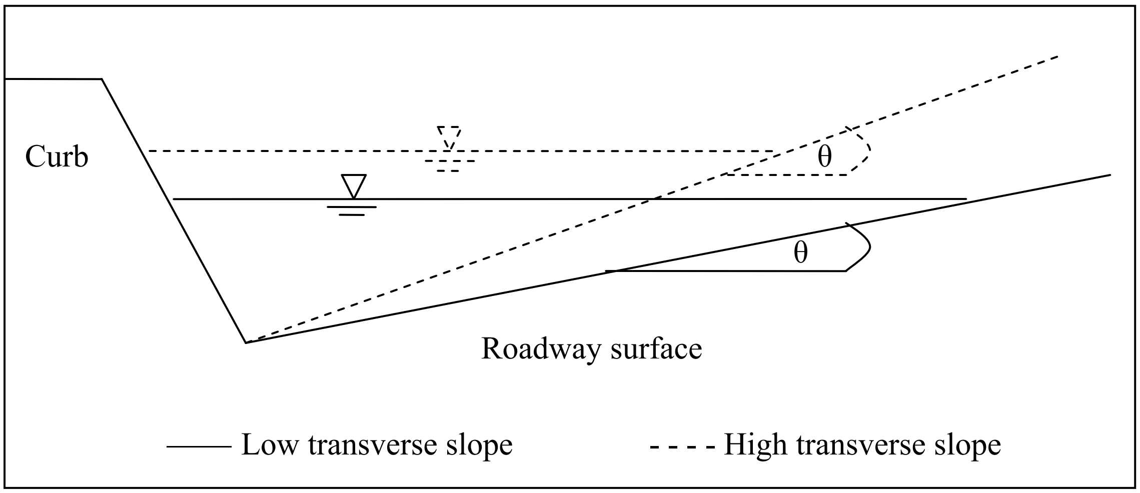


Figure 4.20 Comparison of roadway cross-section areas by different transverse slopes

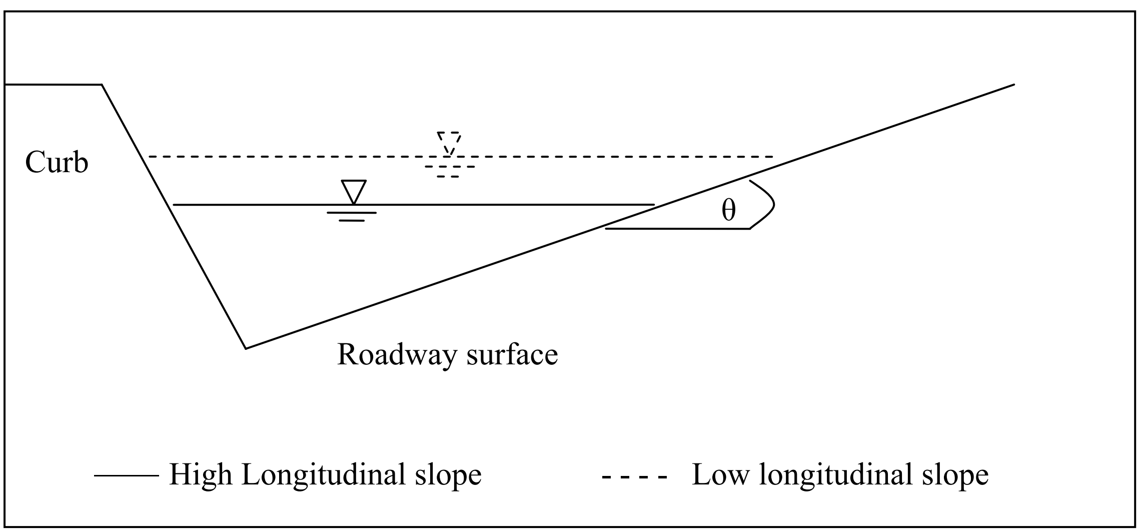


Figure 4.21 Comparison of roadway cross-section areas with different longitudinal slopes

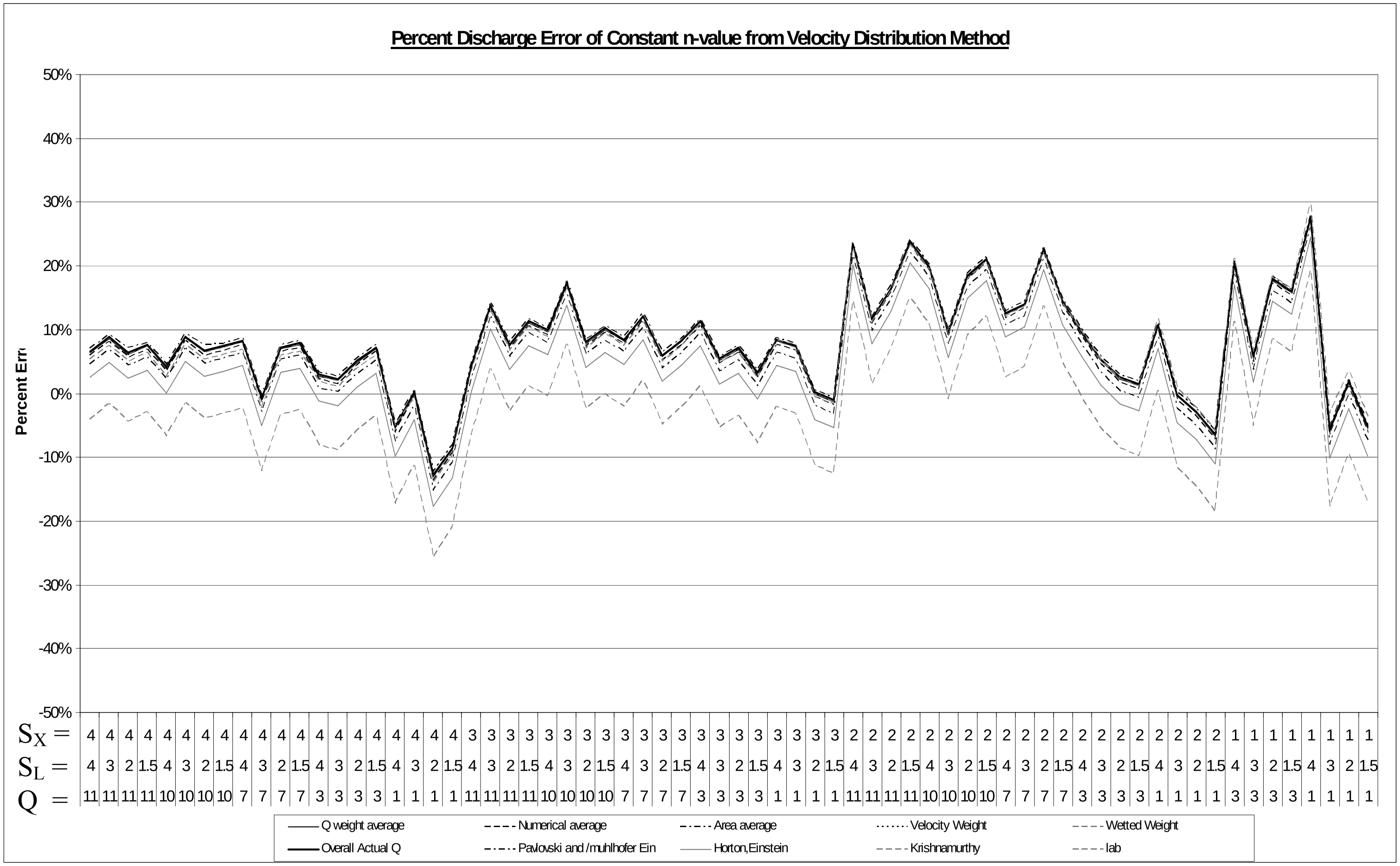


Figure 4.22 Percent error of estimated discharge by various averaging methods in different transverse slopes (TxDOT concrete surface)

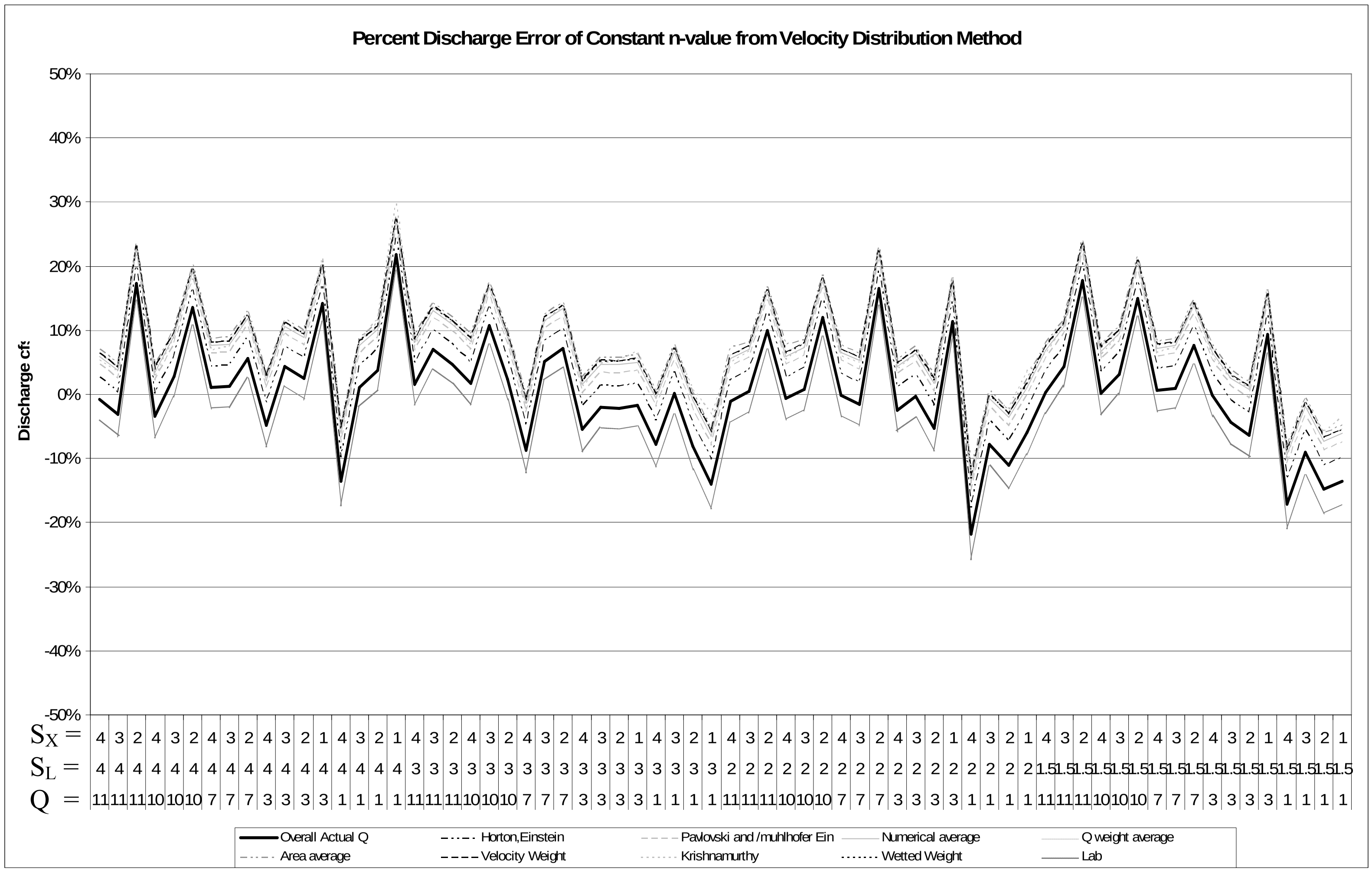


Figure 4.23 Percent error of estimated discharge by various averaging methods in different longitudinal slopes (TxDOT concrete Surface)

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

The Prandtl-von Karman velocity distribution method provides acceptable results for estimating flows and n-values of roadway cross-section. Although, the roadway channel is a non-symmetry triangular channel, irregularly shaped channel, compared to typical man-made or natural channels, results still retain high accuracy of discharges compared to measured data. Accuracy and consistency of discharge and n-value calculations for all types of roadway surface are similar. These results imply the method is practicable. Thus, the velocity distribution method is appropriate to calculate flow discharge of these roadway cross-sections.

The discharge calculated from the velocity distribution method is verified with the measured discharge. The result shows consistency with minimal error percentage. The result also shows accuracy and consistency. Consequently a direct conversion of roughness dimension, k, to Manning "n" by theoretical equation transformation can be done with a theoretical transformation using equation 3.12 and 3.13.

This paper also analyzes various average methods of n-values to obtain a single cross-section n-value. The methods of estimating average n-values significantly impact the outcome. The percent error increases significantly by altering the averaging method.

Some methods provide outstanding accuracy on one surface but lack of consistency on the others. As a result, Krishnamurthy and Christensen's method, equation 2.42, was selected based on the most accuracy and consistency of discharge result. Krishnamurthy and Christensen's method n-values show minimum affect due to various flows and transverse and longitudinal slopes as shown in Figure C1.1-1.4 in Appendix C.

Laboratory n-values are shown to vary with increased discharge, and also vary at the same discharge value. Consequently, Krishnamurthy and Christensen's averaging method lacked to indicate discharge and slopes affects. The discharges calculated from constant n-value of all roadway surfaces, Figure 4.22, 4.23 and Appendix A, show the result of increasing percent error along the increasing transverse slope percent and decreasing of discharges.

Since the laboratory n-values show variation due to the discharge and slope. Two methods of n-value, constant and variable, are used in calculating discharge. The results of these two methods are shown in Figure 4.19. The comparison shows improvement of discharge accuracy from variable n-values. The improvement of discharge accuracy from variable n-values is small. It still implies practical uses of variable n-values for the design purposes. The achievement of variable n-value method over the contemporary method, constant n-value, is useful for roadway design. However, benefits of variable n-value might not be sufficient to override the use of constant n-value. Consequently, justification of use varies by the necessity discharge accuracy. It is conclusive that discharge and both slopes have effects on Manning's n-value method and they appears to be the most significant factors for roadway hydraulic design calculation.

5.2 Recommendation for Future Research

The velocity distribution model could be applied to other types of channel or surfaces for further verification. This will extend the velocity distribution method to other types of channel.

Because of water waves, the total spread of the roadway section is estimated from an average of the maximum and minimum spread. This phenomenal creates the overestimated of the total spread. Elimination of water waves is recommended to improve the accuracy.

In this research, the longitudinal slope is based on theoretical survey estimation. The actual longitudinal slope variation can be used to improve calculation accuracy.

In the velocity equations, the estimated parameters, α and β, have the main affect to the outcome. These parameters can be optimized for the unique characteristic of the roadway surfaces, thus establishing a roughness value (k) for roadways. The optimization of α and β values should improve the accuracy and consistency of estimated discharges and n-values.

The rainfall effects should be evaluated with the velocity distribution method. This could provide incite on n-value impact. The amount of affect then should be compared to normal n-value and velocity distribution calculation.

APPENDIX A

ESTIMATED DISCHARGE PLOTS

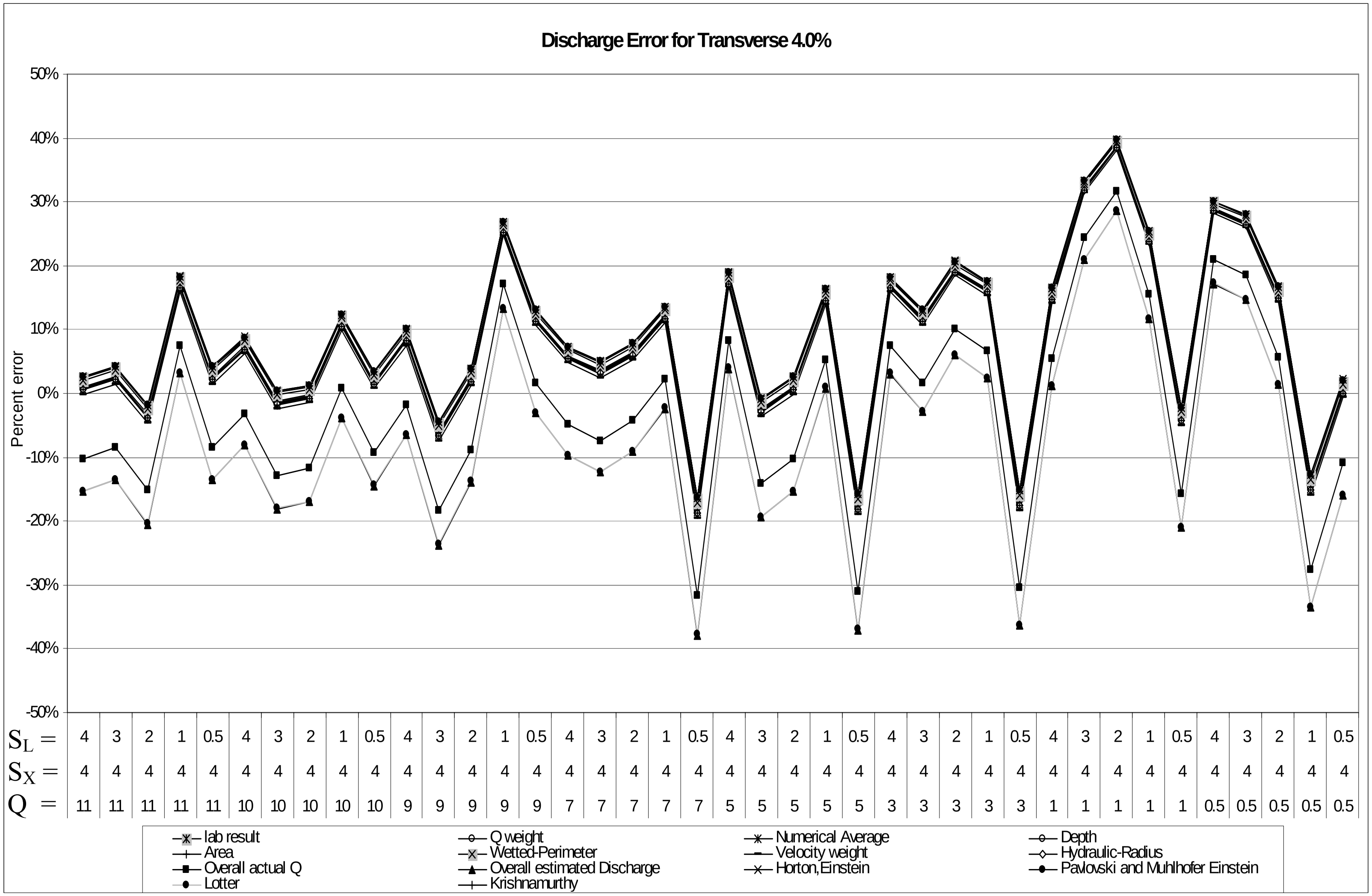


Figure A1.1 Velocity methods discharge estimations (asphalt surface)

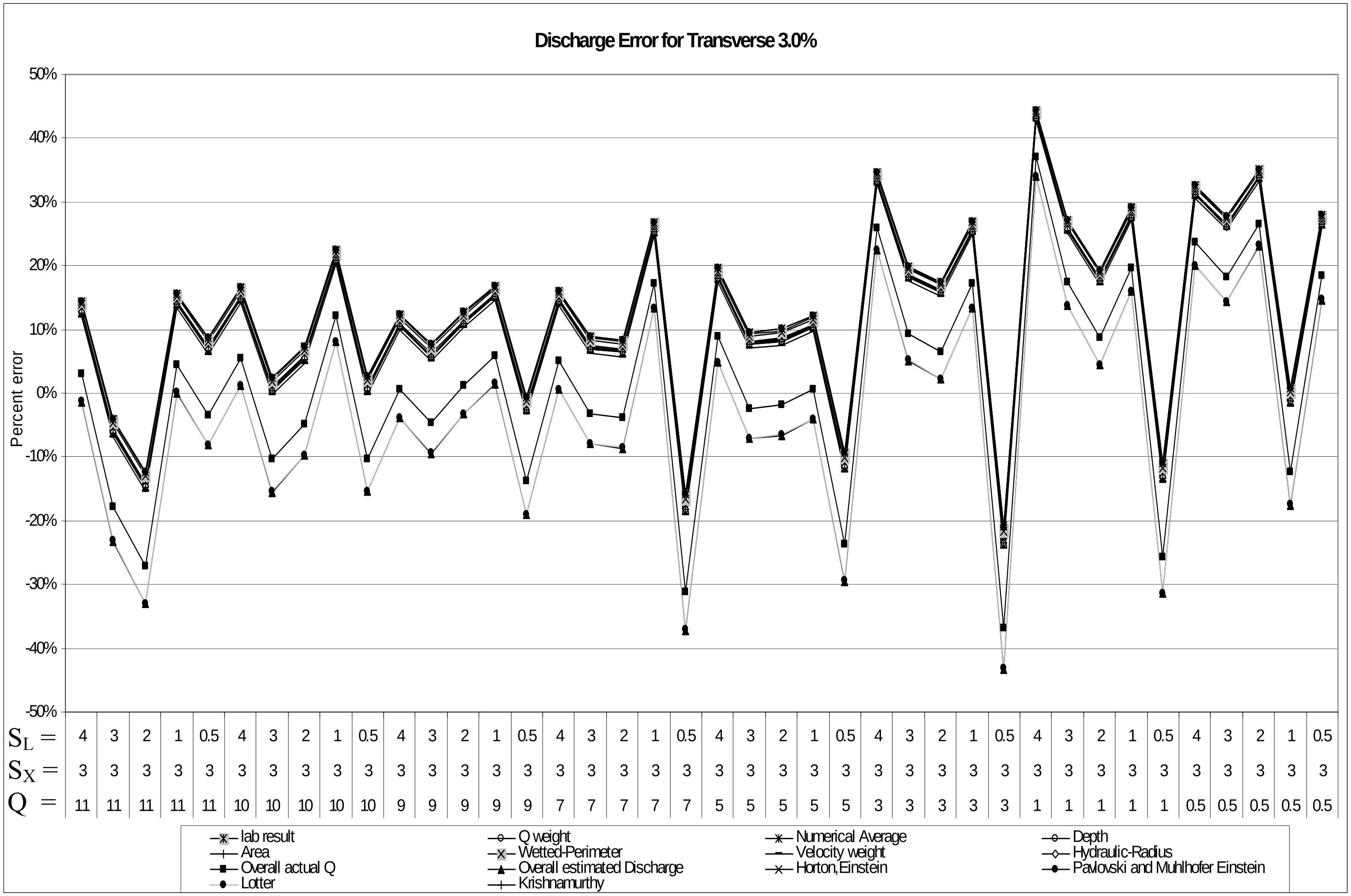


Figure A1.2 Velocity methods discharge estimations (asphalt surface)

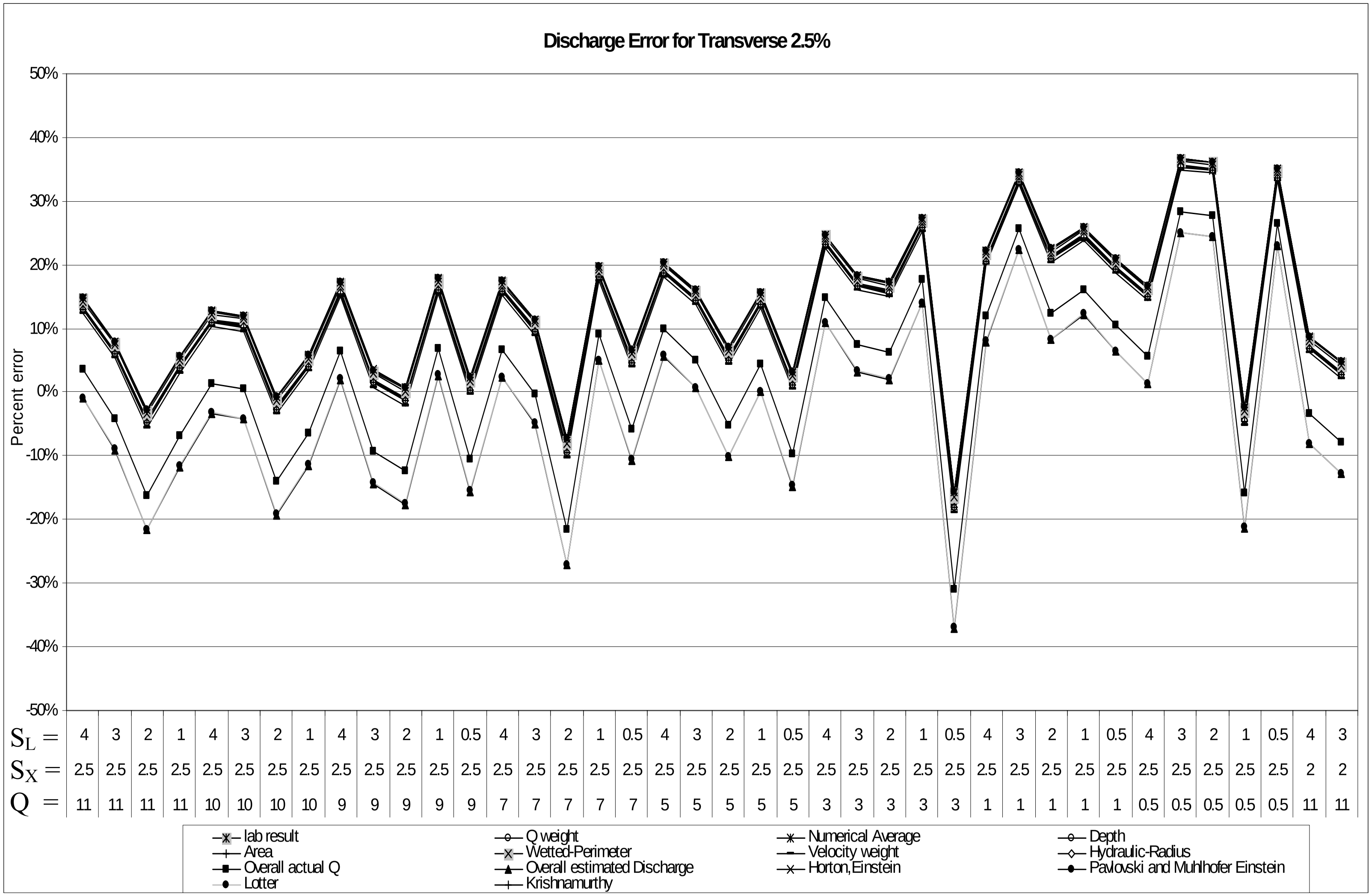


Figure A1.3 Velocity methods discharge estimations (asphalt surface)

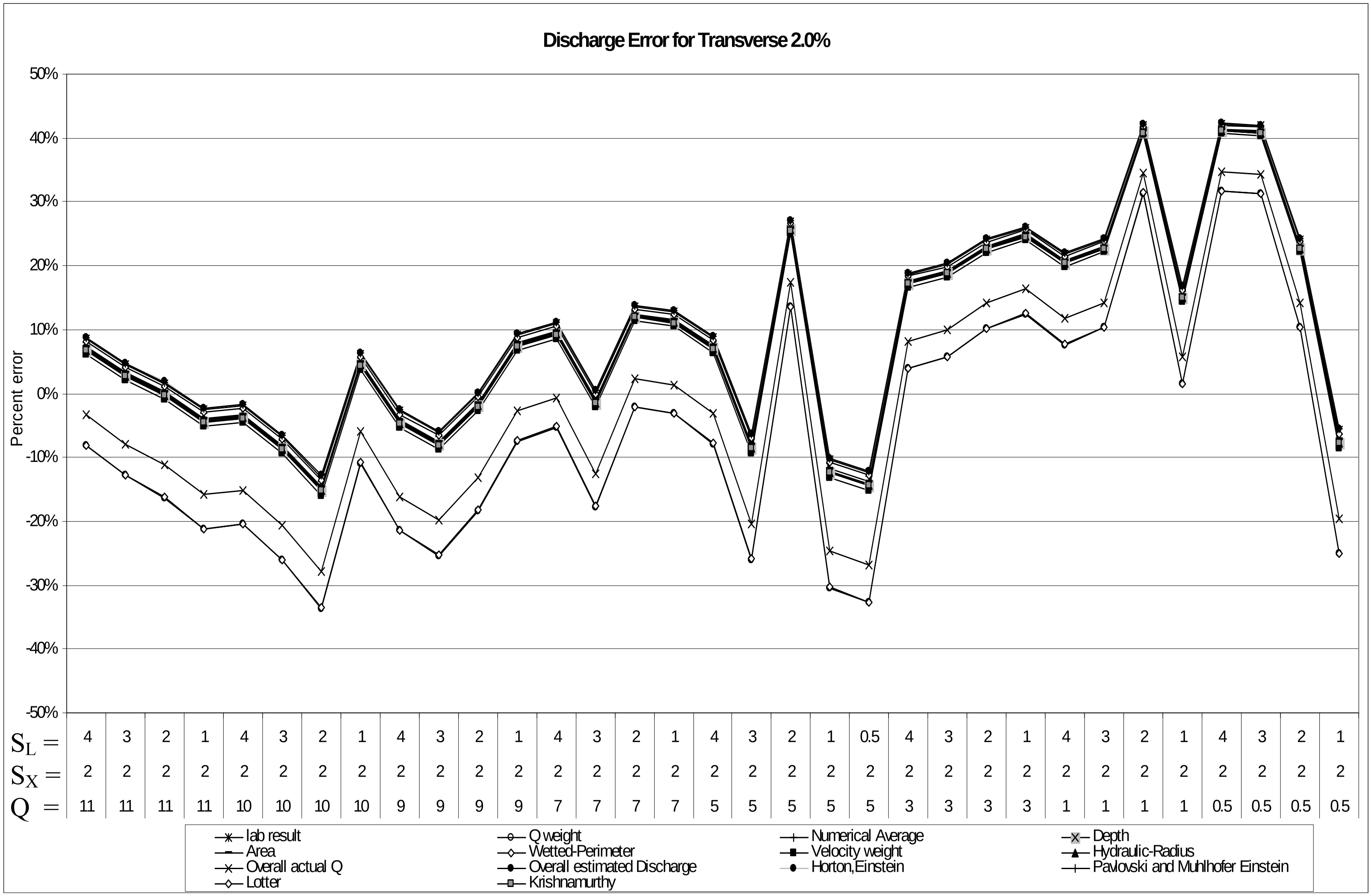


Figure A1.4 Velocity methods discharge estimations (asphalt surface)

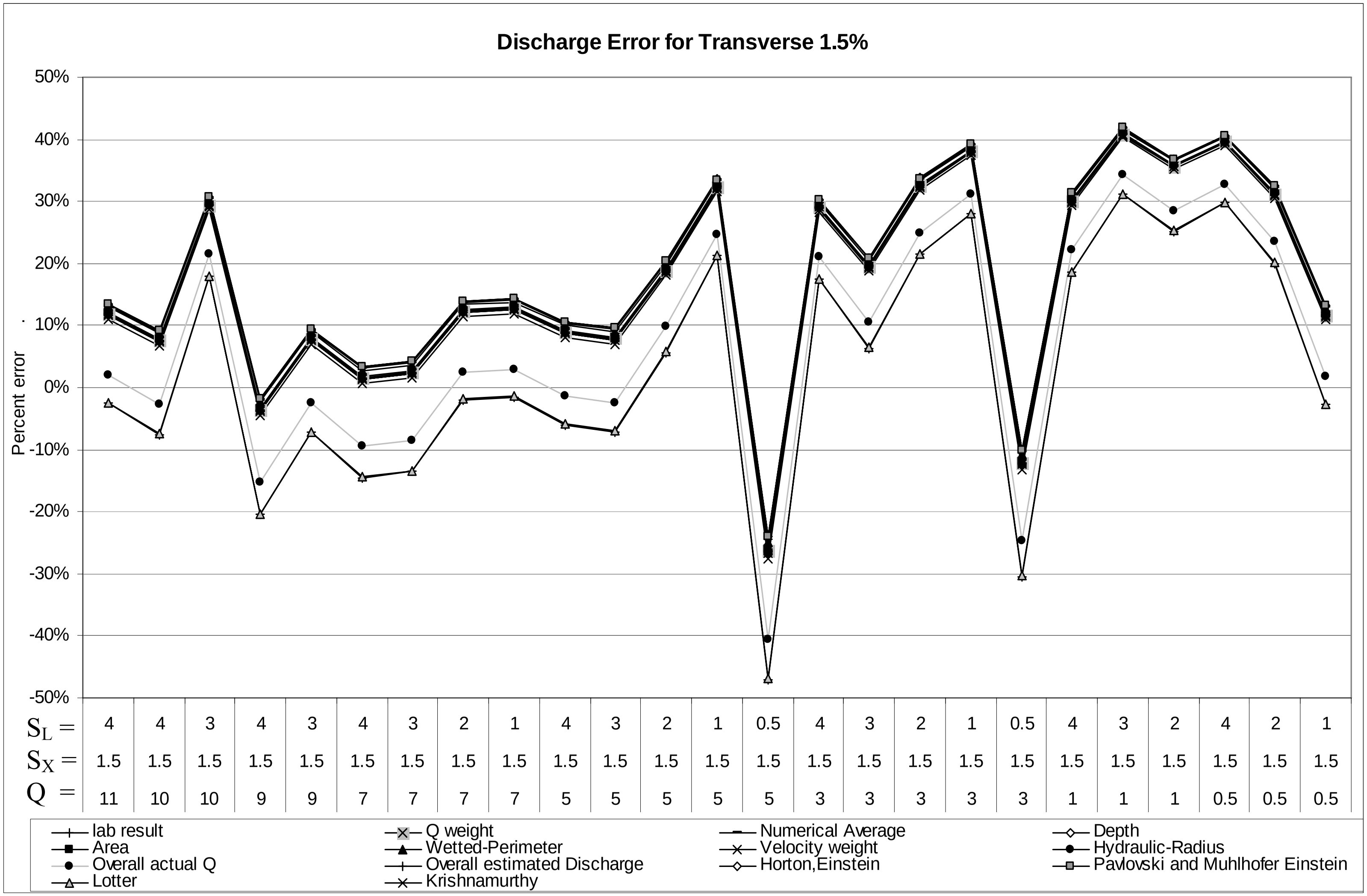


Figure A1.5 Velocity methods discharge estimations (asphalt surface)

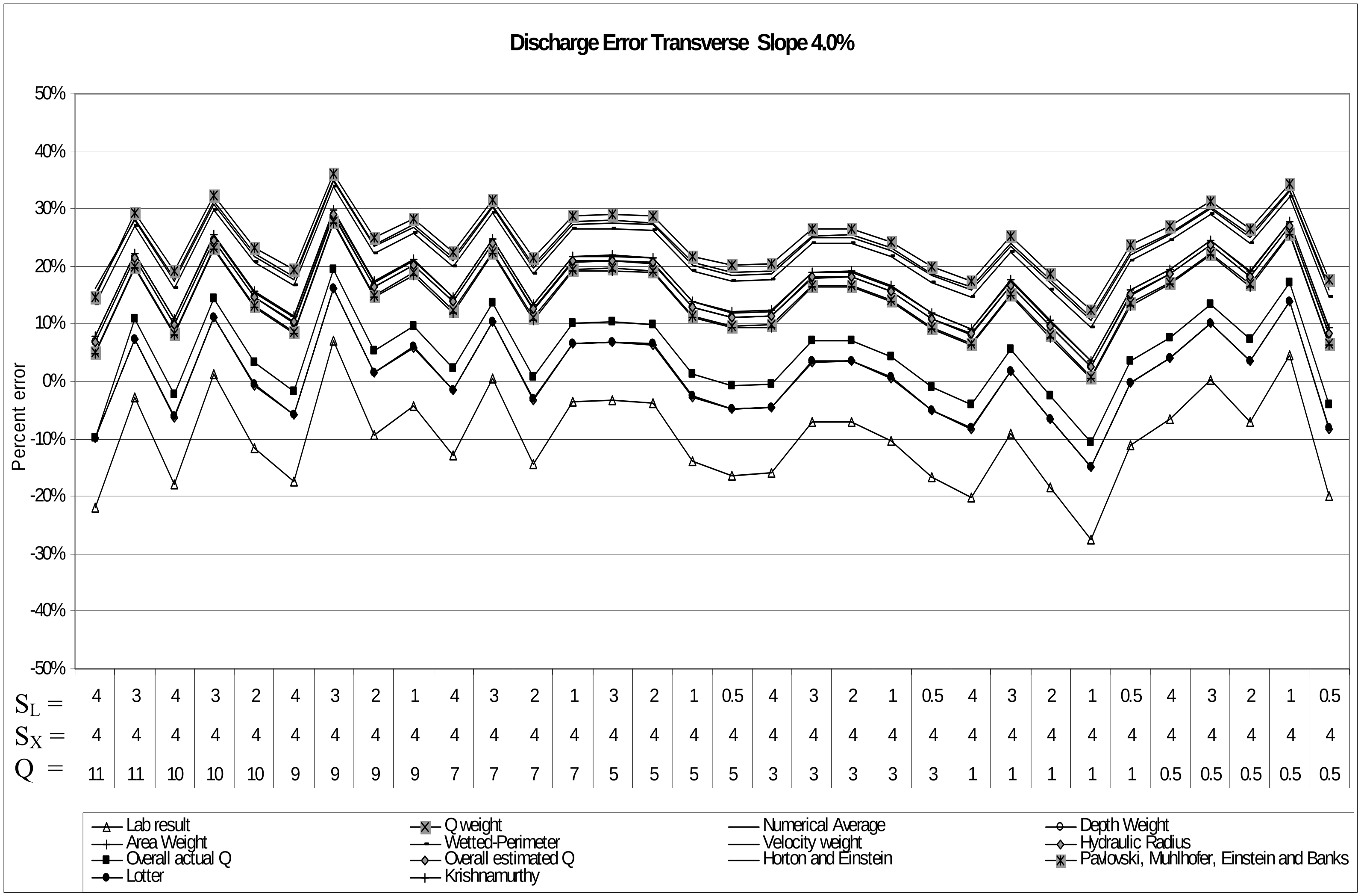


Figure A2.1 Velocity methods discharge estimations (asphalt treatment surface)

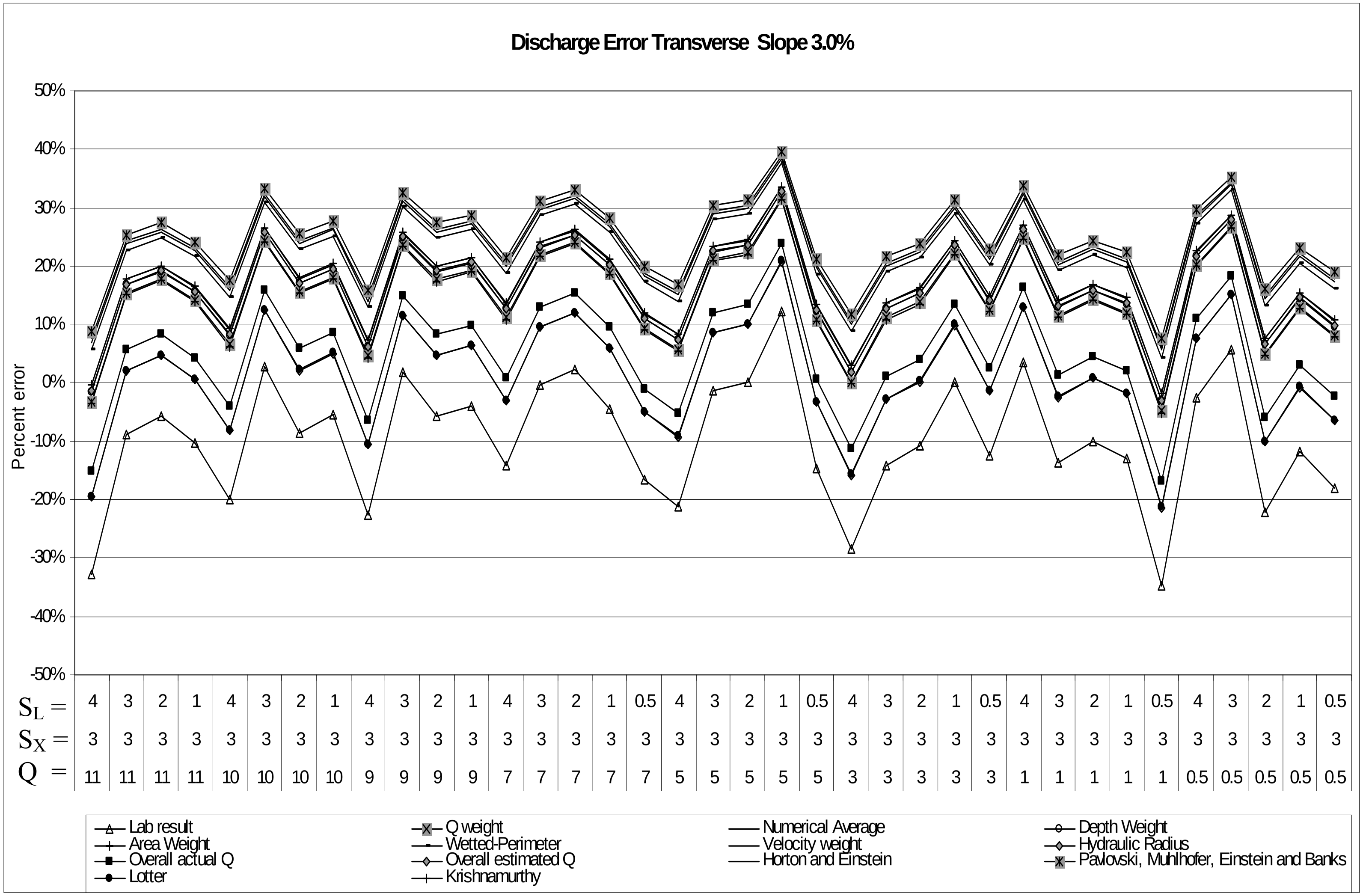


Figure A2.2 Velocity methods discharge estimations (asphalt treatment surface)

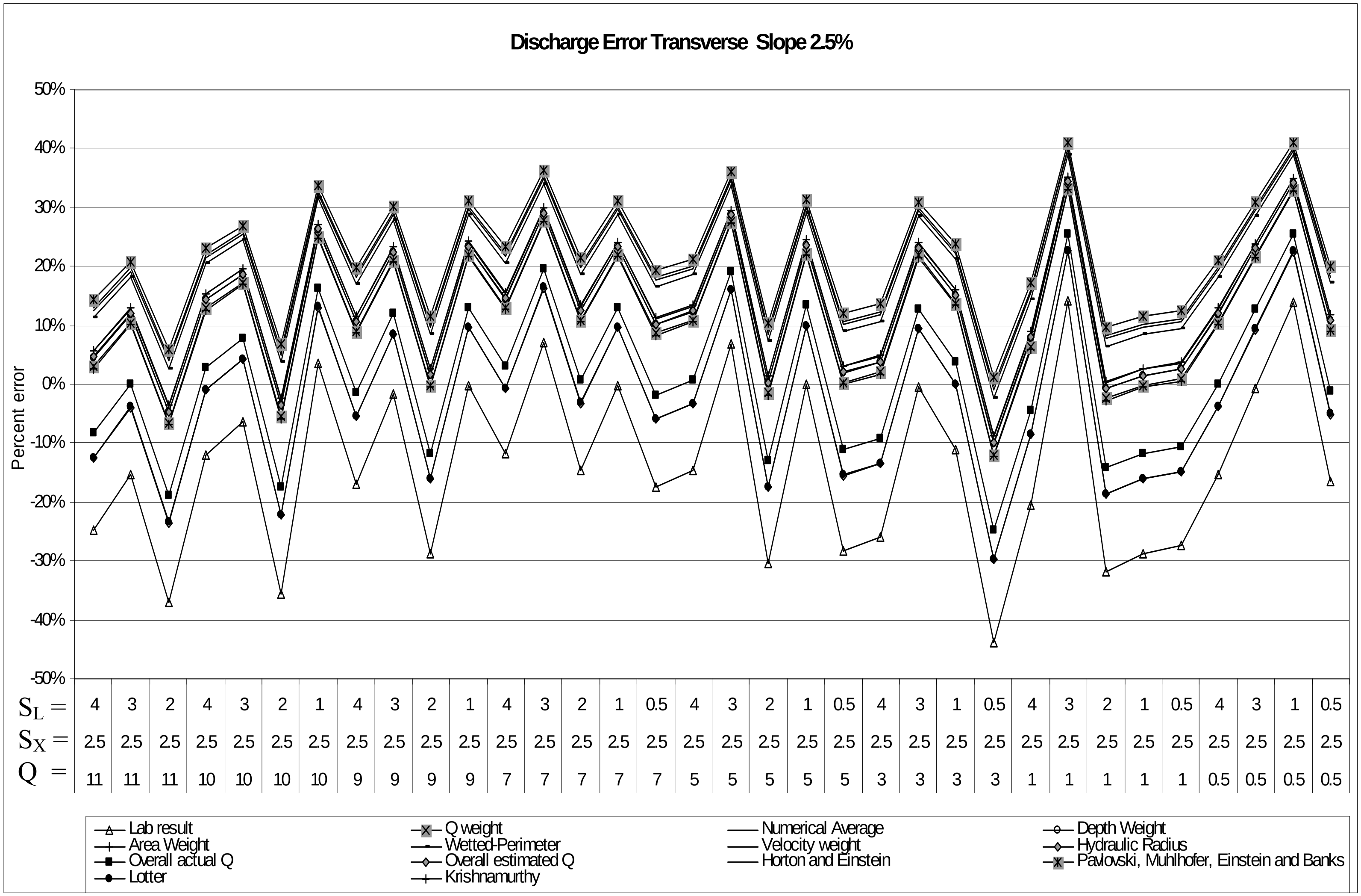


Figure A2.3 Velocity methods discharge estimations (asphalt treatment surface)

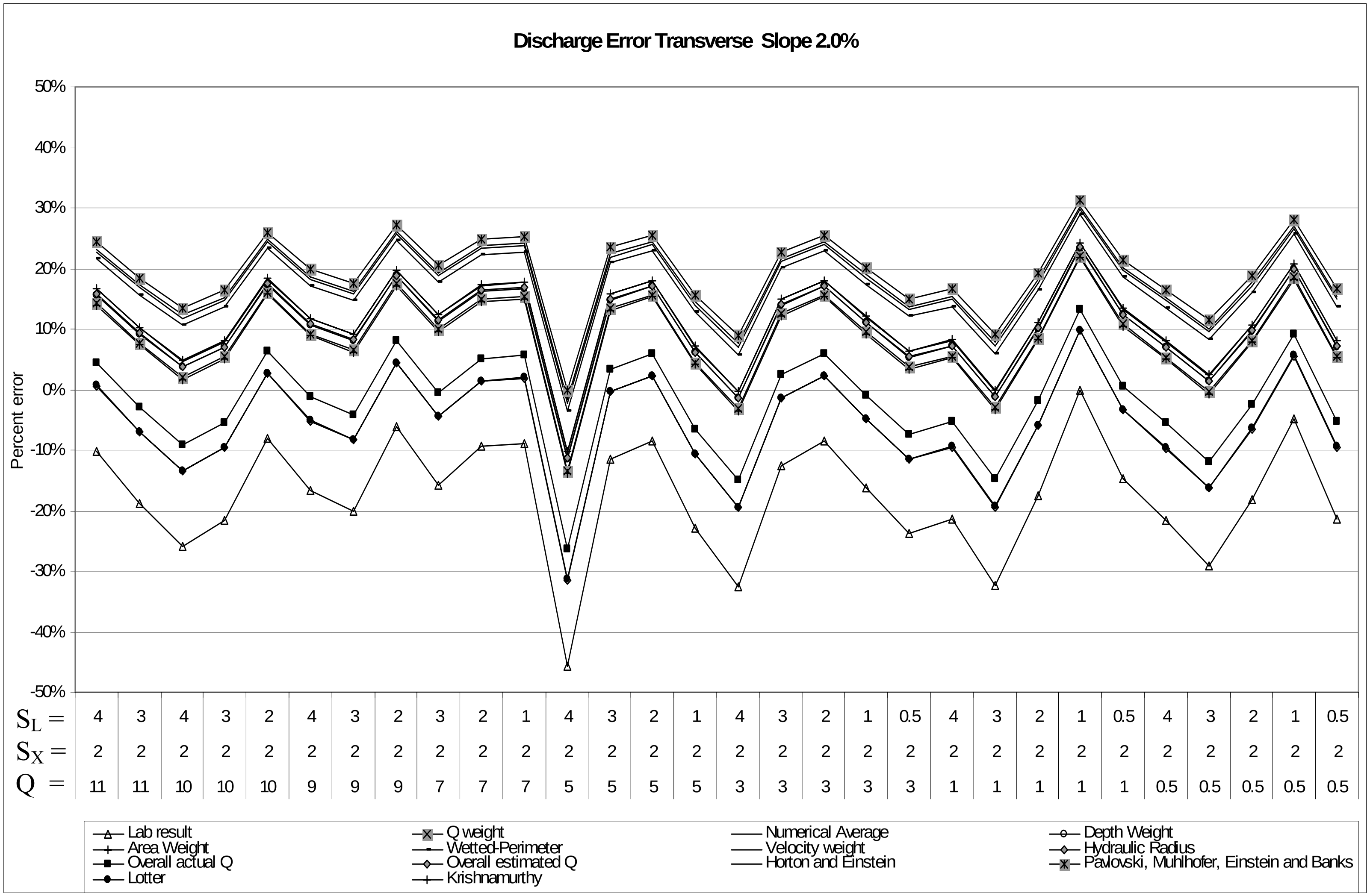


Figure A2.4 Velocity methods discharge estimations (asphalt treatment surface)

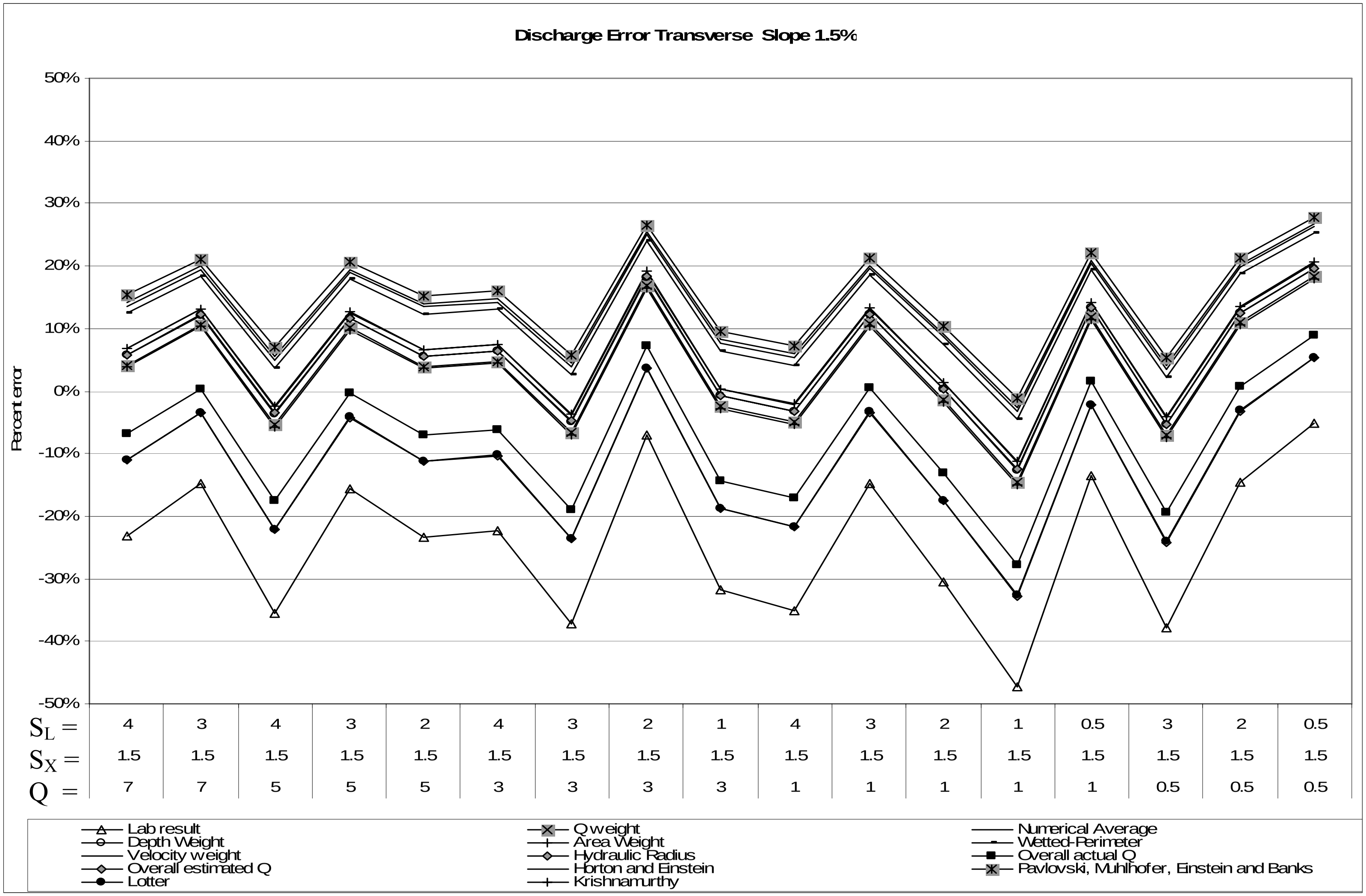


Figure A2.5 Velocity methods discharge estimations (asphalt treatment surface)

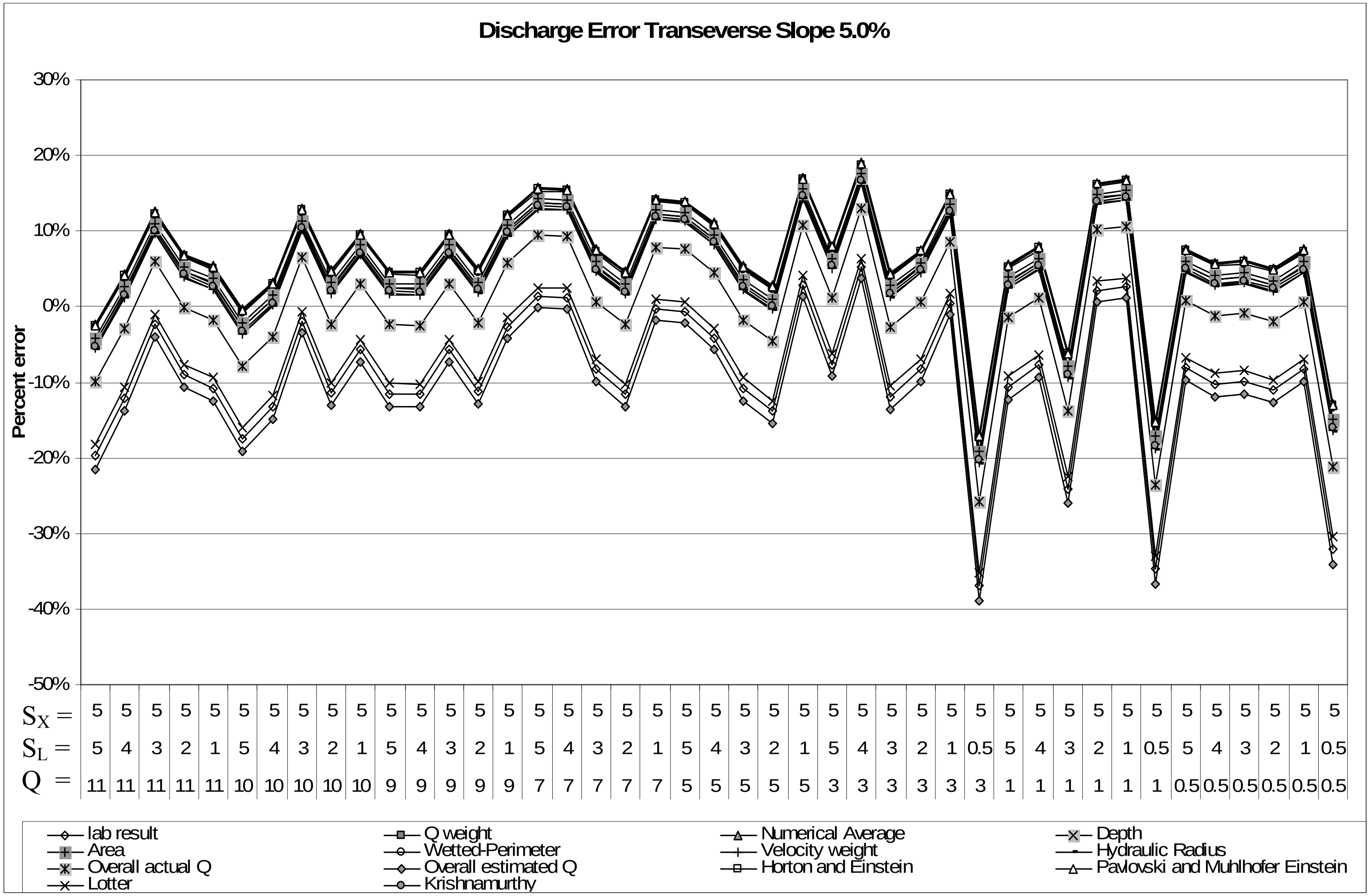


Figure A3.1 Velocity methods discharge estimations (smooth concrete surface)

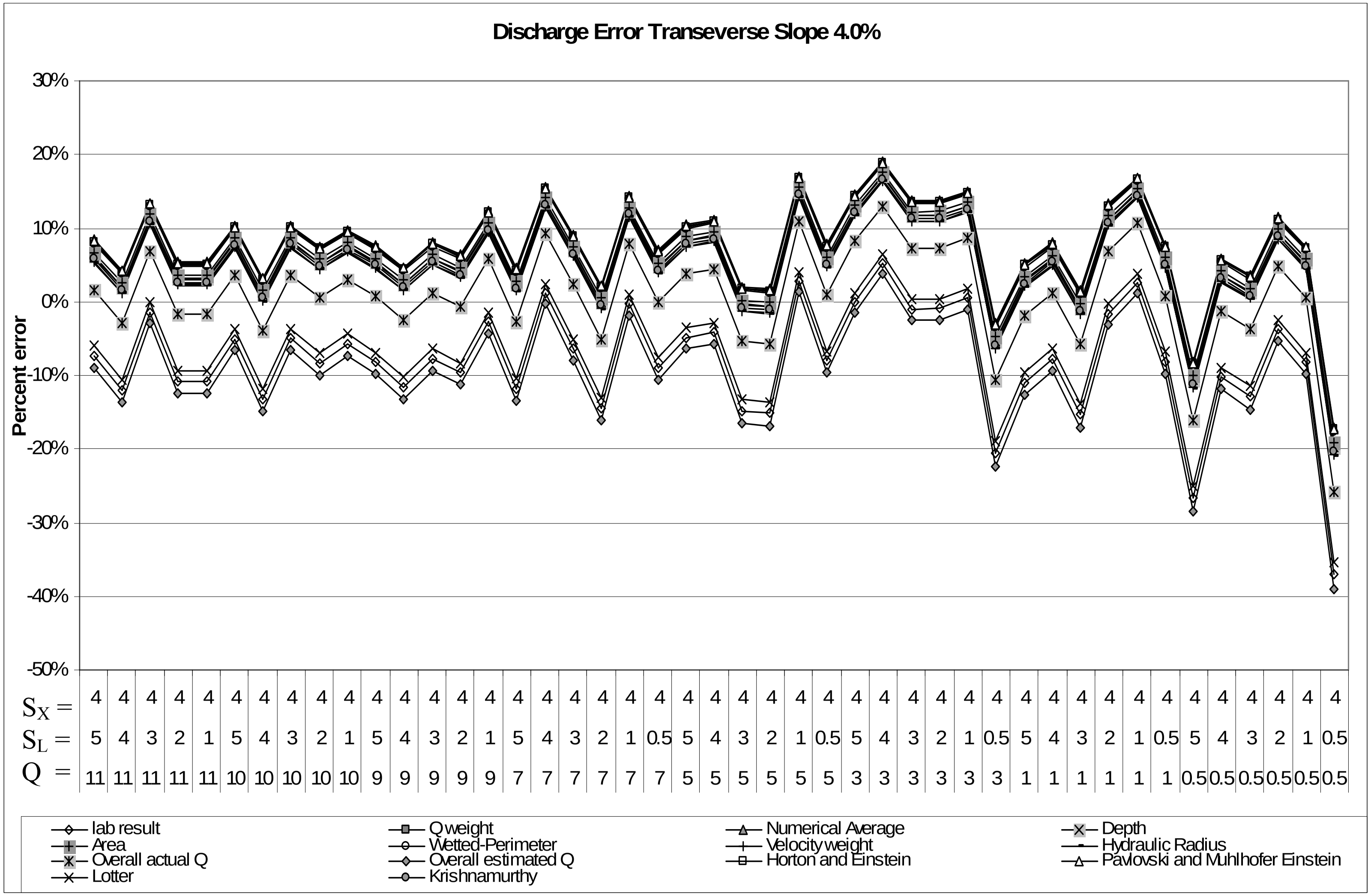


Figure A3.2 Velocity methods discharge estimations (smooth concrete surface)

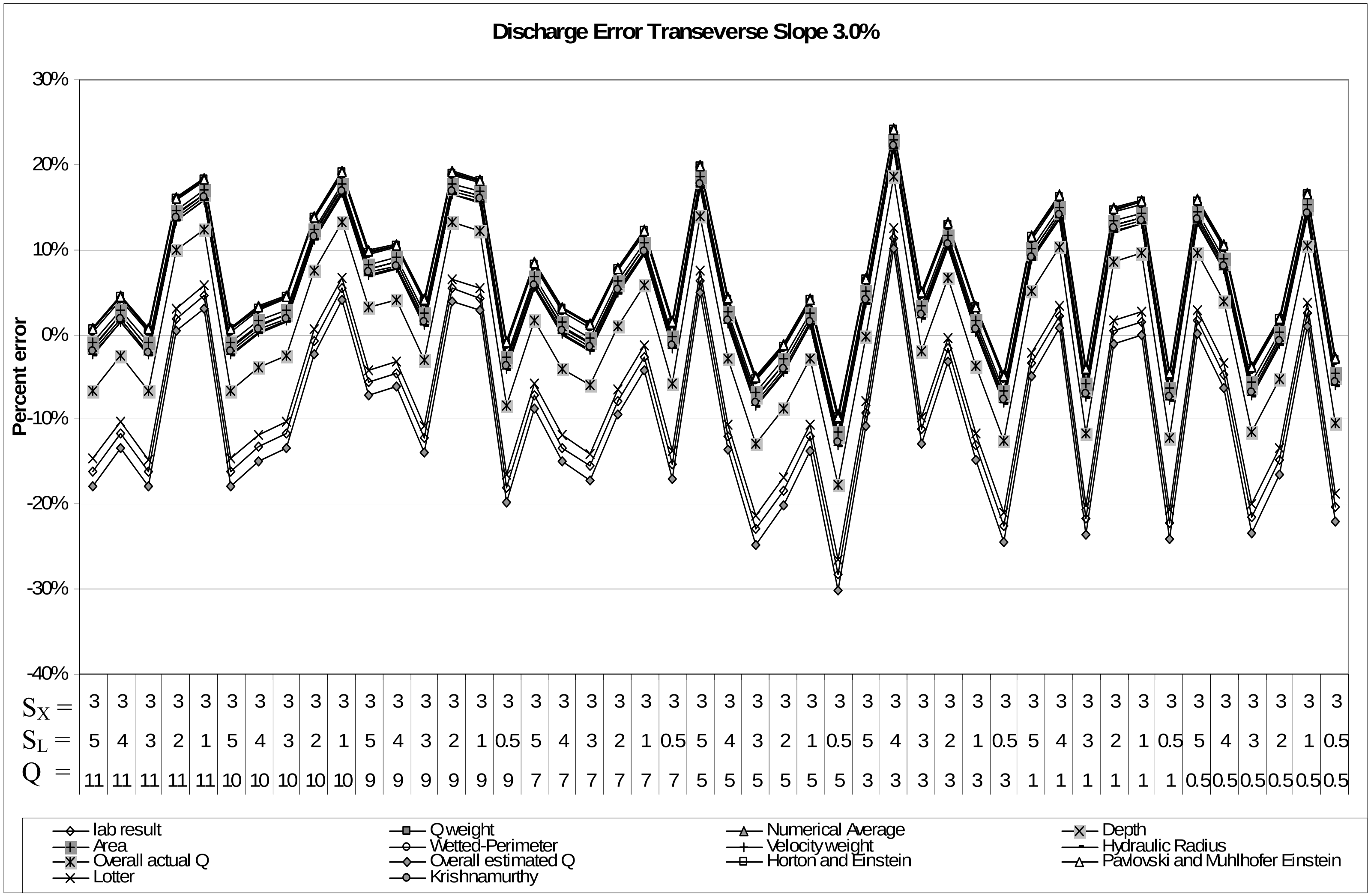


Figure A3.3 Velocity methods discharge estimations (smooth concrete surface)

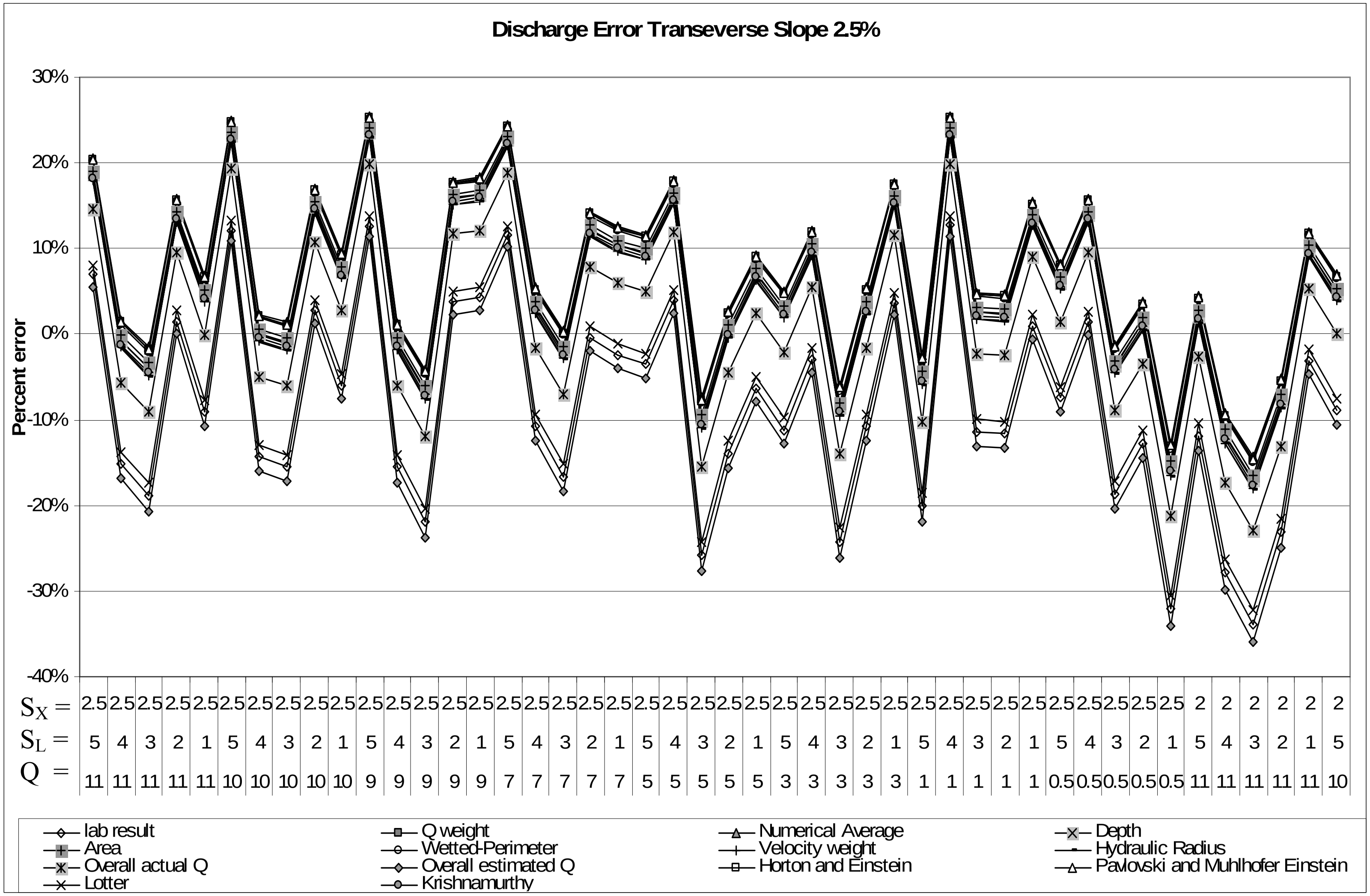


Figure A3.4 Velocity methods discharge estimations (smooth concrete surface)

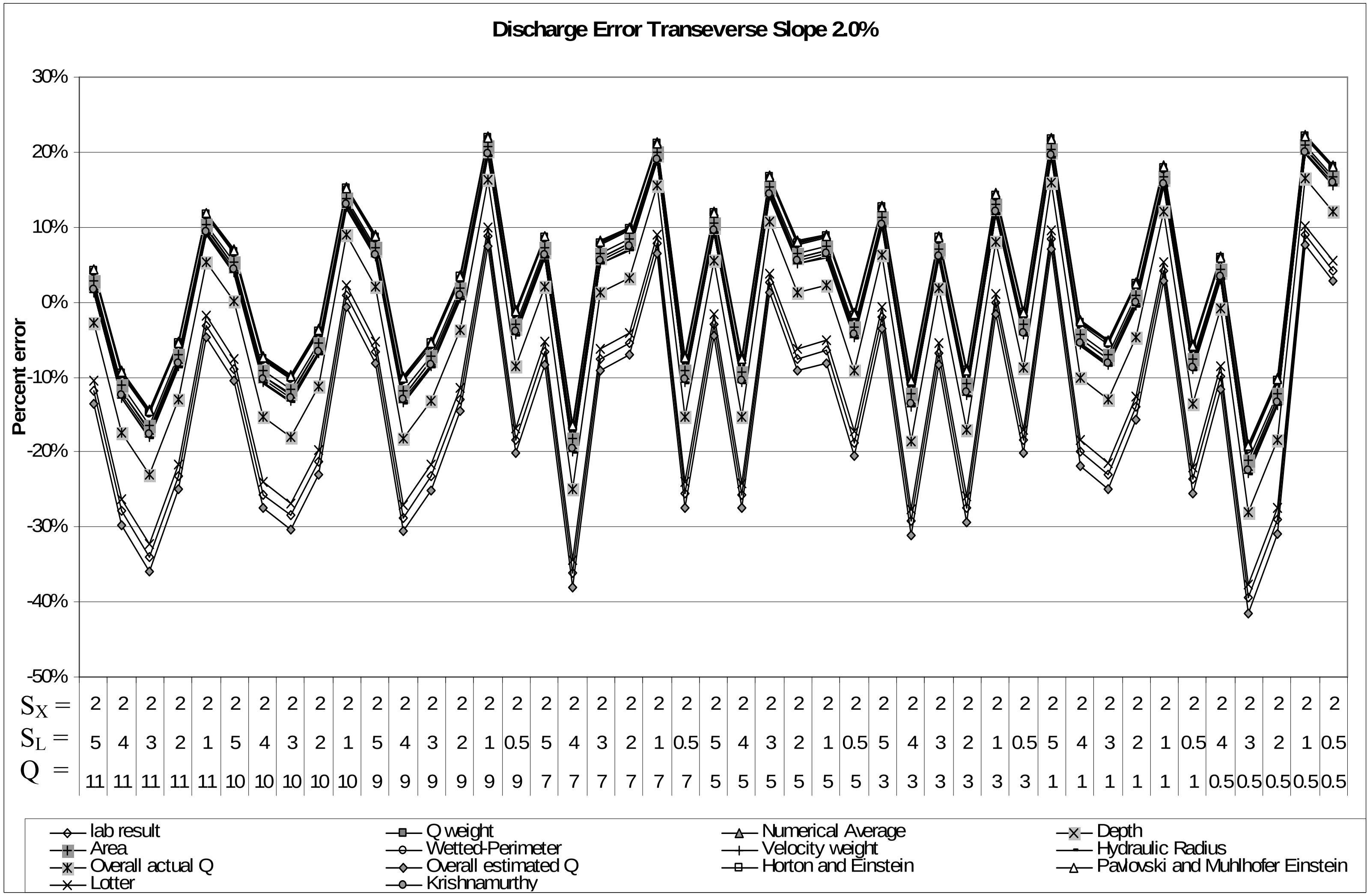


Figure A3.5 Velocity methods discharge estimations (smooth concrete surface)

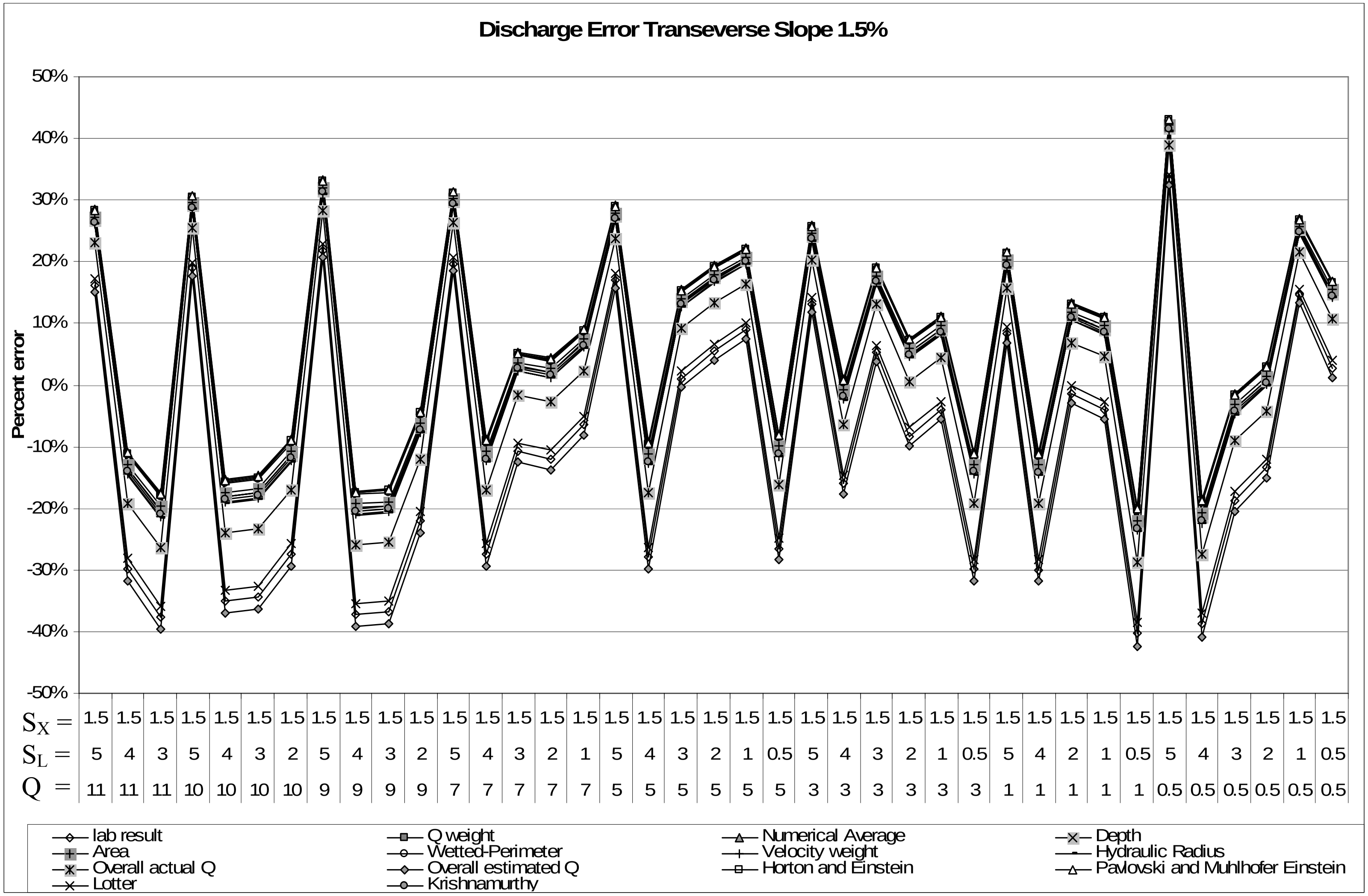


Figure A3.6 Velocity methods discharge estimations (smooth concrete surface)

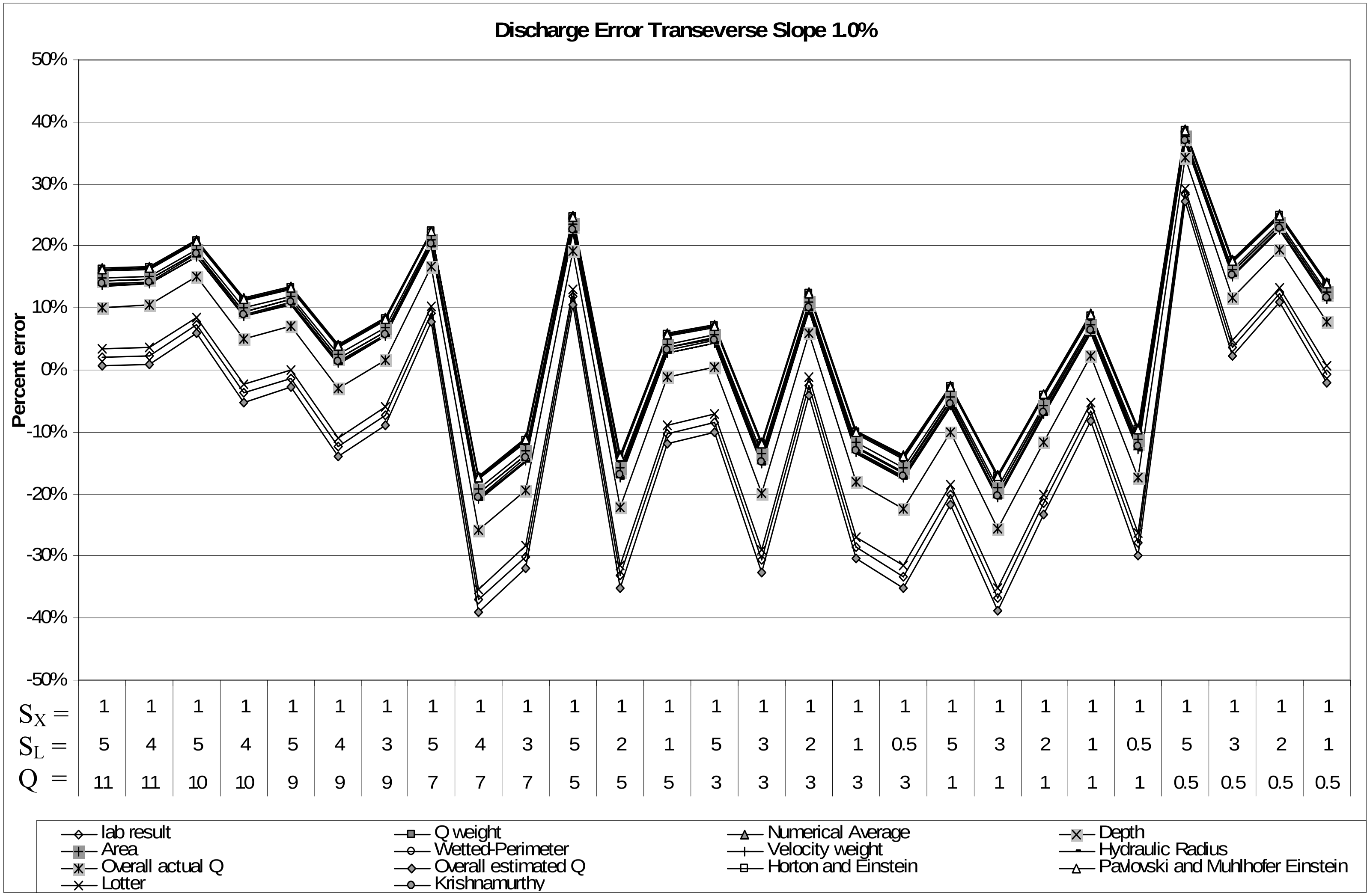


Figure A3.7 Velocity methods discharge estimations (smooth concrete surface)

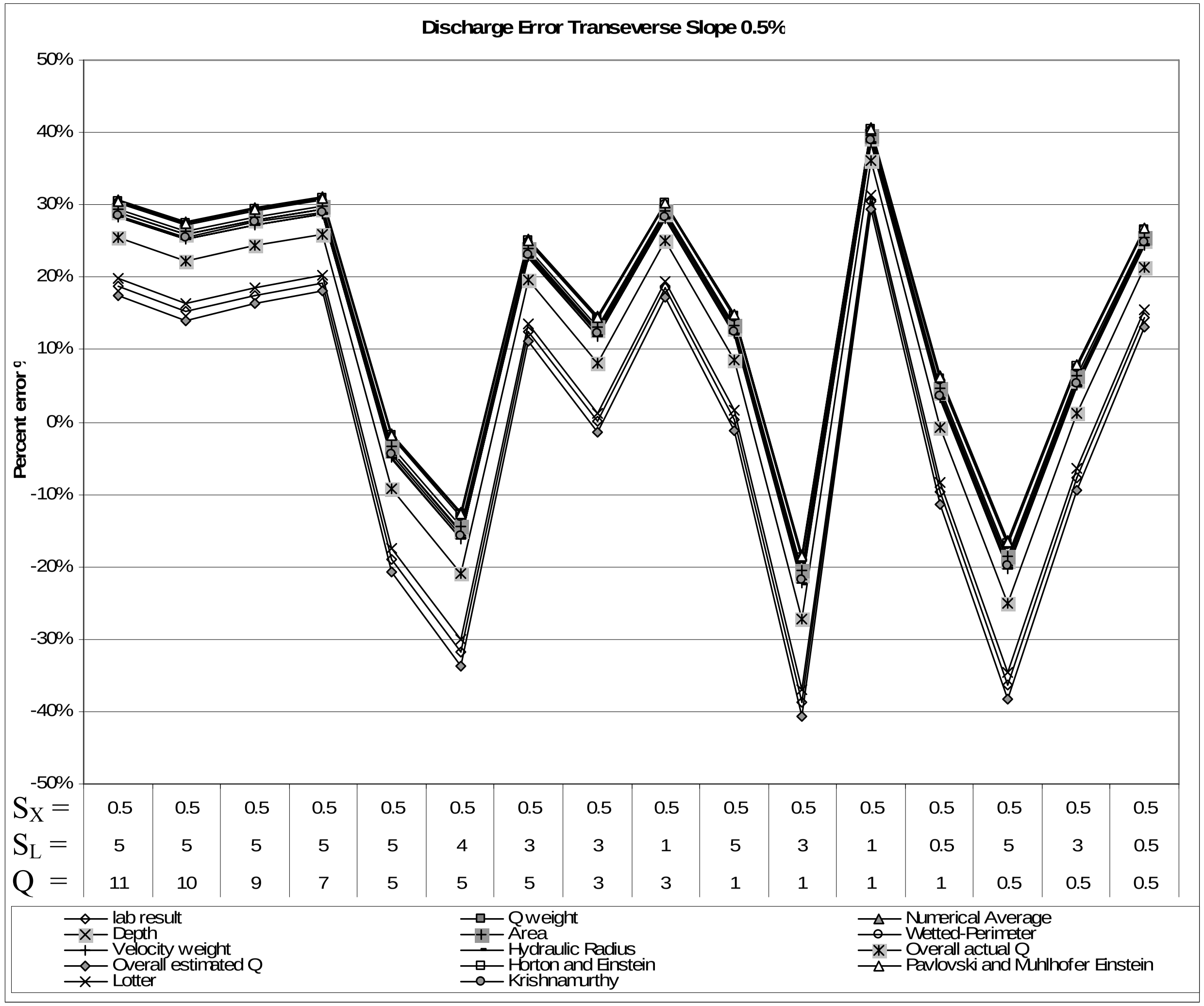


Figure A3.8 Velocity methods discharge estimations (smooth concrete surface)

APPENDIX B

ROADWAY DATA TABLES

Table B1.1 Smooth concrete surface data

Discharge	Oldconcrete Data SL (%)	SX (%)	High Point QWALL (CFS) Initial		Final		Low Point Qfloor (CFS) Initial		Final	Average	Qtotal AVG	Weir (ft) Initial		Final		Depth (ft) Min		Max		Spread Dist T1 (in) T1min		T2max		Curb Distance (in) Cmin		Cmax		Spread Dist T2 (in) T1min		T2max		AVG Spread	n value Geometric	Integrated
actual Q cfs			1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	CFS	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	in		
0.5	0.5%	0.5%	0.495	0.494	0.495	0.495					0.49475	14.12	14.12	14.12	14.12	0.0785	0.079	0.0785	0.0785	28.9375	28.875	28.9688	28.9063	28.9375	28.9375	28.9375	28.9375	154.063	153.438	154.125	155.188	125.281	0.00501	0.005965
1	0.5%	0.5%	1.005	1.005	1.006	1.006					1.0055	14.385	14.385	14.385	14.385	0.095	0.0975	0.095	0.0975	28.6875	28.5938	28.7188	28.625	28.9375	28.9375	28.9375	28.9375	237.313	237.313	237.313	237.313	208.656	0.009703	0.011551
3	0.5%	0.5%	0	0	0	0					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
5	0.5%	0.5%	0	0	0	0					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
7	0.5%	0.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
9	0.5%	0.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
10	0.5%	0.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
11	0.5%	0.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
0.5	0.5%	1.0%	0.485	0.486	0.485	0.486					0.4855	14.12	14.12	14.12	14.12	0.1075	0.1075	0.1075	0.1075	28.8438	28.8125	28.8438	28.8125	28.9375	28.9375	28.9375	28.9375	151.469	151.469	151.781	151.781	122.797	0.014741	0.01755
1	0.5%	1.0%	1.025	1.03	1.04	1.035					1.0325	14.415	14.41	14.42	14.435	0.14	0.1425	0.1395	0.142	28.6563	28.5938	28.6563	28.625	28.9375	28.9375	28.9375	28.9375	172.656	174.938	173.313	175.063	145.359	0.010703	0.012742
3	0.5%	1.0%	3.026	3.023	3.022	3.022					3.02325	14.985	14.985	14.985	14.985	0.2075	0.2125	0.206	0.2125	28.3125	28.2813	28.375	28.3125	28.9375	28.9375	28.9375	28.9375	237.313	237.313	237.313	237.313	208.992	0.010234	0.012184
5	0.5%	1.0%	0	0	0	0					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
7	0.5%	1.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
9	0.5%	1.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
10	0.5%	1.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
11	0.5%	1.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
0.5	0.5%	1.5%	0.521	0.522	0.522	0.522					0.52175	14.145	14.14	14.14	14.14	0.104	0.104	0.105	0.105	28.75	28.8125	28.8438	28.8125	28.9375	28.9375	28.9375	28.9375	120.344	120.344	119.75	119.938	91.2891	0.013229	0.015749
1	0.5%	1.5%	1.005	1.003	1.004	1.002					1.0035	14.37	14.37	14.375	14.375	0.165	0.1675	0.165	0.168	28.5938	28.6563	28.5938	28.5938	28.9375	28.9375	28.9375	28.9375	144.875	146.313	144.906	146.438	117.023	0.014463	0.017219
3	0.5%	1.5%	3.008	3.009	3.008	3.009					3.0085	14.955	14.96	14.965	14.96	0.231	0.238	0.2315	0.2385	28.3125	28.25	28.2813	28.2188	28.9375	28.9375	28.9375	28.9375	200.75	205.5	201.313	205.875	175.094	0.014016	0.016687
5	0.5%	1.5%	5.029	5.033	5.031	5.033					5.0315	15.34	15.343	15.325	15.33	0.274	0.281	0.2755	0.2825	28.1563	28.125	28.125	28.125	28.9375	28.9375	28.9375	28.9375	234.75	235.188	233.875	235.031	206.578	0.012074	0.014375
7	0.5%	1.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
9	0.5%	1.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
10	0.5%	1.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
11	0.5%	1.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
0.5	0.5%	2.0%	0.494	0.498	0.497	0.498					0.49675	14.12	14.12	14.12	14.12	0.125	0.126	0.125	0.125	28.625	28.5625	28.625	28.5938	28.9375	28.9375	28.9375	28.9375	91.625	91.625	90.6875	90.6875	62.5547	0.007848	0.009343
1	0.5%	2.0%	1.025	1.021	1.02	1.021					1.02175	14.39	14.39	14.39	14.39	0.1725	0.1745	0.1735	0.1745	28.4688	28.375	28.4375	28.4063	28.9375	28.9375	28.9375	28.9375	123.844	126.656	124.281	126.688	96.9453	0.012342	0.014693
3	0.5%	2.0%	3.01	3.007	3.009	3.008					3.0085	14.965	14.965	14.95	14.965	0.2495	0.258	0.2525	0.2595	28.25	28.1875	28.2188	28.1875	28.9375	28.9375	28.9375	28.9375	170.938	174.656	171.375	175.125	144.813	0.011662	0.013884
5	0.5%	2.0%	5.001	5	5.002	5					5.00075	15.34	15.32	15.34	15.33	0.2905	0.298	0.2905	0.297	27.9063	27.8438	27.9375	27.875	28.9375	28.9375	28.9375	28.9375	207.125	210.75	207.25	211.188	181.188	0.012786	0.015223
7	0.5%	2.0%	0.712	0.713	0.713	0.714	6.29	6.295	6.289	6.294	7.005	15.61	15.59	15.62	15.58	0.344	0.3505	0.3405	0.346	27.5313	27.5	27.5	27.4688	28.9375	28.9375	28.9375	28.9375	226.469	230.281	225.563	231.063	200.844	0.012282	0.014622
9	0.5%	2.0%	2.715	2.719	2.718	2.721	6.275	6.271	6.273	6.274	8.9915	15.86	15.82	15.89	15.81	0.373	0.379	0.372	0.3805	27.3438	27.2813	27.3438	27.3438	28.9375	28.9375	28.9375	28.9375	237.313	237.313	237.313	237.313	209.984	0.010969	0.013047
10	0.5%	2.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
11	0.5%	2.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
0.5	0.5%	2.5%	0.519	0.514	0.519	0.514					0.5165	14.14	7.1525	14.14	7.1515	0.164	0.164	0.162	0.163	28.6563	28.7813	28.6563	28.8125	28.9375	58.3438	28.9375	58.5	87.75	43.875	88.0625	44.0313	37.2031	0.009342	0.011122
1	0.5%	2.5%	1.0295	1.03	1.03	1.0305					1.03	7.885	7.294	14.385	7.2935	0.195	0.197	0.195	0.1965	28.4688	28.7188	28.4688	28.75	28.9375	71.1875	28.9375	71.3438	111.719	55.25	111.125	55.2188	54.7266	0.012869	0.015309
3	0.5%	2.5%	3.012	3.006	3.012	3.006					3.009	14.965	7.6375	14.965	7.6365	0.279	0.282	0.278	0.283	28.2813	28.625	28.2813	28.5938	28.9375	91.0313	28.9375	91.3125	153.344	76.6875	153.313	77.0313	86.6484	0.012151	0.014466
5	0.5%	2.5%	4.9995	4.999	4.996	4.9955					4.9975	15.3375	7.8655	15.3375	7.865	0.356	0.3615	0.3575	0.3625	27.7813	28.4063	27.7813	28.4063	28.9375	103.844	28.9375	103.281	179.563	89.8125	179.813	90.3438	106.789	0.012026	0.014318
7	0.5%	2.5%	0.757	3.507	0.7555	3.5035	6.2565	10.9405	6.252	10.9335	10.7264	15.6175	8.0165	15.6025	8.0055	0.392	0.3965	0.394	0.397	27.4688	28.3438	27.4688	28.375	28.9375	114.5	28.9375	114.063	197.625	97.3438	197.125	97.9688	119.602	0.012362	0.014718
9	0.5%	2.5%	2.7265	4.499	2.7245	4.495	6.269	11.113	6.267	11.079	12.2933	15.8825	8.15	15.855	8.1565	0.442	0.4465	0.44	0.446	27.2813	28.2188	27.2813	28.25	28.9375	126.813	28.9375	126.063	217.969	106.375	219.375	106.969	134.914	0.013642	0.016242
10	0.5%	2.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
11	0.5%	2.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
0.5	0.5%	3.0%	0.526	0.519	0.521	0.518					0.521	14.14	14.14	14.14	14.14	0.1615	0.1615	0.1615	0.1615	28.9375	28.875	28.875	28.8125	28.9375	28.9375	28.9375	28.9375	83.8125	83.8125	82.75	82.75	54.4063	0.010023	0.011933
1	0.5%	3.0%	0.996	1.006	0.997	1.005					1.001	14.39	14.395	14.39	14.395	0.2005	0.202	0.2	0.202	28.25	28.5	28.5313	28.4063	28.9375	28.9375	28.9375	28.9375	99.9063	103.375	100.906	103.344	73.4609	0.013469	0.016036
3	0.5%	3.0%	3.018	3.01	3.009	3.01					3.01175	14.96	14.96	14.96	14.96	0.293	0.297	0.296	0.296	28.4375	28.3125	28.4375	28.3438	28.9375	28.9375	28.9375	28.9375	144.563	146.531	145	146.813	117.344	0.013178	0.015689
5	0.5%	3.0%	4.987	4.984	4.983	4.983					4.98425	15.34	15.325	15.34	15.325	0.3755	0.3815	0.3735	0.38	28.4375	28.375	28.4688	28.4063	28.9375	28.9375	28.9375	28.9375	162.406	164.625	161.688	164.719	134.938	0.012333	0.014683
7	0.5%	3.0%	0.713	0.714	0.712	0.713	6.293	6.296	6.292	6.295	7.007	15.62	15.59	15.62	15.59	0.399	0.4055	0.3955	0.404	28.4688	28.4063	28.4375	28.4375	28.9375	28.9375	28.9375	28.9375	181.563	183.781	180.625	184.656	154.219	0.012508	0.014891
9	0.5%	3.0%	2.726	2.73	2.73	2.73	6.261	6.262	6.261	6.264	8.991	15.89	15.81	15.86	15.81	0.4295	0.4365	0.429	0.437	27.2813	27.1875	27.25	27.2188	28.9375	28.9375	28.9375	28.9375	199.313	203.531	198.219	203.5	173.906	0.013839	0.016476
10	0.5%	3.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
11	0.5%	3.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
0.5	0.5%	4.0%	0.523	0.523	0.522	0.523					0.52275	14.14	14.14	14.14	14.14	0.18	0.1815	0.1775	0.181	28.4688	28.4063	28.4688	28.4688	28.9375	28.9375	28.9375	28.9375	79.8125	80.5	79.5938	80.5625	51.6641	0.014737	0.017545
1	0.5%	4.0%	0.986	0.986	0.987	0.987					0.9865	14.385	14.385	14.385	14.385	0.2035	0.208	0.201	0.2065	28.25	28.1875	28.2188	28.0938	28.9375	28.9375	28.9375	28.9375	90	91.25	89.5	91.1875	62.2969	0.013178	0.01569
3	0.5%	4.0%	3.005	3.006	3.004	3.006					3.00525	14.965	14.965	14.965	14.965	0.322	0.3255	0.322	0.326	27.7813	27.7188	27.7813	27.7188	28.9375	28.9375	28.9375	28.9375	126.063	128.5	125.281	128.906	99.4375	0.013867	0.016497
5	0.5%	4.0%	4.99	4.989	4.989	4.994					4.9905	15.35	15.32	15.35	15.32	0.367	0.3735	0.366	0.373	27.5625	27.5	27.5625	27.5	28.9375	28.9375	28.9375	28.9375	144.844	147.969	144.406	147.938	118.758	0.013956	0.016616
7	0.5%	4.0%	0.676	0.676	0.677	0.676	6.324	6.321	6.334	6.339	7.00575	15.62	15.59	15.62	15.59	0.423	0.431	0.425	0.4325	27.3125	27.25	27.3125	27.3125	28.9375	28.9375	28.9375	28.9375	156.938	161.063	157.188	162.156	132.039	0.012733	0.01516
9	0.5%	4.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
10	0.5%	4.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
11	0.5%	4.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
0.5	0.5%	5.0%	0.492	0.493	0.493	0.494					0.493	14.12	14.12	14.12	14.12	0.192	0.196	0.193	0.196	28.375	28.3125	28.375	28.375	28.9375	28.9375	28.9375	28.9375	70.5	70.5	70.3125	70.3125	42.0469	0.012251	0.014685
1	0.5%	5.0%	0.986	0.986	0.987	0.985					0.986	14.385	14.385	14.385	14.385	0.255	0.26	0.258	0.261	28.0625	28	28	28	28.9375	28.9375	28.9375	28.9375	80.4375	81.875	80.6875	81.9375	53.2188	0.011455	0.013638
3	0.5%	5.0%	3.009	3.007	3.01	3.008					3.0085	14.96	14.96	14.96	14.96	0.392	0.4	0.391	0.402	28.1875	27.5	28.125	27.5	27.4375	28.9375	27.375	28.9375	106.688	109.625	107.5	109.063	80.3906	0.011273	0.013421
5	0.5%	5.0%	5.046	5.044	5.046	5.041					5.04425	15.34	15.33	15.34	15.33	0.484	0.498	0.482	0.5	27.0625	27	27.125	27	28.9375	28.9375	28.9375	28.9375	127.438	131.125	128.375	131.688	102.609	0.012909	0.015369
7	0.5%	5.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
9	0.5%	5.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
10	0.5%	5.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
11	0.5%	5.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		

Table B1.2 Smooth concrete surface data

	Oldconcrete Data		High Point				Low Point			Average																								
Discharg	SL (%)	SX (%)	QWALL (CFS)				Qfloor (CFS)				Qtotal	Weir (ft)				Depth (ft)				Spread Dist T1 (in)				Curb Distance (in)				Spread Dist T2 (in)				AVG	n value	
actual Q			Initial		Final		Initial		Final		AVG	Initial		Final		Min		Max		T1min		T2max		Cmin		Cmax		T1min		T2max		Spread	Geometri	Integrated
cfs			1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	CFS	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	In		
0.5	1.0%	0.5%	0.485	0.487	0.485	0.487					0.486	14.12	14.12	14.12	14.12	0.043	0.043	0.043	0.044	29.25	29.1875	29.1875	29.1875	28.9375	28.9375	28.9375	28.9375	166.188	166.5	166.125	166.563	137.141	0.009298	0.01107
1	1.0%	0.5%	1	1.022	1.029	1.021					1.018	14.4	14.4	14.4	14.4	0.075	0.075	0.076	0.077	29.125	29.0625	29.125	29	28.9375	28.9375	28.9375	28.9375	189.125	191.125	190.188	191.75	161.469	0.00685	0.008155
3	1.0%	0.5%	3.006	3.005	3.006	3.004					3.00525	14.945	14.944	14.949	14.943	0.125	0.124	0.125	0.131	28.75	28.6875	28.75	28.625	28.9375	28.9375	28.9375	28.9375	237.313	237.313	237.313	237.313	208.609	0.004587	0.005461
5	1.0%	0.5%	0	0	0	0					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
7	1.0%	0.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
9	1.0%	0.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
10	1.0%	0.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
11	1.0%	0.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
0.5	1.0%	1.0%	0.502	0.503	0.502	0.502					0.50225	14.14	14.141	14.14	14.141	0.083	0.084	0.084	0.084	29.0625	29	29.0625	29.0625	28.9375	28.9375	28.9375	28.9375	123.438	124.438	120.125	121.188	93.25	0.010153	0.012088
1	1.0%	1.0%	1.002	1.001	0.998	0.999					1	14.4	14.399	14.401	14.4	0.108	0.112	0.105	0.11	28.875	28.8125	28.8125	28.8125	28.9375	28.9375	28.9375	28.9375	154.188	156.438	153.688	156.063	126.266	0.011442	0.013622
3	1.0%	1.0%	2.991	2.995	2.993	2.994					2.99325	14.96	14.965	14.95	14.955	0.175	0.181	0.173	0.18	28.0625	28.625	28.625	28.5625	28.9375	28.9375	28.9375	28.9375	215.438	219.125	215.938	220.188	189.203	0.01123	0.01337
5	1.0%	1.0%	4.99	4.989	4.991	4.989					4.98975	15.35	15.36	15.36	15.36	0.201	0.211	0.199	0.21	28.4375	28.375	28.5	28.4375	28.9375	28.9375	28.9375	28.9375	237.313	237.313	237.313	237.313	208.875	0.008763	0.010433
7	1.0%	1.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
9	1.0%	1.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
10	1.0%	1.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
11	1.0%	1.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
0.5	1.0%	1.5%	0.504	0.503	0.5	0.498					0.50125	14.145	14.14	14.14	14.14	0.093	0.095	0.092	0.095	29.375	29.3125	29.3125	29.3125	28.9375	28.9375	28.9375	28.9375	93.125	93.8125	92.6875	94.6875	64.25	0.007356	0.008758
1	1.0%	1.5%	0.987	0.986	0.981	0.983					0.98425	14.37	14.37	14.375	14.375	0.121	0.124	0.119	0.123	28.9375	28.8125	28.9375	28.75	28.9375	28.9375	28.9375	28.9375	127.438	130.375	128.375	130.063	100.203	0.012288	0.01463
3	1.0%	1.5%	2.997	2.996	2.999	3					2.998	14.955	14.96	14.965	14.96	0.191	0.196	0.191	0.196	28.6875	28.625	28.625	28.5625	28.9375	28.9375	28.9375	28.9375	170.063	173.625	168.125	172.688	142.5	0.010303	0.012266
5	1.0%	1.5%	4.98	4.979	4.993	4.998					4.9875	15.34	15.343	15.325	15.33	0.221	0.225	0.22	0.225	28.4375	28.375	28.4375	28.4375	28.9375	28.9375	28.9375	28.9375	189.438	193.063	190.125	193.688	163.156	0.008882	0.010575
7	1.0%	1.5%	0.737	0.74	0.739	0.735	6.289	6.289	6.296	6.297	7.0305	15.62	15.615	15.62	15.615	0.245	0.251	0.242	0.25	28.1875	28.125	28.1875	28.1875	28.9375	28.9375	28.9375	28.9375	237.313	237.313	237.313	237.313	209.141	0.01224	0.014572
9	1.0%	1.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
10	1.0%	1.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
11	1.0%	1.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
0.5	1.0%	2.0%	0.505	0.503	0.504	0.503					0.50375	14.105	14.11	14.115	14.11	0.107	0.11	0.11	0.113	28.9375	28.875	28.875	28.8125	28.9375	28.9375	28.9375	28.9375	82.8125	82.8125	81.0625	81.0625	53.0625	0.007051	0.008395
1	1.0%	2.0%	1.012	1.01	1.01	1.009					1.01025	14.38	14.38	14.385	14.38	0.135	0.139	0.133	0.139	28.8125	28.75	28.75	28.6875	28.9375	28.9375	28.9375	28.9375	106.688	108.125	107.188	108.938	78.9844	0.010193	0.012135
3	1.0%	2.0%	2.991	2.992	2.991	2.993					2.99175	14.94	14.95	14.95	14.95	0.203	0.21	0.201	0.207	28.4375	28.375	28.4375	28.375	28.9375	28.9375	28.9375	28.9375	150.438	154.75	148.813	153.063	123.359	0.011316	0.013472
5	1.0%	2.0%	4.994	4.995	5	4.997					4.9965	15.345	15.35	15.34	15.34	0.261	0.268	0.261	0.269	28.0625	28	28.0625	28.0625	28.9375	28.9375	28.9375	28.9375	169.5	173.688	170.063	173.875	143.734	0.010161	0.012098
7	1.0%	2.0%	0.678	0.677	0.678	0.677	6.326	6.325	6.32	6.323	7.001	15.605	15.61	15.615	15.61	0.275	0.281	0.273	0.28	28.0625	28	28	27.9375	28.9375	28.9375	28.9375	28.9375	185.063	199.563	185.063	187.938	161.406	0.00992	0.01181
9	1.0%	2.0%	2.754	2.758	2.758	2.755	6.304	6.302	6.3	6.289	9.055	15.845	15.85	15.845	15.85	0.298	0.303	0.295	0.301	27.9375	27.9375	27.9375	27.875	28.9375	28.9375	28.9375	28.9375	202.688	205.563	200.063	204.438	175.266	0.009528	0.011344
10	1.0%	2.0%	3.698	3.697	3.693	3.692	6.272	6.265	6.261	6.26	9.9595	15.94	15.95	15.935	15.94	0.307	0.311	0.305	0.31	27.9375	27.875	27.875	27.875	28.9375	28.9375	28.9375	28.9375	220.063	223.313	218.438	222.375	193.156	0.011239	0.013381
11	1.0%	2.0%	4.723	4.72	4.718	4.721	6.279	6.278	6.263	6.26	10.9905	16.02	16.025	16.03	16.03	0.313	0.322	0.312	0.321	27.875	27.75	27.8125	27.75	28.9375	28.9375	28.9375	28.9375	237.313	237.313	237.313	237.313	209.516	0.01266	0.015072
0.5	1.0%	2.5%	0.523	0.524	0.526	0.526					0.52475	14.125	14.125	14.125	14.125	0.135	0.15	0.138	0.145	28.75	28.6875	28.75	28.8125	28.9375	28.9375	28.9375	28.9375	80.6875	81.5625	80.4375	81.8125	52.375	0.009412	0.011206
1	1.0%	2.5%	0.999	0.999	0.999	0.999					0.999	14.36	14.36	14.36	14.36	0.15	0.16	0.152	0.165	28.5625	28.5	28.5625	28.625	28.9375	28.9375	28.9375	28.9375	91.375	92.875	91.4375	92.8125	63.5625	0.008308	0.009891
3	1.0%	2.5%	2.994	2.992	2.993	2.991					2.9925	14.96	14.96	14.96	14.96	0.2	0.22	0.202	0.215	28.5	28.4375	28.4375	28.4375	28.9375	28.9375	28.9375	28.9375	141.063	145	145	145.063	115.578	0.013966	0.016627
5	1.0%	2.5%	4.988	4.99	4.989	4.987					4.9885	15.36	15.35	15.36	15.35	0.27	0.285	0.267	0.282	28.3125	28.25	28.25	28.25	28.9375	28.9375	28.9375	28.9375	161.563	161.688	161.688	161.813	133.422	0.012068	0.014368
7	1.0%	2.5%	0.695	0.694	0.692	0.696	6.292	6.295	6.292	6.301	6.98925	15.63	15.61	15.63	15.61	0.3	0.31	0.285	0.338	28.125	28	28.0625	27.75	28.9375	28.9375	28.9375	28.9375	177.25	178.688	178.375	179.75	150.531	0.011887	0.014152
9	1.0%	2.5%	2.701	2.707	2.709	2.707	6.288	6.282	6.281	6.282	8.98925	15.86	15.865	15.84	15.845	0.32	0.325	0.321	0.338	27.9375	27.875	27.875	27.75	28.9375	28.9375	28.9375	28.9375	191.688	193.375	190.563	192.813	164.25	0.011009	0.013107
10	1.0%	2.5%	3.77	3.77	3.772	3.769	6.286	6.286	6.276	6.281	10.0525	15.96	15.96	15.91	15.96	0.35	0.365	0.349	0.362	27.75	27.625	27.6875	27.5625	28.9375	28.9375	28.9375	28.9375	197.375	199.563	198.313	200.25	171.219	0.010864	0.012934
11	1.0%	2.5%	4.759	4.761	4.76	4.757	6.252	6.261	6.256	6.261	11.0168	16.08	16.02	16.06	16	0.37	0.385	0.367	0.383	27.5	27.375	27.4375	27.375	28.9375	28.9375	28.9375	28.9375	199.438	204.625	200.063	205.813	175.063	0.011602	0.013813
0.5	1.0%	3.0%	0.49	0.489	0.49	0.489					0.4895	14.125	14.125	14.125	14.125	0.118	0.12	0.12	0.12	28.625	28.5625	28.5625	28.5625	28.9375	28.9375	28.9375	28.9375	76.5625	76.5625	75.6875	75.6875	47.5469	0.010587	0.012605
1	1.0%	3.0%	0.989	0.991	0.992	0.993					0.99125	14.375	14.375	14.375	14.375	0.165	0.168	0.164	0.168	28.3125	28.25	28.375	28.25	28.9375	28.9375	28.9375	28.9375	84.4375	86.5625	84.125	86.6875	57.1563	0.008511	0.010133
3	1.0%	3.0%	3.019	3.011	3.011	3.009					3.0125	14.96	14.96	14.96	14.96	0.248	0.252	0.246	0.251	28.0625	28	28.0625	28.0625	28.9375	28.9375	28.9375	28.9375	129.438	132.125	127.938	131.688	102.25	0.013273	0.015802
5	1.0%	3.0%	4.985	4.982	4.983	4.975					4.98125	15.34	15.31	15.34	15.31	0.298	0.301	0.296	0.301	27.8125	27.75	27.75	27.6875	28.9375	28.9375	28.9375	28.9375	147.438	151.25	148.688	157.938	123.578	0.013331	0.015871
7	1.0%	3.0%	0.704	0.703	0.706	0.707	6.267	6.273	6.275	6.275	6.9775	15.62	15.62	15.58	15.58	0.333	0.339	0.331	0.338	27.6875	27.625	27.6875	27.5625	28.9375	28.9375	28.9375	28.9375	157.375	159.063	158.438	160	131.078	0.011092	0.013206
9	1.0%	3.0%	2.743	2.735	2.742	2.737	6.271	6.278	6.276	6.279	9.01525	15.87	15.82	15.87	15.82	0.352	0.355	0.35	0.355	27.625	27.5625	27.5625	27.5	28.9375	28.9375	28.9375	28.9375	171.188	174	170.688	173.75	144.844	0.011221	0.013359
10	1.0%	3.0%	3.746	3.742	3.743	3.74	6.256	6.257	6.256	6.255	9.99875	16.01	15.94	16.01	15.96	0.362	0.368	0.36	0.367	27.4375	27.4375	27.5	27.4375	28.9375	28.9375	28.9375	28.9375	176.313	180.188	177.188	180.438	151.078	0.011325	0.013483
11	1.0%	3.0%	4.753	4.762	4.76	4.761	6.256	6.258	6.26	6.254	11.016	16.09	16.01	16.06	16.01	0.383	0.389	0.382	0.388	27.375	27.3125	27.3125	27.3125	28.9375	28.9375	28.9375	28.9375	177.375	182.563	178.438	182.688	152.938	0.010609	0.012631
0.5	1.0%	4.0%	0.532	0.532	0.532	0.532					0.532	14.13	14.13	14.13	14.13	0.14	0.145	0.14	0.145	28.6875	28.5	28.0625	28.375	28.9375	28.9375	28.9375	28.9375	71	71.0625	71	71.0625	42.625	0.011647	0.013866
1	1.0%	4.0%	0.996	0.996	0.996	0.994					0.9955	14.375	14.375	14.375	14.375	0.17	0.17	0.17	0.172	28.1875	28.3125	28.25	28.4375	28.9375	28.9375	28.9375	28.9375	80.75	80.875	80.875	80.9375	52.5625	0.010895	0.012971
3	1.0%	4.0%	3.004	3.004	3.008	3.01					3.0065	14.96	14.95	14.96	14.95	0.265	0.27	0.26	0.273	28.1875	28	28.125	28.0625	28.9375	28.9375	28.9375	28.9375	100.063	102.813	101.375	105.625	74.375	0.009084	0.010815
5	1.0%	4.0%	4.983	4.983	4.989	4.989					4.986	15.34	15.31	15.34	15.31	0.3	0.305	0.295	0.31	27.8125	27.625	27.875	27.75	28.9375	28.9375	28.9375	28.9375	120.938	126.813	121.063	127	96.1875	0.010935	0.013019
7	1.0%	4.0%	0.696	0.695	0.696	0.695	6.297	6.298	6.296	6.298	6.99275	15.63	15.61	15.63	15.61	0.37	0.375	0.365	0.38	27.5	27.375	27.4375	27.3125	28.9375	28.9375	28.9375	28.9375	136.25	140.313	135.563	141	110.875	0.011349	0.013511
9	1.0%	4.0%	2.724	2.738	2.723	2.74	6.268	6.282	6.276	6.281	9.008	15.86	15.84	15.86	15.83	0.395	0.405	0.397	0.41	27.375	27.25	27.5	27.4375	28.9375	28.9375	28.9375	28.9375	146	152.938	147.063	152.625	122.266	0.011449	0.013631
10	1.0%	4.0%	3.806	3.806	3.805	3.808	6.257	6.258	6.256	6.267	10.0658	15.99	15.94	15.975	15.95	0.41	0.425	0.42	0.43	27.25	27.125	27.3125	27.1875	28.9375	28.9375	28.9375	28.9375	150.563	155.688	151.063	156.125	126.141	0.011122	0.013241
11	1.0%	4.0%	4.752	4.745	4.748	4.743	6.26	6.248	6.25	6.246	10.998	16.09	16.01	16.08	16.04	0.45	0.47	0.46	0.48	27.125	27	27.1875	27.0625	28.9375	28.9375	28.9375	28.9375	156.563	161.625	157.063	162.25	132.281	0.011531	0.013729
0.5	1.0%	5.0%	0.495	0.499	0.496	0.499					0.49725	14.125	14.125	14.125	14.125	0.154	0.154	0.155	0.155	28.3125	28.3125	28.3125	28.3125	28.9375	28.9375	28.9375	28.9375	63.6875	63.6875	62.4375	62.4375	34.75	0.010361	0.012335
1	1.0%	5.0%	1.028	1.029	1.029	1.03					1.029	14.395	14.395	14.395	14.395	0.19	0.191	0.19	0.192	28.25	28.1875	28.1875	28.1875	28.9375	28.9375	28.9375	28.9375	74.5	74.75	74.375	74.6875	46.375	0.011289	0.013441
3	1.0%	5.0%	3	2.997	2.994	2.997					2.997	14.97	14.97	14.97	14.97	0.291	0.298	0.289	0.297	28	27.9375	28	28	28.9375	28.9375	28.9375	28.9375	95.5	97.125	94.6875	98.0625	68.3594	0.009759	0.011618
5	1.0%	5.0%	4.984	4.99	4.982	4.986					4.9855	14.345	14.33	14.345	14.33	0.333	0.338	0.33	0.34	27.6875	27.625	27.6875	27.5625	28.9375	28.9375	28.9375	28.9375	115.438	118.125	114.688	118.813	89.125	0.012263	0.014599
7	1.0%	5.0%	0.702	0.702	0.702	0.703	6.287	6.293	6.292	6.298	6.99475	15.62	15.61	15.62	15.61	0.38	0.391	0.382	0.39	27.4375	27.375	27.4375	27.3125	28.9375	28.9375	28.9375	28.9375	129.375	130.813	128.438	131.188	102.563	0.013297	0.015831
9	1.0%	5.0%	2.737	2.74	2.738	2.739	6.249	6.245	6.243	6.254	8.98625	15.88	15.81	15.86	15.84	0.429	0.438	0.431	0.439	27.0625	27	27.125	27	28.9375	28.9375	28.9375	28.9375	136.75	139.313	135.438	139.063	110.594	0.013322	0.015042
10	1.0%	5.0%	3.746	3.739	3.744	3.743	6.248	6.245	6.247	6.247	9.98975	15.96	15.99	15.91	15.98	0.451	0.46	0.45	0.459	27	26.9375	27	26.875	28.9375	28.9375	28.9375	28.9375	143.813	145.375	142.688	145.563	117.406	0.013333	0.015874
11	1.0%	5.0%	4.737	4.732	4.734	4.73	6.263	6.27	6.269	6.268	11.0008	16.05	16.01	16.08	16.03	0.475	0.481	0.473	0.48	26.9375	26.9375	26.9375	26.9375	28.9375	28.9375	28.9375	28.9375	150.438	153.5	149.688	153.688	124.891	0.014289	0.017012

Table B1.3 Smooth concrete surface data

	Oldconcrete Data		High Point				Low Point			Average																								
Discharg	SL (%)	SX (%)	QWALL (CFS)				Qfloor (CFS)				Qtotal	Weir (ft)				Depth (ft)				Spread Dist T1 (in)				Curb Distance (in)				Spread Dist T2 (in)				AVG	n value	
actual Q			Initial		Final		Initial		Final		AVG	Initial		Final		Min		Max		T1min		T2max		Cmin		Cmax		T1min		T2max		Spread	Geometri	Integrated
cfs			1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	CFS	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	In		
0.5	2.0%	0.5%	0.505	0.505	0.504	0.505					0.50475	14.12	14.12	14.12	14.12	0.055	0.057	0.055	0.056	29.0625	29	29.0625	29.0625	28.9375	28.9375	28.9375	28.9375	150.438	151.125	149.5	150.438	121.328	0.009118	0.010856
1	2.0%	0.5%	1.028	1.022	1.029	1.021					1.025	14.4	14.4	14.4	14.4	0.092	0.094	0.092	0.093	28.9375	28.9375	29	28.9375	28.9375	28.9375	28.9375	28.9375	223.125	224.5	225.938	225.5	195.813	0.016089	0.019155
3	2.0%	0.5%	3.023	3.026	3.026	3.025					3.025	14.965	14.965	14.965	14.965	0.125	0.13	0.123	0.131	28.75	28.6875	28.75	28.75	28.9375	28.9375	28.9375	28.9375	237.313	237.313	237.313	237.313	208.578	0.006442	0.007669
5	2.0%	0.5%	0	0	0	0					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
7	2.0%	0.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
9	2.0%	0.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
10	2.0%	0.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
11	2.0%	0.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
0.5	2.0%	1.0%	0.482	0.483	0.484	0.484					0.48325	14.12	14.12	14.12	14.12	0.073	0.075	0.073	0.074	28.9375	28.9375	29	28.9375	28.9375	28.9375	28.9375	28.9375	98.1875	98.8125	97.125	97.125	68.8594	0.006632	0.007896
1	2.0%	1.0%	1.006	1.006	1.006	1.006					1.006	14.395	14.395	14.395	14.395	0.105	0.11	0.103	0.11	28.875	28.8125	28.8125	28.8125	28.9375	28.9375	28.9375	28.9375	133.125	136.938	134.75	135.938	106.359	0.010165	0.012102
3	2.0%	1.0%	3.039	3.04	3.041	3.044					3.041	14.965	14.965	14.965	14.965	0.149	0.154	0.147	0.155	28.75	28.6875	28.75	28.625	28.9375	28.9375	28.9375	28.9375	178.188	181.5	177.75	181.125	150.938	0.008552	0.010181
5	2.0%	1.0%	5.001	5.003	5.002	5.007					5.00325	15.35	15.33	15.35	15.33	0.185	0.191	0.183	0.189	28.5	28.4375	28.5	28.375	28.9375	28.9375	28.9375	28.9375	237.313	237.313	237.313	237.313	208.859	0.01237	0.014727
7	2.0%	1.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
9	2.0%	1.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
10	2.0%	1.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
11	2.0%	1.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
0.5	2.0%	1.5%	0.517	0.516	0.517	0.517					0.51675	14.125	14.125	14.125	14.125	0.092	0.093	0.093	0.093	28.875	28.8125	28.8125	28.8125	28.9375	28.9375	28.9375	28.9375	91.5625	91.5625	93.125	93.125	63.5156	0.009786	0.011651
1	2.0%	1.5%	1.021	1.029	1.023	1.027					1.025	14.39	14.39	14.39	14.39	0.112	0.115	0.112	0.115	28.8125	28.8125	28.75	28.6875	28.9375	28.9375	28.9375	28.9375	110.188	112.313	111.125	112.938	82.875	0.01004	0.011954
3	2.0%	1.5%	2.981	2.98	2.983	2.983					2.98175	14.965	14.965	14.965	14.965	0.169	0.177	0.171	0.179	28.4375	28.375	28.375	28.375	28.9375	28.9375	28.9375	28.9375	149.188	154.563	150.063	154.875	123.781	0.010062	0.01198
5	2.0%	1.5%	5.007	5.002	5.006	5.002					5.00425	15.325	15.36	15.325	15.36	0.203	0.21	0.201	0.21	28.3125	28.25	28.3125	28.1875	28.9375	28.9375	28.9375	28.9375	163.125	169.5	161.063	167.75	137.094	0.007868	0.009367
7	2.0%	1.5%	0.746	0.744	0.744	0.744	6.275	6.276	6.279	6.274	7.0205	15.62	15.61	15.62	15.61	0.232	0.239	0.23	0.241	28.1875	28.0625	28.125	28.0625	28.9375	28.9375	28.9375	28.9375	201.125	206.563	200.438	205.938	175.406	0.01083	0.012894
9	2.0%	1.5%	2.741	2.74	2.74	2.74	6.25	6.272	6.25	6.275	9.002	15.88	15.81	15.88	15.81	0.254	0.266	0.252	0.265	28.0625	28.0625	28	27.875	28.9375	28.9375	28.9375	28.9375	225.188	231.75	227.063	233.125	201.281	0.012198	0.014523
10	2.0%	1.5%	3.75	3.751	3.75	3.753	6.254	6.258	6.255	6.254	10.0063	15.98	15.94	15.98	15.94	0.272	0.281	0.27	0.282	27.9375	27.875	27.875	27.875	28.9375	28.9375	28.9375	28.9375	237.313	237.313	237.313	237.313	209.422	0.012187	0.014509
11	2.0%	1.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	#DIV/0!	#DIV/0!
0.5	2.0%	2.0%	0.512	0.505	0.508	0.506					0.50775	14.125	14.125	14.125	14.125	0.11	0.112	0.11	0.11	28.8125	28.75	28.75	28.875	28.9375	28.9375	28.9375	28.9375	82.75	82.75	81.5625	81.5625	53.3594	0.010039	0.011952
1	2.0%	2.0%	0.993	0.987	0.98	0.982					0.9855	14.39	14.39	14.39	14.39	0.125	0.128	0.125	0.129	28.6875	28.9375	28.6875	28.6875	28.9375	28.9375	28.9375	28.9375	100.438	102.938	99.5	101.438	72.3281	0.011684	0.013911
3	2.0%	2.0%	2.97	2.981	2.994	2.986					2.98275	14.93	14.93	14.93	14.93	0.203	0.209	0.201	0.21	28.4375	28.375	28.375	28.3125	28.9375	28.9375	28.9375	28.9375	136.188	140.125	137.125	141	110.234	0.011863	0.014124
5	2.0%	2.0%	4.987	4.983	4.983	4.982					4.98375	14.33	14.325	15.33	15.325	0.232	0.238	0.23	0.238	28.3125	28.25	28.3125	28.25	28.9375	28.9375	28.9375	28.9375	152.438	155.5	151.5	155.125	125.359	0.01	0.011906
7	2.0%	2.0%	0.729	0.719	0.721	0.719	6.303	6.3	6.305	6.302	7.0245	15.61	15.605	15.61	15.605	0.261	0.269	0.26	0.266	28.1875	28.0625	28.25	28.125	28.9375	28.9375	28.9375	28.9375	167.188	171.938	169.125	172.75	142.094	0.009913	0.011802
9	2.0%	2.0%	2.719	2.723	2.724	2.732	6.265	6.266	6.269	6.267	8.99125	15.81	15.84	15.815	15.84	0.298	0.306	0.295	0.301	28	27.9375	28.0625	28	28.9375	28.9375	28.9375	28.9375	184.188	187.438	183.125	187.125	157.469	0.010178	0.012117
10	2.0%	2.0%	3.753	3.754	3.754	3.752	6.255	6.26	6.258	6.255	10.0103	15.995	15.915	15.925	15.98	0.306	0.311	0.308	0.312	27.9375	27.875	27.9375	27.9375	28.9375	28.9375	28.9375	28.9375	199.438	203.5	198.188	203.938	173.344	0.011828	0.014082
11	2.0%	2.0%	4.744	4.748	4.747	4.749	6.262	6.253	6.259	6.259	11.0053	16.04	16.09	16.035	16.095	0.315	0.321	0.313	0.319	27.8125	27.75	27.875	27.75	28.9375	28.9375	28.9375	28.9375	208.438	212.313	207.688	211.438	182.172	0.012286	0.014627
0.5	2.0%	2.5%	0.508	0.506	0.507	0.508					0.50725	14.13	14.125	14.14	14.135	0.11	0.112	0.111	0.112	28.75	28.6875	28.8125	28.75	28.9375	28.9375	28.9375	28.9375	74.75	74.75	73.5	73.5	45.375	0.009422	0.011218
1	2.0%	2.5%	0.993	0.995	0.99	0.989					0.99175	14.39	14.389	14.38	14.395	0.145	0.148	0.144	0.148	28.5625	28.5	28.625	28.5625	28.9375	28.9375	28.9375	28.9375	83.125	86.4375	84.4375	86.1875	56.4844	0.008636	0.010282
3	2.0%	2.5%	2.997	2.994	2.989	2.999					2.99475	14.975	14.975	14.98	14.98	0.208	0.212	0.206	0.211	28.3125	28.25	28.25	28.1875	28.9375	28.9375	28.9375	28.9375	121.063	123.125	120.438	123.188	93.7031	0.011063	0.013171
5	2.0%	2.5%	5.007	5.009	5.001	5.003					5.005	15.355	15.35	15.345	15.35	0.25	0.256	0.248	0.256	28.1875	28.125	28.125	28	28.9375	28.9375	28.9375	28.9375	144.438	147.125	144.938	147.5	117.891	0.012223	0.014552
7	2.0%	2.5%	0.719	0.72	0.718	0.719	6.294	6.291	6.292	6.298	7.01275	15.605	15.615	15.6	15.605	0.278	0.286	0.272	0.282	27.875	27.875	27.9375	27.9375	28.9375	28.9375	28.9375	28.9375	150.438	152.313	149.188	152.188	123.125	0.00978	0.011644
9	2.0%	2.5%	2.739	2.741	2.739	2.74	6.283	6.291	6.296	6.3	9.03225	15.87	15.875	15.84	15.85	0.301	0.31	0.302	0.309	27.9375	27.875	27.875	27.8125	28.9375	28.9375	28.9375	28.9375	156.688	160.75	157.063	161.188	131.047	0.008964	0.010672
10	2.0%	2.5%	3.706	3.7	3.699	3.698	6.258	6.267	6.264	6.275	9.96675	15.945	15.94	15.935	15.945	0.315	0.321	0.313	0.32	27.75	27.6875	27.8125	27.6875	28.9375	28.9375	28.9375	28.9375	162.438	167.313	163.188	168.063	137.516	0.009241	0.011002
11	2.0%	2.5%	4.718	4.717	4.717	4.719	6.261	6.269	6.26	6.258	10.9798	16.025	16.03	16.02	16.025	0.325	0.332	0.323	0.333	27.625	27.5625	27.625	27.625	28.9375	28.9375	28.9375	28.9375	169.313	175.25	169.125	176.438	144.922	0.009657	0.011497
0.5	2.0%	3.0%	0.497	0.497	0.497	0.499					0.4975	14.135	14.125	14.13	14.13	0.112	0.112	0.113	0.133	28.75	28.6875	28.75	28.625	28.9375	28.9375	28.9375	28.9375	70.8125	70.8125	71.25	71.25	42.3281	0.010772	0.012824
1	2.0%	3.0%	0.997	0.997	0.991	0.998					0.99575	14.385	14.38	14.39	14.38	0.14	0.144	0.141	0.144	28.5	28.5	28.5625	28.5	28.9375	28.9375	28.9375	28.9375	81.75	83.5	79.5625	82.375	53.2813	0.009969	0.011869
3	2.0%	3.0%	2.994	2.993	2.995	2.996					2.9945	14.97	14.965	14.973	14.97	0.203	0.21	0.205	0.213	28.3125	28.25	28.25	28.1875	28.9375	28.9375	28.9375	28.9375	113.125	116.375	114.438	116.938	86.9688	0.012271	0.014609
5	2.0%	3.0%	5.01	5.009	5	4.997					5.004	15.36	15.35	15.355	15.35	0.275	0.282	0.273	0.28	28.0625	28	28.125	28.125	28.9375	28.9375	28.9375	28.9375	131.75	134.813	130.5	134.938	104.922	0.012078	0.01438
7	2.0%	3.0%	0.7	0.699	0.704	0.702	6.323	6.321	6.331	6.33	7.0275	15.595	15.6	15.61	15.605	0.291	0.303	0.294	0.303	27.875	27.875	27.9375	27.8125	28.9375	28.9375	28.9375	28.9375	145.438	148.188	146.313	148.813	119.313	0.012131	0.014443
9	2.0%	3.0%	2.685	2.684	2.683	2.684	6.307	6.309	6.31	6.308	8.9925	15.83	15.84	15.825	15.83	0.31	0.318	0.308	0.318	27.8125	27.75	27.8125	27.75	28.9375	28.9375	28.9375	28.9375	148.438	152.938	149.188	152.75	123.047	0.01029	0.01225
10	2.0%	3.0%	3.753	3.75	3.747	3.746	6.261	6.262	6.255	6.254	10.007	15.95	14.94	15.955	15.945	0.338	0.346	0.34	0.345	27.6875	27.625	27.625	27.625	28.9375	28.9375	28.9375	28.9375	153.125	156.438	151.438	155.188	126.406	0.009916	0.011806
11	2.0%	3.0%	4.724	4.723	4.715	4.713	6.269	6.27	6.27	6.265	10.9873	16.005	16	16.01	16.02	0.345	0.352	0.348	0.353	27.5	27.4375	27.4375	27.4375	28.9375	28.9375	28.9375	28.9375	156.688	159.938	155.438	159.813	130.516	0.009839	0.011714
0.5	2.0%	4.0%	0.505	0.504	0.506	0.507					0.5055	14.145	14.14	14.135	14.145	0.121	0.121	0.123	0.123	28.6875	28.625	28.625	28.625	28.9375	28.9375	28.9375	28.9375	63.9375	63.9375	63.4375	63.4375	35.0469	0.01027	0.012227
1	2.0%	4.0%	1	0.998	0.992	0.993					0.99575	14.385	14.39	14.38	14.384	0.165	0.168	0.164	0.167	28.4375	28.375	28.5	28.375	28.9375	28.9375	28.9375	28.9375	71.1875	71.5	70.5	70.6875	42.5469	0.008703	0.010361
3	2.0%	4.0%	3.015	3.018	3.02	3.022					3.01875	14.985	14.99	14.98	14.975	0.238	0.245	0.24	0.245	28.25	28.1875	28.1875	28.1875	28.9375	28.9375	28.9375	28.9375	93.4375	98.3125	94.5	98.4375	67.9688	0.010073	0.011993
5	2.0%	4.0%	4.974	4.972	4.977	4.976					4.97475	15.35	15.345	15.34	15.345	0.298	0.305	0.3	0.307	28.125	28.0625	28.125	28	28.9375	28.9375	28.9375	28.9375	113.125	118.125	114.125	118.375	87.8594	0.012126	0.014437
7	2.0%	4.0%	0.668	0.673	0.667	0.667	6.324	6.321	6.334	6.339	6.99825	15.605	15.61	15.62	15.615	0.339	0.345	0.341	0.349	27.6875	27.5625	27.6875	27.6875	28.9375	28.9375	28.9375	28.9375	126.188	129.063	125.438	129.188	99.8125	0.0121	0.014406
9	2.0%	4.0%	2.72	2.718	2.715	2.71	6.28	6.284	6.289	6.285	9.00025	15.845	15.84	15.83	15.82	0.365	0.372	0.362	0.37	27.625	27.5	27.625	27.5625	28.9375	28.9375	28.9375	28.9375	136.188	139.563	135.438	138.938	109.953	0.012192	0.014515
10	2.0%	4.0%	3.708	3.71	3.709	3.705	6.269	6.274	6.284	6.283	9.9855	15.94	15.935	15.93	15.93	0.381	0.389	0.379	0.386	27.5	27.375	27.4375	27.375	28.9375	28.9375	28.9375	28.9375	136.438	141.5	138.188	142.688	112.281	0.011617	0.01383
11	2.0%	4.0%	4.723	4.72	4.73	4.726	6.257	6.26	6.245	6.247	10.977	16.015	16.03	16.035	16.025	0.398	0.407	0.4	0.41	27.3125	27.25	27.25	27.25	28.9375	28.9375	28.9375	28.9375	141.438	146.813	140.5	146.063	116.438	0.011638	0.013855
0.5	2.0%	5.0%	0.517	0.518	0.517	0.518					0.5175	14.185	14.19	14.18	14.175	0.145	0.145	0.142	0.146	28.8125	28.6875	28.75	28.75	28.9375	28.9375	28.9375	28.9375	59.375	59.375	58.6875	58.6875	30.2813	0.009713	0.011563
1	2.0%	5.0%	1.018	1.017	1.023	1.021					1.01975	14.385	14.39	14.385	14.387	0.172	0.174	0.171	0.175	28.5	28.4375	28.5	28.375	28.9375	28.9375	28.9375	28.9375	65.6875	67.0625	65.1875	66.8125	37.7344	0.008889	0.010583
3	2.0%	5.0%	2.999	2.998	3.001	3.006					3.001	14.96	14.965	14.98	14.975	0.271	0.276	0.267	0.273	28.1875	27.125	28.125	27	28.9375	28.9375	28.9375	28.9375	85.4375	88.9375	86.375	89.0625	59.8438	0.010355	0.012328
5	2.0%	5.0%	4.975	4.978	4.97	4.969					4.973	15.345	15.34	15.335	15.335	0.321	0.327	0.317	0.325	28.0625	27.9375	28	27.875	28.9375	28.9375	28.9375	28.9375	102.438	105.688	101.5	117.188	78.7344	0.013212	0.015729
7	2.0%	5.0%	0.728	0.731	0.731	0.73	6.289	6.286	6.28	6.277	7.013	15.63	15.635	15.645	15.64	0.368	0.374	0.363	0.371	27.625	27.5625	27.625	27.5	28.9375	28.9375	28.9375	28.9375	112.188	116.5	111.125	117.188	86.6719	0.011928	0.014201
9	2.0%	5.0%	2.761	2.76	2.769	2.772	6.277	6.28	6.273	6.275	9.04175	15.835	15.84	15.85	15.825	0.393	0.4	0.398	0.404	27.375	27.3125	27.375	27.375	28.9375	28.9375	28.9375	28.9375	122.438	128.938	121.938	128.438	98.0781	0.012898	0.015365
10	2.0%	5.0%	3.755	3.75	3.754	3.753	6.259	6.257	6.254	6.253	10.0088	15.954	15.94	15.932	15.93	0.412	0.417	0.409	0.415	27.1875	27.125	27.25	27.125	28.9375	28.9375	28.9375	28.9375	126.313	133.75	127.5	133.188	103.016	0.013288	0.015821
11	2.0%	5.0%	4.768	4.769	4.765	4.759	6.253	6.26	6.253	6.255	11.0205	16.025	16.03	16.05	16.045	0.42	0.427	0.413	0.423	27.125	27	27.1875	27.0625	28.9375	28.9375	28.9375	28.9375	130.438	137.75	131.5	138.063	107.344	0.013483	0.016053

Table B1.4 Smooth concrete surface data

	Oldconcrete Data		High Point				Low Point			Average																								
Discharg	SL (%)	SX (%)	QWALL (CFS)				Qfloor (CFS)				Qtotal	Weir (ft)				Depth (ft)				Spread Dist T1 (in)				Curb Distance (in)				Spread Dist T2 (in)				AVG	n value	
actual Q			Initial		Final		Initial		Final		AVG	Initial		Final		Min		Max		T1min		T2max		Cmin		Cmax		T1min		T2max		Spread	Geometri	Integrated
cfs			1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	CFS	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	in		
0.5	3.0%	0.5%	0.504	0.505	0.499	0.5					0.502	14.125	14.123	14.115	14.11	0.052	0.052	0.05	0.05	29.3125	29.25	29.375	29.3125	28.9375	28.9375	28.9375	28.9375	174.438	177.125	173.125	177.563	146.25	0.018508	0.022035
1	3.0%	0.5%	1.015	1.017	1.015	1.016					1.01575	14.38	14.38	14.385	14.386	0.068	0.07	0.065	0.072	29.125	29	29.0625	29	28.9375	28.9375	28.9375	28.9375	222.063	226.125	221.688	226.563	195.063	0.019714	0.02347
3	3.0%	0.5%	2.998	2.994	3.006	3.007					3.00125	15.97	15.965	15.975	15.96	0.1	0.105	0.1	0.105	28.8125	28.75	28.875	28.75	28.9375	28.9375	28.9375	28.9375	237.313	237.313	237.313	237.313	208.516	0.007966	0.009472
5	3.0%	0.5%	4.982	4.98	4.97	4.975					4.97675	15.31	15.305	15.3	15.295	0.125	0.13	0.125	0.133	28.6875	28.625	28.625	28.6875	28.9375	28.9375	28.9375	28.9375	237.313	237.313	237.313	237.313	208.656	0.0048	0.005714
7	3.0%	0.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
9	3.0%	0.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
10	3.0%	0.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
11	3.0%	0.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
0.5	3.0%	1.0%	0.491	0.491	0.491	0.491					0.491	14.115	14.115	14.115	14.115	0.07	0.072	0.07	0.07	28.8125	28.75	28.875	28.75	28.9375	28.9375	28.9375	28.9375	95.8125	95.9375	95.75	95.875	67.0469	0.007445	0.008864
1	3.0%	1.0%	0.981	0.993	0.991	0.991					0.989	14.385	14.385	14.385	14.385	0.095	0.1	0.098	0.103	28.6875	28.625	28.75	28.6875	28.9375	28.9375	28.9375	28.9375	138.75	141.563	137.688	141.688	111.234	0.014292	0.017016
3	3.0%	1.0%	2.984	2.984	2.987	2.987					2.9855	14.96	14.96	14.96	14.96	0.148	0.154	0.145	0.152	28.625	28.5625	28.5625	28.5	28.9375	28.9375	28.9375	28.9375	185.188	189.563	184.688	189.063	158.563	0.012176	0.014496
5	3.0%	1.0%	4.986	4.987	4.987	4.988					4.987	15.365	15.365	15.365	15.365	0.182	0.19	0.185	0.193	28.5	28.4375	28.5625	27.5	28.9375	28.9375	28.9375	28.9375	221.313	226.438	221.438	227.188	195.844	0.012801	0.01524
7	3.0%	1.0%	0.676	0.674	0.676	0.674	6.3	6.3	6.3	6.3	6.975	15.61	15.59	15.61	15.59	0.193	0.204	0.195	0.205	28.3125	28.25	28.375	28.3125	28.9375	28.9375	28.9375	28.9375	237.313	237.313	237.313	237.313	209	0.010879	0.012953
9	3.0%	1.0%	2.71	2.708	2.707	2.711	6.304	6.303	6.307	6.303	9.01325	15.86	15.825	15.86	15.825	0.203	0.21	0.205	0.21	28.125	28.0625	28.1875	28.125	28.9375	28.9375	28.9375	28.9375	237.313	237.313	237.313	237.313	209.188	0.008436	0.010043
10	3.0%	1.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
11	3.0%	1.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
0.5	3.0%	1.5%	0.51	0.487	0.509	0.517					0.50575	14.125	14.12	14.13	14.125	0.085	0.087	0.085	0.088	28.8125	28.75	28.8125	28.6875	28.9375	28.9375	28.9375	28.9375	88.1875	88.75	88.0625	88.5625	59.625	0.010348	0.01232
1	3.0%	1.5%	1.023	1.022	1.024	1.02					1.02225	14.395	14.39	14.395	14.385	0.115	0.199	0.117	0.121	28.75	28.625	28.625	28.5625	28.9375	28.9375	28.9375	28.9375	107.688	110.438	108.188	111.063	80.7031	0.011447	0.013628
3	3.0%	1.5%	3.022	3.025	3.02	3.019					3.0215	14.955	14.96	14.962	14.97	0.145	0.152	0.146	0.154	28.4375	28.375	28.5	28.375	28.9375	28.9375	28.9375	28.9375	142.063	146.563	143.063	147.5	116.375	0.01033	0.012299
5	3.0%	1.5%	5.007	5.011	5.035	5.026					5.01975	15.325	15.33	15.345	15.35	0.185	0.192	0.188	0.195	28.1875	28.125	28.3125	28.1875	28.9375	28.9375	28.9375	28.9375	161.188	164.063	159.438	165.688	134.391	0.009113	0.010849
7	3.0%	1.5%	0.73	0.731	0.734	0.733	6.3	6.301	6.305	6.299	7.03325	15.61	15.595	15.615	15.62	0.215	0.221	0.217	0.225	28.125	28.0625	28.1875	28.125	28.9375	28.9375	28.9375	28.9375	191.688	195.75	190.625	194.688	165.063	0.011259	0.013404
9	3.0%	1.5%	2.67	2.675	2.674	2.674	6.297	6.295	6.285	6.29	8.965	15.825	15.83	15.81	15.805	0.247	0.259	0.245	0.256	28	27.9375	28.0625	28	28.9375	28.9375	28.9375	28.9375	220.688	224.063	219.188	223.125	193.766	0.013547	0.016129
10	3.0%	1.5%	3.672	3.67	3.666	3.663	6.292	6.295	6.3	6.297	9.96375	15.945	15.95	15.95	15.94	0.255	0.262	0.257	0.265	27.8125	27.9375	27.875	27.9375	28.9375	28.9375	28.9375	28.9375	225.688	230.813	224.438	229.688	199.766	0.013224	0.015744
11	3.0%	1.5%	4.639	4.741	4.638	4.633	6.28	6.285	6.3	6.299	10.9538	16.04	16.025	16.03	16.035	0.268	0.275	0.265	0.274	27.75	27.9375	27.75	27.9375	28.9375	28.9375	28.9375	28.9375	237.313	237.313	237.313	237.313	209.469	0.013647	0.016247
0.5	3.0%	2.0%	0.486	0.484	0.472	0.472					0.4785	14.115	14.11	14.105	14.11	0.098	0.1	0.1	0.102	29.9375	29.875	29.9375	29.8125	28.9375	28.9375	28.9375	28.9375	80.5	80.5	81.0625	81.0625	50.8906	0.011515	0.013709
1	3.0%	2.0%	0.997	0.999	0.998	0.997					0.99775	14.375	14.38	14.385	14.38	0.123	0.128	0.125	0.13	29.75	29.6875	29.75	29.625	28.9375	28.9375	28.9375	28.9375	93.125	95.1875	92.6875	95.0625	64.3125	0.010311	0.012276
3	3.0%	2.0%	3.029	3.03	3.008	3.01					3.01925	14.965	14.97	14.96	14.97	0.17	0.177	0.172	0.178	29.5625	29.5	29.5	29.4375	28.9375	28.9375	28.9375	28.9375	127.688	132.063	125.438	131.938	99.7813	0.011031	0.013134
5	3.0%	2.0%	5.009	5.002	5.002	4.998					5.00275	15.335	15.34	15.325	15.345	0.203	0.21	0.205	0.21	29.375	29.25	29.3125	29.25	28.9375	28.9375	28.9375	28.9375	141.188	144.125	141.438	145.188	113.688	0.009409	0.011201
7	3.0%	2.0%	0.713	0.714	0.708	0.707	6.317	6.315	6.327	6.325	7.0315	16.605	15.61	16.615	15.61	0.25	0.256	0.251	0.257	28.625	28.5625	28.75	27.6875	28.9375	28.9375	28.9375	28.9375	153.438	157.563	152.688	158.063	127.031	0.008986	0.010698
9	3.0%	2.0%	2.7	2.706	2.702	2.71	6.281	6.285	6.282	6.29	8.989	15.825	15.84	15.835	15.84	0.279	0.285	0.28	0.287	28.4375	28.375	28.375	28.3125	28.9375	28.9375	28.9375	28.9375	182.688	183.25	181.438	184.063	154.484	0.011865	0.014114
10	3.0%	2.0%	3.736	3.732	3.743	3.731	6.295	6.297	6.292	6.29	10.029	15.94	15.93	15.945	15.945	0.291	0.3	0.295	0.303	28.25	28.125	28.25	28.1875	28.9375	28.9375	28.9375	28.9375	191.438	194.875	190.188	195.375	164.766	0.012625	0.015031
11	3.0%	2.0%	4.725	4.724	4.724	4.722	6.267	6.268	6.272	6.282	10.996	16.035	16.04	16.03	16.035	0.297	0.305	0.295	0.305	27.9375	27.8125	28	27.875	28.9375	28.9375	28.9375	28.9375	203.688	207.188	204.438	208.313	178	0.014166	0.016865
0.5	3.0%	2.5%	0.504	0.504	0.505	0.504					0.50425	14.11	14.11	14.11	14.11	0.102	0.105	0.1	0.105	28.8125	28.75	28.875	28.75	28.9375	28.9375	28.9375	28.9375	73.375	73.375	72.6875	72.6875	44.2344	0.010858	0.012927
1	3.0%	2.5%	1.02	1.019	1.02	1.018					1.01925	14.39	14.39	14.39	14.39	0.128	0.135	0.13	0.137	28.6875	28.625	28.75	28.625	28.9375	28.9375	28.9375	28.9375	82.6875	85.75	83.25	86.0625	55.7656	0.009973	0.011873
3	3.0%	2.5%	3.014	3.013	3.015	3.012					3.0135	14.98	14.98	14.98	14.98	0.202	0.21	0.205	0.211	28.375	28.25	28.3125	28.25	28.9375	28.9375	28.9375	28.9375	113.188	117.813	114.688	119.063	87.8906	0.01135	0.013513
5	3.0%	2.5%	4.995	5.004	5.011	5.015					5.00625	15.365	15.365	15.365	15.365	0.252	0.258	0.255	0.26	28.1875	28.125	28.125	28.0625	28.9375	28.9375	28.9375	28.9375	130.438	134.563	129.688	134.063	104.063	0.010699	0.012738
7	3.0%	2.5%	0.7	0.702	0.703	0.699	6.323	6.325	6.327	6.329	7.027	15.61	15.62	15.61	15.62	0.283	0.292	0.28	0.293	27.9375	27.875	27.9375	27.8125	28.9375	28.9375	28.9375	28.9375	136.938	142.438	138.688	142.188	112.172	0.009301	0.011073
9	3.0%	2.5%	2.712	2.711	2.71	2.709	6.293	6.291	6.292	6.29	9.002	15.81	15.86	15.81	15.86	0.305	0.312	0.306	0.31	27.8125	27.75	27.875	27.8125	28.9375	28.9375	28.9375	28.9375	159.688	162.688	158.438	163.063	133.156	0.011496	0.013687
10	3.0%	2.5%	3.718	3.717	3.716	3.715	6.279	6.277	6.278	6.276	9.994	15.915	15.98	15.915	15.98	0.305	0.31	0.305	0.308	27.5625	27.5	27.625	27.5625	28.9375	28.9375	28.9375	28.9375	168.688	170.063	165.438	171.688	141.406	0.012176	0.014496
11	3.0%	2.5%	4.698	4.697	4.699	4.696	6.27	6.266	6.267	6.268	10.9653	15.99	16.08	15.99	16.08	0.315	0.323	0.317	0.321	27.625	27.5625	27.6875	27.5625	28.9375	28.9375	28.9375	28.9375	175.688	179.438	173.063	181.063	149.703	0.012931	0.015395
0.5	3.0%	3.0%	0.492	0.491	0.488	0.488					0.48975	14.11	14.11	14.11	14.11	0.11	0.112	0.11	0.113	28.8125	28.75	28.8125	28.6875	28.9375	28.9375	28.9375	28.9375	65.6875	67.5	66.0625	68	38.0469	0.010084	0.012005
1	3.0%	3.0%	0.988	0.989	0.987	0.988					0.988	14.38	14.38	14.38	14.38	0.14	0.145	0.141	0.145	28.5625	28.5	28.5625	28.5625	28.9375	28.9375	28.9375	28.9375	80.0625	81.25	79.6875	81.4375	52.0625	0.011546	0.013746
3	3.0%	3.0%	3.014	3.015	3.019	3.02					3.017	14.985	14.98	14.99	14.98	0.203	0.21	0.2	0.21	28.25	28.125	28.1875	28.125	28.9375	28.9375	28.9375	28.9375	106.688	110	105.563	110.25	79.9531	0.011905	0.014173
5	3.0%	3.0%	5.03	5.028	5.025	5.024					5.02675	15.345	15.35	15.345	15.335	0.253	0.262	0.255	0.263	28.0625	28	28.125	28	28.9375	28.9375	28.9375	28.9375	126.688	131.313	125.063	131.938	100.703	0.013227	0.015748
7	3.0%	3.0%	0.689	0.688	0.689	0.69	6.327	6.335	6.331	6.334	7.02075	15.605	15.6	15.595	15.59	0.286	0.291	0.285	0.293	28	27.0625	28.0625	27.0625	28.9375	28.9375	28.9375	28.9375	135.688	139.188	136.063	139.438	110.047	0.011978	0.01426
9	3.0%	3.0%	2.692	2.696	2.699	2.695	6.306	6.308	6.307	6.307	9.0025	15.86	15.85	15.84	15.845	0.32	0.33	0.318	0.327	27.875	27.875	27.875	27.8125	28.9375	28.9375	28.9375	28.9375	140.063	142.688	138.438	143.063	113.203	0.010043	0.011957
10	3.0%	3.0%	3.724	3.726	3.721	3.723	6.275	6.274	6.274	6.28	9.99925	15.915	15.91	15.92	15.925	0.335	0.342	0.338	0.345	27.8125	27.8125	27.75	27.6875	28.9375	28.9375	28.9375	28.9375	140.438	145.625	141.5	146.063	115.641	0.009566	0.011389
11	3.0%	3.0%	4.713	4.71	4.709	4.71	6.273	6.273	6.274	6.268	10.9825	16.01	16.015	16.025	16.02	0.345	0.3583	0.348	0.36	27.6875	27.625	27.6875	27.5625	28.9375	28.9375	28.9375	28.9375	147.688	154.563	148.75	155.438	123.969	0.010503	0.012504
0.5	3.0%	4.0%	0.509	0.508	0.507	0.508					0.508	14.16	14.16	14.16	14.16	0.119	0.121	0.12	0.121	28.5625	28.5	28.5625	28.375	28.9375	28.9375	28.9375	28.9375	60.6875	61.25	61.1875	61.4375	32.6406	0.010331	0.012299
1	3.0%	4.0%	1.05	1.004	1.052	1.051					1.03925	14.41	14.41	14.41	14.41	0.158	0.16	0.16	0.163	28.4375	28.375	28.4375	28.3125	28.9375	28.9375	28.9375	28.9375	70.0625	72.625	70.375	73.8125	43.3281	0.010775	0.012829
3	3.0%	4.0%	2.993	2.995	2.996	3					2.996	14.975	14.97	14.975	14.98	0.227	0.233	0.21	0.237	28.1875	28.125	28.25	28.1875	28.9375	28.9375	28.9375	28.9375	87.6875	91.1875	86.1875	90.9375	60.8125	0.009225	0.010983
5	3.0%	4.0%	4.991	4.992	4.989	5.001					4.99325	15.35	15.34	15.345	15.355	0.275	0.282	0.273	0.283	27.9375	27.875	28	27.9375	28.9375	28.9375	28.9375	28.9375	108.688	112.563	107.563	113.25	82.5781	0.012557	0.014949
7	3.0%	4.0%	0.702	0.705	0.706	0.707	6.311	6.312	6.313	6.311	7.01675	15.64	15.63	15.62	15.65	0.295	0.303	0.298	0.307	27.8125	27.6875	27.8125	27.75	28.9375	28.9375	28.9375	28.9375	119.563	125.438	120.25	124.5	94.6719	0.012889	0.015345
9	3.0%	4.0%	2.673	2.674	2.674	2.674	6.305	6.304	6.302	6.303	8.97725	16.84	16.85	16.83	16.83	0.323	0.346	0.329	0.343	27.5625	27.5	27.5625	27.5625	28.9375	28.9375	28.9375	28.9375	127.688	133.563	128.063	132.5	102.906	0.012569	0.014963
10	3.0%	4.0%	3.689	3.69	3.691	3.689	6.273	6.29	6.289	6.285	9.974	15.95	16	15.9	15.9	0.345	0.348	0.342	0.351	27.5	27.4375	27.375	27.375	28.9375	28.9375	28.9375	28.9375	130.438	134.438	131.188	135.063	105.359	0.012034	0.014328
11	3.0%	4.0%	4.691	4.694	4.695	4.693	6.263	6.257	6.255	6.254	10.9505	16	16.02	16.05	16.09	0.355	0.361	0.35	0.3683	27.3125	27.25	27.375	27.25	28.9375	28.9375	28.9375	28.9375	129.688	135.688	130.25	136.188	105.656	0.011042	0.013146
0.5	3.0%	5.0%	0.518	0.511	0.51	0.512					0.51275	14.12	14.115	14.118	14.12	0.135	0.138	0.135	0.135	28.5	28.4375	28.5625	28.4375	28.9375	28.9375	28.9375	28.9375	56.25	56.3125	55.6875	56.4375	27.6875	0.009441	0.01124
1	3.0%	5.0%	0.995	0.992	0.996	0.996					0.99525	14.385	14.38	14.383	14.382	0.172	0.178	0.175	0.177	28.4375	28.375	28.4375	28.3125	28.9375	28.9375	28.9375	28.9375	63.6875	67.8125	64.0625	66.75	37.1875	0.010758	0.012808
3	3.0%	5.0%	2.997	2.996	2.993	2.99					2.994	14.98	14.975	14.98	14.978	0.238	0.242	0.235	0.24	28.1875	27.125	28.25	27.125	28.9375	28.9375	28.9375	28.9375	89.0625	91.1875	87.6875	92.1875	62.3594	0.014305	0.017031
5	3.0%	5.0%	5.005	5.003	5.002	5.001					5.00275	15.345	15.35	15.351	15.348	0.295	0.3	0.293	0.299	27.9375	27.875	28	27.875	28.9375	28.9375	28.9375	28.9375	97.5	101.25	98.375	101.438	71.7188	0.012366	0.014723
7	3.0%	5.0%	0.689	0.688	0.693	0.691	6.299	6.307	6.298	6.303	6.992	15.635	15.625	15.62	15.63	0.33	0.335	0.328	0.335	27.875	27.8125	27.9375	27.8125	28.9375	28.9375	28.9375	28.9375	107.5	111.438	108.063	110.563	81.5313	0.012459	0.014834
9	3.0%	5.0%	2.688	2.69	2.679	2.683	6.279	6.282	6.283	6.281	8.96625	15.845	15.84	15.846	15.83	0.355	0.36	0.352	0.359	27.625	27.5625	27.625	27.625	28.9375	28.9375	28.9375	28.9375	117.375	121.438	116.313	120.5	91.2969	0.013166	0.015674
10	3.0%	5.0%	3.713	3.712	3.702	3.704	6.279	6.277	6.29	6.287	9.991	15.945	15.93	15.925	15.935	0.363	0.37	0.36	0.37	27.4375	27.375	27.375	27.375	28.9375	28.9375	28.9375	28.9375	118.438	123.813	119.813	122.688	93.7969	0.012698	0.015118
11	3.0%	5.0%	4.718	4.717	4.726	4.723	6.276	6.277	6.267	6.264	10.992	16.025	16.02	16.02	16.022	0.375	0.383	0.372	0.383	27.25	27.1875	27.25	27.25	28.9375	28.9375	28.9375	28.9375	121.438	128.5	122.813	127.875	97.9219	0.012965	0.015435

Table B1.5 Smooth concrete surface data

Oldconcrete Data			High Point				Low Point				Average																							
Discharg	SL (%)	SX (%)	QWALL (CFS)				Qfloor (CFS)				Qtotal	Weir (ft)				Depth (ft)				Spread Dist T1 (in)				Curb Distance (in)				Spread Dist T2 (in)				AVG	n value	
actual Q			Initial		Final		Initial		Final		AVG	Initial		Final		Min		Max		T1min		T2max		Cmin		Cmax		T1min		T2max		Spread	Geometri	Integrated
cfs			1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	CFS	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	In		
0.5	4.0%	0.5%	0.497	0.496	0.494	0.493					0.495	14.1	14.102	14.103	14.104	0.021	0.022	0.022	0.022	29.1875	29.125	29.1875	29.0625	28.9375	28.9375	28.9375	28.9375	223.375	229.875	221.438	229.688	196.953	0.048082	0.057244
1	4.0%	0.5%	1	1.001	1.005	1.006					1.003	14.375	14.38	14.39	14.384	0.085	0.09	0.08	0.09	29.0625	29.125	29.125	29.0625	28.9375	28.9375	28.9375	28.9375	226.063	230	225.438	230	198.781	0.02422	0.028836
3	4.0%	0.5%	2.997	2.995	2.992	2.996					2.995	14.955	14.96	14.965	14.96	0.115	0.12	0.115	0.123	28.75	28.625	28.8125	28.6875	28.9375	28.9375	28.9375	28.9375	237.313	237.313	237.313	237.313	208.594	0.009207	0.010962
5	4.0%	0.5%	4.999	4.995	5.001	5.002					4.99925	15.335	15.345	15.33	15.335	0.145	0.158	0.145	0.155	28.5625	28.5	28.625	28.5625	28.9375	28.9375	28.9375	28.9375	237.313	237.313	237.313	237.313	208.75	0.005517	0.006569
7	4.0%	0.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
9	4.0%	0.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
10	4.0%	0.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
11	4.0%	0.5%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
0.5	4.0%	1.0%	0.534	0.534	0.534	0.534					0.534	14.15	14.15	14.15	14.15	0.075	0.075	0.075	0.077	28.6875	28.625	28.75	28.6875	28.9375	28.9375	28.9375	28.9375	144.313	144.313	144.688	144.688	115.813	0.034106	0.040605
1	4.0%	1.0%	0.996	0.996	0.997	0.996					0.99825	14.385	14.385	14.385	14.385	0.095	0.1	0.095	0.103	28.625	28.5625	28.6875	28.625	28.9375	28.9375	28.9375	28.9375	160.063	160.063	160.625	160.625	131.719	0.025739	0.030644
3	4.0%	1.0%	3.006	3.003	3.003	3.002					3.0035	14.96	14.96	14.96	14.96	0.145	0.152	0.147	0.154	28.5625	28.5625	28.5625	28.5	28.9375	28.9375	28.9375	28.9375	183.188	194	183.25	192	159.563	0.014237	0.01695
5	4.0%	1.0%	4.999	4.992	5	4.993					4.996	15.345	15.345	15.345	15.345	0.17	0.182	0.171	0.185	27.375	28.3125	27.4375	27.375	28.9375	28.9375	28.9375	28.9375	215.25	227.188	220.5	225.625	194.516	0.014505	0.01727
7	4.0%	1.0%	0.718	0.719	0.718	0.719	6.339	6.341	6.335	6.342	7.05775	15.6	15.59	15.6	15.59	0.18	0.195	0.185	0.2	28.3125	28.25	28.3125	28.25	28.9375	28.9375	28.9375	28.9375	237.313	237.313	237.313	237.313	209.031	0.012426	0.014794
9	4.0%	1.0%	2.705	2.7	2.7	2.701	6.312	6.318	6.315	6.322	9.01825	15.87	15.82	15.87	15.82	0.19	0.2	0.188	0.203	28.1875	28.1875	28.25	28.25	28.9375	28.9375	28.9375	28.9375	237.313	237.313	237.313	237.313	209.094	0.00973	0.011584
10	4.0%	1.0%	3.709	3.712	3.708	3.712	6.292	6.295	6.293	6.295	10.004	16.01	15.94	16.01	15.94	0.19	0.205	0.19	0.207	28.25	28.1875	28.1875	28.125	28.9375	28.9375	28.9375	28.9375	237.313	237.313	237.313	237.313	209.125	0.008773	0.010445
11	4.0%	1.0%	4.669	4.687	4.669	4.67	6.283	6.274	6.282	6.275	10.9523	16.11	16.04	16.11	16.04	0.195	0.21	0.195	0.207	28.1875	28.125	28.25	28.1875	28.9375	28.9375	28.9375	28.9375	237.313	237.313	237.313	237.313	209.125	0.008012	0.009539
0.5	4.0%	1.5%	0.488	0.487	0.487	0.487					0.48725	14.105	14.105	14.105	14.105	0.09	0.09	0.09	0.09	28.6875	28.6875	28.75	28.75	28.9375	28.9375	28.9375	28.9375	84.625	84.625	84.4375	84.4375	55.8125	0.010376	0.012354
1	4.0%	1.5%	1.036	1.036	1.036	1.035					1.03575	14.39	14.39	14.39	14.39	0.115	0.12	0.115	0.12	28.5	28.4375	28.4375	28.4375	28.9375	28.9375	28.9375	28.9375	98.8125	98.75	97.9375	97.9375	69.9063	0.008892	0.010586
3	4.0%	1.5%	2.999	3.002	2.999	3.004					3.001	14.965	14.965	14.965	14.965	0.155	0.165	0.155	0.16	28.25	28.1875	28.1875	28.1875	28.9375	28.9375	28.9375	28.9375	134.563	144.313	133.438	140.625	110.031	0.010352	0.012325
5	4.0%	1.5%	4.982	4.982	4.98	4.979					4.98075	15.345	15.345	15.345	15.345	0.195	0.205	0.195	0.2	28.125	28.0625	28.1875	28.125	28.9375	28.9375	28.9375	28.9375	163.938	170.25	164.125	170.438	139.063	0.011619	0.013833
7	4.0%	1.5%	0.692	0.692	0.691	0.692	6.331	6.331	6.33	6.337	7.024	15.61	15.61	15.61	15.61	0.215	0.225	0.22	0.23	27.9375	27.9375	28.0625	27.9375	28.9375	28.9375	28.9375	28.9375	184.563	194.125	185.188	194.438	161.609	0.012316	0.014663
9	4.0%	1.5%	2.697	2.695	2.696	2.697	6.292	6.34	6.291	6.3	9.002	15.88	15.82	15.88	15.82	0.235	0.24	0.23	0.24	28	27.875	27.9375	27.8125	28.9375	28.9375	28.9375	28.9375	214.188	219.125	214.438	220.063	189.047	0.014599	0.017381
10	4.0%	1.5%	3.721	3.722	3.72	3.721	6.297	6.297	6.296	6.292	10.0165	15.965	16.01	15.965	16.01	0.24	0.245	0.235	0.245	27.875	27.75	27.8125	27.6875	28.9375	28.9375	28.9375	28.9375	223.063	228.063	223.438	229.188	198.156	0.01488	0.017715
11	4.0%	1.5%	4.742	4.741	4.74	4.736	6.288	6.288	6.288	6.291	11.0285	16.065	16.12	16.065	16.12	0.245	0.25	0.245	0.25	27.8125	27.75	27.75	27.625	28.9375	28.9375	28.9375	28.9375	227.375	229.438	227.063	229.688	200.656	0.013966	0.016628
0.5	4.0%	2.0%	0.49	0.491	0.479	0.477					0.48425	14.13	14.13	14.105	14.105	0.083	0.087	0.082	0.085	28.5625	28.5625	28.5625	28.5625	28.9375	28.9375	28.9375	28.9375	75.625	75.625	76.375	76.375	47.4375	0.010918	0.012998
1	4.0%	2.0%	0.973	0.97	0.971	0.972					0.9715	14.385	14.385	14.385	14.385	0.118	0.124	0.115	0.122	28.5625	28.5	28.5625	28.5	28.9375	28.9375	28.9375	28.9375	86	88.25	86.1875	87.1875	58.375	0.009434	0.011231
3	4.0%	2.0%	2.988	2.986	2.988	2.989					2.98775	14.96	14.96	14.96	14.96	0.181	0.187	0.18	0.188	28.5	28.4375	28.4375	28.375	28.9375	28.9375	28.9375	28.9375	121.313	125.813	121.938	125.375	95.1719	0.011315	0.01347
5	4.0%	2.0%	5.01	5	5.01	5					5.005	15.35	15.35	15.35	15.35	0.221	0.234	0.218	0.225	28.3125	28.25	28.1875	28.25	28.9375	28.9375	28.9375	28.9375	139.813	142.375	135.75	142	111.734	0.010354	0.012327
7	4.0%	2.0%	0.666	0.664	0.666	0.664	6.331	6.326	6.326	6.331	6.9935	15.6	15.6	15.6	15.6	0.25	0.254	0.253	0.26	28.125	28	28.0625	27.9375	28.9375	28.9375	28.9375	28.9375	164.5	168	163.188	167.438	137.75	0.012963	0.015433
9	4.0%	2.0%	2.667	2.67	2.671	2.67	6.29	6.29	6.293	6.29	8.96025	15.86	15.84	15.86	15.84	0.26	0.268	0.26	0.27	27.9375	27.875	27.9375	27.875	28.9375	28.9375	28.9375	28.9375	181.938	185.375	181.75	186.813	156.063	0.014137	0.01683
10	4.0%	2.0%	3.66	3.67	3.666	3.67	6.3	6.3	6.292	6.298	9.964	15.98	15.94	15.98	15.94	0.265	0.275	0.264	0.273	27.875	27.8125	27.875	27.8125	28.9375	28.9375	28.9375	28.9375	188.313	195.625	187.625	196.75	164.234	0.01459	0.01737
11	4.0%	2.0%	4.685	4.683	4.685	4.681	6.3	6.311	6.321	6.31	10.994	16.11	16.05	16.11	16.05	0.27	0.28	0.268	0.279	27.8125	27.6875	27.875	27.6875	28.9375	28.9375	28.9375	28.9375	197.938	204.813	197.5	204.688	173.469	0.015302	0.018218
0.5	4.0%	2.5%	0.5	0.501	0.499	0.509					0.50225	14.108	14.105	14.11	14.109	0.083	0.086	0.09	0.093	28.9375	28.875	28.875	28.8125	28.9375	28.9375	28.9375	28.9375	70.5	70.5	70.5625	70.5625	41.6563	0.010749	0.012798
1	4.0%	2.5%	0.97	0.969	0.971	0.972					0.9705	14.37	14.371	14.368	14.369	0.102	0.112	0.1	0.11	28.625	28.5625	28.5625	28.5	28.9375	28.9375	28.9375	28.9375	80.125	81.0625	80.4375	81.0625	52.1094	0.010117	0.012045
3	4.0%	2.5%	2.98	2.979	2.959	2.96					2.9695	14.965	14.963	14.966	14.967	0.175	0.185	0.18	0.185	28.3125	28.1875	28.375	28.25	28.9375	28.9375	28.9375	28.9375	104.063	107.75	105.063	107.938	77.9219	0.009646	0.011484
5	4.0%	2.5%	4.998	4.997	4.996	4.993					4.996	15.34	15.36	15.355	15.36	0.205	0.215	0.21	0.215	27.1875	28.0625	27.125	27.0625	28.9375	28.9375	28.9375	28.9375	121.125	123.313	121.688	124.063	95.1875	0.009781	0.011644
7	4.0%	2.5%	0.691	0.7	0.695	0.689	6.349	6.351	6.347	6.352	7.0435	15.601	15.61	15.605	15.615	0.25	0.26	0.255	0.26	28	27.9375	28.0625	28	28.9375	28.9375	28.9375	28.9375	137.063	140.625	138.063	141.813	111.391	0.010544	0.012563
9	4.0%	2.5%	2.663	2.662	2.654	2.66	6.332	6.34	6.333	6.342	8.9965	15.855	15.86	15.85	15.865	0.27	0.285	0.275	0.29	27.875	27.8125	27.9375	27.875	28.9375	28.9375	28.9375	28.9375	153.438	158.313	154.188	159.063	128.375	0.012071	0.014371
10	4.0%	2.5%	3.702	3.7	3.705	3.704	6.317	6.32	6.314	6.308	10.0175	15.95	15.96	15.945	15.94	0.275	0.29	0.28	0.29	27.75	27.6875	27.75	27.0625	28.9375	28.9375	28.9375	28.9375	164.438	167.625	164.563	168.313	138.672	0.013332	0.015872
11	4.0%	2.5%	4.7	4.715	4.709	4.71	6.309	6.314	6.315	6.313	11.0213	16.025	16.01	16.09	16.025	0.295	0.305	0.295	0.31	27.625	27.9375	27.625	27.9375	28.9375	28.9375	28.9375	28.9375	171.688	147.625	172.188	175.5	138.969	0.01234	0.014692
0.5	4.0%	3.0%	0.518	0.519	0.51	0.52					0.51675	14.125	14.13	14.135	14.135	0.095	0.095	0.095	0.095	28.6875	28.625	28.8125	28.75	28.9375	28.9375	28.9375	28.9375	68	68	68.125	68.125	39.3438	0.012117	0.014425
1	4.0%	3.0%	0.989	0.995	0.99	0.988					0.9905	14.39	14.385	14.38	14.38	0.12	0.125	0.12	0.13	28.5	28.5625	28.5	28.5625	28.9375	28.9375	28.9375	28.9375	73.9375	74.125	74.0625	74.9375	45.7344	0.009414	0.011207
3	4.0%	3.0%	3.007	3.006	3.009	3.013					3.00875	14.96	14.97	14.985	14.99	0.175	0.185	0.17	0.185	28.1875	28.125	28.25	28.1875	28.9375	28.9375	28.9375	28.9375	97.125	98.3125	96.3125	98.1875	69.2969	0.009401	0.011192
5	4.0%	3.0%	5.02	5.019	5.017	5.018					5.0185	15.36	15.35	15.365	15.35	0.255	0.24	0.225	0.235	27.9375	27.875	27.9375	27.8125	28.9375	28.9375	28.9375	28.9375	117.188	120.063	118.063	120.188	90.9844	0.011646	0.013865
7	4.0%	3.0%	0.651	0.65	0.645	0.643	6.358	6.347	6.346	6.342	6.9955	15.59	15.585	15.59	15.58	0.255	0.27	0.285	0.3	27.875	27.8125	27.9375	27.875	28.9375	28.9375	28.9375	28.9375	125.438	128.5	126.188	128.688	99.3281	0.010537	0.012545
9	4.0%	3.0%	2.712	2.707	2.702	2.705	6.334	6.33	6.354	6.347	9.04775	15.82	15.84	15.87	15.865	0.285	0.295	0.285	0.3	27.8125	27.75	27.8125	27.75	28.9375	28.9375	28.9375	28.9375	135.688	138.938	135.5	138.438	109.359	0.010545	0.012554
10	4.0%	3.0%	3.705	3.7	3.696	3.699	6.309	6.333	6.307	6.33	10.0198	15.94	15.92	15.934	15.925	0.305	0.32	0.305	0.325	27.75	27.6875	27.75	27.6875	28.9375	28.9375	28.9375	28.9375	142.688	145.938	141.938	145.188	116.219	0.011195	0.013328
11	4.0%	3.0%	4.703	4.7	4.71	4.705	6.328	6.33	6.31	6.308	11.0235	16.05	16.025	16.05	16.02	0.31	0.33	0.315	0.33	27.625	27.5625	27.5625	27.5	28.9375	28.9375	28.9375	28.9375	147.188	150	147.438	150	121.094	0.011357	0.013522
0.5	4.0%	4.0%	0.513	0.51	0.514	0.51					0.51175	14.14	14.14	14.14	14.14	0.1	0.105	0.1	0.105	28.75	28.6875	28.625	28.5	28.9375	28.9375	28.9375	28.9375	59.875	59.875	60	60	31.2969	0.009744	0.011601
1	4.0%	4.0%	1.005	1.004	1.007	1.006					1.0055	14.4	14.4	14.38	14.38	0.125	0.13	0.125	0.13	28.4375	28.4375	28.4375	28.4375	28.9375	28.9375	28.9375	28.9375	70.5625	70.5625	70.625	70.625	42.1563	0.012369	0.014726
3	4.0%	4.0%	2.991	2.992	2.991	2.992					2.9915	14.99	14.99	14.99	14.99	0.2	0.205	0.2	0.205	28.375	28.25	28.1875	28.125	28.9375	28.9375	28.9375	28.9375	92.0625	92.0625	92.125	92.125	63.8594	0.011934	0.014209
5	4.0%	4.0%	4.995	4.993	4.993	4.991					4.993	15.35	15.36	15.35	15.36	0.255	0.265	0.255	0.265	27.9375	28	27.8125	27.875	28.9375	28.9375	28.9375	28.9375	101.25	105	101.375	105.063	75.2656	0.011555	0.013756
7	4.0%	4.0%	0.672	0.673	0.674	0.673	6.325	6.33	6.329	6.327	7.00075	15.64	15.64	15.64	15.64	0.28	0.29	0.28	0.295	27.8125	27.6875	27.8125	27.625	28.9375	28.9375	28.9375	28.9375	115.75	119.563	115.563	119.688	89.9063	0.010541	0.01255
9	4.0%	4.0%	2.673	2.674	2.674	2.674	6.32	6.332	6.325	6.331	9.00075	15.88	15.84	15.88	15.84	0.32	0.335	0.32	0.33	27.5625	27.4375	27.6875	27.5625	28.9375	28.9375	28.9375	28.9375	122.688	127.625	122.563	127.75	97.5938	0.009953	0.011849
10	4.0%	4.0%	3.689	3.69	3.691	3.689	6.324	6.33	6.324	6.324	10.0153	15.99	15.94	15.99	15.94	0.34	0.35	0.34	0.35	27.625	27.5	27.625	27.5	28.9375	28.9375	28.9375	28.9375	116.938	128.125	116.875	128.25	94.9844	0.010729	0.012773
11	4.0%	4.0%	4.691	4.694	4.695	4.693	6.297	6.295	6.296	6.297	10.9895	16.08	16.04	16.08	16.04	0.355	0.37	0.36	0.37	27.875	27.4375	27.875	27.4375	28.9375	28.9375	28.9375	28.9375	125.75	129.063	125.438	129.5	99.7813	0.011374	0.013542
0.5	4.0%	5.0%	0.507	0.506	0.507	0.507					0.50675	14.13	14.13	14.13	14.13	0.12	0.12	0.12	0.12	28.625	28.625	28.625	28.625	28.9375	28.9375	28.9375	28.9375	57.3125	57.3125	57.3125	57.3125	28.6875	0.012221	0.01455
1	4.0%	5.0%	1.012	1.012	1.012	1.012					1.012	14.4	14.4	14.4	14.4	0.145	0.145	0.145	0.145	28.25	28.125	28.25	28.1875	28.9375	28.9375	28.9375	28.9375	67.9375	67.9375	67.9375	67.9375	39.7344	0.014676	0.017473
3	4.0%	5.0%	2.97	2.978	2.972	2.975					2.97375	14.96	14.96	14.96	14.96	0.205	0.21	0.205	0.21	28.0625	27.9375	28.0625	27.9375	28.9375	28.9375	28.9375	28.9375	85.375	85.375	85.375	85.375	57.375	0.013309	0.015845
5	4.0%	5.0%	4.966	4.965	4.965	4.962					4.9645	15.35	15.35	15.35	15.35	0.265	0.278	0.265	0.28	27.75	27.625	27.8125	27.6875	28.9375	28.9375	28.9375	28.9375	94.625	96.5625	94.375	96.4375	67.7813	0.012385	0.014745
7	4.0%	5.0%	0.692	0.689	0.693	0.686	6.361	6.357	6.354	6.361	7.04825	15.64	15.62	15.64	15.62	0.295	0.303	0.295	0.307	27.5625	27.5	27.5625	27.4375	28.9375	28.9375	28.9375	28.9375	104.063	105.563	104.375	105.438	77.3438	0.012417	0.014783
9	4.0%	5.0%	2.679	2.677	2.676	2.677	6.322	6.32	6.335	6.33	9.004	15.83	15.86	15.83	15.86	0.34	0.35	0.34	0.355	27.375	27.3125	27.375	27.25	28.9375	28.9375	28.9375	28.9375	114.188	115.938	114.375	115.875	87.7656	0.013607	0.0162
10	4.0%	5.0%	3.642	3.642	3.645	3.643	6.323	6.319	6.324	6.325	9.96575	15.98	15.94	15.98	15.94	0.355	0.37	0.36	0.37	27.25	27.1875	27.3125	27.25	28.9375	28.9375	28.9375	28.9375	118.25	118.813	118.375	119.063	91.375	0.013681	0.016287
11	4.0%	5.0%	4.703	4.632	4.7	4.702	6.296	6.288	6.296	6.294	10.9778	16.06	16.01	16.06	16.01	0.375	0.385	0.375	0.38	27.1875	27.0625	27.1875	27.125	28.9375	28.9375	28.9375	28.9375	118.375	122.25	118.125	121.938	93.0313	0.013028	0.015511

Table B1.6 Smooth concrete surface data

	Oldconcrete Data		High Point				Low Point			Average																									
Discharge	SL (%)	SX (%)	QWALL (CFS)				Qfloor (CFS)				Qtotal	Weir (ft)				Depth (ft)				Spread Dist T1 (in)				Curb Distance (in)				Spread Dist T2 (in)				AVG	n value	
actual Q			Initial		Final		Initial		Final		AVG	Initial		Final		Min		Max		T1min		T2max		Cmin		Cmax		T1min		T2max		Spread	Geometri	Integrated
cfs			1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	CFS	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	In		
0.5	5.0%	0.5%	0.47	0.47	0.47	0.47					0.47	14.105	14.105	14.175	14.105	0.047	0.05	0.046	0.051	29.4375	29.5	29.4375	29.5625	29.75	29.875	29.75	29.75	175.188	175.188	175.75	175.75	145.984	0.018946	0.022557
1	5.0%	0.5%	1.01	1.02	1.02	1.02					1.0175	14.4	13.39	13.39	13.39	0.054	0.061	0.061	0.068	29.375	29.4375	29.3125	29.375	29.8125	29.6875	29.75	29.875	180.438	180.438	179.313	179.313	150.5	0.01216	0.014477
3	5.0%	0.5%	2.99	2.99	2.99	2.99					2.99	14.965	14.965	14.965	14.965	0.113	0.119	0.108	0.119	29.1875	29.25	29.1875	29.25	29.75	29.75	29.6875	29.8125	237.688	237.688	237.688	237.688	208.469	0.010273	0.012231
5	5.0%	0.5%	5	5	5.02	5.02					5.01	15.34	15.4	15.335	15.335	0.125	0.14	0.126	0.141	29	29.0625	29.0625	29.125	29.75	29.75	29.8125	29.8125	237.688	237.688	237.688	237.688	208.625	0.006142	0.007312
7	5.0%	0.5%	0.61	0.61	0.62	0.62	6.38	6.38	6.38	6.38	6.995	15.61	15.61	15.61	15.61	0.12	0.14	0.12	0.135	29.0625	29.1875	29.0625	29.125	29.75	29.8125	29.75	29.8125	237.688	237.688	237.688	237.688	208.578	0.004375	0.005208
9	5.0%	0.5%	2.63	2.64	2.64	2.64	6.37	6.36	6.38	6.36	9.005	15.845	15.845	15.845	15.845	0.14	0.16	0.142	0.165	29.0625	29.125	29.125	29.1875	29.75	29.8125	29.8125	29.75	237.688	237.688	237.688	237.688	208.563	0.003382	0.004027
10	5.0%	0.5%	3.66	3.66	3.66	3.67	6.35	6.35	6.36	6.36	10.0175	15.945	15.945	15.945	15.945	0.15	0.173	0.155	0.18	28.9375	29	28.875	29	29.75	29.8125	29.8125	29.75	237.688	237.688	237.688	237.688	208.734	0.003058	0.00364
11	5.0%	0.5%	4.66	4.66	4.66	4.66	6.36	6.36	6.36	6.36	11.02	16.05	16.05	16.05	16.05	0.162	0.175	0.163	0.179	28.875	28.9375	28.9375	28.9375	29.75	29.1875	29.75	29.8125	237.688	237.688	237.688	237.688	208.766	0.002773	0.003301
0.5	5.0%	1.0%	0.483	0.46	0.46	0.458					0.46525	14.12	14.089	14.088	14.087	0.05	0.055	0.053	0.06	29.4375	29.5	29.4375	29.4375	29.75	29.8125	29.75	29.8125	85.5	88.375	86	88.875	57.7344	0.005627	0.006699
1	5.0%	1.0%	1.015	1.018	1.02	1.017					1.0175	14.391	14.393	14.393	14.395	0.08	0.09	0.082	0.095	29.25	29.3125	29.25	29.3125	29.75	29.8125	29.75	29.8125	125.625	125.625	126.188	126.188	96.625	0.011144	0.013267
3	5.0%	1.0%	3.033	3.018	3.011	3.009					3.01775	14.972	14.968	14.972	14.968	0.12	0.125	0.118	0.125	29	29.0625	29.0625	29.125	29.75	29.8125	29.75	29.8125	172.188	176.5	172.313	176.063	145.203	0.011363	0.013528
5	5.0%	1.0%	5.01	5.02	5.02	5.01					5.015	15.335	15.335	15.335	15.335	0.135	0.15	0.13	0.148	29.0625	29.125	29	29.0625	29.8125	29.75	29.75	29.8125	178.5	186	179	186.063	153.328	0.011459	0.013643
7	5.0%	1.0%	0.64	0.64	0.64	0.64	6.37	6.37	6.37	6.36	7.0075	15.61	15.61	15.61	15.61	0.13	0.15	0.14	0.155	28.8125	28.9375	28.75	28.875	29.8125	29.75	29.75	29.8125	221.063	230.313	221.625	230.938	197.141	0.010936	0.013019
9	5.0%	1.0%	2.64	2.64	2.66	2.65	6.36	6.36	6.37	6.37	9.0125	15.845	15.845	15.6	15.86	0.168	0.175	0.165	0.18	28.875	28.9375	28.8125	28.875	29.8125	29.75	29.75	29.8125	237.313	237.313	237.313	237.313	208.438	0.00945	0.01125
10	5.0%	1.0%	3.723	3.713	3.709	3.712	6.362	6.351	6.351	6.355	10.069	15.93	15.95	15.946	15.942	0.165	0.18	0.17	0.182	28.9375	29	28.875	28.9375	29.75	29.8125	29.75	29.8125	237.375	237.375	237.25	237.25	208.375	0.007828	0.010451
11	5.0%	1.0%	4.776	4.783	4.761	4.76	6.356	6.341	6.355	6.355	11.1218	16.058	16.062	16.066	16.069	0.185	0.2	0.185	0.195	28.75	28.875	28.625	28.8125	29.75	29.8125	29.75	29.8125	237.375	237.375	237.25	237.25	208.547	0.010784	0.01132
0.5	5.0%	1.5%	0.518	0.519	0.517	0.516					0.5175	14.125	14.125	14.125	14.125	0.055	0.06	0.05	0.06	29.3125	29.25	29.375	29.3125	29.75	29.8125	29.75	29.8125	83.4375	86.4375	83.625	86.75	55.75	0.010983	0.013076
1	5.0%	1.5%	1.04	1.039	1.038	1.04					1.03925	14.405	14.405	14.405	14.405	0.09	0.095	0.085	0.09	29.1875	29.125	29.25	29.1875	29.75	29.8125	29.75	29.8125	98.5	103.5	99	103.75	72	0.010799	0.012856
3	5.0%	1.5%	3.021	3.025	3.024	3.027					3.02425	14.965	14.965	14.965	14.965	0.12	0.13	0.125	0.135	29	28.9375	29.0625	28.9375	29.75	29.8125	29.75	29.8125	136.125	140.625	136	140.5	109.328	0.011295	0.013448
5	5.0%	1.5%	5.014	5.015	5.015	5.009					5.01325	15.32	15.32	15.32	15.32	0.145	0.155	0.145	0.16	28.6875	28.625	28.6875	28.1875	29.75	29.8125	29.75	29.8125	154.813	159.438	155.563	159.063	128.422	0.010461	0.012454
7	5.0%	1.5%	0.627	0.624	0.622	0.621	6.369	6.371	6.375	6.37	6.99475	15.63	15.63	15.63	15.63	0.155	0.17	0.16	0.175	28.625	28.5625	28.6875	28.625	29.75	29.8125	29.75	29.8125	176.063	180.125	176.188	180.063	149.484	0.011249	0.013392
9	5.0%	1.5%	2.697	2.693	2.694	2.694	6.339	6.338	6.335	6.337	9.03175	15.85	15.82	15.85	15.82	0.175	0.185	0.175	0.185	28.625	28.5625	28.5625	28.5	29.75	29.8125	29.75	29.8125	188.438	194.25	188.25	194	162.672	0.010918	0.012998
10	5.0%	1.5%	3.653	3.649	3.657	3.652	6.368	6.37	6.368	6.385	10.0205	15.96	15.94	15.96	15.94	0.18	0.195	0.18	0.2	28.5625	28.4375	28.6875	28.5625	29.75	29.8125	29.75	29.8125	195	201.938	194.875	201.25	169.703	0.011017	0.013116
11	5.0%	1.5%	4.635	4.63	4.61	4.606	6.357	6.334	6.342	6.346	10.9655	16.04	16.05	16.045	16.055	0.185	0.205	0.19	0.205	28.5	28.375	28.5625	28.4375	29.75	29.8125	29.75	29.8125	201.125	207.375	201.625	207.563	175.953	0.011084	0.013197
0.5	5.0%	2.0%	0.487	0.486	0.485	0.485					0.48575	14.105	14.105	14.105	14.105	0.055	0.06	0.058	0.06	29.125	29.0625	29.125	29	29.75	29.8125	29.75	29.8125	68.125	72.1875	68.25	72.0625	41.0781	0.008363	0.009956
1	5.0%	2.0%	0.976	0.973	0.976	0.972					0.97425	14.39	14.39	14.39	14.39	0.1	0.105	0.102	0.106	29	28.9375	29.0625	29	29.75	29.8125	29.75	29.8125	78.3125	82.1875	78.6875	82.4375	51.4063	0.007517	0.008949
3	5.0%	2.0%	3.02	3.021	3.019	3.023					3.02075	14.965	14.965	14.965	14.965	0.153	0.16	0.15	0.157	28.75	28.625	28.6875	28.625	29.75	29.8125	29.75	29.8125	117.563	123.188	117.688	123.313	91.7656	0.011397	0.013569
5	5.0%	2.0%	4.997	4.995	4.996	4.996					4.9965	15.36	15.34	15.36	15.34	0.18	0.195	0.185	0.2	28.5625	28.5	28.5625	28.4375	29.75	29.8125	29.75	29.8125	133	140.25	133.625	140.5	108.328	0.01072	0.012763
7	5.0%	2.0%	0.655	0.654	0.649	0.654	6.362	6.361	6.363	6.361	7.01475	15.64	15.63	15.64	15.63	0.215	0.222	0.215	0.22	28.5	28.4375	28.5625	28.4375	29.75	29.8125	29.75	29.8125	150.188	157.688	150.5	157.938	125.594	0.011325	0.013483
9	5.0%	2.0%	2.649	2.638	2.648	2.641	6.364	6.369	6.372	6.385	9.0115	15.85	15.82	15.85	15.82	0.228	0.235	0.23	0.235	28.4375	28.3125	28.5	28.375	29.75	29.8125	29.75	29.8125	169.688	177.063	169.438	177.625	145.047	0.012958	0.015427
10	5.0%	2.0%	3.701	3.699	3.703	3.698	6.328	6.323	6.325	6.326	10.0258	15.97	15.94	15.97	15.94	0.24	0.25	0.24	0.253	28.3125	28.25	28.3125	28.25	29.75	29.8125	29.75	29.8125	174.063	182.563	174.938	182	150.109	0.012756	0.015187
11	5.0%	2.0%	4.593	4.6	4.593	4.6	6.365	6.365	6.365	6.365	10.9615	16.06	16.02	16.06	16.02	0.255	0.26	0.255	0.265	28.375	28.1875	28.375	28.25	29.75	29.8125	29.75	29.8125	178.938	187.188	178.313	186.938	154.547	0.012607	0.015009
0.5	5.0%	2.5%	0.529	0.528	0.531	0.533					0.53025	14.13	14.13	14.13	14.13	0.09	0.095	0.09	0.095	29.25	29.1875	29.3125	29.25	29.75	29.8125	29.75	29.8125	66.75	69.6875	66.375	69.375	38.7969	0.009422	0.011217
1	5.0%	2.5%	0.99	0.988	0.99	0.989					0.98925	14.38	14.38	14.38	60	0.12	0.128	0.12	0.13	29.125	29.0625	29.1875	29.125	29.75	29.8125	29.75	29.8125	76.6875	80.9375	76.875	81.3125	49.8281	0.009838	0.011713
3	5.0%	2.5%	3.038	3.037	3.04	3.036					3.03775	14.97	14.97	14.97	14.97	0.165	0.18	0.165	0.175	28.8125	28.75	28.75	28.6875	29.75	29.8125	29.75	29.8125	110.438	116.063	109.75	116.313	84.3906	0.013108	0.015606
5	5.0%	2.5%	4.999	5	5.004	5.006					5.00275	15.36	15.35	15.36	15.35	0.195	0.205	0.195	0.205	28.6875	28.5625	28.6875	28.5	29.75	29.8125	29.75	29.8125	126.063	131.875	125.813	131.75	100.266	0.012597	0.014997
7	5.0%	2.5%	0.621	0.62	0.622	0.624	6.364	6.364	6.361	6.373	6.98725	15.61	15.59	15.61	15.59	0.205	0.21	0.205	0.215	28.625	28.5	28.625	28.5	29.75	29.8125	29.75	29.8125	138.625	141.438	137.875	141.625	111.328	0.011921	0.014192
9	5.0%	2.5%	2.666	2.668	2.666	2.669	6.341	6.341	6.342	6.349	9.0105	15.89	15.81	15.89	15.81	0.215	0.23	0.22	0.23	28.5625	28.4375	28.5625	28.4375	29.75	29.8125	29.75	29.8125	153.25	157.313	153.375	156.438	126.594	0.013037	0.015522
10	5.0%	2.5%	3.634	3.632	3.634	3.639	6.337	6.343	6.34	6.341	9.975	16	15.91	16	15.91	0.23	0.24	0.225	0.24	28.4375	28.375	28.4375	28.375	29.75	29.8125	29.75	29.8125	157.5	161.25	156.875	161.375	130.844	0.012859	0.015309
11	5.0%	2.5%	4.65	4.648	4.647	4.645	6.331	6.33	6.34	6.341	10.983	16.09	16.03	16.09	16.03	0.24	0.25	0.24	0.255	28.375	28.3125	28.4375	28.3125	29.75	29.8125	29.75	29.8125	166.75	171	166.125	171.125	140.391	0.014098	0.016784
0.5	5.0%	3.0%	0.489	0.49	0.49	0.49					0.48975	14.125	14.125	14.125	14.125	0.09	0.085	0.085	0.085	29.1875	29.125	29.125	29.125	29.5	29.5	29.5	29.5	64.3125	65.875	65.875	65.875	36.3438	0.010845	0.012911
1	5.0%	3.0%	1.015	1.016	1.016	1.016					1.01575	14.4	14.395	14.395	14.395	0.11	0.12	0.12	0.12	29.0625	29	29	29	29.5	29.5	29.5	29.5	75.625	77.8125	77.8125	77.8125	48.25	0.012171	0.014491
3	5.0%	3.0%	2.979	2.974	2.974	2.974					2.97525	14.965	14.965	14.965	14.965	0.175	0.19	0.19	0.19	28.875	28.6875	28.6875	28.6875	29.5	29.5	29.5	29.5	96.4375	100.063	100.063	100.063	70.4219	0.008786	0.01046
5	5.0%	3.0%	5	4.999	4.999	4.999					4.99925	15.365	15.365	15.365	15.365	0.2	0.205	0.205	0.205	28.5625	28.4375	28.4375	28.4375	29.5	29.5	29.5	29.5	113.188	117.313	117.313	117.313	87.8125	0.01359	0.01618
7	5.0%	3.0%	0.655	0.67	0.67	0.67	6.368	6.363	6.363	6.363	7.0305	15.61	15.62	15.62	15.62	0.23	0.25	0.25	0.25	28.25	28.1875	28.1875	28.1875	29.5	29.5	29.5	29.5	129.813	133.5	133.5	133.5	104.375	0.013135	0.015638
9	5.0%	3.0%	2.694	2.693	2.693	2.693	6.31	6.31	6.31	6.31	9.00325	15.865	15.89	15.89	15.89	0.245	0.265	0.265	0.265	28.1875	28.0625	28.0625	28.0625	29.5	29.5	29.5	29.5	143	148.375	148.375	148.375	118.938	0.014827	0.017652
10	5.0%	3.0%	3.697	3.702	3.702	3.702	6.33	6.331	6.331	6.331	10.0315	15.98	15.95	15.95	15.95	0.275	0.285	0.285	0.285	28.1875	28.125	28.125	28.125	29.5	29.5	29.5	29.5	152.5	156.375	156.375	156.375	127.266	0.015715	0.01871
11	5.0%	3.0%	4.655	4.657	4.657	4.657	6.32	6.326	6.326	6.326	10.981	16.11	16.01	16.01	16.01	0.28	0.295	0.295	0.295	28.125	28.0625	28.0625	28.0625	29.5	29.5	29.5	29.5	156.438	161.313	161.313	161.313	132.016	0.015739	0.018738
0.5	5.0%	4.0%	0.521	0.522	0.52	0.519					0.5205	14.13	14.13	14.13	14.13	0.115	0.12	0.115	0.12	29	28.9375	29	28.9375	29.5	29.5	29.5	29.5	60.0625	60.0625	59.9375	59.9375	31.0313	0.011369	0.013523
1	5.0%	4.0%	1.026	1.027	1.028	1.029					1.0275	14.4	14.4	14.4	14.4	0.125	0.148	0.125	0.145	28.875	28.8125	28.8125	28.75	29.5	29.5	29.5	29.5	71.375	71.375	71.25	71.25	42.5	0.0134	0.015954
3	5.0%	4.0%	3.028	3.027	3.027	3.028					3.0275	14.99	14.99	14.99	14.99	0.188	0.205	0.19	0.2	28.5	28.4375	28.5	28.4375	29.5	29.5	29.5	29.5	88.5	89.375	88.5625	89.3125	60.4688	0.011642	0.01386
5	5.0%	4.0%	4.999	4.991	4.993	4.99					4.99325	15.34	15.36	15.34	15.36	0.237	0.25	0.24	0.25	28.1875	28.125	28.25	28.1875	29.5	29.5	29.5	29.5	100.063	101.938	99.875	101.938	72.7656	0.011552	0.013754
7	5.0%	4.0%	0.672	0.671	0.67	0.671	6.356	6.353	6.349	6.348	7.0225	15.65	15.62	15.65	15.62	0.275	0.29	0.275	0.292	28.0625	28	28.0625	28	29.5	29.3125	29.5	29.4375	112.813	114.563	112.25	114.313	85.4531	0.012614	0.015018
9	5.0%	4.0%	2.646	2.647	2.646	2.65	6.325	6.332	6.326	6.33	8.9755	15.86	15.84	15.86	15.84	0.297	0.31	0.3	0.31	27.9375	27.875	27.8125	27.75	29.5	29.75	29.5	29.5	120.313	124	120.188	123.813	94.2344	0.01283	0.015275
10	5.0%	4.0%	3.723	3.72	3.723	3.72	6.301	6.314	6.301	6.314	10.029	15.92	15.96	15.92	15.96	0.315	0.328	0.32	0.332	27.8125	27.75	27.75	27.6875	29.625	29.625	29.625	29.625	118.563	122.563	118.313	122.125	92.6406	0.012063	0.014349
11	5.0%	4.0%	4.668	4.671	4.668	4.671	6.295	6.301	6.295	6.301	10.9675	16	16.11	16	16.11	0.342	0.354	0.3	0.355	27.75	27.6875	27.6875	27.625	29.625	29.625	29.625	29.625	123.063	124.75	122.563	124.438	96.0156	0.010927	0.013089
0.5	5.0%	5.0%	0.485	0.483	0.485	0.486					0.48475	14.1	14.1	14.1	14.1	0.108	0.113	0.109	0.115	28.6875	28.5625	28.6875	28.625	28.9375	28.9375	28.9375	28.9375	52.4375	54.3125	52.5	54.1875	24.7188	0.0096	0.011429
1	5.0%	5.0%	1.03	1.029	1.021	1.026					1.0265	14.385	14.385	14.385	14.385	0.143	0.154	0.141	0.15	28.5	28.4375	28.4375	28.4375	28.9375	28.9375	28.9375	28.9375	63.4375	64.625	63.5	63.8125	35.3906	0.011817	0.014069
3	5.0%	5.0%	2.995	2.994	2.996	2.995					2.995	14.97	14.98	14.97	14.98	0.214	0.223	0.221	0.229	28.125	28	28.125	28.0625	28.9375	28.9375	28.9375	28.9375	79.1875	81.9375	79.0625	81.9375	52.4531	0.011571	0.013776
5	5.0%	5.0%	5.021	5.026	5.024	5.028					5.02475	15.36	15.37	15.36	15.37	0.251	0.268	0.253	0.267	27.875	27.75	27.9375	27.875	28.9375	28.9375	28.9375	28.9375	89.375	93.125	89.5625	92.8125	63.3594	0.011431	0.013609
7	5.0%	5.0%	0.637	0.637	0.638	0.635	6.342	6.342	6.349	6.351	6.98275	15.62	15.64	15.62	15.64	0.296	0.305	0.293	0.306	27.75	27.625	27.6875	27.6875	28.9375	28.9375	28.9375	28.9375	94.1875	98.0625	94.6875	97.9375	68.5313	0.010106	0.012032
9	5.0%	5.0%	2.661	2.662	2.663	2.664	6.342	6.347	6.346	6.345	9.0075	15.88	15.82	15.88	15.82	0.334	0.347	0.335	0.349	27.5625	27.4375	27.75	27.625	28.9375	28.9375	28.9375	28.9375	106.438	110	106.563	109.688	80.5781	0.012079	0.014381
10	5.0%	5.0%	3.642	3.642	3.637	3.638	6.31	6.309	6.316	6.306	9.95	15.95	15.98	15.95	15.98	0.345	0.355	0.34	0.36	27.5625	27.4375	27.625	27.375	28.9375	28.9375	28.9375	28.9375	116.313	118.125	116.375	118.25	89.7656	0.014628	0.017415
11	5.0%	5.0%	4.632	4.632	4.633	4.635	6.339	6.341	6.338	6.345	10.9738	16.11	16.01	16.11	16.01	0.375	0.38	0.37	0.375	27.25	27.1875	27.375	27.25	28.9375	28.9375	28.9375	28.9375	116.25	118.813	116.313	118.75	90.2656	0.013425	0.015983

Table B2.1 Asphalt surface data

Discharg	SL (%)	SX (%)	QWALL (CFS)				Qfloor (CFS)				Qtotal	Depth (ft)				Spread Dist T1 (in)				Curb Distance (in)				Spread Dist T2 (in)				AVG	n value	
actual Q			Initial		Final		Initial		Final		AVG	Min		Max		T1min		T2max		Cmin		Cmax		T1min		T2max		Spread	Geometri	Integrated
cfs			1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	CFS	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	In		
0.5	0.5%	0.5%	0.495	0.4945	0.495	0.495	0	0	0	0	0.49488	0.0785	0.079	0.0785	0.0785	28.9688	28.875	28.9688	28.9063	28.9375	28.9375	28.9375	28.9375	154.094	153.563	154.125	155.188	125.313	0.00506	0.00602
1	0.5%	0.5%	1.0055	1.0055	1.006	1.006	0	0	0	0	1.00575	0.0945	0.0975	0.095	0.0975	28.7188	28.625	28.7188	28.625	28.9375	28.9375	28.9375	28.9375	237.313	237.313	237.313	237.313	208.641	0.00972	0.01157
3	0.5%	0.5%																												
5	0.5%	0.5%																												
7	0.5%	0.5%																												
9	0.5%	0.5%																												
10	0.5%	0.5%																												
11	0.5%	0.5%																												
0.5	0.5%	1.0%	0.485	0.486	0.485	0.486	0	0	0	0	0.4855	0.1075	0.1075	0.1075	0.1075	28.8438	28.8125	28.8438	28.8125	28.9375	28.9375	28.9375	28.9375	151.469	151.469	151.781	151.781	122.797	0.01548	0.01843
1	0.5%	1.0%	1.025	1.03	1.04	1.035	0	0	0	0	1.0325	0.14	0.1425	0.1395	0.142	28.6563	28.5938	28.6563	28.625	28.9375	28.9375	28.9375	28.9375	172.656	174.938	173.313	175.063	145.359	0.01141	0.01358
3	0.5%	1.0%	3.026	3.023	3.022	3.022	0	0	0	0	3.02325	0.2075	0.2125	0.2125	0.2125	28.3125	28.2813	28.375	28.3125	28.9375	28.9375	28.9375	28.9375	237.313	237.313	237.313	237.313	208.992	0.01024	0.01219
5	0.5%	1.0%																												
7	0.5%	1.0%																												
9	0.5%	1.0%																												
10	0.5%	1.0%																												
11	0.5%	1.0%																												
0.5	0.5%	1.5%	0.49	0.49	0.489	0.489	0	0	0	0	0.4895	0.145	0.15	0.145	0.15	29.4063	29.375	29.4063	29.375	29.7813	29.7188	29.7813	29.7188	143.438	143.438	143.438	143.438	114.047	0.02464	0.02934
1	0.5%	1.5%	0.976	0.976	0.971	0.971	0	0	0	0	0.9735	0.16	0.1675	0.16	0.1675	28.6563	28.6563	28.6563	28.6563	29.5938	29.4375	29.5938	29.4375	157.219	157.813	156.938	157.906	128.813	0.01724	0.02053
3	0.5%	1.5%	2.987	2.987	2.989	2.989	0	0	0	0	2.988	0.225	0.235	0.235	0.235	28.5938	28.7813	28.5938	28.7813	29.875	30.1563	29.875	30.1563	198	208.188	198.25	208.5	174.547	0.01264	0.01505
5	0.5%	1.5%	5.03	5.03	5.03	5.03	0	0	0	0	5.03	0.29	0.31	0.29	0.31	28.75	28.5625	28.75	28.5625	29.8125	30.0625	29.8125	30.0625	237.313	237.313	237.313	237.313	208.656	0.01201	0.0143
7	0.5%	1.5%																												
9	0.5%	1.5%																												
10	0.5%	1.5%																												
11	0.5%	1.5%																												
0.5	0.5%	2.0%	0.513	0.51	0.5	0.499	0	0	0	0	0.5055	0.135	0.145	0.145	0.15	40.25	40.3125	40.125	40.0938	41.125	41.0625	41.125	40.9688	125.594	125.594	125.469	125.469	85.3359	0.01781	0.02121
1	0.5%	2.0%	1.006	1.008	1.009	1.01	0	0	0	0	1.00825	0.18	0.19	0.195	0.205	39.8438	40	40	40.0313	40.625	40.7188	40.8438	40.7813	135.031	141.719	135.156	136.719	97.1875	0.01262	0.01502
3	0.5%	2.0%	3.001	2.997	2.974	2.976	0	0	0	0	2.987	0.265	0.28	0.285	0.285	39.7813	39.75	39.7188	39.6875	40.6563	40.6875	40.8438	40.5	184	187.688	186.813	190.281	147.461	0.01289	0.01535
5	0.5%	2.0%	4.938	4.937	4.911	4.91	0	0	0	0	4.924	0.29	0.31	0.29	0.31	30	29.75	30.0625	29.8125	30.875	30.625	30.6875	30.8125	214.75	217.688	211.5	215.563	184.969	0.01432	0.01705
7	0.5%	2.0%	0.625	0.626	0.625	3.4265	6.225	6.223	6.226	6.23	7.55163	0.375	0.43	0.38	0.425	39.125	38.8438	39.0625	39.1875	40.6875	40.5938	40.9063	41.0313	226.688	230.5	227.563	231.25	189.945	0.01248	0.01486
9	0.5%	2.0%																												
10	0.5%	2.0%																												
11	0.5%	2.0%																												
0.5	0.5%	2.5%	0.544	0.544	0.525	0.525	0	0	0	0	0.5345	0.115	0.125	0.11	0.12	38.0313	37.8438	38.0313	38.125	38.5625	38.4688	38.8125	38.875	102.531	108.031	102.438	107.938	67.2266	0.01295	0.01542
1	0.5%	2.5%	1.126	1.126	1.115	1.115	0	0	0	0	1.1205	0.16	0.1675	0.165	0.175	37.875	38	38.0938	38.1875	38.375	38.4688	38.9063	38.9375	115.125	133.5	115.625	133.813	86.4766	0.01241	0.01478
3	0.5%	2.5%	3.11	3.11	3.101	3.101	0	0	0	0	3.1055	0.27	0.3	0.3	0.3	37.7813	38	37.625	37.875	38.5625	38.75	38.8438	38.9063	158.5	169.594	157.281	170.438	126.133	0.01184	0.0141
5	0.5%	2.5%	5.006	5.006	5.004	5.004	0	0	0	0	5.005	0.295	0.335	0.295	0.335	37.8438	37.9063	37.6875	37.875	39.5938	40	39.1875	39.5625	179.5	193.531	180.719	193.656	149.023	0.01151	0.0137
7	0.5%	2.5%	0.819	0.819	0.812	0.812	6.25	6.25	6.248	6.248	7.0645	0.34	0.375	0.34	0.375	37.4375	37.6563	37.5625	37.8125	38.375	38.5	38.875	39.0625	196.219	203.313	195.813	203.875	162.188	0.01014	0.01208
9	0.5%	2.5%	2.895	2.895	2.89	2.89	6.224	6.224	6.21	6.21	9.1095	0.375	0.42	0.39	0.425	37.375	37.8125	37.5938	37.875	39.25	39.2813	39.6563	39.6563	205.594	223.594	205.063	225	177.148	0.01001	0.01191
10	0.5%	2.5%																												
11	0.5%	2.5%																												
0.5	0.5%	3.0%	0.487	0.487	0.489	0.489	0	0	0	0	0.488	0.1225	0.1225	0.1225	0.1225	38.3438	38.4063	38.2188	38.25	38.9063	38.875	38.875	38.875	100.188	100.188	100.625	100.625	62.1016	0.01546	0.01841
1	0.5%	3.0%	1.045	1.045	1.036	1.036	0	0	0	0	1.0405	0.175	0.19	0.195	0.21	38.1875	38.25	38.1875	38.25	38.875	39	38.9375	38.5625	123.563	125.344	123.563	125.438	86.2578	0.01731	0.02061
3	0.5%	3.0%	2.967	2.967	2.956	2.956	0	0	0	0	2.9615	0.295	0.32	0.315	0.315	37.5938	37.75	37.5	37.7813	38.6563	38.7188	38.6563	38.75	147.938	151.563	148.25	152.594	112.43	0.01226	0.01459
5	0.5%	3.0%	5.05	5.051	5.03	5.03	0	0	0	0	5.04025	0.32	0.38	0.33	0.38	37.625	38.1563	37.625	35.2188	38.8125	38.75	38.5625	38.7813	170.469	179.688	172.125	181.719	138.844	0.01273	0.01515
7	0.5%	3.0%	0.814	0.814	0.834	0.834	6.18	6.18	6.16	6.16	6.994	0.38	0.425	0.38	0.425	37.0438	37.5	37.1563	37.625	38.6875	38.9688	38.5625	38.8438	195.719	205.094	190.125	204.844	161.614	0.01376	0.01638
9	0.5%	3.0%	2.933	2.933	2.929	2.929	6.129	6.129	6.133	6.133	9.062	0.39	0.44	0.39	0.44	37.6875	37.7188	37.6563	37.6563	38.7188	38.75	38.6875	38.9688	202.813	217	202.625	216.938	172.164	0.01262	0.01503
10	0.5%	3.0%	3.93	3.93	3.914	3.914	6.119	6.119	6.146	6.146	10.0545	0.38	0.475	0.38	0.475	37.5	37.5938	37.4688	37.6563	38.5625	38.6875	38.125	38.625	202.75	221.906	208.219	220.656	175.828	0.01202	0.01431
11	0.5%	3.0%	4.855	4.855	4.854	4.854	6.12	6.12	6.116	6.116	10.9725	0.39	0.475	0.39	0.475	37.5313	37.4063	37.4688	37.9375	38.625	38.7188	38.6875	38.5	207.75	219.125	209.5	218.75	176.195	0.01108	0.01319
0.5	0.5%	4.0%	0.517	0.51	0.513	0.508	0	0	0	0	0.512	0.16	0.17	0.16	0.17	38.125	37.9688	38.125	38.0938	38.6563	38.8125	38.5938	38.75	87.4063	87.4063	87.3125	87.3125	49.2813	0.0126	0.015
1	0.5%	4.0%	1.0245	1.0265	1.021	1.0225	0	0	0	0	1.02363	0.21	0.22	0.21	0.22	37.9375	38	37.9375	37.9375	38.5	38.7188	38.4375	38.7188	100.125	103.125	100.063	103.094	63.6484	0.01252	0.01491
3	0.5%	4.0%	2.985	2.986	2.9785	2.979	0	0	0	0	2.98213	0.33	0.34	0.335	0.335	37.875	37.3125	37.4375	37.5	38.6563	38.8438	38.6563	38.75	126.375	137.281	126.375	137.281	94.2969	0.01238	0.01474
5	0.5%	4.0%	5.028	5.028	5.0195	5.016	0	0	0	0	5.02288	0.405	0.415	0.405	0.415	38.125	37.9688	38.125	38.0313	38.6563	38.8438	38.7188	38.8438	145.156	155.531	145.094	155.5	112.258	0.01158	0.01378
7	0.5%	4.0%	0.821	0.822	0.821	0.824	6.19	6.189	6.2	6.215	7.0205	0.45	0.46	0.45	0.46	37.2188	37.1563	37.125	37.125	38.375	38.6875	38.3438	38.625	161.469	175.563	161.438	175.594	131.359	0.01262	0.01502
9	0.5%	4.0%	2.8	2.799	2.792	2.791	6.2	6.201	6.208	6.209	9	0.43	0.44	0.43	0.44	36.75	36.8125	36.7188	36.7813	37.125	37.3125	37.1563	37.3125	165.969	180.188	165.938	180.281	136.328	0.0109	0.01298
10	0.5%	4.0%	3.744	3.743	3.742	3.742	6.21	6.211	6.212	6.212	9.954	0.47	0.48	0.47	0.48	36.75	36.75	36.75	36.7188	37.4375	37.5	37.4375	37.5313	174.625	185.906	174.625	185.844	143.508	0.01126	0.01341
11	0.5%	4.0%	4.785	4.786	4.786	4.786	6.215	6.215	6.216	6.216	11.0013	0.49	0.5	0.49	0.5	36.7188	36.6875	36.6878	36.6565	37.0625	37.2813	37.0628	37.2503	174.938	190.313	177.375	190.438	146.578	0.01079	0.01284

Table B2.2 Asphalt surface data

Discharg	SL (%)	SX (%)	QWALL (CFS)				Qfloor (CFS)				Qtotal	Depth (ft)				Spread Dist T1 (in)				Curb Distance (in)				Spread Dist T2 (in)				AVG	n value	
actual Q			Initial		Final		Initial		Final		AVG	Min		Max		T1min		T2max		Cmin		Cmax		T1min		T2max		Spread	Geometri	Integrated
cfs			1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	CFS	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	In		
0.5	1.0%	1.5%	0.508	0.507	0.502	0.503	0	0	0	0	0.505	0.099	0.0975	0.097	0.099	38.125	38.25	38.1875	38.2188	38.7188	38.7813	38.7813	39.25	121.438	127.875	121.438	127.844	86.4531	0.01649	0.01964
1	1.0%	1.5%	1.01	1.011	1.005	1.006	0	0	0	0	1.008	0.1	0.1	0.1	0.1	38.25	38.3438	38.2813	38.375	38.7188	38.9375	38.7813	39	131.375	141.656	131.375	141.656	98.2031	0.01147	0.01365
3	1.0%	1.5%	2.997	2.998	2.992	2.992	0	0	0	0	2.99475	0.155	0.165	0.165	0.165	37.8125	38.25	37.8438	38.1875	38.0938	38.6563	38.0625	38.625	163.031	178.25	163.094	178.25	132.633	0.0086	0.01024
5	1.0%	1.5%	5.016	5.015	5.011	5.01	0	0	0	0	5.013	0.195	0.205	0.2	0.205	37.75	37.8125	37.75	37.9063	38.4375	38.4688	38.4375	38.7813	191.031	210.344	191.031	210.438	162.906	0.00889	0.01058
7	1.0%	1.5%	0.833	0.832	0.834	0.833	6.281	6.283	6.275	6.274	7.11125	0.245	0.275	0.245	0.275	37.5625	37.6875	38.0938	37.7188	38.4688	38.5625	38.5	38.5313	213.813	235	213.813	235.094	186.664	0.00902	0.01074
9	1.0%	1.5%																												
10	1.0%	1.5%																												
11	1.0%	1.5%																												
0.5	1.0%	2.0%	0.492	0.493	0.489	0.489	0	0	0	0	0.49075	0.12	0.1265	0.1215	0.1265	38.2813	38.375	38.1875	38.2813	38.9688	39.125	38.875	38.9375	100.688	102.719	101.156	103.969	63.8516	0.01189	0.01416
1	1.0%	2.0%	1.001	1.001	0.999	0.999	0	0	0	0	1	0.14	0.1435	0.1405	0.143	37.8438	37.9688	37.875	37.9688	38.4688	38.5313	38.0938	38.4375	115.156	118.625	115.156	118.188	78.8672	0.01028	0.01224
3	1.0%	2.0%	2.979	2.975	2.97	2.979	0	0	0	0	2.97575	0.19	0.2	0.2	0.2	37.4375	37.5	37.4063	37.4688	38.4375	38.5313	38.4688	38.4688	144.219	153	144.063	152.813	111.07	0.00862	0.01026
5	1.0%	2.0%	5.005	5.007	5.018	5.018	0	0	0	0	5.012	0.2775	0.29	0.2775	0.29	37.2188	37.5625	37.1875	37.5313	38	38.2188	37.9375	38.0938	175.625	187.844	175.313	187.656	144.234	0.01027	0.01222
7	1.0%	2.0%	0.829	0.831	0.82	0.821	6.144	6.14	6.153	6.168	6.9765	0.28	0.29	0.28	0.29	37.2188	37.3125	37.1563	37.25	37.875	37.9688	37.9063	38.0313	190.938	198.656	190.938	198.813	157.602	0.0084	0.01
9	1.0%	2.0%	2.895	2.894	2.889	2.89	6.127	6.126	6.148	6.146	9.02875	0.3	0.345	0.3	0.345	37.125	37.2188	37.0938	37.2188	37.8438	37.9063	37.9063	37.875	208.375	206.75	208.531	206.906	170.477	0.00888	0.01057
10	1.0%	2.0%	3.83	3.833	3.806	3.807	6.146	6.145	6.132	6.133	9.958	0.305	0.365	0.305	0.365	36.875	36.9375	36.875	36.9375	37.8438	38.0938	37.625	38.0313	212.969	223.563	213.188	223.656	181.438	0.0095	0.01131
11	1.0%	2.0%	4.887	4.882	4.9	4.901	6.105	6.105	6.129	6.13	11.0098	0.33	0.3925	0.33	0.3925	36.9063	36.9688	36.9063	37.0313	37.75	37.8438	37.6875	37.75	228.906	228.75	229.063	228.813	191.93	0.00999	0.0119
0.5	1.0%	2.5%	0.503	0.502	0.498	0.498	0	0	0	0	0.50025	0.135	0.135	0.135	0.135	37.75	37.7813	37.75	37.7813	38.2188	38.2813	38.25	38.2813	88.625	93.5625	88.5938	93.5625	53.3203	0.01048	0.01248
1	1.0%	2.5%	1.016	1.017	1.013	1.013	0	0	0	0	1.01475	0.14	0.145	0.14	0.145	37.875	37.9375	37.8125	37.875	38.375	38.5938	38.4063	38.5938	103.594	111.844	103.938	112.031	69.9766	0.01076	0.01281
3	1.0%	2.5%	2.989	2.99	2.982	2.983	0	0	0	0	2.986	0.21	0.22	0.22	0.22	37.4688	37.2188	37.4063	37.5625	38.2813	38.5313	38.3125	38.5938	126.094	132.313	126.156	132.25	91.7891	0.00744	0.00886
5	1.0%	2.5%	4.98	4.983	4.97	4.97	0	0	0	0	4.97575	0.26	0.275	0.26	0.275	37.4688	37.5938	37.4375	37.6563	38.625	38.625	38.5625	38.6563	156.219	162.594	156.406	162.813	121.969	0.00953	0.01134
7	1.0%	2.5%	0.851	0.851	0.845	0.843	6.16	6.165	6.158	6.161	7.0085	0.285	0.305	0.285	0.31	37.0625	37.2188	37.1563	37.25	38.0313	38.5938	38.0313	38.7188	166.906	180.063	166.875	179.906	136.266	0.00913	0.01087
9	1.0%	2.5%	2.828	2.827	2.82	2.823	6.154	6.155	6.15	6.157	8.9785	0.31	0.35	0.31	0.35	36.6875	37	36.75	36.9063	37.9063	38.4375	37.8438	38.5313	178.906	189.875	178.813	189.969	147.555	0.00879	0.01047
10	1.0%	2.5%	3.821	3.821	3.818	3.819	6.128	6.128	6.15	6.153	9.9595	0.35	0.395	0.35	0.395	35.0938	36.6875	36.5313	36.7188	37.7813	38.4688	37.8125	38.5	177.813	197.531	177.781	197.5	151.398	0.00852	0.01015
11	1.0%	2.5%	4.848	4.849	4.836	4.837	6.129	6.132	6.108	6.106	10.9613	0.345	0.415	0.345	0.415	37.125	36.6563	36.625	36.3438	37.7813	38.0938	37.8125	38.125	188.75	207.281	188.75	207.344	161.344	0.00916	0.01091
0.5	1.0%	3.0%	0.512	0.511	0.511	0.511	0	0	0	0	0.51125	0.14	0.14	0.14	0.14	37.7188	37.75	37.6878	37.719	38.4063	38.4375	38.4375	38.5313	85.4375	86.4063	85.4375	86.4063	48.203	0.01053	0.01254
1	1.0%	3.0%	1.001	1.002	1	1	0	0	0	0	1.00075	0.15	0.15	0.15	0.15	38.0625	38.0938	38	38.0938	38.6563	38.875	38.7188	38.8438	97.1875	98	97.1563	98	59.5234	0.00943	0.01122
3	1.0%	3.0%	3.042	3.043	3.021	3.022	0	0	0	0	3.032	0.225	0.225	0.225	0.225	37.3438	37.2813	37.2813	37.2815	38.4375	38.625	38.375	38.6563	124.219	126.75	124.219	126.719	88.1797	0.00888	0.01057
5	1.0%	3.0%	5.015	5.016	5.02	5.021	0	0	0	0	5.018	0.2985	0.2985	0.2985	0.2985	37.0625	37.125	37.0313	37.125	38.4375	38.5313	38.4688	38.5	140.344	144.313	140.344	144.125	105.195	0.00856	0.01019
7	1.0%	3.0%	0.915	0.915	0.915	0.915	6.18	6.18	6.195	6.195	7.1025	0.301	0.301	0.301	0.301	36.9688	37	36.9375	37	38.0938	38.4375	38.25	38.4065	155.656	162.813	155.656	162.813	122.258	0.00908	0.01081
9	1.0%	3.0%	2.975	2.975	2.96	2.96	6.18	6.18	6.15	6.15	9.1325	0.35	0.35	0.35	0.35	36.6563	36.875	36.6565	37.0313	38.2188	38.4688	38.1875	38.4375	171.188	176.406	171.156	176.375	136.977	0.00954	0.01136
10	1.0%	3.0%	3.58	3.58	3.55	3.55	6.176	6.176	6.16	6.16	9.733	0.342	0.342	0.342	0.342	36.75	36.75	36.7188	36.75	37.375	38.5	37.3125	38.4688	175.313	181.563	175.313	181.5	141.68	0.00981	0.01168
11	1.0%	3.0%	4.965	4.965	4.955	4.955	6.135	6.135	6.14	6.14	11.0975	0.38	0.38	0.38	0.38	36.625	36.6563	36.594	36.6565	37.4375	38.5	37.4688	38.5	179.063	185.875	179.063	185.875	145.836	0.00928	0.01104
0.5	1.0%	4.0%	0.5	0.489	0.492	0.492	0	0	0	0	0.49325	0.135	0.135	0.135	0.135	38.4375	38.4688	38.4063	38.4063	38.9375	38.9375	38.9688	38.9688	95.75	95.75	95.6875	95.7188	57.2969	0.01277	0.0152
1	1.0%	4.0%	1.033	1.038	1.044	1.043	0	0	0	0	1.0395	0.15	0.16	0.15	0.16	38.4688	38.375	38.4063	38.3438	39.2188	39.0938	39.3125	39	97.9063	101.219	97.9375	101.125	61.1484	0.01142	0.0136
3	1.0%	4.0%	2.991	2.992	3.004	3.006	0	0	0	0	2.99825	0.23	0.24	0.24	0.24	38.2188	38.1875	38.1875	38.1875	38.4375	38.5625	38.4688	38.5313	122.906	131.906	122.938	131.875	89.2109	0.01543	0.01837
5	1.0%	4.0%	5.001	5.003	5.031	5.028	0	0	0	0	5.01575	0.305	0.315	0.305	0.315	38.3125	37.9688	38.2813	37.9375	38.625	39.0938	38.625	39.0625	128.5	134.875	128.531	134.844	93.5625	0.0101	0.01203
7	1.0%	4.0%	0.82	0.821	0.822	0.23	6.174	6.183	6.185	6.184	6.85475	0.335	0.345	0.335	0.345	37.7188	38.0625	37.6875	38	38.75	38.9375	38.8125	38.875	141.125	159.5	141.125	159.531	112.453	0.01234	0.01469
9	1.0%	4.0%	2.82	2.819	2.814	2.813	6.172	6.175	6.173	6.17	8.989	0.345	0.355	0.345	0.355	37.8438	37.8438	37.875	37.9063	38.7813	38.9063	38.8125	38.8438	152.688	159.875	152.719	159.844	118.414	0.0106	0.01261
10	1.0%	4.0%	3.824	3.826	3.801	3.803	6.167	6.162	6.16	6.163	9.9765	0.39	0.4	0.39	0.4	37.6563	37.7813	37.5938	37.8125	38.8125	38.9375	38.8438	39	158.844	171.5	158.875	171.563	127.484	0.01164	0.01386
11	1.0%	4.0%	4.862	4.863	4.863	4.867	6.168	6.164	6.165	6.166	11.0295	0.39	0.4	0.39	0.4	37.625	37.6563	37.625	37.625	38.1875	38.7188	38.1563	38.625	163.531	174.125	163.531	174.188	131.211	0.01136	0.01353

Table B2.3 Asphalt surface data

Discharg	SL (%)	SX (%)	QWALL (CFS)				Qfloor (CFS)				Qtotal	Depth (ft)				Spread Dist T1 (in)				Curb Distance (in)				Spread Dist T2 (in)				AVG	n value	
actual Q			Initial		Final		Initial		Final		AVG	Min		Max		T1min		T2max		Cmin		Cmax		T1min		T2max		Spread	Geometri	Integrated
cfs			1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	CFS	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	In		
0.5	2.0%	1.5%	0.49	0.491	0.487	0.488	0	0	0	0	0.489	0.08	0.085	0.08	0.085	37.8125	38.0938	37.8125	38.0938	38.5313	38.8125	38.5	38.3125	104.469	104.625	104.344	106.594	67.0547	0.01226	0.0146
1	2.0%	1.5%	1.027	1.027	1.023	1.022	0	0	0	0	1.02475	0.095	0.105	0.095	0.105	37.8125	37.8438	37.8438	37.8438	38.0313	38.5625	38.375	38.8125	121.625	127.813	121.656	127.781	86.8828	0.01148	0.01367
3	2.0%	1.5%	3.021	3.02	3.014	3.014	0	0	0	0	3.01725	0.14	0.15	0.15	0.15	37.5	37.6875	37.4688	37.6563	38.125	38.8438	38.1563	38.8125	151.094	172.031	151.094	172	123.977	0.01018	0.01212
5	2.0%	1.5%	5.062	5.061	5.055	5.051	0	0	0	0	5.05725	0.1825	0.19	0.1825	0.19	37.125	37.8438	37.4063	37.8438	38.5313	38.875	38.5313	38.875	191.563	205.188	191.25	205.188	160.742	0.01202	0.0143
7	2.0%	1.5%	0.732	0.731	0.723	0.722	6.268	6.277	6.252	6.251	6.989	0.205	0.215	0.205	0.215	37.1875	37.5313	37.25	37.5313	38.5625	38.875	38.5938	38.9063	219.469	239.156	219.469	239.219	191.953	0.01398	0.01665
9	2.0%	1.5%																												
10	2.0%	1.5%																												
11	2.0%	1.5%																												
0.5	2.0%	2.0%	0.486	0.488	0.483	0.4835	0	0	0	0	0.48513	0.1	0.1	0.1	0.1	37.8125	38.4375	37.7813	38.4375	38.5625	38.75	38.5625	38.6563	86.6563	86.4375	86.6565	86.625	48.4766	0.0082	0.00976
1	2.0%	2.0%	0.99	0.991	0.99	0.989	0	0	0	0	0.99	0.109	0.109	0.109	0.109	37.7188	37.9063	37.7188	37.9063	38.2106	38.625	38.25	38.6563	101.094	103.625	101.084	103.625	64.5445	0.00873	0.01039
3	2.0%	2.0%	2.993	3	3.007	3.005	0	0	0	0	3.00125	0.181	0.181	0.181	0.181	38.3438	38.4063	38.3125	38.9065	38.9375	39.3125	38.9065	39.3125	129.188	138.563	129.188	138.563	95.3828	0.00806	0.0096
5	2.0%	2.0%	5	4.999	5	5.001	0	0	0	0	5	0.203	0.203	0.203	0.203	37.875	37.9688	37.875	37.9688	38.6875	39.125	38.6563	39.094	153.906	169.656	154.188	169.656	123.93	0.0098	0.01167
7	2.0%	2.0%	0.743	0.745	0.731	0.735	6.246	6.248	6.261	6.257	6.9915	0.245	0.245	0.245	0.245	37.5625	37.6563	37.4375	37.5938	38.75	39	38.625	38.9688	177.688	187.969	177.75	187.594	145.188	0.00967	0.01151
9	2.0%	2.0%	2.803	2.801	2.8	2.799	6.231	6.229	6.227	6.225	9.02875	0.26	0.29	0.26	0.29	38.2813	38.0625	38.3438	38.0625	38.75	39.2813	38.7188	38.7813	207.063	222.375	206.938	222.344	176.492	0.01386	0.0165
10	2.0%	2.0%	3.761	3.759	3.701	3.697	6.224	6.22	6.22	6.218	9.95	0.285	0.32	0.285	0.32	37.5	37.5313	36.8438	37.4688	38.875	38.5313	38.9063	39.0938	215.813	229.906	215.75	229.688	185.453	0.01436	0.0171
11	2.0%	2.0%	4.745	4.75	4.754	4.756	6.21	6.212	6.224	6.225	10.969	0.285	0.305	0.28	0.315	37.5	37.7813	37.4063	37.7813	38.75	39.25	38.7813	39.2188	214.875	229.938	213.813	229.969	184.531	0.01287	0.01532
0.5	2.0%	2.5%	0.48	0.479	0.478	0.477	0	0	0	0	0.4785	0.095	0.095	0.095	0.095	38.1875	38.7188	38.0938	38.7188	38.7188	39.0313	38.7188	39.0313	82.375	84.4375	82.4688	84.5313	45.0234	0.00984	0.01171
1	2.0%	2.5%	1.02	1.021	1.015	1.013	0	0	0	0	1.01725	0.135	0.135	0.135	0.135	38.2188	38.25	38.1875	38.3438	39	38.9375	38.9688	38.9688	94.4688	96.875	94.4688	96.8438	57.4141	0.00887	0.01056
3	2.0%	2.5%	2.898	2.99	2.978	2.98	0	0	0	0	2.9615	0.19	0.195	0.194	0.194	37.9688	38	37.9063	38	38.7188	38.875	38.6875	38.8438	125.563	133	125.438	132.906	91.2578	0.01049	0.01249
5	2.0%	2.5%	5.012	5.015	5.004	5.003	0	0	0	0	5.0085	0.2425	0.26	0.2425	0.26	37.6563	37.7813	37.6563	37.875	38.5	38.6563	38.5625	38.7188	140.188	149.219	140.188	149.219	106.961	0.00944	0.01124
7	2.0%	2.5%	0.763	0.765	0.773	0.772	6.247	6.25	6.262	6.257	7.02225	0.29	0.315	0.295	0.31	37.5	37.625	37.5313	37.6875	38.4688	38.8125	38.4688	38.8438	154.594	169.406	154.594	169.5	124.438	0.01013	0.01206
9	2.0%	2.5%	2.766	2.765	2.756	2.752	6.268	6.26	6.232	6.222	9.00525	0.315	0.325	0.315	0.325	37.4688	37.5313	37.4688	37.5	38.3125	38.4063	38.25	38.4688	164.25	177.5	164.281	177.563	133.406	0.00947	0.01128
10	2.0%	2.5%	3.751	3.752	3.769	3.77	6.216	6.218	6.236	6.236	9.987	0.325	0.345	0.325	0.345	37.125	37.4375	37.0313	37.375	38.25	38.4375	38.3438	38.3438	170.531	181.031	170.531	181.156	138.57	0.00942	0.01122
11	2.0%	2.5%	4.735	4.737	4.758	4.756	6.197	6.196	6.216	6.221	10.954	0.32	0.35	0.32	0.35	37.2188	37.25	37.625	37.1875	38.1563	38.3125	37.4063	38.3125	185.5	198.688	185.438	198.625	154.742	0.01161	0.01383
0.5	2.0%	3.0%	0.493	0.494	0.493	0.492	0	0	0	0	0.493	0.0985	0.0985	0.0985	0.0985	39.25	38.8438	39.1875	38.75	38.9063	39.3125	38.9063	39.25	82.9688	82.9688	82.9375	82.9375	43.9453	0.0122	0.01453
1	2.0%	3.0%	0.983	0.982	0.981	0.98	0	0	0	0	0.9815	0.1295	0.1595	0.1295	0.1595	38.5313	38.5	38.4375	38.4375	39.0938	39.3438	39.0625	39.2188	87.5313	89.3438	89	89.4063	50.3438	0.0087	0.01035
3	2.0%	3.0%	3.005	3.004	3.003	3.001	0	0	0	0	3.00325	0.21	0.217	0.217	0.217	38.4375	38.625	38.5313	38.5625	39.1563	39.25	39.1875	39.2813	109.219	118.719	109.219	118.625	75.4063	0.00841	0.01001
5	2.0%	3.0%	5.027	5.028	5.024	5.023	0	0	0	0	5.0255	0.2615	0.274	0.26	0.275	38.2188	38.4063	38.0938	38.3438	38.8438	38.5625	38.875	38.6563	126.188	135.875	126.063	135.938	92.75	0.00869	0.01035
7	2.0%	3.0%	0.797	0.796	0.792	0.793	6.246	6.241	6.238	6.237	7.035	0.295	0.323	0.293	0.3205	38.125	38.2813	38.125	38.1875	38.75	39.25	39.125	39.0938	137.031	145.938	136.906	145.813	103.242	0.00757	0.00901
9	2.0%	3.0%	2.764	2.762	2.75	2.75	6.238	6.245	6.242	6.244	8.99875	0.3085	0.3265	0.3065	0.325	37.75	38.2188	37.6563	38.1875	38.8125	38.8125	38.5313	38.5938	152.219	162.25	152.031	162.156	119.211	0.00948	0.01128
10	2.0%	3.0%	3.805	3.806	3.8	3.803	6.2	6.197	6.234	6.235	10.02	0.326	0.3545	0.325	0.3555	38	38.25	37.9063	38.125	38.9063	39.25	38.875	39.2813	156.156	168.938	156.125	169	124.484	0.0096	0.01142
11	2.0%	3.0%	4.758	4.754	4.741	4.743	6.21	6.212	6.21	6.214	10.9605	0.354	0.3685	0.445	0.3705	37.5625	38.0313	37.4063	37.9375	38.6563	39.0938	38.4375	38.0625	165.938	175.156	165.938	175.188	132.82	0.01033	0.0123
0.5	2.0%	4.0%	0.506	0.505	0.514	0.514	0	0	0	0	0.50975	0.125	0.125	0.125	0.125	37.625	37.8438	37.5625	37.9063	38.2813	38.4688	38.25	38.4688	72.1563	73.2188	72.125	73.1563	34.9297	0.0101	0.01202
1	2.0%	4.0%	1.014	1.015	1.008	1.005	0	0	0	0	1.0105	0.135	0.135	0.135	0.135	37.7813	37.8438	37.625	37.8438	38.4375	38.5938	38.4375	38.5313	81.3125	82.7813	81.3125	82.7813	44.2734	0.00965	0.01148
3	2.0%	4.0%	2.99	2.991	2.988	2.99	0	0	0	0	2.98975	0.225	0.2325	0.2325	0.2325	37.1563	37.3125	37.2188	37.3438	38.2188	38.4375	38.1563	38.4063	97.4375	104.031	97.4375	104.031	63.4766	0.00851	0.01014
5	2.0%	4.0%	5.062	5.061	5.06	5.055	0	0	0	0	5.0595	0.295	0.305	0.295	0.305	36.9688	37.2813	36.9063	37.2188	38.1875	38.5313	38.125	38.5313	114.813	123.844	114.75	123.844	82.2188	0.01002	0.01193
7	2.0%	4.0%	0.752	0.753	0.747	0.748	6.271	6.272	6.258	6.257	7.0145	0.32	0.33	0.32	0.33	36.6875	37.125	36.625	37.0625	38.0938	38.375	38.0313	38.375	126.531	134.5	126.594	134.5	93.6563	0.01022	0.01217
9	2.0%	4.0%	2.834	2.683	2.676	2.676	6.273	6.27	6.261	6.26	8.98325	0.355	0.365	0.355	0.365	36.7188	37.1563	36.7188	37.1563	38.125	38.4688	38.0625	38.4688	137.344	145.906	137.281	145.906	104.672	0.01074	0.01278
10	2.0%	4.0%	3.74	3.743	3.76	3.761	6.267	6.262	6.26	6.254	10.0118	0.375	0.39	0.375	0.39	36.6563	37.0625	36.5938	37.125	38.2188	38.5	38.2813	38.5625	139.313	149.438	139.281	149.5	107.523	0.01036	0.01233
11	2.0%	4.0%	4.723	4.722	4.714	4.715	6.252	6.253	6.245	6.24	10.966	0.3875	0.405	0.3875	0.405	36.4375	36.9063	36.4375	36.8438	38.1875	38.4375	38.1563	38.5	145.531	156.875	145.594	156.813	114.547	0.0112	0.01333

Table B2.4 Asphalt surface data

Discharg	SL (%)	SX (%)	QWALL (CFS)				Qfloor (CFS)				Qtotal	Depth (ft)				Spread Dist T1 (in)				Curb Distance (in)				Spread Dist T2 (in)				AVG	n value	
actual Q			Initial		Final		Initial		Final		AVG	Min		Max		T1min		T2max		Cmin		Cmax		T1min		T2max		Spread	Geometri	Integrated
cfs			1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	CFS	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	In		
0.5	3.0%	1.5%	0.515	0.515	0.509	0.509	0	0	0	0	0.512	0.0575	0.0575	0.0575	0.0575	38.3438	38.4375	38.2188	38.5938	39.0938	39.25	38.8438	39.2188	102.906	102.906	102.875	103	64.5234	0.0127	0.01512
1	3.0%	1.5%	1.039	1.04	1.042	1.041	0	0	0	0	1.0405	0.09	0.09	0.09	0.09	38.2813	38.1875	38.2188	38.3125	39.1563	39.1875	38.9688	39.3125	118.406	122.75	119.406	123	82.6406	0.01207	0.01437
3	3.0%	1.5%	3.018	3.017	3.012	3.014	0	0	0	0	3.01525	0.1375	0.1425	0.1425	0.1425	38.0313	38.2188	38	38.2188	39.0313	39.2188	39.2188	39.375	164.625	173.531	164.844	173.656	131.047	0.01434	0.01707
5	3.0%	1.5%	5.001	5	4.989	4.99	0	0	0	0	4.995	0.18	0.1875	0.183	0.19	37.5625	37.7813	37.8438	38.0313	39.1563	39.2188	39.3125	39.4375	182.406	190.875	182.469	190.813	148.836	0.01206	0.01436
7	3.0%	1.5%	0.724	0.724	0.727	0.726	6.245	6.241	6.232	6.231	6.9625	0.1975	0.2125	0.2	0.208	38.0313	37.875	38.1875	38.0625	38.8125	38.6563	39.0313	38.9063	219.469	221.563	219.781	221.813	182.617	0.015	0.01785
9	3.0%	1.5%	2.805	2.8	2.788	2.787	6.211	6.217	6.198	6.201	9.00175	0.215	0.225	0.219	0.225	37.5938	37.6563	37.4063	37.4688	39.0313	39.1563	38.9063	39	229.344	232.531	229.281	232.719	193.438	0.01346	0.01602
10	3.0%	1.5%	3.727	3.7	3.73	3.731	6.21	6.21	6.222	6.228	9.9395	0.215	0.2325	0.2165	0.13	37.5	37.5938	37.4063	37.4063	38.75	39	38.6563	38.7813	233.688	240.156	233.563	240.031	199.383	0.01324	0.01576
11	3.0%	1.5%																												
0.5	3.0%	2.0%	0.491	0.491	0.493	0.493	0	0	0	0	0.492	0.08	0.084	0.081	0.086	38.7188	39.0938	38.625	39.1875	39.6875	39.75	39.6875	39.875	84.3125	85.5625	84.2813	85.6563	46.0469	0.0086	0.01024
1	3.0%	2.0%	1.044	1.042	1.039	1.039	0	0	0	0	1.041	0.11	0.11	0.12	0.125	39.1563	39.0625	39.1563	39	39.75	39.75	39.75	39.9375	101.406	103.406	101.281	103.563	63.3203	0.0095	0.01131
3	3.0%	2.0%	3.029	3.03	3.025	3.027	0	0	0	0	3.02775	0.17	0.1775	0.1765	0.1765	38.5313	38.8125	38.4375	39	39.25	39.2813	37.5625	39.2813	121.344	130.188	120.906	134.031	87.9219	0.00789	0.0094
5	3.0%	2.0%	4.976	4.978	4.987	4.984	0	0	0	0	4.98125	0.215	0.255	0.2135	0.257	38.4063	38.25	38.375	38.625	38.375	39.0313	38.375	39.0625	142.219	154.281	149.625	156.938	112.352	0.00944	0.01124
7	3.0%	2.0%	0.741	0.739	0.744	0.745	6.835	6.243	6.239	6.246	7.133	0.235	0.2425	0.238	0.2455	38.3438	37.9688	38.3438	38.0938	39.0938	39.3438	39.0625	39.3125	181.438	184.438	181.344	183.125	144.398	0.01152	0.01372
9	3.0%	2.0%	2.675	2.678	2.683	2.681	6.243	6.238	6.224	6.221	8.91075	0.2575	0.265	0.2575	0.265	37.7813	37.8438	37.8125	38.0938	39.1875	39.25	39.0625	39.2188	196.406	209.75	196.594	209.531	165.188	0.01439	0.01713
10	3.0%	2.0%	3.747	3.751	3.705	3.706	6.236	6.235	6.227	6.239	9.9615	0.265	0.2725	0.2675	0.2765	38.375	37.9063	38.2188	37.9063	39.125	39.2813	39.25	39.25	204.75	221.031	204.75	221.125	174.813	0.01503	0.01789
11	3.0%	2.0%	4.791	4.789	4.787	4.787	6.201	6.198	6.194	6.194	10.9853	0.255	0.27	0.258	0.273	37.9688	38.1563	37.9688	37.9063	39.125	39.3125	38.5938	39.5	212	224.719	209.719	224.813	179.813	0.01466	0.01745
0.5	3.0%	2.5%	0.501	0.499	0.497	0.498	0	0	0	0	0.49875	0.0925	0.0925	0.0925	0.0925	38.625	38.6875	38.6563	38.7188	39.2813	39.3125	39.2188	39.2813	77.5	80.6875	77.5625	80.625	40.4219	0.00868	0.01033
1	3.0%	2.5%	1.005	1.008	1.013	1.013	0	0	0	0	1.00975	0.115	0.115	0.115	0.115	38.5625	38.6875	38.4688	38.5938	39.2188	39.3438	39.1563	39.375	90.6875	95.7813	90.7188	95.9063	54.6953	0.00967	0.01151
3	3.0%	2.5%	2.992	2.99	2.989	2.987	0	0	0	0	2.9895	0.175	0.1825	0.1825	0.1825	38.2813	38.375	38.2813	38.4063	39.125	39.2813	39.0313	39.375	117.844	126.156	117.969	126.281	83.7266	0.01012	0.01205
5	3.0%	2.5%	5.005	5.01	5.003	5.002	0	0	0	0	5.005	0.215	0.225	0.215	0.225	38.0625	38.0938	38.0625	38.1563	38.875	39	38.9688	39.125	135.594	141.625	135.625	141.625	100.523	0.0098	0.01167
7	3.0%	2.5%	0.796	0.796	0.789	0.789	6.247	6.248	6.272	6.273	7.0525	0.2525	0.2625	0.2525	0.26	37.875	37.9375	37.8438	37.9375	38.9063	39.0625	38.9688	39.125	146.031	155.781	143.5	158.031	112.938	0.00952	0.01134
9	3.0%	2.5%	2.69	2.691	2.682	2.68	6.228	6.23	6.225	6.224	8.9125	0.2725	0.295	0.2725	0.295	38.0938	38.2188	38.0625	38.1563	38.7813	38.9375	38.8438	39.0625	162.281	173.688	162.156	173.625	129.805	0.01093	0.01301
10	3.0%	2.5%	3.817	3.815	3.812	3.81	6.24	6.235	6.243	6.248	10.055	0.269	0.29	0.269	0.29	37.8125	37.75	37.75	37.75	38.7813	38.7503	38.7813	38.7188	168.594	181.719	168.625	181.781	137.414	0.01129	0.01344
11	3.0%	2.5%	4.756	4.76	4.759	4.762	6.222	6.224	6.22	6.218	10.9803	0.287	0.3065	0.287	0.3065	37.6563	37.875	37.7188	37.7813	38.6875	38.9063	38.7813	38.9375	174.375	182.938	174.281	182.875	140.859	0.01099	0.01309
0.5	3.0%	3.0%	0.505	0.504	0.508	0.509	0	0	0	0	0.5065	0.099	0.101	0.0985	0.1005	38.7188	38.7188	38.6875	38.75	39.125	39.1563	39.125	39.1563	78.3125	78.6875	78.3438	78.6875	39.7891	0.01104	0.01314
1	3.0%	3.0%	0.985	0.986	0.987	0.99	0	0	0	0	0.987	0.125	0.129	0.125	0.129	38.4063	38.469	38.375	38.4375	39.0313	39.25	39.0315	39.25	84.5625	87.75	84.4065	87.875	47.7266	0.00921	0.01097
3	3.0%	3.0%	2.955	2.952	2.951	2.95	0	0	0	0	2.952	0.183	0.189	0.188	0.188	38.2188	38.5625	38.2813	38.5625	39.4063	39.5938	39.4063	39.6563	112.094	117.313	112.125	117.344	76.3125	0.01079	0.01285
5	3.0%	3.0%	4.985	4.99	4.994	4.995	0	0	0	0	4.991	0.235	0.2425	0.235	0.2425	37.6875	37.9688	37.6875	37.8125	38.5938	39.1563	38.5625	39.3125	126.844	134.531	126.719	134.688	92.9063	0.01077	0.01282
7	3.0%	3.0%	0.622	0.624	0.629	0.629	6.26	6.261	6.252	6.251	6.882	0.2675	0.2775	0.2675	0.2775	37.9688	38.125	37.9688	38.1563	39.1875	39.4375	39.2188	39.5	136.406	144	136.375	144.063	102.156	0.00908	0.01081
9	3.0%	3.0%	2.796	2.793	2.778	2.78	6.26	6.262	6.262	6.261	9.048	0.29	0.3065	0.2895	0.3065	37.875	38.25	37.875	38.2188	39.125	39.4688	39.125	39.5313	149.844	157.469	149.906	157.531	115.633	0.01063	0.01265
10	3.0%	3.0%	3.823	3.825	3.717	3.715	6.235	6.236	6.232	6.231	10.0035	0.3125	0.329	0.3125	0.3285	37.6875	37.9063	37.7188	37.9063	38.9375	39.4063	38.9688	39.4688	150.563	161.656	150.625	161.688	118.328	0.01025	0.01221
11	3.0%	3.0%	4.81	4.807	4.775	4.776	6.24	6.243	6.239	6.24	11.0325	0.323	0.344	0.323	0.344	37.3438	37.9688	37.4375	37.9688	39.0625	39.5	39.125	39.4375	162.25	172.844	162.281	172.813	129.867	0.01189	0.01416
0.5	3.0%	4.0%	0.508	0.507	0.499	0.5	0	0	0	0	0.5035	0.105	0.105	0.105	0.105	38.3954	38.5938	38.4375	38.5625	39.1563	39.2813	39.1875	39.3125	72.375	73.8125	72.375	73.875	34.6121	0.01229	0.01463
1	3.0%	4.0%	0.997	1	0.984	0.985	0	0	0	0	0.9915	0.13	0.135	0.13	0.135	38.4063	38.5625	38.3125	38.5938	39.2188	39.3438	39.2188	39.2813	78.625	80.4063	78.6563	80.375	41.0469	0.00987	0.01175
3	3.0%	4.0%	3.027	3.024	3.01	3.007	0	0	0	0	3.017	0.205	0.21	0.21	0.21	38.125	38.25	38.0625	38.25	39.0313	39.1875	39	39.1875	105.188	108.656	105.125	108.594	68.7188	0.0128	0.01524
5	3.0%	4.0%	5.059	5.055	5.074	5.075	0	0	0	0	5.06575	0.27	0.2775	0.27	0.2775	38	38.1563	38.0313	38.0938	38.9063	39.0625	38.9063	39	118	121.875	118	122.188	81.9453	0.01213	0.01444
7	3.0%	4.0%	0.728	0.73	0.733	0.732	6.269	6.275	6.28	6.271	7.0045	0.2975	0.31	0.2975	0.31	37.9688	38.0938	37.9688	38.0938	38.9688	39.125	38.875	39.0938	124.313	128.531	124.313	130.969	89	0.01095	0.01304
9	3.0%	4.0%	2.765	2.766	2.756	2.754	6.244	6.25	6.257	6.26	9.013	0.345	0.355	0.345	0.355	37.6563	37.7813	37.6563	37.7813	38.875	39.0625	38.875	39.0625	132.5	138.344	132.563	138.438	97.7422	0.0109	0.01298
10	3.0%	4.0%	3.749	3.757	3.75	3.748	6.24	6.239	6.245	6.35	10.0195	0.3525	0.365	0.3525	0.365	37.5938	37.8125	37.5938	37.8125	38.6563	38.8438	38.5938	38.8438	134.375	139.813	134.375	139.813	99.3906	0.01023	0.01218
11	3.0%	4.0%	4.757	4.752	4.762	4.76	6.231	6.233	6.235	6.24	10.9925	0.355	0.365	0.355	0.365	37.5313	37.625	37.4063	37.625	38.5625	38.7813	38.625	38.7813	138.438	145.188	138.5	145.125	104.266	0.01062	0.01264

Table B2.5 Asphalt surface data

Discharg	SL (%)	SX (%)	QWALL (CFS)				Qfloor (CFS)				Qtotal	Depth (ft)			
actual Q			Initial		Final		Initial		Final		AVG	Min		Max	
cfs			1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	CFS	1st run	2nd run	1st run	2nd run
0.5	4.0%	1.5%	0.49	0.492	0.489	0.491	0	0	0	0	0.4905	0.081	0.081	0.081	0.056
1	4.0%	1.5%	0.994	0.996	1.001	1.002	0	0	0	0	0.99825	0.0875	0.0875	0.0875	0.0875
3	4.0%	1.5%	3.007	3.011	3.001	3.004	0	0	0	0	3.00575	0.12	0.1275	0.1275	0.1275
5	4.0%	1.5%	5.017	5.018	5.014	5.016	0	0	0	0	5.01625	0.1625	0.17	0.1675	0.17
7	4.0%	1.5%	0.733	0.728	0.726	0.727	6.235	6.235	6.232	6.234	6.9625	0.2	0.2075	0.2	0.2075
9	4.0%	1.5%	2.812	2.812	2.798	2.796	6.217	6.218	6.2	6.205	9.0145	0.215	0.23	0.215	0.23
10	4.0%	1.5%	3.742	3.747	3.746	3.743	6.226	6.217	6.211	6.212	9.961	0.2075	0.225	0.2075	0.225
11	4.0%	1.5%	4.751	4.75	4.746	4.747	6.181	6.183	6.17	6.171	10.9248	0.2	0.235	0.2	0.235
0.5	4.0%	2.0%	0.51	0.51	0.512	0.512	0	0	0	0	0.511	0.0775	0.0775	0.0775	0.0775
1	4.0%	2.0%	0.98	0.983	0.978	0.981	0	0	0	0	0.9805	0.1075	0.1075	0.1075	0.1075
3	4.0%	2.0%	3.022	3.023	3.016	3.017	0	0	0	0	3.0195	0.1525	0.1575	0.1575	0.1575
5	4.0%	2.0%	4.989	4.992	4.99	4.987	0	0	0	0	4.9895	0.1925	0.2	0.195	0.2
7	4.0%	2.0%	0.685	0.686	0.689	0.69	6.234	6.232	6.233	6.231	6.92	0.215	0.225	0.215	0.225
9	4.0%	2.0%	2.779	2.78	3.28	3.2765	6.2	6.208	6.1995	6.197	9.23	0.255	0.2625	0.255	0.2625
10	4.0%	2.0%	3.785	3.782	3.755	3.777	6.2	6.197	6.192	6.19	9.9695	0.2575	0.2675	0.2575	0.2675
11	4.0%	2.0%	4.772	4.774	4.771	4.774	6.198	6.195	6.203	6.3	10.9968	0.24	0.2875	0.24	0.2875
0.5	4.0%	2.5%	0.482	0.483	0.483	0.483	0	0	0	0	0.48275	0.0965	0.0965	0.0965	0.0975
1	4.0%	2.5%	1.02	1.02	1.016	1.017	0	0	0	0	1.01825	0.119	0.1215	0.119	0.1225
3	4.0%	2.5%	2.99	2.992	2.994	2.988	0	0	0	0	2.991	0.1725	0.18	0.181	0.181
5	4.0%	2.5%	4.997	4.987	4.984	4.984	0	0	0	0	4.988	0.214	0.222	0.214	0.2215
7	4.0%	2.5%	0.74	0.739	0.745	0.734	6.211	6.21	6.229	6.234	6.9605	0.23	0.2405	0.232	0.241
9	4.0%	2.5%	2.75	2.75	2.748	2.75	6.21	6.211	6.207	6.206	8.958	0.253	0.2635	0.254	0.264
10	4.0%	2.5%	3.736	3.739	3.74	3.741	6.185	6.192	6.185	6.189	9.92675	0.2575	0.2765	0.258	0.2775
11	4.0%	2.5%	4.805	4.804	4.804	4.807	6.164	6.166	6.172	6.172	10.9735	0.2775	0.3	0.2775	0.3
0.5	4.0%	3.0%	0.504	0.503	0.506	0.507	0	0	0	0	0.505	0.0925	0.0925	0.0925	0.0925
1	4.0%	3.0%	0.986	0.987	0.991	0.991	0	0	0	0	0.98875	0.105	0.105	0.105	0.105
3	4.0%	3.0%	3.033	3.029	3.031	3.039	0	0	0	0	3.033	0.1725	0.175	0.17	0.17
5	4.0%	3.0%	5.02	5.121	5.018	5.019	0	0	0	0	5.0445	0.22	0.23	0.22	0.23
7	4.0%	3.0%	0.842	0.84	0.836	0.835	6.213	6.214	6.22	6.216	7.054	0.245	0.255	0.245	0.255
9	4.0%	3.0%	2.781	2.782	2.778	2.779	6.197	6.188	6.214	6.21	8.98225	0.265	0.28	0.265	0.28
10	4.0%	3.0%	3.761	3.762	3.773	3.769	6.188	6.19	6.177	6.173	9.94825	0.2675	0.2825	0.2675	0.2825
11	4.0%	3.0%	4.725	4.727	4.72	4.722	6.19	6.192	6.186	6.182	10.911	0.2775	0.2925	0.2775	0.2925
0.5	4.0%	4.0%	0.49	0.489	0.487	0.486	0	0	0	0	0.488	0.099	0.102	0.099	0.102
1	4.0%	4.0%	0.983	0.982	0.983	0.982	0	0	0	0	0.9825	0.138	0.144	0.138	0.144
3	4.0%	4.0%	3.009	3.008	3.005	3.005	0	0	0	0	3.00675	0.191	0.1975	0.1975	0.1975
5	4.0%	4.0%	5.009	5.008	5.015	5.014	0	0	0	0	5.0115	0.24	0.25	0.24	0.25
7	4.0%	4.0%	0.812	0.811	0.814	0.815	6.204	6.203	6.2	6.199	7.0145	0.2875	0.297	0.2875	0.297
9	4.0%	4.0%	2.868	2.866	2.862	2.861	6.183	6.181	6.186	6.185	9.048	0.302	0.309	0.302	0.309
10	4.0%	4.0%	3.791	3.79	3.783	3.784	6.185	6.184	6.177	6.178	9.968	0.31	0.3195	0.31	0.3195
11	4.0%	4.0%	4.823	4.822	4.835	4.824	6.179	6.178	6.155	6.156	10.993	0.336	0.342	0.336	0.342

Discharg	SL (%)	SX (%)	Spread Dist T1 (in)				Curb Distance (in)				Spread Dist T2 (in)				AVG	n value	
actual Q			T1min		T2max		Cmin		Cmax		T1min		T2max		Spread	Geometri	Integrated
cfs			1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	In		
0.5	4.0%	1.5%	38.5313	38.75	38.7188	38.75	39.0938	39.5938	39.2188	39.5938	89.0313	91.3125	89.25	91.5	51.5859	0.00838	0.00998
1	4.0%	1.5%	39.6875	39.8438	39.625	39.9063	40.5	40.625	40.4688	40.5625	126.135	126.125	126.125	126.125	86.362	0.01634	0.01946
3	4.0%	1.5%	39.6563	39.75	39.5938	39.6875	40.6875	40.875	40.6875	40.875	162.875	168.375	162.938	168.438	125.984	0.01521	0.01811
5	4.0%	1.5%	39.5313	39.8125	39.5	39.75	40.5625	40.75	40.625	40.75	193.031	194.844	193.031	194.844	154.289	0.01532	0.01824
7	4.0%	1.5%	39.0313	39.2188	39.0313	39.2188	40.5625	40.8438	40.5313	40.9063	198.031	201.594	198.094	201.715	160.733	0.01224	0.01457
9	4.0%	1.5%	39.2188	39.375	39.1563	39.375	40.1563	40.3125	40.5938	40.8125	223.25	227.75	223.188	228.313	186.344	0.01404	0.01672
10	4.0%	1.5%	40.125	39.4375	40.3438	39.4063	40.6563	39.9375	40.875	40.125	230.031	236.188	230.25	236.344	193.375	0.01404	0.01671
11	4.0%	1.5%	39.4063	39.5938	39.3438	39.5938	40.6563	40.8438	40.6563	40.9063	236.875	242.281	236.906	242.281	200.102	0.01402	0.01669
0.5	4.0%	2.0%	38.5938	38.7813	38.5313	38.7813	39.4688	30.5	39.5313	39.625	86.2813	86.2813	86.3125	86.3125	47.625	0.01047	0.01246
1	4.0%	2.0%	38.5	38.75	38.5	38.5938	39.4063	39.7188	39.4063	39.6875	98.875	102.625	98.8125	102.625	62.1484	0.0111	0.01322
3	4.0%	2.0%	37.9688	38.0938	37.9688	38.1875	39.375	39.4688	39.2813	39.4688	133.125	135.125	133.125	134.094	95.8125	0.01143	0.01361
5	4.0%	2.0%	37.75	37.9375	37.7188	37.9688	38.7188	39.4063	38.6875	39.5	153.469	153.469	153.469	153.406	115.609	0.0114	0.01358
7	4.0%	2.0%	37.875	37.7188	37.8125	37.7188	39.1875	39.4063	39.1875	39.3438	160.688	169.938	160.688	170	127.547	0.00977	0.01163
9	4.0%	2.0%	37.25	37.8958	37.25	37.375	38.75	39.3438	38.75	39.4063	181.75	185.25	181.688	185.25	146.042	0.01151	0.0137
10	4.0%	2.0%	37.375	37.5938	37.375	37.5938	39.125	39.375	39.1563	39.375	187.063	192.906	187	192.906	152.484	0.01194	0.01422
11	4.0%	2.0%	37.375	37.625	37.375	37.5625	39.1875	39.3438	39.0938	39.4063	195.344	156.125	195.406	203.125	150.016	0.01123	0.01337
0.5	4.0%	2.5%	39.6563	39.8125	39.8438	39.9063	39.9688	40.125	40.125	40.3125	80.375	80.375	80.5	80.5625	40.6484	0.01055	0.01256
1	4.0%	2.5%	40	40.25	40.125	40.3438	40.5938	40.8125	40.7188	40.9688	89.9688	92.0938	90.0625	92.25	50.9141	0.00905	0.01077
3	4.0%	2.5%	39.625	44.9063	39.7813	44.9688	40.3125	40.6563	40.4375	40.8125	108.875	112.406	109	112.375	68.3438	0.00675	0.00803
5	4.0%	2.5%	38.375	40.1875	40	40.3125	40.5313	40.9688	40.5938	41.0938	115.375	130.75	115.563	130.75	83.3906	0.0071	0.00845
7	4.0%	2.5%	39.0938	39.7188	39.25	39.9375	40.0938	40.3125	40.2813	40.5313	139.813	148.625	139.813	148.625	104.719	0.00908	0.01082
9	4.0%	2.5%	39.0313	39.625	39.1563	39.7813	39.6875	40.7188	39.7188	40.75	149.938	158.063	150.063	158.219	114.672	0.00904	0.01076
10	4.0%	2.5%	38	38.875	38.125	39	39.5625	40.1563	39.5625	40.2813	160.188	169.125	160.438	169.25	126.25	0.01049	0.01249
11	4.0%	2.5%	38.0625	38.7188	38	38.875	39.5938	40.375	39.4688	40.3438	126.656	186.656	126.875	186.844	118.344	0.01019	0.01213
0.5	4.0%	3.0%	38.625	38.75	38.6875	38.8125	39.6875	39.8438	39.6875	39.9063	75.5313	75.5313	75.5625	75.5938	36.8359	0.0104	0.01238
1	4.0%	3.0%	38.5313	38.6563	38.5313	38.7188	39.7188	39.9063	39.75	39.6563	82.9063	87.1875	82.875	87.1563	46.4219	0.00991	0.01179
3	4.0%	3.0%	38.1563	38.2813	38.1563	38.2813	39.625	39.8125	39.5625	39.75	99.0625	107.469	99.125	107.421	65.0505	0.00796	0.00948
5	4.0%	3.0%	37.875	38.0625	37.875	38.125	39.7813	52.625	39.9063	39.8125	113.688	123.188	113.688	123.25	80.4688	0.00839	0.00999
7	4.0%	3.0%	37.75	38.125	37.7188	38.0938	39.0938	39.6875	39.1563	39.6875	133.25	137.823	133.219	135.281	96.9714	0.00904	0.01076
9	4.0%	3.0%	37.5	37.5938	37.5625	37.6563	39.5313	39.7813	39.5313	39.7813	146	150.563	145.938	150.438	110.656	0.01099	0.01309
10	4.0%	3.0%	37.2188	38.1875	37.5	38.3125	39.625	39.875	39.5625	39.9375	149.125	156.344	149.094	156.719	115.016	0.01102	0.01312
11	4.0%	3.0%	37.3125	37.625	37.3125	37.6875	39.4688	39.2188	39.4375	39.6563	155.063	161.875	155.031	161.938	120.992	0.01151	0.0137
0.5	4.0%	4.0%	38.1875	38.375	38.1875	38.375	39.5938	39.75	39.5625	39.6875	68.9375	70.625	68.9375	70.6563	31.5078	0.01143	0.0136
1	4.0%	4.0%	38.1563	38.4688	38.2188	38.5	39.625	39.9688	39.5938	40	76.4375	76.4688	76.4375	76.3438	38.0859	0.00933	0.01111
3	4.0%	4.0%	37.875	38.1875	37.875	38.1875	39.6563	40	39.5938	40.0625	99.1875	102.156	99.1563	102.188	62.6406	0.01155	0.01375
5	4.0%	4.0%	37.6563	38	37.5938	38.0625	39.6875	40.0313	39.5938	40.0938	105.469	108.063	105.438	108.063	68.9297	0.00889	0.01059
7	4.0%	4.0%	37.5	37.6875	37.5	37.6875	39.8438	40.0313	39.9063	40.0938	114.813	121.313	114.844	121.375	80.4922	0.00963	0.01146
9	4.0%	4.0%	37.5625	37.8438	37.5625	37.9063	39.8125	40.0313	39.8125	40.0313	126.656	135	126.719	135	93.125	0.01108	0.0132
10	4.0%	4.0%	37.4375	37.625	37.4375	37.625	39.5313	39.8125	39.5313	39.75	133.156	139.313	133.188	139.313	98.7109	0.01173	0.01396
11	4.0%	4.0%	37.4375	37.5625	37.4375	37.9375	39.6875	40.125	39.625	40.1875	138.031	141.781	138.063	141.781	102.32	0.0117	0.01393

Table B3.1 TxDOT Concrete surface data

Rain Data - Smooth Concrete																																				
SL (%)	SX (%)	QWALL (CFS)				Qfloor (CFS)				Qtotal	Rainfall (gpm)				Depth (ft)				Spread Dist T1 (in)				Curb Distance (in)				Spread Dist T2 (in)				AVG	n value	
		Initial		Final		Initial		Final		AVG	Initial		Final		Min		Max		T1min		T2max		Cmin		Cmax		T1min		T2max		Spread	Geometric	Integrated
		1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	CFS	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	In		
0.04	0.04	0.997	0.998	0.996	0.997					0.997					0.135	0.135	0.14	0.14	46.938	46.875	46.875	46.813	48.125	48.125	48.125	48.125	90.5	91.938	90.813	92.813	91.516	0.014114	0.016804
0.04	0.04	3.006	3.007	3.005	3.008					3.0065					0.205	0.205	0.21	0.21	46.688	46.688	46.75	46.75	48.125	48.125	48.125	48.125	113.313	113.313	113.938	113.938	113.6255	0.013753	0.016374
0.04	0.04	0.685	0.664	0.685	0.686	6.343	6.337	6.34	6.337	7.01925					0.28	0.28	0.285	0.285	46.375	46.375	46.438	46.438	48.125	48.125	48.125	48.125	131.125	131.125	135.25	135.25	133.1875	0.01178	0.014025
0.04	0.04	3.706	3.712	3.707	3.713	6.305	6.31	6.304	6.311	10.017					0.31	0.31	0.31	0.31	46.125	46.125	46.188	46.188	48.125	48.125	48.125	48.125	144.438	144.438	147	147	145.719	0.01192	0.014191
0.04	0.04	4.702	4.698	4.703	4.699	6.289	6.291	6.29	6.295	10.99175					0.335	0.335	0.34	0.34	46.188	46.25	46.125	46.188	48.125	48.125	48.125	48.125	151.563	151.563	153.438	153.438	152.5005	0.012924	0.015387
0.04	0.04	0.973	0.974	0.975	0.975					0.97425	6.44	6.36	8.23	8.69	0.135	0.135	0.14	0.14	46.938	47	46.875	46.938	48.125	48.125	48.125	48.125	90	92.25	92.375	93.875	92.125	0.014665	0.017459
0.04	0.04	2.99	2.991	2.991	2.991					2.99075	7.27	7.19	9.36	9.47	0.205	0.205	0.21	0.21	46.813	46.813	46.75	46.75	48.125	48.125	48.125	48.125	113.438	113.438	114.938	114.938	114.188	0.014013	0.016683
0.04	0.04	0.665	0.667	0.666	0.668	6.32	6.313	6.323	6.317	6.98475	6.81	6.58	7.85	7.89	0.28	0.28	0.285	0.285	46.5	46.5	46.438	46.438	48.125	48.125	48.125	48.125	135.625	135.375	138.938	138.938	137.219	0.013319	0.015857
0.04	0.04	3.718	3.713	3.719	3.712	6.288	6.287	6.287	6.293	10.00425	7.85	7.7	8.32	8.27	0.315	0.315	0.32	0.32	46.25	46.25	46.188	46.188	48.125	48.125	48.125	48.125	144.625	144.625	148.438	148.438	146.5315	0.012147	0.014462
0.04	0.04	4.687	4.68	4.682	4.682	6.261	6.261	6.261	6.26	10.9435	7.556	7.602	8.589	8.695	0.345	0.345	0.355	0.355	46.063	46.063	46	46	48.125	48.125	48.125	48.125	149.5	149.5	153.75	153.75	151.625	0.012714	0.015137
0.04	0.04	0.969	0.968	0.95	0.958					0.96625	26.84	26.81	26.85	26.78	0.153	0.153	0.155	0.155	46.938	46.938	46.875	46.875	48.125	48.125	48.125	48.125	92.125	92.125	94.375	94.375	93.25	0.015271	0.018181
0.04	0.04	2.963	2.95	2.948	2.949					2.95	26.87	27.36	26.89	27.36	0.2	0.2	0.205	0.21	46.75	46.75	46.688	46.688	48.125	48.125	48.125	48.125	113.25	113.25	114.938	114.938	114.094	0.014011	0.01668
0.04	0.04	0.616	0.615	0.615	0.615	6.318	6.319	6.315	6.312	6.93125	27.32	27.32	27.31	27.34	0.28	0.285	0.285	0.295	46.563	46.563	46.5	46.5	48.125	48.125	48.125	48.125	133	132.875	136.563	136.313	134.6878	0.01233	0.014679
0.04	0.04	3.646	3.648	3.649	3.648	6.268	6.27	6.27	6.268	9.91675	26.1	26.03	26.06	26.02	0.34	0.325	0.345	0.335	46.25	46.25	46.188	46.188	48.125	48.125	48.125	48.125	146.188	145.750.5	149.0002	148.625	110.9533	0.012461	0.014836
0.04	0.04	4.689	4.696	4.69	4.695	6.245	6.24	6.235	6.239	10.93225	25.36	25.52	26.4	26.58	0.345	0.35	0.35	0.36	46.25	46.25	46.188	46.188	48.125	48.125	48.125	48.125	152.188	150.5	155	154.188	152.969	0.013057	0.015546
0.04	0.04	0.88	0.88	0.88	0.88					0.88	52.91	53.24	53.19	53.28	0.14	0.145	0.145	0.15	47.063	47	47	46.938	48.125	48.125	48.125	48.125	91.375	92.125	93.75	93.75	92.75	0.01504	0.017905
0.04	0.04	2.852	2.851	2.853	2.848					2.851	51.39	51.53	51.43	51.54	0.2	0.2	0.205	0.205	46.75	46.75	46.688	46.688	48.125	48.125	48.125	48.125	112.938	112.938	114.5	114.5	113.719	0.014012	0.016682
0.04	0.04	0.576	0.577	0.577	0.575	6.312	6.32	6.324	6.32	6.89525	52.64	52.75	52.75	52.73	0.3	0.3	0.305	0.305	46.5	46.5	46.438	46.438	48.125	48.125	48.125	48.125	136.188	136.188	138.5	138.5	137.344	0.013312	0.015848
0.04	0.04	3.592	3.588	3.592	3.59	6.277	6.276	6.264	6.268	9.86175	52.73	52.77	52.74	52.76	0.34	0.34	0.345	0.345	46.313	46.313	46.25	46.25	48.125	48.125	48.125	48.125	148.688	148.688	151.313	151.313	150.0005	0.01331	0.015846
0.04	0.04	4.642	4.642	4.64	4.643	6.223	6.239	6.23	6.246	10.87625	51.63	51.64	51.63	51.64	0.345	0.345	0.35	0.35	46.25	46.25	46.25	46.25	48.125	48.125	48.125	48.125	150.688	150.688	151.938	151.938	151.313	0.012504	0.014886
0.04	0.03	1.006	1.006	1.007	1.007					1.0065					0.13	0.13	0.13	0.13	47.063	47.063	47.063	47.063	48.125	48.125	48.125	48.125	99.625	99.625	99.625	99.625	99.625	0.013482	0.016051
0.04	0.03	3.006	3.004	3.004	3.002					3.004					0.18	0.18	0.185	0.185	46.875	46.875	46.813	46.813	48.125	48.125	48.125	48.125	123.688	123.688	124.75	124.75	124.219	0.012663	0.015076
0.04	0.03	0.706	0.707	0.706	0.707	6.293	6.297	6.293	6.298	7.00175					0.245	0.245	0.25	0.25	46.625	46.625	46.563	46.563	48.125	48.125	48.125	48.125	150.313	150.313	151.5	151.5	150.9065	0.012048	0.014344
0.04	0.03	3.76	3.767	3.76	3.761	6.253	6.262	6.262	6.259	10.021					0.29	0.29	0.295	0.295	46.438	46.438	46.375	46.375	48.125	48.125	48.125	48.125	163.938	163.938	164.625	164.625	164.2815	0.011647	0.013666
0.04	0.03	4.772	4.768	4.77	4.77	6.25	6.234	6.25	6.234	11.012					0.3	0.3	0.305	0.305	46.313	46.313	46.313	46.313	48.125	48.125	48.125	48.125	171.875	171.875	173	173	172.4375	0.012707	0.015128
0.04	0.03	0.982	0.981	0.983	0.981					0.98175	6.94	6.93	8.04	10.2	0.115	0.115	0.12	0.12	47.188	47.188	47.125	47.125	48.125	48.125	48.125	48.125	99.813	99.813	101.188	101.188	100.5005	0.014115	0.016804
0.04	0.03	2.9734	2.967	2.97	2.968					2.9696	8.33	7.6	8.23	7.68	0.185	0.185	0.19	0.19	46.813	46.813	46.75	46.75	48.125	48.125	48.125	48.125	122.125	124.125	125	126.25	124.375	0.012823	0.015266
0.04	0.03	0.678	0.682	0.677	0.681	6.289	6.301	6.289	6.3	6.97425	8.07	7.82	8.11	7.8	0.255	0.26	0.26	0.27	46.563	46.563	46.563	46.5	48.125	48.125	48.125	48.125	147.75	149.75	151.125	153.688	150.5783	0.011967	0.014247
0.04	0.03	3.715	3.715	3.711	3.714	6.241	6.239	6.238	6.241	9.9535	7.52	7.66	7.6	7.56	0.29	0.29	0.295	0.3	46.5	46.438	46.438	46.375	48.125	48.125	48.125	48.125	166.813	164.75	168	167.875	166.8595	0.012399	0.014762
0.04	0.03	4.754	4.744	4.746	4.746	6.244	6.248	6.245	6.246	10.99325	7.029	7.163	7.046	7.11	0.305	0.3	0.31	0.31	46.5	46.438	46.438	46.375	48.125	48.125	48.125	48.125	169.688	169.813	171.188	172.75	170.8598	0.012249	0.014583
0.04	0.03	0.945	0.945	0.945	0.945					0.945	27.68	27.63	27.67	27.66	0.13	0.13	0.135	0.135	47.188	47.063	47.188	47	48.125	48.125	48.125	48.125	99.063	99.063	101.875	101.875	100.469	0.014031	0.016705
0.04	0.03	2.945	2.95	2.948	2.947					2.9475	28.67	28.66	28.69	28.6	0.18	0.18	0.185	0.19	46.875	46.875	46.813	46.813	48.125	48.125	48.125	48.125	126.438	122.875	127.875	125.938	125.7815	0.013344	0.015887
0.04	0.03	0.641	0.63	0.641	0.632	6.303	6.317	6.3	6.316	6.945	27.61	27.55	27.6	27.51	0.235	0.24	0.24	0.25	46.5	46.5	46.438	46.438	48.125	48.125	48.125	48.125	150.813	150	152.75	153.313	151.719	0.012346	0.014698
0.04	0.03	3.667	3.662	3.663	3.6631	6.273	6.261	6.27	6.259	9.929525	26.49	26.29	26.39	26.28	0.29	0.29	0.295	0.3	46.3751	46.375	46.313	46.313	48.125	48.125	48.125	48.125	168.5	166.063	170.188	169.125	168.469	0.012858	0.015308
0.04	0.03	4.721	4.717	4.72	4.718	6.243	6.238	6.241	6.24	10.9595	27.34	27.35	27.38	27.38	0.3	0.3	0.305	0.31	46.25	46.25	46.188	46.188	48.125	48.125	48.125	48.125	171.625	169.5	175	173.125	172.3125	0.012694	0.015113
0.04	0.03	0.893	0.89	0.892	0.89					0.89125	52.62	52.94	52.89	52.47	0.125	0.125	0.13	0.13	47.063	47.063	47	47	48.125	48.125	48.125	48.125	99.125	99.125	100.5	100.5	99.8125	0.013597	0.016188
0.04	0.03	2.869	2.87	2.871	2.868					2.8695	52.8	52.86	52.71	52.96	0.19	0.19	0.195	0.195	46.813	46.813	46.75	46.75	48.125	48.125	48.125	48.125	124.375	124.375	125.813	125.813	125.094	0.013138	0.015641
0.04	0.03	0.614	0.613	0.613	0.612	6.286	6.294	6.285	6.288	6.90125	52.01	52.31	52.49	52.3	0.25	0.25	0.255	0.255	46.625	46.625	46.563	46.563	48.125	48.125	48.125	48.125	151.813	151.188	153.188	153.188	152.3443	0.012467	0.014842
0.04	0.03	3.568	3.567	3.567	3.568	6.264	6.265	6.267	6.264	9.8325	51.3	51.23	51.27	51	0.285	0.285	0.29	0.29	46.375	46.375	46.313	46.375	48.125	48.125	48.125	48.125	167.625	167.625	170.25	170.25	168.9375	0.013048	0.015534
0.04	0.03	4.682	4.672	4.681	4.667	6.232	6.226	6.233	6.222	10.90375	49.67	49.64	55.65	55.65	0.3	0.3	0.305	0.305	46.313	46.313	46.25	46.25	48.125	48.125	48.125	48.125	170.938	170.938	172.75	172.75	171.844	0.012545	0.014936
0.04	0.02	1.002	1.003	1.002	1.003					1.0025					0.11	0.11	0.115	0.115	47.063	47.25	47	47.188	48.125	48.125	48.125	48.125	111.375	111.375	114.75	114.75	113.0625	0.012712	0.015134
0.04	0.02	3.015	3.013	3.013	3.014					3.01375					0.155	0.155	0.16	0.16	47	47	46.938	46.938	48.125	48.125	48.125	48.125	140.125	140.125	142	142	141.0625	0.010904	0.012982
0.04	0.02	0.677	0.674	0.675	0.675	6.327	6.328	6.328	6.328	7.003					0.205	0.205	0.21	0.21	46.875	46.875	46.813	46.813	48.125	48.125	48.125	48.125	175.375	175.375	178.563	178.563	176.969	0.011151	0.013276
0.04	0.02	3.713	3.715	3.716	3.715	6.297	6.296	6.298	6.298	10.012					0.27	0.27	0.275	0.275	46.625	46.625	46.563	46.563	48.125	48.125	48.125	48.125	207.438	207.438	208.063	208.063	207.7505	0.013778	0.016403
0.04	0.02	4.752	4.752	4.752	4.729	6.266	6.253	6.265	6.25	11.00475					0.285	0.285	0.29	0.29	46.563	46.563	46.5	46.5	48.125	48.125	48.125	48.125	209.938	209.938	212.125	212.125	211.0315	0.013227	0.015747
0.04	0.02	0.988	0.988	0.986	0.986					0.987	7.89	7.85	7.92	7.98	0.119	0.119	0.123	0.123	47.25	47.25	47.188	47.188	48.125	48.125	48.125	48.125	113.125	113.125	114	114	113.5625	0.012833	0.015279
0.04	0.02	2.973	2.967	2.977	2.968					2.97125	8.45	7.95	10.89	11.95	0.16	0.16	0.165	0.165	47.063	47	47	46.938	48.125	48.125	48.125	48.125	138.688	140.375	141	143.188	140.8128	0.010881	0.012954
0.04	0.02	0.693	0.689	0.689	0.688	6.312	6.305	6.317	6.305	6.9995	7.95	7.95	8.23	8.44	0.22	0.225	0.225	0.235	46.875	46.813	46.813	46.75	48.125	48.125	48.125	48.125	177.25	177.813	180	181.313	179.094	0.011608	0.01382
0.04	0.02	3.766	3.768	3.766	3.767	6.276	6.27	6.276	6.265	10.0385	8.79	8.84	8.84	8.88	0.275	0.285	0.28	0.275	46.75	46.625	46.688	46.563	48.125	48.125	48.125	48.125	205.625	205.265	208.125	208.125	206.785	0.013494	0.016065
0.04	0.02	4.68	4.668	4.679	4.675	6.252	6.256	6.253	6.257	10.93	8.891	8.877	8.906	8.958	0.28	0.27	0.285	0.28	46.625	46.688	46.563	46.625	48.125	48.125	48.125	48.125	212.438	210.625	214	213.375	212.6095	0.01363	0.016227
0.04	0.02	0.93	0.931	0.931	0.93					0.9305	28.42	28.42	28.42	28.41	0.1	0.1	0.104	0.104	47.25	47.25	47.188	47.188	48.125	48.125	48.125	48.125	113.563	113.563	114.375	114.375	113.969	0.013258	0.015785
0.04	0.02	2.943	2.94	2.942	2.939					2.941	27.36	27.25	27.25	27.21	0.16	0.16	0.165	0.165	47.063	47.063	47	47	48.125	48.125	48.125	48.125	140.625	140.625	141.688	141.688	141.1565	0.011028	0.013129
0.04	0.02	0.635	0.63	0.635	0.63	6.305	6.307	6.305	6.308	6.93875	26.46	26.66	26.58	26.77	0.225	0.225	0.23	0.23	46.75	46.75	46.688	46.688	48.125	48.125	48.125	48.125	181.813	181.813	183.75	183.75	182.7815	0.012556	0.014948
0.04	0.02	3.69	3.691	3.693	3.69	6.279	6.286	6.285	6.29	9.976	27.01	26.81	27.06	26.59	0.26	0.26	0.265	0.265	46.688	46.688	46.625	46.625	48.125	48.125	48.125	48.125	204.75	204.75	208.25	208.25	206.5	0.013459	0.016024
0.04	0.02	4.692	4.693	4.69	4.693	6.245	6.243	6.245	6.244	10.93625	25.36	25.37	26.42	26.4	0.265	0.265	0.27	0.27	46.688	46.688	46.625	46.625	48.125	48.125	48.125	48.125	209.813	209.813	212.125	212.125	210.969	0.013224	0.015744
0.04	0.02	0.884	0.884	0.885	0.885					0.8845	52.06	52.06	52.04	52.05	0.1	0.105	0.105	0.11	47.375	47.25	47.3125	47.1875	48.125	48.125	48.125	48.125	114.4375	114.6875	117	117	115.7813	0.014121	0.016812
0.04	0.02	2.873	2.87	2.871	2.87					2.871	53.37	53.43	53.36	53.44	0.155	0.16	0.16	0.165	47.1875	47.125	47.125	47.0625	48.125	48.125	48.125	48.125	140.125	140.125	142.375	142.375	141.25	0.011	0.013096
0.04	0.02	0.561	0.561	0.56	0.56	6.313	6.316	6.315	6.32	6.8765	51.83	51.88	52.02	52.02	0.22	0.225	0.225	0.23	46.9375	46.875	46.875	46.8125	48.125	48.125	48.125	48.125	180.6875	178.3125	182	187.6875	182.1719	0.012397	0.014759
0.04	0.02	3.62	3.679	3.623	3.623	6.27	6.266	6.262	6.265	9.902	51.95	51.92	52	51.87	0.275	0.26	0.28	0.27	46.75	46.75	46.6875	46.6875	48.125	48.125	48.125	48.125	203.125	203	206.188	206.1875	204.6251	0.013041	0.015526
0.04	0.02	4.665	4.643	4.656	4.648	6.245	6.248	6.244	6.25	10.89725	52.72	52.96	52.69	52.96	0.28	0.28	0.285	0.29	46.6875	46.6875	46.5625	46.5625	48.125	48.125	48.125	48.125	209.5625	210	212.4375	213	211.25	0.013253	0.015778

Table B3.2 TxDOT concrete surface data

Rain Data - Smooth Concrete																																			
SL (%)	SX (%)	QWALL (CFS)				Qfloor (CFS)				Qtotal	Rainfall (gpm)				Depth (ft)				Spread Dist T1 (in)				Curb Distance (in)				Spread Dist T2 (in)				AVG	n value	
		Initial		Final		Initial		Final		AVG	Initial		Final		Min		Max		T1min		T2max		Cmin		Cmax		T1min		T2max		Spread	Geometric	Integrated
		1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	CFS	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	In		
0.04	0.01	0.999	1	0.998	1					0.99925					0.095	0.09	0.1	0.095	47.5	47.5	47.4375	47.4375	48.125	48.125	48.125	48.125	148.063	148.0625	151.75	151.75	149.9064	0.013109	0.015607
0.04	0.01	2.99	2.99	2.99	2.99					2.99					0.12	0.12	0.125	0.13	47.25	47.25	47.1875	47.1875	48.125	48.125	48.125	48.125	202	201.875	205.875	206.875	204.1563	0.013683	0.01629
0.04	0.01	4.999	5	5	5					4.99975					0.14	0.14	0.145	0.145	47.125	47.125	47.0625	47.0625	48.125	48.125	48.125	48.125	230	230	241	241	235.5	0.013345	0.015888
										0																					0		
										0																					0		
0.04	0.01	0.972	0.974	0.973	0.974					0.97325	8.68	8.71	8.683	8.722	0.095	0.085	0.1	0.09	47.5	47.4375	47.4375	47.375	48.125	48.125	48.125	48.125	148	149.75	151.6875	153.75	150.7969	0.013493	0.016064
0.04	0.01	2.972	2.973	2.98	2.979					2.976	5.083	5.025	9.071	9.056	0.13	0.13	0.135	0.135	47.1875	47.1875	47.125	47.125	48.125	48.125	48.125	48.125	206.25	204.5625	208	208.375	206.5469	0.014233	0.016946
0.04	0.01	4.975	4.976	4.979	4.98					4.9775	6.967	5.988	9.986	9.991	0.145	0.15	0.15	0.155	47.1875	47.1875	47.125	47.125	48.125	48.125	48.125	48.125	236.25	234.875	238	241.1875	237.3281	0.013662	0.016266
										0																					0		
										0																					0		
0.04	0.01	0.935	0.937	0.937	0.937					0.9365	26.03	26.13	26.73	26.18	0.085	0.085	0.088	0.088	47.375	47.375	47.3125	47.3125	48.125	48.125	48.125	48.125	152.75	152.75	159.75	159.75	156.25	0.01555	0.018513
0.04	0.01	2.946	2.944	2.943	2.948					2.94525	25.43	25.49	26.04	26	0.135	0.135	0.14	0.14	47.1875	47.1875	47.125	47.125	48.125	48.125	48.125	48.125	207	207	217.25	217.25	212.125	0.015584	0.018554
0.04	0.01	4.936	4.942	4.949	4.937					4.941	25.47	25.49	26.71	26.7	0.155	0.155	0.16	0.16	47.1875	47.1875	47.125	47.125	48.125	48.125	48.125	48.125	235.5	235.5	238.5625	238.5625	237.0313	0.013591	0.016181
										0																					0		
										0																					0		
0.04	0.01	0.869	0.87	0.869	0.871					0.86975	51.84	51.83	51.79	51.96	0.087	0.087	0.09	0.09	47.375	47.375	47.3125	47.3125	48.125	48.125	48.125	48.125	150	150	163	163	156.5	0.015888	0.018915
0.04	0.01	2.887	2.891	2.889	2.888					2.88875	46.95	46.99	59.02	59.75	0.125	0.125	0.13	0.13	47.375	47.3125	47.3125	47.25	48.125	48.125	48.125	48.125	203.6875	206.6875	205	209.6875	206.2656	0.014074	0.016756
0.04	0.01	4.87	4.871	4.872	4.872					4.87125	52.63	52.71	52.64	52.67	0.15	0.15	0.155	0.155	47.1875	47.1875	47.125	47.125	48.125	48.125	48.125	48.125	234.625	239.25	237.6875	243.5	238.7656	0.013967	0.016628
										0																					0		
										0																					0		
0.04	0.005	0.985	0.99	0.986	0.986					0.98675					0.07	0.07	0.075	0.075	47.5	47.5	47.4375	47.4375	48.125	48.125	48.125	48.125	189	189	210	210	199.5	0.012163	0.014481
										0																					0		
										0																					0		
										0																					0		
										0																					0		
0.04	0.005	0.977	0.977	0.976	0.977					0.97675	7.008	6.983	7.193	7.041	0.061	0.061	0.064	0.064	47.5625	47.5625	47.5	47.5	48.125	48.125	48.125	48.125	193	193	214.25	214.25	203.625	0.012957	0.015426
										0																					0		
										0																					0		
										0																					0		
										0																					0		
0.04	0.005	0.932	0.933	0.933	0.933					0.93275	25.21	25.18	25.3	25.37	0.065	0.065	0.069	0.069	47.5625	47.5625	47.625	47.625	48.125	48.125	48.125	48.125	189.5	189.5	218	218	203.75	0.013142	0.015647
										0																					0		
										0																					0		
										0																					0		
										0																					0		
0.04	0.005	0.898	0.898	0.898	0.897					0.89775	51.62	51.98	51.81	51.91	0.069	0.069	0.068	0.068	47.5625	47.5625	47.5	47.5	48.125	48.125	48.125	48.125	194	194	221	221	207.5	0.013649	0.01625
										0																					0		
										0																					0		
										0																					0		
										0																					0		
0.03	0.005	0.994	0.995	0.995	0.996					0.995					0.07	0.068	0.08	0.07	47.625	47.563	47.688	47.5	48.125	48.125	48.125	48.125	215	215	216	216	215.5	0.013478	0.016046
0.03	0.005									0																					0		
0.03	0.005									0																					0		
0.03	0.005									0																					0		
0.03	0.005									0																					0		
0.03	0.005	0.976	0.979	0.98	0.978					0.97825	6.95	6.79	8.45	8.53	0.075	0.07	0.08	0.075	47.625	47.625	47.563	47.563	48.125	48.125	48.125	48.125	220	220	221	221	220.5	0.014539	0.01731
0.03	0.005									0																					0		
0.03	0.005									0																					0		
0.03	0.005									0																					0		
0.03	0.005									0																					0		
0.03	0.005	0.93	0.933	0.932	0.932					0.93175	27.5	27.52	27.54	27.5	0.7	0.7	0.8	0.73	47.625	47.625	47.5	47.563	48.125	48.125	48.125	48.125	220	220	221	221	220.5	0.013997	0.016664
0.03	0.005									0																					0		
0.03	0.005									0																					0		
0.03	0.005									0																					0		
0.03	0.005									0																					0		
0.03	0.005	0.88	0.88	0.88	0.879					0.87975	53.9	54.3	53.98	54.32	0.075	0.08	0.08	0.083	47.688	47.625	47.625	47.563	48.125	48.125	48.125	48.125	222	222	223	223	222.5	0.014941	0.017788
0.03	0.005									0																					0		
0.03	0.005									0																					0		
0.03	0.005									0																					0		
0.03	0.005									0																					0		

Table B3.3 TxDOT concrete surface data

Rain Data - Smooth Concrete																																								
SL (%)	SX (%)	QWALL (CFS)				Qfloor (CFS)				Qtotal	Rainfall (gpm)				Depth (ft)				Spread Dist T1 (in)				Curb Distance (in)				Spread Dist T2 (in)				AVG	n value	
		Initial		Final		Initial		Final		AVG	Initial		Final		Min		Max		T1min		T2max		Cmin		Cmax		T1min		T2max		Spread	Geometric	Integrated
		1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	CFS	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	In		
0.03	0.01	0.996	0.996	0.997	0.996					0.99625					0.095	0.095	0.09	0.095	47.375	47.375	47.375	47.375	48.125	48.125	48.125	48.125	154	154	162	162	158	0.014021	0.016693
0.03	0.01	3.02	3.022	3.023	3.018					3.02075					0.14	0.14	0.145	0.145	47.25	47.25	47.25	47.25	48.125	48.125	48.125	48.125	206.063	206.063	207.5	207.5	206.7815	0.012233	0.014564
0.03	0.01									0																					0		
0.03	0.01									0																					0		
0.03	0.01									0																					0		
0.03	0.01	0.974	0.975	0.974	0.975					0.9745	6.7	6.62	6.7	6.63	0.095	0.08	0.1	0.09	47.438	47.375	47.375	7.313	48.125	48.125	48.125	48.125	157.75	157.75	162	161.375	159.7188	0.014656	0.017449
0.03	0.01	2.968	2.966	2.97	2.969					2.22625	7.6	7.7	7.64	7.6	0.135	0.138	0.14	0.14	47.188	47.188	47.125	47.125	48.125	48.125	48.125	48.125	206	206	206.75	206.75	206.375	0.012309	0.014655
0.03	0.01									0																					0		
0.03	0.01									0																					0		
0.03	0.01									0																					0		
0.03	0.01	0.937	0.939	0.938	0.939					0.93825	26.05	26.04	27.19	26.99	0.095	0.09	0.1	0.095	47.5	47.375	47.3375	47.313	48.125	48.125	48.125	48.125	157.5	158.188	162.688	162.063	160.1098	0.014695	0.017495
0.03	0.01	2.959	0.955	2.955	2.959					2.457	25.44	25.45	26.35	26.36	0.14	0.14	0.145	0.145	47.125	47.125	47.125	47.125	48.125	48.125	48.125	48.125	206.063	206.063	208.813	208.813	207.438	0.012421	0.014788
0.03	0.01									0																					0		
0.03	0.01									0																					0		
0.03	0.01									0																					0		
0.03	0.01	0.886	0.892	0.884	0.889					0.88775	51.92	51.83	52	51.85	0.09	0.093	0.095	0.095	47.688	47.625	47.625	47.563	48.125	48.125	48.125	48.125	159.625	159.625	163.75	163.75	161.6875	0.015081	0.017955
0.03	0.01	2.89	2.887	2.888	2.887					2.888	53.12	53.16	53.13	53.17	0.135	0.135	0.14	0.14	47.188	47.25	47.125	47.188	48.125	48.125	48.125	48.125	206.375	206.375	210.5	210.5	208.4375	0.012659	0.015071
0.03	0.01									0																					0		
0.03	0.01									0																					0		
0.03	0.01									0																					0		
0.03	0.02	0.997	0.999	0.999	1					0.99875					0.115	0.115	0.117	0.12	47.125	47.125	47.0625	47.0625	48.125	48.125	48.125	48.125	117.75	116.375	118.75	119.75	118.1563	0.01349	0.016061
0.03	0.02	3.001	2.999	3	2.999					2.99975					0.175	0.175	0.19	0.19	46.75	46.75	46.6875	46.6875	48.125	48.125	48.125	48.125	149.5	148.0625	148.5	150.5625	149.1563	0.011885	0.01415
0.03	0.02	0.695	0.695	0.697	0.697	6.322	6.315	6.312	6.316	7.01225					0.23	0.23	0.235	0.235	46.6875	46.6875	46.625	46.625	48.125	48.125	48.125	48.125	184.25	184.8125	185.75	186.4375	185.3125	0.011411	0.013585
0.03	0.02	3.748	3.758	3.748	3.753	6.289	6.3	6.288	6.297	10.04525					0.27	0.27	0.28	0.28	46.5625	46.5625	46.5	46.5	48.125	48.125	48.125	48.125	211.75	210.625	212.25	212.25	211.7188	0.012704	0.015125
0.03	0.02	4.702	4.678	4.689	4.989	6.291	6.293	6.28	6.3	11.0555					0.28	0.28	0.285	0.285	46.5	46.4375	46.5	46.5	48.125	48.125	48.125	48.125	217	217.6875	218.375	218.625	217.9219	0.01275	0.015179
0.03	0.02	0.991	0.991	0.991	0.99					0.99075	8.8	8.819	8.795	8.81	0.12	0.12	0.12	0.125	47.0625	47.0625	47	47	48.125	48.125	48.125	48.125	119.625	119.125	120	119.75	119.625	0.014069	0.01675
0.03	0.02	2.979	2.978	2.978	2.978					2.97825	7.887	7.926	7.919	7.903	0.17	0.17	0.175	0.173	46.9375	46.9375	46.875	46.875	48.125	48.125	48.125	48.125	150.25	149.875	150.75	150.125	150.25	0.012189	0.014512
0.03	0.02	0.693	0.693	0.692	0.694	6.292	6.291	6.289	6.291	6.98375	8.017	7.962	8	7.955	0.235	0.23	0.24	0.235	46.5625	46.6875	46.625	46.625	48.125	48.125	48.125	48.125	188	186	188.6875	186.75	187.1094	0.011833	0.014088
0.03	0.02	3.746	3.744	3.745	3.745	6.26	6.262	6.249	6.252	10.00075	8.805	8.938	8.902	8.963	0.275	0.27	0.28	0.28	46.4375	46.375	46.5	46.4375	48.125	48.125	48.125	48.125	211.5	211.5	212.5	212.5	212	0.012811	0.015252
0.03	0.02	4.761	4.765	4.763	4.766	6.237	6.231	6.236	6.233	10.998	8.029	8.016	8.081	8.026	0.285	0.285	0.29	0.29	46.375	46.375	46.4375	46.4375	48.125	48.125	48.125	48.125	219.5	219.6875	220.75	220.5625	220.125	0.01325	0.015775
0.03	0.02	0.96	0.959	0.958	0.959					0.959	27.46	27.53	27.48	27.56	0.115	0.12	0.12	0.125	47.125	47.125	47.0625	47.1875	48.125	48.125	48.125	48.125	115.625	119.625	121.0625	121.4375	119.4375	0.013855	0.016495
0.03	0.02	2.943	2.942	2.94	2.942					2.94175	26.29	26.31	26.34	26.3	0.17	0.17	0.175	0.173	47.0625	46.8125	47	46.75	48.125	48.125	48.125	48.125	147.6875	147.6875	150	151.625	149.25	0.011873	0.014135
0.03	0.02	0.69	0.691	0.69	0.691	6.28	6.286	6.29	6.283	6.97525	25.91	26.02	26.02	26.01	0.24	0.235	0.245	0.24	46.6875	46.6875	46.625	46.625	48.125	48.125	48.125	48.125	187.25	187.125	188.1875	188.3125	187.7188	0.011907	0.014176
0.03	0.02	3.69	3.666	3.688	3.668	6.263	6.266	6.262	6.263	9.9415	27.5	24.68	27.46	24.18	0.275	0.275	0.28	0.28	46.375	46.4375	46.3125	46.375	48.125	48.125	48.125	48.125	210	210	213.25	213.25	211.625	0.012778	0.015213
0.03	0.02	4.678	4.678	4.677	4.681	6.28	6.27	6.275	6.273	10.953	26.24	26.19	26.2	26.15	0.285	0.28	0.29	0.285	46.4375	46.5	46.375	46.4375	48.125	48.125	48.125	48.125	217	217.375	219.75	218.375	218.125	0.012849	0.015298
0.03	0.02	0.88	0.882	0.881	0.881					0.881	52.12	51.94	52	51.83	0.115	0.12	0.12	0.125	47	47.125	47.0625	47.0625	48.125	48.125	48.125	48.125	118.1875	118.375	119.125	120	118.9219	0.013917	0.016569
0.03	0.02	2.893	2.901	2.894	2.899					2.89675	51.02	51.05	50.91	50.96	0.17	0.17	0.175	0.175	46.9375	46.9375	46.875	46.875	48.125	48.125	48.125	48.125	148	148	150	150	149	0.011751	0.01399
0.03	0.02	0.583	0.584	0.581	0.584	6.293	6.304	6.291	6.307	6.88175	52.05	52.06	52.05	52.07	0.235	0.235	0.24	0.24	46.75	46.6875	46.6875	46.625	48.125	48.125	48.125	48.125	181.3125	183.25	188	186.375	184.7344	0.011304	0.013458
0.03	0.02	3.707	3.708	3.708	3.706	6.268	6.27	6.266	6.271	9.976	51.06	51	51.07	50.96	0.275	0.27	0.28	0.28	46.5625	46.5	46.5	46.4375	48.125	48.125	48.125	48.125	209.75	209.75	216.4375	216.438	213.0939	0.012962	0.01542
0.03	0.02	4.64	4.637	4.639	4.639	6.255	6.25	6.252	6.25	10.8905	62.45	52.56	52.52	52.58	0.28	0.28	0.285	0.285	46.375	46.3125	46.3125	46.25	48.125	48.125	48.125	48.125	216.75	216.75	222	218.75	218.5625	0.012973	0.015445
0.03	0.03	0.997	0.995	0.996	0.994					0.9955					0.12	0.138	0.125	0.14	47.0625	47.0625	47	47	48.125	48.125	48.125	48.125	100.625	100.5	100.5625	102.8125	101.125	0.012741	0.015168
0.03	0.03	3.012	3.012	3.01	3.011					3.01125					0.195	0.195	0.2	0.2	46.75	46.75	46.6875	46.6875	48.125	48.125	48.125	48.125	127.75	128.6875	130.9375	130.625	129.5	0.013102	0.015598
0.03	0.03	0.684	0.685	0.685	0.684	6.339	6.324	6.34	6.326	7.01675					0.27	0.275	0.275	0.28	46.5625	46.5625	46.5	46.5	48.125	48.125	48.125	48.125	150.6875	154.625	156.8125	156	154.5313	0.011412	0.013586
0.03	0.03	3.715	3.712	3.716	3.714	6.323	6.298	6.327	6.297	10.0255					0.31	0.31	0.315	0.315	46.25	46.1875	46.25	46.125	48.125	48.125	48.125	48.125	160.4375	165.1875	168.5	168.875	165.75	0.010472	0.012467
0.03	0.03	4.716	4.721	4.72	4.722	6.282	6.29	6.289	6.293	11.00825					0.335	0.325	0.34	0.33	46.125	46.125	46.125	46.0625	48.125	48.125	48.125	48.125	166.8125	170	173.5	174.5	171.2031	0.010752	0.012801
0.03	0.03	0.948	0.94	0.941	0.94					0.94225	6.892	7.345	9.765	9.635	0.13	0.135	0.135	0.14	47	47	46.9375	46.9375	48.125	48.125	48.125	48.125	100.875	100.875	101.1875	102.1875	101.2813	0.013293	0.015826
0.03	0.03	2.99	2.986	2.989	2.987					2.988	7.896	8.134	7.677	8.091	0.195	0.2	0.2	0.205	46.625	46.6875	46.6875	46.625	48.125	48.125	48.125	48.125	127.938	127.9375	130.938	130.9375	129.4378	0.013114	0.015613
0.03	0.03	0.656	0.656	0.655	0.656	6.289	6.296	6.288	6.293	6.94725	7.339	7.328	7.415	7.201	0.27	0.28	0.275	0.27	46.5	46.5	46.4375	46.4375	48.125	48.125	48.125	48.125	152.6875	152.6875	155.375	155.375	154.0313	0.011364	0.013529
0.03	0.03	3.753	3.756	3.752	3.754	6.265	6.264	6.267	6.266	10.01925	8.222	8.275	8.263	8.289	0.32	0.32	0.325	0.325	46.3125	46.3125	46.375	46.375	48.125	48.125	48.125	48.125	168	168	169.5	169.5	168.75	0.011115	0.013232
0.03	0.03	4.725	4.733	4.73	4.732	6.235	6.228	6.233	6.226	10.9605	7.759	6.894	7.732	6.882	0.335	0.335	0.34	0.34	46.125	46.1875	46.1875	46.25	48.125	48.125	48.125	48.125	172.5	173.1875	174.75	174.8125	173.8125	0.01136	0.013525
0.03	0.03	0.94	0.94	0.941	0.941					0.9405	26.7	26.69	26.7	26.74	0.135	0.135	0.14	0.14	47.125	47.0625	47	47	48.125	48.125	48.125	48.125	101.25	101.25	103	103	102.125	0.013296	0.01583
0.03	0.03	2.951	2.95	2.95	2.951					2.9505	26.1	26.06	26.08	26.03	0.195	0.2	0.2	0.205	46.75	46.6875	46.6875	46.625	48.125	48.125	48.125	48.125	129.188	128.188	130	130	129.344	0.013051	0.015538
0.03	0.03	0.617	0.616	0.617	0.615	6.316	6.31	6.307	6.31	6.927	26.49	26.56	26.49	26.56	0.265	0.27	0.27	0.28	46.5	46.5	46.4375	46.4375	48.125	48.125	48.125	48.125	152	154.375	155.25	156.5	154.5313	0.011478	0.013665
0.03	0.03	3.677	3.667	3.678	3.666	6.283	6.268	6.294	6.267	9.95	25.65	28.08	25.63	28.09	0.325	0.33	0.33	0.335	46.25	46.25	46.1875	46.1875	48.125	48.125	48.125	48.125	164.75	164.75	168.438	168.4375	166.5939	0.010654	0.012684
0.03	0.03	4.642	4.641	4.643	4.645	6.273	6.28	6.278	6.28	10.9205	25.61	26.79	25.58	26.78	0.355	0.335	0.34	0.34	46.1875	46.1875	46.125	46.125	48.125	48.125	48.125	48.125	169	169	173.125	173.125	171.0625	0.01072	0.012763
0.03	0.03	0.879	0.884	0.88	0.882					0.88125	51.59	52.36	51.66	52.28	0.135	0.14	0.14	0.145	47	47	46.9375	46.9375	48.125	48.125	48.125	48.125	100.625	100.625	103.5	103.5	102.0625	0.013354	0.015898
0.03	0.03	2.893	2.895	2.894	2.898					2.895	52.18	53.16	52.22	53.19	0.2	0.2	0.205	0.205	46.4375	46.4375	46.5	46.5	48.125	48.125	48.125	48.125	130	130	131.563	131.563	130.7815	0.013746	0.016365
0.03	0.03	0.56	0.539	0.543	0.551	6.317	6.309	6.337	6.04	6.799	52.16	52.27	52.27	52.29	0.275	0.275	0.28	0.28	46.5625	46.5625	46.625	46.625	48.125	48.125	48.125	48.125	152.8125	152.8125	154.8125	154.8125	153.8125	0.011341	0.013503
0.03	0.03	3.566	3.568	3.57	3.568	6.285	6.28	6.282	6.282	9.85025	52.46	52.34	53.84	53.44	0.325	0.325	0.33	0.33	46.0625	46.0625	46.125	46	48.125	48.125	48.125	48.125	166.8125	166.8125	168.4375	168.4375	167.625	0.010983	0.013076
0.03	0.03	4.597	4.603	4.596	4.607	6.264	6.273	6.263	6.268	10.86775	52.6	52.43	52.62	52.24	0.335	0.335	0.34	0.34	46.0625	46.0625	46.0625	46.0625	48.125	48.125	48.125	48.125	171.375	171.375	173.25	173.25	172.3125	0.011028	0.013129

Table B3.4 TxDOT concrete surface data

Rain Data - Smooth Concrete																																	
SL (%)	SX (%)	QWALL (CFS)				Qfloor (CFS)				Qtotal	Rainfall (gpm)				Depth (ft)				Spread Dist T1 (in)				Curb Distance (in)				Spread Dist T2 (in)				AVG	n value	
		Initial		Final		Initial		Final		AVG	Initial		Final		Min		Max		T1min		T2max		Cmin		Cmax		T1min		T2max		Spread	Geometric	Integrated
		1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	CFS	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	In		
0.03	0.04	0.999	0.999	0.998	1					0.999					0.155	0.155	0.158	0.158	46.875	46.8125	46.875	46.8125	48.125	48.125	48.125	48.125	91.375	91.375	92	92	91.6875	0.012279	0.014619
0.03	0.04	3.011	3.011	3.012	3.011					3.01125					0.22	0.22	0.225	0.225	46.625	46.625	46.625	46.625	48.125	48.125	48.125	48.125	116.313	116.3125	117	117	116.6564	0.01342	0.015977
0.03	0.04	0.682	0.684	0.682	0.686	6.302	6.302	6.302	6.305	6.98625					0.315	0.315	0.32	0.32	46.4375	46.4375	46.4375	46.4375	48.125	48.125	48.125	48.125	141.25	141.25	142.875	142.875	142.0625	0.013254	0.015779
0.03	0.04	3.72	3.72	3.722	3.726	6.274	6.276	6.275	6.274	9.99675					0.34	0.34	0.345	0.345	46.25	46.25	46.25	46.25	48.125	48.125	48.125	48.125	152.625	152.625	153.5	153.5	153.0625	0.012455	0.014829
0.03	0.04	4.753	4.748	4.752	4.741	6.278	6.287	6.274	6.282	11.02875					0.36	0.36	0.365	0.365	46.125	46.125	46.125	46.125	48.125	48.125	48.125	48.125	155.3125	155.3125	156.0625	156.0625	155.6875	0.012068	0.014367
0.03	0.04	0.965	0.964	0.963	0.965					0.96425	7.613	7.446	7.512	7.514	0.15	0.155	0.16	0.16	46.875	46.875	46.8125	46.8125	48.125	48.125	48.125	48.125	91.5	91.5	93	93	92.25	0.012915	0.015376
0.03	0.04	2.983	2.982	2.982	2.984					2.98275	7.558	7.597	7.549	7.538	0.22	0.215	0.225	0.22	46.6875	46.75	46.75	46.6875	48.125	48.125	48.125	48.125	116.188	116.1875	117.25	117.25	116.7189	0.013453	0.016017
0.03	0.04	0.664	0.662	0.663	0.661	6.292	6.298	6.301	6.297	6.9595	7.605	7.934	7.842	7.771	0.318	0.318	0.32	0.32	46.25	46.25	46.125	46.3125	48.125	48.125	48.125	48.125	142.1875	142.75	142.75	142.75	142.6094	0.013546	0.016128
0.03	0.04	3.714	3.713	3.714	3.714	6.258	6.254	6.264	6.252	9.97075	7.212	7.157	7.194	7.15	0.34	0.34	0.345	0.345	46.1875	46.125	46.1875	46.1875	48.125	48.125	48.125	48.125	152.25	152.25	153.5	153.5	152.875	0.012431	0.0148
0.03	0.04	4.663	4.667	4.663	4.673	6.273	6.275	6.275	6.273	10.9405	8.081	8.032	7.982	8.155	0.355	0.355	0.36	0.36	46	46	46.0625	46.0625	48.125	48.125	48.125	48.125	154.625	154.625	155.5	155.5	155.0625	0.01199	0.014275
0.03	0.04	0.964	0.965	0.964	0.966					0.96475	24.38	24.42	24.39	24.42	0.15	0.15	0.155	0.155	46.875	46.875	46.9375	46.8125	48.125	48.125	48.125	48.125	92.5	92.5	93.125	93.125	92.8125	0.012862	0.015313
0.03	0.04	2.927	2.938	2.932	2.942					2.93475	25.13	26.09	25.11	26.42	0.215	0.22	0.22	0.225	46.625	46.6875	46.5625	46.625	48.125	48.125	48.125	48.125	115.25	115.25	115.25	116.25	115.5	0.012918	0.01538
0.03	0.04	0.648	0.631	0.649	0.652	6.281	6.284	6.282	6.287	6.9285	26.21	26.11	26.17	26.11	0.305	0.305	0.31	0.31	46.25	46.3125	46.3125	46.25	48.125	48.125	48.125	48.125	139.438	139.4375	142	142	140.7189	0.012831	0.015276
0.03	0.04	3.679	3.671	3.68	3.675	6.256	6.256	6.257	6.253	9.93175	27.37	27.3	27.32	27.32	0.34	0.345	0.345	0.35	46.0625	46.125	46.0625	46.0625	48.125	48.125	48.125	48.125	150	150	153	153	151.5	0.012029	0.014321
0.03	0.04	4.658	4.656	4.657	4.658	6.25	6.256	6.251	6.256	10.9105	27.28	27.25	28.47	27.3	0.38	0.38	0.385	0.385	46.0625	46.0625	46	46	48.125	48.125	48.125	48.125	152.75	152.75	156	156	154.375	0.01175	0.013989
0.03	0.04	0.882	0.889	0.881	0.888					0.885	52.03	52.02	51.97	52.06	0.133	0.155	0.16	0.16	46.9375	46.9375	46.9375	46.9375	48.125	48.125	48.125	48.125	92.6875	92.6875	93.1875	93.1875	92.9375	0.013147	0.015652
0.03	0.04	2.883	2.881	2.88	2.88					2.881	51.6	51.55	51.6	51.53	0.235	0.235	0.24	0.24	46.625	46.625	46.625	46.625	48.125	48.125	48.125	48.125	117	117	119.4375	119.438	118.2189	0.014293	0.017017
0.03	0.04	0.566	0.566	0.567	0.567	6.313	6.294	6.312	6.296	6.87025	51.77	51.73	51.8	51.85	0.305	0.305	0.31	0.31	46.3125	46.3125	46.3125	46.3125	48.125	48.125	48.125	48.125	139.625	139.625	140.6875	140.6875	140.1563	0.012612	0.015015
0.03	0.04	3.614	3.614	3.615	3.619	6.27	6.268	6.268	6.268	9.884	52.76	52.6	52.65	52.65	0.34	0.34	0.345	0.35	46.25	46.125	46.1875	46	48.125	48.125	48.125	48.125	149.75	150	154	153.125	151.7188	0.012072	0.014372
0.03	0.04	4.621	4.623	4.626	4.618	6.273	6.281	6.281	6.266	10.89725	51.64	51.59	51.52	51.51	0.385	0.38	0.39	0.385	46	46	46.0625	45.9375	48.125	48.125	48.125	48.125	153.75	152.125	156	156	154.4688	0.011741	0.013978
0.02	0.04	1.002	1	1	1					1.0005					0.185	0.175	0.19	0.18	47.063	47.063	47.188	47.188	48.125	48.125	48.125	48.125	98.813	96.125	96.813	96.125	96.969	0.012888	0.015344
0.02	0.04	3.005	3.004	3.004	3.006					3.00475					0.23	0.23	0.24	0.245	47.125	47	47.188	47.125	48.125	48.125	48.125	48.125	122.063	122.063	122.125	122.188	122.1098	0.013186	0.015699
0.02	0.04	0.718	0.718	0.717	0.718	6.354	6.35	6.353	6.344	7.068					0.316	0.315	0.315	0.32	46.625	46.688	46.688	46.688	48.125	48.125	48.125	48.125	150.688	150.375	151.125	150.688	150.719	0.013437	0.015997
0.02	0.04	3.731	3.731	3.733	3.735	6.309	6.314	6.31	6.318	10.04525					0.375	0.37	0.38	0.38	46.438	46.438	46.563	46.563	48.125	48.125	48.125	48.125	162.125	162.625	162.5	163.375	162.6563	0.012652	0.015063
0.02	0.04	4.731	4.731	4.733	4.735	6.298	6.297	6.299	6.3	11.031					0.4	0.4	0.405	0.405	46.5	46.438	46.563	46.438	48.125	48.125	48.125	48.125	163.625	163.625	165.563	165.563	164.594	0.012076	0.014377
0.02	0.04	0.961	0.961	0.96	0.962					0.961	6.235	6.392	8.863	8.568	0.18	0.18	0.185	0.185	47.4375	47.5	47.5	47.5625	48.125	48.125	48.125	48.125	96.6875	96.125	96.5	96.1875	96.375	0.012826	0.015269
0.02	0.04	2.975	2.983	2.976	2.984					2.9795	8.884	8.899	8.897	8.912	0.235	0.22	0.245	0.225	47	47	47.0625	47.0625	48.125	48.125	48.125	48.125	122.3125	122.4375	123.375	122.5625	122.6719	0.013518	0.016094
0.02	0.04	0.708	0.707	0.707	0.707	6.289	6.276	6.278	6.274	6.9865	6.994	6.989	8.048	8.053	0.315	0.33	0.32	0.34	46.5	46.5625	46.5625	46.625	48.125	48.125	48.125	48.125	150.6875	150.6875	150.5	150.5	150.5938	0.013537	0.016117
0.02	0.04	3.514	3.516	3.513	3.518	6.228	6.233	6.234	6.218	9.7435	7.912	7.866	7.888	7.824	0.39	0.385	0.395	0.39	46.5625	46.625	46.625	46.6875	48.125	48.125	48.125	48.125	162.3125	162.3125	163.375	163.375	162.8438	0.01302	0.0155
0.02	0.04	4.676	4.674	4.679	4.676	6.222	6.224	6.225	6.226	10.9005	7.15	7.155	7.132	7.154	0.395	0.395	0.405	0.405	46.625	46.3125	46.6875	46.4375	48.125	48.125	48.125	48.125	164.75	165	165.8125	166.0625	165.4063	0.012368	0.014725
0.02	0.04	0.995	0.99	0.994	0.994					0.99325	25.55	25.54	25.55	25.51	0.175	0.175	0.18	0.18	47.1875	47.5625	47.125	47	48.125	48.125	48.125	48.125	96.0625	96.75	98.1875	98.1875	97.29688	0.012826	0.015269
0.02	0.04	2.972	2.968	2.97	2.967					2.96925	24.91	24.9	24.89	24.89	0.24	0.24	0.245	0.245	47.125	47.0625	47	47	48.125	48.125	48.125	48.125	123	123	123	123	123	0.013518	0.016094
0.02	0.04	0.668	0.667	0.667	0.667	6.334	6.335	6.334	6.338	7.0025	25.67	25.66	25.66	25.66	0.325	0.325	0.33	0.33	46.75	46.8125	46.6875	46.625	48.125	48.125	48.125	48.125	150.375	150.375	151.875	151.087	150.928	0.013537	0.016117
0.02	0.04	3.699	3.695	3.698	3.697	6.279	6.287	6.28	6.297	9.983	25.79	25.68	25.6	25.7	0.385	0.385	0.395	0.395	46.4375	46.1875	46.3125	46.3125	48.125	48.125	48.125	48.125	162.5	162.5	163.5625	163.5625	163.0313	0.01302	0.0155
0.02	0.04	4.677	4.678	4.677	4.673	6.244	6.236	6.233	6.237	10.91375	27.06	26.86	27.09	26.88	0.405	0.405	0.415	0.415	46.125	46.1875	46.1875	46.25	48.125	48.125	48.125	48.125	165.8125	165.8125	166.9375	166.9375	166.375	0.012368	0.014725
0.02	0.04	0.908	0.906	0.907	0.906					0.90675	53.1	53.1	53.12	53.12	0.185	0.18	0.185	0.185	47.3125	47.375	47.375	47.4375	48.125	48.125	48.125	48.125	95	95	95.125	95.125	95.0625	0.011466	0.013651
0.02	0.04	2.897	2.897	2.896	2.897					2.89675	51.19	51.26	51.24	51.25	0.235	0.235	0.24	0.24	47	47	47.0625	47.0625	48.125	48.125	48.125	48.125	121.8125	121.8125	121.8125	121.8125	121.8125	0.013055	0.015542
0.02	0.04	0.674	0.678	0.676	0.678	6.241	6.242	6.243	6.239	6.91775	50.94	51.15	51.16	51.16	0.315	0.34	0.32	0.345	46.75	46.8125	46.8125	46.8125	48.125	48.125	48.125	48.125	150.375	150.375	151.3125	151.3125	150.8438	0.013487	0.016067
0.02	0.04	3.617	3.615	3.618	3.618	6.226	6.226	6.223	6.222	9.84125	51.96	51.84	51.94	51.79	0.385	0.385	0.39	0.39	46.4375	46.625	46.5	46.6875	48.125	48.125	48.125	48.125	162.125	162.125	163.0625	163.0625	162.5938	0.012714	0.015137
0.02	0.04	4.686	4.691	4.682	4.695	6.22	6.22	6.217	6.218	10.90725	54.41	54.42	54.42	54.46	0.395	0.395	0.405	0.405	46	46.125	46.125	46.1875	48.125	48.125	48.125	48.125	168	168	168.125	168.125	168.0625	0.013116	0.015616
0.02	0.03	0.991	0.99	0.991	0.99					0.9905					0.165	0.16	0.17	0.162	47.3125	47.5	47.4375	47.4375	48.125	48.125	48.125	48.125	102.125	102.125	103.25	103.25	102.6875	0.010995	0.01309
0.02	0.03	2.99	2.989	2.99	2.986					2.98875					0.225	0.22	0.23	0.225	47.375	47.3125	47.4375	47.25	48.125	48.125	48.125	48.125	132.125	132.125	132.75	132.75	132.4375	0.011559	0.013762
0.02	0.03	0.705	0.704	0.706	0.702	6.301	6.3	6.3	6.298	7.004					0.295	0.295	0.3	0.3	47.0625	47	47.125	46.9375	48.125	48.125	48.125	48.125	168.0625	168.0625	168.4375	168.438	168.2501	0.0127	0.015119
0.02	0.03	3.739	3.74	3.74	3.738	6.247	6.251	6.25	6.247	9.988					0.34	0.345	0.345	0.35	46.6875	46.875	46.75	46.8125	48.125	48.125	48.125	48.125	182.0625	182.0625	182.4375	182.4375	182.25	0.011965	0.014245
0.02	0.03	4.785	4.78	4.778	4.776	6.224	6.228	6.229	6.225	11.00625					0.365	0.365	0.37	0.365	46.75	46.6875	46.8125	46.75	48.125	48.125	48.125	48.125	186.25	186.25	185.75	185.75	185.75	0.011618	0.013832
0.02	0.03	0.977	0.98	0.977	0.977					0.97775	7.982	7.929	8.083	8.035	0.16	0.16	0.165	0.165	47.1875	47.1875	47.25	47.25	48.125	48.125	48.125	48.125	104.75	104.75	105.1875	105.1875	104.9688	0.012293	0.014636
0.02	0.03	2.977	2.973	2.972	2.975					2.97425	7.282	7.229	7.897	7.987	0.22	0.22	0.225	0.225	47.6875	47.6875	47.75	47.75	48.125	48.125	48.125	48.125	135.1875	135.0625	135.8125	136	135.5156	0.012562	0.014955
0.02	0.03	0.725	0.726	0.725	0.726	6.275	6.273	6.28	6.269	6.99975	6.207	6.393	10.62	10.612	0.3	0.3	0.305	0.305	46.6875	46.5625	46.75	46.5625	48.125	48.125	48.125	48.125	168.4375	168.25	169.5	169.0625	168.8125	0.012934	0.015398
0.02	0.03	3.775	3.773	3.774	3.775	6.244	6.242	6.243	6.243	10.01725	7.585	7.545	7.561	7.594	0.325	0.335	0.33	0.355	46.4375	46.5	46.5	46.5625	48.125	48.125	48.125	48.125	183.4375	184.1875	184.4375	185.5	184.3906	0.0125	0.014882
0.02	0.03	4.78	4.775	4.779	4.772	6.223	6.24	6.224	6.242	11.00875	6.608	6.696	6.673	6.683	0.355	0.355	0.36	0.365	46.25	46.3125	46.3125	46.375	48.125	48.125	48.125	48.125	187.5	187.5625	188.75	188.75	188.1406	0.012253	0.014588
0.02	0.03	0.925	0.926	0.925	0.926					0.9255	26.66	26.68	26.68	26.68	0.165	0.16	0.17	0.165	47.25	47.5625	47.3125	47.5	48.125	48.125	48.125	48.125	105.0625	105.0625	105.3125	105.3125	105.1875	0.012466	0.014842
0.02	0.03	2.922	2.916	2.917	2.918					2.91825	25.34	25.39	25.34	25.44	0.225	0.22	0.23	0.225	47.375	47.4375	47.4375	47.4375	48.125	48.125	48.125	48.125	134.625	134.75	135.6875	135.5625	135.1563	0.012612	0.015015
0.02	0.03	0.632	0.632	0.632	0.632	6.289	6.291	6.287	6.288	6.92075	25.46	25.39	25.44	25.39	0.295	0.29	0.305	0.305	46.5625	46.625	46.625	46.6875	48.125	48.125	48.125	48.125	167.5	167.5625	168.625	168.625	168.0781	0.012814	0.015255
0.02	0.03	3.668	3.664	3.665	3.663	6.252	6.264	6.259	6.255	9.9225	25.8	26.1	25.81	26.09	0.345	0.35	0.355	0.36	46.4375	46.4375	46.5	46.5	48.125	48.125	48.125	48.125	183.5625	183.6875	185.0625	185	184.3281	0.01156	0.013763
0.02	0.03	4.686	4.691	4.684	4.693	6.222	6.223	6.222	6.22	10.91025	25.7	25.1	25.68	25.06	0.36	0.36	0.37	0.37	46.375	46.375	46.375	46.4375	48.125	48.125	48.125	48.125	187.375	187.375	188.8125	188.8125	188.0938	0.012283	0.014624
0.02	0.03	0.873	0.873	0.874	0.877					0.87425	52.28	52.28	52.48	51.54	0.16	0.16	0.165	0.165	47.0625	47.875	47.6875	47.8125	48.125	48.125	48.125	48.125	105.125	105.125	105.125	105.125	105.125	0.012252	0.014587
0.02	0.03	2.86	2.858	2.856	2.86					2.8585	52.62	52.6	52.64	52.76	0.22	0.22	0.225	0.225	47.125	47.6875	47.3125	47.625	48.125	48.125	48.125	48.125	135.125	135.125	135.875	135.875	135.5	0.01274	0.015167
0.02	0.03	0.562	0.563	0.562	0.564	6.308	6.305	6.306	6.309	6.86975	53.46	53.33	53.36	53.26	0.3	0.3	0.305	0.305	47.25	47.3125	47.3125	47.25	48.125	48.125	48.125	48.125	169.0625	169.0625	169.375	169.375	169.2188	0.012926	0.015389
0.02	0.03	3.625	3.623	3.62	3.622	6.237	6.235	6.237	6.23	9.85725	53.88	53.89	53.87	53.89	0.325	0.335	0.33	0.355	47.0625	47.0625	47.1875	47.125	48.125	48.125	48.125	48.125	183.6875	183.6875	184.0625	184.0625	183.875	0.012299	0.014642
0.02	0.03	4.656	4.655	4.657	4.655	6.213	6.208	6.203	6.209	10.864	51.13	51.3	51.28	51.25	0.355	0.355	0.36	0.365	46.3125	46.25	46.4375	46.375	48.125	48.125	48.125	48.125	187.875	188.0625	188.9375	188.5	188.3438	0.012346	0.014698

Table B3.5 TxDOT concrete surface data

Rain Data - Smooth Concrete																																	
SL (%)	SX (%)	QWALL (CFS)				Qfloor (CFS)				Qtotal	Rainfall (gpm)				Depth (ft)				Spread Dist T1 (in)				Curb Distance (in)				Spread Dist T2 (in)				AVG	n value	
		Initial		Final		Initial		Final		AVG	Initial		Final		Min		Max		T1min		T2max		Cmin		Cmax		T1min		T2max		Spread	Geometric	Integrated
		1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	CFS	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	In		
0.02	0.02	0.979	0.975	0.98	0.976					0.9775					0.13	0.135	0.135	0.14	47.25	47.25	47.3125	47.3125	48.125	48.125	48.125	48.125	122.0625	122.25	122.625	122.625	122.3906	0.013014	0.015494
0.02	0.02	3.006	3.004	3.007	3.005					3.0055					0.195	0.195	0.2	0.2	47	47	47.125	46.9375	48.125	48.125	48.125	48.125	159.0625	159.0625	159.0625	159.0625	159.0625	0.012302	0.014646
0.02	0.02	0.694	0.695	0.695	0.695	6.317	6.314	6.315	6.314	7.00975					0.25	0.25	0.26	0.255	46.75	46.75	46.8125	46.6875	48.125	48.125	48.125	48.125	187.125	187.125	187.125	187.125	187.125	0.009616	0.011449
0.02	0.02	3.724	3.721	3.721	3.72	6.283	6.278	6.272	6.283	10.0005					0.3	0.3	0.305	0.305	46.5	46.5625	46.5625	46.625	48.125	48.125	48.125	48.125	211.5625	211.5625	211.5625	211.5625	211.5625	0.010369	0.012345
0.02	0.02	4.738	4.725	4.739	4.721	6.255	6.261	6.257	6.259	10.98875					0.32	0.31	0.325	0.315	46.4375	46.5	46.5	46.5625	48.125	48.125	48.125	48.125	222.625	221.25	222.6875	222.9375	222.375	0.011192	0.013324
0.02	0.02	0.97	0.972	0.971	0.97					0.97075	8.971	8.992	8.972	8.993	0.13	0.13	0.135	0.135	47.25	47.25	47.25	47.25	48.125	48.125	48.125	48.125	125.5	125.3125	126.5625	126.5625	125.9844	0.014545	0.017317
0.02	0.02	2.972	2.973	2.971	2.971					2.97175	7.587	7.498	7.503	7.334	0.19	0.19	0.195	0.195	46.9375	46.9375	47	47	48.125	48.125	48.125	48.125	158.875	158.875	158.5625	159.5625	158.9688	0.012357	0.014712
0.02	0.02	0.694	0.692	0.693	0.694	6.305	6.307	6.303	6.304	6.998	8.634	8.642	8.793	8.749	0.255	0.255	0.26	0.26	46.6875	46.75	46.75	46.8125	48.125	48.125	48.125	48.125	186.0625	186.0625	187.0625	187.0625	186.5625	0.009497	0.011307
0.02	0.02	3.692	3.692	3.691	3.692	6.26	6.265	6.266	6.266	9.956	7.583	7.64	7.576	7.619	0.3	0.3	0.305	0.305	46.625	46.625	46.6875	46.6875	48.125	48.125	48.125	48.125	217.0625	217.0625	218.0625	218.0625	217.5625	0.011427	0.013604
0.02	0.02	4.691	4.697	4.693	4.697	6.257	6.25	6.258	6.249	10.948	8.536	8.423	8.369	8.172	0.31	0.31	0.32	0.32	46.5625	46.5625	46.625	46.625	48.125	48.125	48.125	48.125	224	224	226.9375	226.9375	225.4688	0.011737	0.013973
0.02	0.02	0.955	0.956	0.958	0.959					0.957	26.36	26.31	26.31	26.36	0.14	0.14	0.145	0.145	47.1875	47.1875	47.1875	47.1875	48.125	48.125	48.125	48.125	123.8125	122.625	123.8125	123.5	123.4375	0.013031	0.015514
0.02	0.02	2.947	2.944	2.943	2.944					2.9445	26.69	26.72	26.73	26.77	0.19	0.19	0.195	0.195	47.0625	47.0625	47.0625	47.0625	48.125	48.125	48.125	48.125	158.9375	158.9375	159.625	159.625	159.2813	0.012366	0.014722
0.02	0.02	0.642	0.638	0.639	0.639	6.308	6.3	6.301	6.298	6.94125	26.82	26.72	26.73	26.77	0.245	0.245	0.255	0.255	46.8125	46.8125	46.875	46.875	48.125	48.125	48.125	48.125	191.6875	191.6875	192.75	192.6875	192.2031	0.010578	0.012594
0.02	0.02	3.625	3.625	3.624	3.624	6.362	6.276	6.272	6.273	9.92	27.36	27.4	27.28	27.37	0.3	0.295	0.305	0.3	46.5625	46.5625	46.5625	46.5625	48.125	48.125	48.125	48.125	212.75	212.75	213.9375	213.9375	213.3438	0.009975	0.011876
0.02	0.02	4.74	4.739	4.738	4.74	6.237	6.24	6.238	6.24	10.978	26.22	26.37	26.23	26.39	0.31	0.31	0.315	0.315	46.5625	46.5625	46.5625	46.5625	48.125	48.125	48.125	48.125	220.9375	222.9375	222.4375	222.4375	222.1875	0.011105	0.013221
0.02	0.02	0.856	0.856	0.856	0.856					0.856	52.2	52.19	52.2	52.15	0.125	0.13	0.13	0.135	47.3125	47.3125	47.25	47.25	48.125	48.125	48.125	48.125	121.8125	121.8125	122	122	121.9063	0.012871	0.015324
0.02	0.02	2.849	2.855	2.849	2.856					2.85225	51.52	51.62	51.57	51.6	0.185	0.187	0.19	0.19	47.0625	47	47	46.9375	48.125	48.125	48.125	48.125	157.25	157.25	160	160	158.625	0.012353	0.014707
0.02	0.02	0.558	0.558	0.557	0.557	6.318	6.327	6.323	6.32	6.8795	50.95	51.01	50.98	51.05	0.235	0.25	0.24	0.255	46.875	46.6875	46.8125	46.75	48.125	48.125	48.125	48.125	188.5	188.5	189.375	191.625	189.5	0.010087	0.012009
0.02	0.02	3.604	3.601	3.605	3.6	6.277	6.278	6.274	6.282	9.88025	53.47	53.51	53.5	53	0.295	0.3	0.3	0.305	46.5625	46.625	46.6875	46.5625	48.125	48.125	48.125	48.125	212.4375	212.4375	212.4375	212.3125	212.4063	0.010508	0.01251
0.02	0.02	4.69	4.69	4.688	4.693	6.257	6.258	6.255	6.256	10.94675	51.5	51.51	51.48	51.52	0.325	0.33	0.33	0.335	46.5625	46.5	46.625	46.4375	48.125	48.125	48.125	48.125	220.75	220.75	224.25	223.375	222.2813	0.01109	0.013203
0.02	0.01	0.995	0.996	0.996	0.996					0.99575					0.105	0.105	0.11	0.11	47.4375	47.4375	47.5	47.5	48.125	48.125	48.125	48.125	155.5	155.5	159.375	159.375	157.4375	0.011232	0.013372
0.02	0.01	3.029	3.028	3.025	3.028					3.0275					0.15	0.15	0.16	0.16	47.25	47.125	47.3125	47.0625	48.125	48.125	48.125	48.125	198.75	207.5	200.5	211.3125	204.5156	0.009617	0.011449
0.02	0.01									0																					0		
0.02	0.01									0																					0		
0.02	0.01									0																					0		
0.02	0.01	0.99	0.992	0.991	0.993					0.9915	6.939	6.998	7.007	7.027	0.105	0.11	0.11	0.115	47.375	48.5	47.4375	47.4375	48.125	48.125	48.125	48.125	158.6875	158.6875	161.1875	161.1875	159.9375	0.011706	0.013937
0.02	0.01	2.956	2.953	2.955	2.957					2.95525	6.978	7.54	8.003	8.105	0.16	0.15	0.165	0.155	47.25	47.3125	47.1875	47.25	48.125	48.125	48.125	48.125	207.125	207.125	210.438	210.4375	208.7814	0.01048	0.012477
0.02	0.01									0																					0		
0.02	0.01									0																					0		
0.02	0.01									0																					0		
0.02	0.01	0.952	0.953	0.952	0.95					0.95175	26.23	26.24	26.21	26.29	0.105	0.11	0.11	0.115	47.4375	47.4375	47.375	47.375	48.125	48.125	48.125	48.125	157.3125	158.6875	160.5	161.25	159.4375	0.011632	0.013848
0.02	0.01	2.943	2.944	2.945	2.947					2.94475	25.36	25.33	25.47	25.47	0.155	0.16	0.16	0.165	47.25	47.25	47.1875	47.1875	48.125	48.125	48.125	48.125	202.5	210.625	206.5625	213.5	208.2969	0.010319	0.012285
0.02	0.01									0																					0		
0.02	0.01									0																					0		
0.02	0.01									0																					0		
0.02	0.01	0.867	0.867	0.866	0.866					0.8665	52.36	52.39	52.41	52.42	0.115	0.11	0.12	0.115	47.3125	47.3125	47.25	47.25	48.125	48.125	48.125	48.125	155.0625	155.375	157.625	161.25	157.3281	0.011397	0.013568
0.02	0.01	2.884	2.887	2.888	2.888					2.88675	52.02	52.06	52.03	52.05	0.155	0.16	0.16	0.165	47.125	47.1875	47.0625	47.125	48.125	48.125	48.125	48.125	203	210.0625	207.5	214.75	208.8281	0.010423	0.012409
0.02	0.01									0																					0		
0.02	0.01									0																					0		
0.02	0.01									0																					0		
0.02	0.005	0.999	0.998	0.997	0.998					0.998					0.095	0.095	0.1	0.1	47.5625	47.5625	47.625	47.625	48.125	48.125	48.125	48.125	212.0625	212.0625	212.0625	212.0625	212.0625	0.010364	0.012338
0.02	0.005									0																					0		
0.02	0.005									0																					0		
0.02	0.005									0																					0		
0.02	0.005									0																					0		
0.02	0.005	0.978	0.977	0.978	0.977					0.9775	7	7.13	8.503	8.409	0.085	0.09	0.09	0.095	47.625	47.5625	47.5625	47.625	48.125	48.125	48.125	48.125	215.75	215.75	218.5	218.5	217.125	0.011259	0.013404
0.02	0.005									0																					0		
0.02	0.005									0																					0		
0.02	0.005									0																					0		
0.02	0.005									0																					0		
0.02	0.005	0.928	0.926	0.927	0.927					0.927	25.23	25.22	25.21	25.23	0.095	0.09	0.1	0.095	47.6875	47.625	47.75	47.75	48.125	48.125	48.125	48.125	221	221	221	221	221	0.012101	0.014407
0.02	0.005									0																					0		
0.02	0.005									0																					0		
0.02	0.005									0																					0		
0.02	0.005									0																					0		
0.02	0.005	0.888	0.888	0.889	0.888					0.88825	52.41	52.39	52.39	52.36	0.095	0.095	0.1	0.1	47.5625	47.5625	47.5625	47.5625	48.125	48.125	48.125	48.125	217	217	217	217	217	0.011147	0.013271
0.02	0.005									0																					0		
0.02	0.005									0																					0		
0.02	0.005									0																					0		
0.02	0.005									0																					0		

Table B3.6 TxDOT concrete surface data

Rain Data - Smooth Concrete																																	
SL (%)	SX (%)	QWALL (CFS)				Qfloor (CFS)				Qtotal	Rainfall (gpm)				Depth (ft)				Spread Dist T1 (in)				Curb Distance (in)				Spread Dist T2 (in)				AVG	n value	
		Initial		Final		Initial		Final		AVG	Initial		Final		Min		Max		T1min		T2max		Cmin		Cmax		T1min		T2max		Spread	Geometric	Integrated
		1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	CFS	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	In		
0.015	0.04	0.987	0.988	0.988	0.989					0.988					0.19	0.19	0.195	0.195	47.6875	47.6875	47.6875	47.8125	49	49	49	49	98.5625	98.5625	98.875	98.875	98.71875	0.012331	0.014681
0.015	0.04	2.98	2.979	2.979	2.978					2.979					0.255	0.25	0.26	0.265	47.25	47.3125	47.25	47.375	49	49	49	49	124	124	124.1875	124.1875	124.0938	0.012246	0.014579
0.015	0.04	0.689	0.69	0.689	0.689	6.353	6.355	6.358	6.354	7.04425					0.335	0.345	0.34	0.35	46.9375	46.9375	47	46.8125	49	49	49	49	153.5625	153.6875	154.4375	155.1875	154.2188	0.012653	0.015064
0.015	0.04	3.68	3.682	3.68	3.68	6.324	6.328	6.323	6.327	10.006					0.395	0.4	0.405	0.41	46.875	46.875	46.9375	46.9375	49	49	49	49	167.0625	166.625	168.375	167.8125	167.4688	0.012135	0.014448
0.015	0.04	4.697	4.695	4.696	4.694	6.301	6.301	6.3	6.3	10.996					0.405	0.405	0.415	0.415	46.6875	46.6875	46.75	46.75	49	49	49	49	172.5625	172.5625	173.3125	173.9375	173.0938	0.012533	0.014921
0.015	0.04	0.955	0.956	0.954	0.954					0.95475	7.362	7.318	7.344	7.32	0.175	0.175	0.185	0.185	47.6875	48.9375	47.75	48.9375	49	49	49	49	99.125	99.6875	99.125	99.6875	99.40625	0.012609	0.015012
0.015	0.04	2.966	2.969	2.968	2.966					2.96725	7.942	7.754	7.933	7.813	0.265	0.265	0.27	0.27	47.3125	47.3125	47.4375	47.4375	49	49	49	49	124.5	124.5	124.5	124.5	124.5	0.012333	0.014683
0.015	0.04	0.69	0.692	0.69	0.691	6.322	6.316	6.313	6.317	7.00775	7.772	7.452	7.728	7.391	0.365	0.365	0.37	0.37	47	47	47.0625	47.0625	49	49	49	49	155.25	155.25	155.25	155.25	155.25	0.012947	0.015414
0.015	0.04	3.65	3.646	3.651	3.647	6.287	6.28	6.288	6.275	9.931	5.969	5.957	5.954	5.966	0.39	0.395	0.395	0.395	46.6875	46.75	46.75	46.8125	49	49	49	49	169.9375	169.9375	169.9375	169.9375	169.9375	0.01295	0.015418
0.015	0.04	4.703	4.7	4.704	4.701	6.283	6.276	6.291	6.274	10.983	8.004	8.104	8.099	8.154	0.395	0.4	0.405	0.405	46.75	46.75	46.8125	46.8125	49	49	49	49	174.1875	174.1875	174.1875	174.1875	174.1875	0.012812	0.015254
0.015	0.04	0.957	0.957	0.955	0.954					0.95675	26.19	26.17	26.18	26.19	0.2	0.195	0.205	0.205	47.625	47.6875	47.625	47.688	49	49	49	49	98.5625	98.4375	98.6875	98.75	98.60938	0.011962	0.014242
0.015	0.04	2.947	2.945	2.942	2.944					2.9445	26.24	26.26	26.23	26.23	0.255	0.25	0.26	0.255	47.4375	47.438	47.438	47.438	49	49	49	49	123.0625	123.625	124.5625	129.6875	125.2344	0.012614	0.015017
0.015	0.04	0.647	0.648	0.648	0.648	6.314	6.31	6.316	6.308	6.96975	26	26.04	26	26.01	0.335	0.355	0.34	0.36	47	46.9375	47.0625	47	49	49	49	49	153.5	153.5	153.5	153.5	153.5	0.01244	0.014811
0.015	0.04	3.675	3.67	3.675	3.668	6.273	6.281	6.278	6.281	9.95025	26.34	26.3	26.3	26.28	0.395	0.4	0.405	0.41	46.6875	46.6875	46.75	46.75	49	49	49	49	167.4375	167.875	168.875	168.8125	168.25	0.012397	0.014759
0.015	0.04	4.65	4.646	4.652	4.651	6.266	6.262	6.268	6.258	10.91325	26.52	26.5	26.53	26.51	0.405	0.405	0.415	0.415	46.6875	46.625	46.8125	46.6875	49	49	49	49	173.125	173.0625	173.9375	173.9375	173.5156	0.012678	0.015094
0.015	0.04	0.885	0.885	0.885	0.885					0.885	52.72	52.76	52.73	52.77	0.195	0.19	0.205	0.195	47.6875	47.6875	47.6875	48.8125	49	49	49	49	98.9375	98.4375	99	98.5625	98.73438	0.011999	0.014286
0.015	0.04	2.894	2.896	2.893	2.897					2.895	52.62	52.6	52.6	52.62	0.245	0.255	0.25	0.265	47.375	47.25	47.375	47.25	49	49	49	49	125.4375	125.8125	125.25	125.875	125.5938	0.012758	0.015189
0.015	0.04	0.542	0.543	0.542	0.545	6.323	6.312	6.314	6.312	6.86825	51.71	51.79	51.8	51.78	0.355	0.355	0.365	0.365	46.8125	46.9375	46.8125	46.9375	49	49	49	49	154.4375	154.4375	155.5625	155.5625	155	0.013026	0.015508
0.015	0.04	3.553	3.55	3.552	3.55	6.299	6.296	6.3	6.297	9.84925	51.46	51.49	51.5	51.48	0.41	0.405	0.405	0.41	46.75	46.75	46.75	46.75	49	49	49	49	169.375	169.25	170.4375	170.375	169.8594	0.012889	0.015345
0.015	0.04	4.548	4.552	4.549	4.55	6.28	6.286	6.285	6.289	10.83475	52.4	52.37	52.41	52.28	0.415	0.415	0.425	0.425	46.6875	46.625	46.75	46.6875	49	49	49	49	172.375	172.5	173.125	173.125	172.7813	0.012497	0.014879
0.015	0.03	0.989	0.992	0.989	0.993					0.99075					0.165	0.165	0.17	0.168	47.8125	47.875	47.75	47.8125	49	49	49	49	107.375	107.375	107.875	107.875	107.625	0.011776	0.01402
0.015	0.03	3.003	3.005	3.004	3.002					3.0035					0.235	0.234	0.24	0.24	47.5	47.5	47.375	47.4375	49	49	49	49	139.75	139.75	140.25	140.25	140	0.012473	0.014849
0.015	0.03	0.758	0.758	0.758	0.758	6.247	6.249	6.245	6.255	7.007					0.315	0.315	0.32	0.32	47.0625	47.125	47	47.4375	49	49	49	49	171.875	171.875	173.3125	173.313	172.5939	0.012034	0.014327
0.015	0.03	3.784	3.786	3.78	3.786	6.215	6.208	6.21	6.215	9.996					0.355	0.35	0.36	0.365	46.875	46.9375	46.8125	46.875	49	49	49	49	189.375	189.375	191.625	191.625	190.5	0.012113	0.014421
0.015	0.03	4.802	4.806	4.801	4.805	6.224	6.217	6.22	6.213	11.022					0.364	0.375	0.37	0.38	46.6875	46.875	46.625	46.75	49	49	49	49	192.75	192.75	195.25	195.25	194	0.011736	0.013973
0.015	0.03	0.985	0.985	0.984	0.985					0.98475	6.815	6.832	6.824	6.843	0.17	0.168	0.18	0.17	47.8125	47.8125	47.75	47.75	49	49	49	49	107.75	107.75	108.4375	108.438	108.0939	0.0119	0.014168
0.015	0.03	2.958	2.959	2.958	2.96					2.95875	7.36	7.481	7.361	7.461	0.225	0.235	0.23	0.24	47.5625	47.5625	47.5	47.5	49	49	49	49	139.813	139.813	140.25	140.25	140.0315	0.012573	0.014969
0.015	0.03	0.734	0.724	0.732	0.727	6.358	6.355	6.36	6.352	7.0855	7.454	7.144	7.143	7.094	0.315	0.315	0.32	0.32	47.125	47.1875	47.0625	47.125	49	49	49	49	172.3125	172.313	172.313	172.313	172.3129	0.011806	0.014056
0.015	0.03	3.684	3.689	3.685	3.69	6.314	6.318	6.31	6.319	10.00225	6.423	6.438	6.417	6.448	0.365	0.36	0.37	0.365	47	47.125	46.9375	47	49	49	49	49	189.8125	189.8125	189.8125	189.8125	189.8125	0.011888	0.014153
0.015	0.03	4.703	4.709	4.704	4.703	6.302	6.297	6.3	6.299	11.00425	6.428	6.499	6.453	6.532	0.37	0.365	0.38	0.37	47	46.9375	46.9375	46.875	49	49	49	49	195.375	195.375	196	196	195.6875	0.012069	0.014356
0.015	0.03	0.93	0.931	0.933	0.933					0.93175	25.1	25.08	25.08	25.07	0.17	0.165	0.175	0.17	48.0625	48	48	47.9375	49	49	49	49	107.6875	107.6875	108.1875	108.1875	107.9375	0.011875	0.014137
0.015	0.03	2.935	2.936	2.939	2.939					2.93725	26.04	26.09	26.05	26.03	0.235	0.235	0.24	0.24	47.625	47.6875	47.5625	47.625	49	49	49	49	140	140	140.625	140.625	140.3125	0.012558	0.014951
0.015	0.03	0.695	0.696	0.696	0.694	6.342	6.342	6.348	6.344	7.03925	25.26	25.27	25.27	25.26	0.32	0.32	0.33	0.325	47.25	47.25	47.1875	47.1875	49	49	49	49	173.688	173.688	173.75	173.75	173.719	0.01215	0.014465
0.015	0.03	3.726	3.732	3.734	3.729	6.325	6.313	6.325	6.319	10.05075	26.25	26.22	25.22	26.22	0.365	0.36	0.37	0.365	47.1875	47.125	47.1875	47.0625	49	49	49	49	190.75	190.75	193.375	193.375	192.0625	0.012263	0.014599
0.015	0.03	4.629	4.625	4.627	4.627	6.304	6.312	6.312	6.313	10.93725	26.98	26.97	26.96	26.97	0.37	0.365	0.38	0.37	47.125	47.0625	47.0625	47	49	49	49	49	194.313	194.313	195.5	195.5	194.9065	0.011887	0.014152
0.015	0.03	0.852	0.85	0.851	0.849					0.8505	52.72	52.76	52.73	52.77	0.17	0.17	0.175	0.175	48	47.9375	48	47.938	49	49	49	49	106.5	106.4375	107.5625	106.5	106.75	0.011492	0.013682
0.015	0.03	2.867	2.869	2.868	2.865					2.86725	52.62	52.6	52.6	52.62	0.245	0.23	0.25	0.235	47.6875	47.688	47.688	47.688	49	49	49	49	140.9375	140.938	141	141	140.9689	0.012819	0.015262
0.015	0.03	0.55	0.552	0.552	0.55	6.34	6.345	6.342	6.344	6.89375	51.71	51.79	51.8	51.78	0.315	0.32	0.32	0.325	47.1875	47.1875	47.25	47.25	49	49	49	49	174.6875	172.9375	174.6875	173.875	174.0469	0.012391	0.014752
0.015	0.03	3.572	3.575	3.574	3.576	6.326	6.326	6.32	6.317	9.8965	51.46	51.49	51.5	51.48	0.35	0.355	0.355	0.36	47.1875	47.0625	47.25	47.125	49	49	49	49	190.25	190.25	191.5	191.5	190.875	0.012115	0.014423
0.015	0.03	4.566	4.564	4.566	4.569	6.319	6.315	6.314	6.314	10.88175	52.4	52.37	52.41	52.28	0.375	0.37	0.38	0.38	47.0625	47.0625	47.125	47.125	49	49	49	49	196.0625	196.063	196.125	196.125	196.0939	0.012133	0.014445
0.015	0.02	1.01	1.007	1.01	1.008					1.00875					0.139	0.14	0.141	0.142	48.25	48.25	48.1875	48.188	49.4375	49.4375	49.4375	49.4375	129.375	128.75	129.375	128.75	129.0625	0.013297	0.015831
0.015	0.02	2.998	2.997	2.997	2.998					2.9975					0.205	0.205	0.21	0.21	47.875	47.9375	47.8125	47.875	49.4375	49.4375	49.4375	49.4375	166.125	166.875	166.125	166.875	166.5	0.01244	0.01481
0.015	0.02	0.793	0.793	0.792	0.791	6.24	6.233	6.244	6.237	7.03075					0.265	0.265	0.27	0.27	47.625	47.75	47.5625	47.625	49.4375	49.4375	49.4375	49.4375	207.625	208.375	207.625	208.375	208	0.01186	0.01412
0.015	0.02	3.81	3.804	3.812	3.806	6.215	6.19	6.209	6.192	10.0095					0.305	0.31	0.31	0.315	47.5625	47.625	47.4375	47.5	49.4375	49.4375	49.4375	49.4375	224.625	226.75	224.625	226.75	225.6875	0.011021	0.013122
0.015	0.02	4.767	4.766	4.767	4.764	6.197	6.195	6.198	6.192	10.9615					0.31	0.315	0.315	0.32	47.4375	47.5	47.3125	47.375	49.4375	49.4375	49.4375	49.4375	232.125	234.75	232.125	234.75	233.4375	0.011301	0.013454
0.015	0.02	0.963	0.961	0.962	0.961					0.96175	7.146	7.194	9.124	9.106	0.138	0.138	0.14	0.14	48.1875	48.25	48.125	48.1875	49.4375	49.4375	49.438	49.438	129	129	130	130	129.5	0.014169	0.016869
0.015	0.02	2.941	2.942	2.94	2.943					2.9415	7.363	7.286	7.288	7.287	0.205	0.203	0.21	0.205	47.875	48	47.8125	47.9375	49.4375	49.4375	49.438	49.438	164.875	164.875	167.0625	167.0625	165.9688	0.01252	0.014906
0.015	0.02	0.767	0.767	0.768	0.767	6.223	6.224	6.222	6.223	6.99025	8.246	8.306	8.054	7.985	0.265	0.26	0.27	0.265	47.5	47.75	47.5	47.6875	49.4375	49.438	49.438	49.438	208	208	209.375	209.375	208.6875	0.01204	0.014334
0.015	0.02	3.728	3.728	3.73	3.724	6.209	6.225	6.22	6.218	9.9455	6.782	6.758	7.438	7.418	0.305	0.305	0.31	0.31	47.4375	47.5	47.375	47.4375	49.4375	49.438	49.438	49.438	224.5	224.5	226	226	225.25	0.011017	0.013116
0.015	0.02	4.796	4.8	4.803	4.794	6.22	6.207	6.217	6.209	11.0115	7.69	7.693	7.726	7.75	0.31	0.315	0.315	0.32	47.3125	47.4375	47.1875	47.375	49.4375	49.438	49.438	49.438	229	229	231	231	230	0.010693	0.012731
0.015	0.02	0.943	0.94	0.94	0.94					0.94075	27.36	27.34	27.34	27.34	0.135	0.14	0.135	0.14	48.1875	48.188	48.25	48.1875	49.4375	49.438	49.438	49.438	129.875	129.25	130	129.25	129.5938	0.013644	0.016244
0.015	0.02	2.936	2.934	2.933	2.933					2.934	26.62	26.57	26.67	26.59	0.205	0.21	0.21	0.21	47.9375	48	47.8125	48	49.4375	49.4375	49.438	49.438	166.75	166.75	167	167	166.875	0.012545	0.014935
0.015	0.02	0.704	0.702	0.703	0.703	6.245	6.233	6.237	6.232	6.93975	27.74	27.79	27.76	27.82	0.25	0.25	0.26	0.26	47.8125	47.8125	47.875	47.8125	49.4375	49.438	49.438	49.438	208	208	208	208.4375	208.1094	0.011904	0.014172
0.015	0.02	3.7	3.698	3.696	3.696	6.219	6.215	6.222	6.212	9.9145	26.76	26.76	26.75	26.76	0.305	0.315	0.315	0.325	47.25	47.4375	47.25	47.5	49.4375	49.438	49.438	49.438	223.5	224.75	224.75	227.25	225.0625	0.010982	0.013075
0.015	0.02	4.762	4.76	4.76	4.763	6.21	6.21	6.209	6.209	10.97075	26.05	26.09	26.07	26.08	0.315	0.315	0.33	0.33	47.5625	47.5	47.5625	47.5625	49.4375	49.438	49.438	49.438	233.3125	233.3125	234.875	234.875	234.0938	0.01131	0.013465
0.015	0.02	0.897	0.896	0.896	0.897					0.8965	51.85	51.8	51.8	51.74	0.125	0.125	0.13	0.13	48.375	48.25	48.375	48.25	49.4375	49.438	49.438	49.438	128.3125	128.25	130.0625	130.125	129.1875	0.013301	0.015835
0.015	0.02	2.897	2.897	2.895	2.899					2.897	51.94	52	51.96	52.01	0.205	0.205	0.215	0.21	47.9375	48	48	48	49.4375	49.4375	49.438	49.438	167.375	167.375	167.8125	167.8125	167.5938	0.012654	0.015065
0.015	0.02	0.657	0.655	0.655	0.654	6.196	6.193	6.198	6.192	6.85	52.8	52.83	52.84	52.82	0.264	0.266	0.27	0.271	47.8125	47.8125	47.875	47.8125	49.4375	49.438	49.438	49.438	207.8125	207.8125	209.0625	209.0625	208.4375	0.012018	0.014308
0.015	0.02	3.65	3.644	3.649	3.643	6.199	6.199	6.198	6.2	9.8455	52.67	52.78	52.7	52.71	0.305	0.31	0.315	0.325	47.375	47.625	47.375	47.625	49.4375	49.438	49.438	49.438	224.5625	223.5625	225.875	224.625	224.6563	0.010904	0.012982
0.015	0.02	4.711	4.705	4.707	4.703	6.178	6.185	6.18	6.191	10.89	52.53	52.56	52.54	52.56	0.325	0.31	0.33	0.32	47.375	47.5	47.375	47.5	49.4375	49.438	49.438	49.438	229.5	230.5625	232.5625	232.0625	231.1719	0.010881	0.012964

Table B3.7 TxDOT concrete surface data

Rain Data - Smooth Concrete																																	
SL (%)	SX (%)	QWALL (CFS)				Qfloor (CFS)				Qtotal	Rainfall (gpm)				Depth (ft)				Spread Dist T1 (in)				Curb Distance (in)				Spread Dist T2 (in)				AVG	n value	
		Initial		Final		Initial		Final		AVG	Initial		Final		Min		Max		T1min		T2max		Cmin		Cmax		T1min		T2max		Spread	Geometric	Integrated
		1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	CFS	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	In		
0.015	0.01	0.976	0.976	0.977	0.976					0.97625					0.117	0.11	0.119	0.115	48.4375	48.4375	48.375	48.375	49.4375	49.4375	49.4375	49.4375	167.75	163.875	172.25	163.875	166.9375	0.012133	0.014445
0.015	0.01	2.969	2.967	2.97	2.966					2.968					0.163	0.16	0.166	0.165	48.3125	48.40625	48.25	48.4375	49.4375	49.4375	49.4375	49.4375	218.5	219.1875	218.25	218.25	218.5469	0.010454	0.012446
0.015	0.01									0																					0		
0.015	0.01									0																					0		
0.015	0.01									0																					0		
0.015	0.01	0.999	0.997	1.001	0.998					0.99875	8.267	7.798	8.157	7.832	0.115	0.11	0.117	0.115	48.5	48.4375	48.4375	48.375	49.4375	49.438	49.438	49.438	171.375	169.6875	172.375	171.6875	171.2813	0.012773	0.015207
0.015	0.01	2.993	2.998	2.996	2.999					2.9965	7.667	7.698	7.163	7.153	0.17	0.16	0.17	0.165	48.25	48.3125	48.1875	48.25	49.4375	49.438	49.438	49.438	219.875	219.875	220.875	220.875	220.375	0.010606	0.012625
0.015	0.01									0																					0		
0.015	0.01									0																					0		
0.015	0.01									0																					0		
0.015	0.01	0.989	0.992	0.99	0.99					0.99025	26.64	26.68	26.67	26.66	0.119	0.114	0.12	0.118	48.5	48.5	48.5625	48.4375	49.4375	49.4375	49.4375	49.4375	174.4375	174.125	174.4375	175.125	174.5313	0.013276	0.015806
0.015	0.01	2.969	2.969	2.97	2.974					2.9705	26.78	26.71	26.76	26.68	0.165	0.165	0.17	0.17	48.4375	48.4375	48.375	48.3125	49.4375	49.4375	49.4375	49.4375	221.5	218.125	221.5	221.5	220.6563	0.010578	0.012593
0.015	0.01									0																					0		
0.015	0.01									0																					0		
0.015	0.01									0																					0		
0.015	0.01	0.99	0.99	0.989	0.99					0.98975	52.81	52.25	52.79	52.26	0.121	0.115	0.121	0.12	48.5625	48.5	48.5	48.4375	49.4375	49.438	49.438	49.438	178.4375	174.4375	178.75	178.9375	177.6406	0.013439	0.016
0.015	0.01	3.003	3.004	3.005	3.004					3.004	51.74	51.89	51.73	51.91	0.165	0.168	0.17	0.17	48.3125	48.3125	48.25	48.25	49.4375	49.438	49.438	49.438	222.0625	222.3125	222.0625	222.3125	222.1875	0.010534	0.012541
0.015	0.01									0																					0		
0.015	0.01									0																					0		
0.015	0.01									0																					0		
0.015	0.005	0.496	0.496	0.495	0.496					0.49575					0.075	0.075	0.075	0.075	48.6875	48.625	48.625	48.5625	49.4375	49.4375	49.4375	49.4375	187.0625	188.5	187.0625	188.5	187.7813	0.01762	0.020977
0.015	0.005	0.994	0.994	0.993	0.993					0.9935					0.091	0.092	0.092	0.092	48.6875	48.6875	48.625	48.625	49.4375	49.4375	49.4375	49.4375	224.5	225	224.5	225	224.75	0.01299	0.015466
0.015	0.005									0																					0		
0.015	0.005									0																					0		
0.015	0.005									0																					0		
0.015	0.005	0.488	0.487	0.489	0.488					0.488	7.636	7.701	7.748	7.839	0.082	0.082	0.082	0.082	48.6875	48.688	48.688	48.625	49.4375	49.438	49.438	49.438	197.3125	196.625	196.625	196.625	196.7969	0.01644	0.019673
0.015	0.005	0.976	0.976	0.977	0.975					0.976	7.08	7.09	7.075	7.08	0.098	0.098	0.098	0.098	48.625	48.625	48.625	48.625	49.4375	49.438	49.438	49.438	227	227	227	227	227	0.011999	0.014285
0.015	0.005									0																					0		
0.015	0.005									0																					0		
0.015	0.005									0																					0		
0.015	0.005	0.504	0.503	0.504	0.504					0.50375	26.44	26.45	26.45	26.44	0.085	0.09	0.087	0.095	48.75	48.6875	48.625	48.625	49.4375	49.4375	49.4375	49.4375	212.125	212.125	212.125	213	212.3438	0.017727	0.021105
0.015	0.005	0.985	0.984	0.984	0.985					0.9845	26.62	26.51	26.6	26.52	0.095	0.097	0.096	0.097	48.5	48.625	48.4375	48.625	49.4375	49.4375	49.4375	49.4375	241.9375	241.9375	241.9375	241.9375	241.9375	0.012584	0.014981
0.015	0.005									0																					0		
0.015	0.005									0																					0		
0.015	0.005									0																					0		
0.015	0.005	0.506	0.505	0.506	0.505					0.5055	51.43	52.01	51.44	52	0.089	0.088	0.089	0.089	48.6875	48.6875	48.625	48.6875	49.4375	49.438	49.438	49.438	222.0625	222.063	222.063	222.063	222.0629	0.017115	0.020376
0.015	0.005	0.999	1	0.998	0.1					0.77425	52.23	52.53	52.34	52.5	0.099	0.099	0.099	0.099	48.625	48.6875	48.625	48.6875	49.4375	49.438	49.438	49.438	241.5625	241.563	241.563	241.563	241.5629	0.011408	0.013682
0.015	0.005									0																							
0.015	0.005									0																							
0.015	0.005									0																							

Table B4.1 Asphalt treatment surface data

Discharg	SL (%)	SX (%)	QWALL (CFS)				Qfloor (CFS)				Qtotal	Depth (ft)				Spread Dist T1 (in)				Curb Distance (in)				Spread Dist T2 (in)				AVG	n value	
actual Q			Initial		Final		Initial		Final		AVG	Min		Max		T1min		T2max		Cmin		Cmax		T1min		T2max		Spread	Geometri	Integrated
cfs			1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	CFS	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	In		
0.5	4.0%	1.5%	0.50	0.50	0.50	0.50	0.00	0.00	0.00	0.00	0.50	0.100	0.100	0.100	0.100	38.125	38.063	38.125	38.063	38.938	38.906	38.875	38.844	117.469	117.469	117.844	117.844	79.563	0.0261	0.0311
1	4.0%	1.5%	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	1.00	0.115	0.120	0.115	0.120	38.063	38.000	38.094	38.000	39.031	39.063	39.063	39.063	141.250	141.250	141.250	141.250	103.211	0.0263	0.0313
3	4.0%	1.5%	3.01	3.01	3.00	3.00	0.00	0.00	0.00	0.00	3.00	0.173	0.178	0.178	0.178	37.688	37.594	37.719	37.594	38.781	38.781	38.813	38.813	181.063	181.063	181.063	181.063	143.414	0.0210	0.0250
5	4.0%	1.5%	5.04	5.05	5.04	5.04	0.00	0.00	0.00	0.00	5.04	0.220	0.230	0.220	0.230	37.625	37.438	37.625	37.469	38.844	38.938	38.938	38.938	218.875	218.875	218.875	218.875	181.336	0.0233	0.0278
7	4.0%	1.5%	0.82	0.82	0.82	0.81	6.21	6.21	6.20	6.21	7.02	0.240	0.265	0.240	0.265	37.250	37.031	37.188	37.000	38.625	38.563	38.531	38.469	228.906	236.063	229.000	236.063	195.391	0.0204	0.0243
9	4.0%	1.5%																												
10	4.0%	1.5%																												
11	4.0%	1.5%																												
0.5	4.0%	2.0%	0.50	0.50	0.50	0.50	0.00	0.00	0.00	0.00	0.50	0.100	0.105	0.100	0.105	37.906	37.781	37.969	37.781	38.813	38.719	38.875	38.719	96.125	96.125	96.125	96.125	58.266	0.0182	0.0216
1	4.0%	2.0%	0.99	0.99	0.99	0.99	0.00	0.00	0.00	0.00	0.99	0.125	0.135	0.125	0.135	37.750	37.625	37.781	37.656	38.875	38.719	38.938	38.781	116.000	116.000	116.000	116.000	78.297	0.0203	0.0242
3	4.0%	2.0%	2.96	2.97	2.96	2.96	0.00	0.00	0.00	0.00	2.96	0.208	0.215	0.215	0.215	37.594	37.500	37.656	37.500	38.813	38.719	38.875	38.750	149.375	149.375	149.375	149.375	111.813	0.0175	0.0209
5	4.0%	2.0%	5.02	5.03	5.03	5.03	0.00	0.00	0.00	0.00	5.03	0.268	0.275	0.268	0.275	37.438	37.500	37.500	37.250	37.938	38.094	38.000	38.125	177.031	177.031	177.094	177.094	139.641	0.0187	0.0222
7	4.0%	2.0%	0.82	0.82	0.82	0.82	6.24	6.25	6.24	6.25	7.07	0.310	0.318	0.310	0.318	36.938	36.781	36.875	36.719	38.156	38.219	38.500	38.156	193.188	197.344	193.156	197.375	158.438	0.0186	0.0222
9	4.0%	2.0%	2.83	2.83	2.83	2.83	6.20	6.21	6.21	6.22	9.04	0.290	0.295	0.290	0.295	37.281	37.156	37.281	37.219	38.844	38.875	38.719	38.938	216.844	219.094	216.813	219.125	180.734	0.0207	0.0247
10	4.0%	2.0%	3.83	3.83	3.83	3.83	6.20	6.20	6.20	6.20	10.03	0.315	0.325	0.315	0.325	36.844	36.688	36.813	36.750	38.563	38.500	38.625	38.531	225.094	227.563	225.125	227.625	189.578	0.0212	0.0253
11	4.0%	2.0%	4.82	4.82	4.82	4.82	6.20	6.20	6.20	6.21	11.02	0.305	0.315	0.306	0.315	36.875	36.750	36.844	36.813	38.188	37.844	38.188	38.125	227.188	233.000	227.188	235.625	193.930	0.0205	0.0245
0.5	4.0%	2.5%	0.51	0.51	0.51	0.51	0.00	0.00	0.00	0.00	0.51	0.108	0.108	0.108	0.108	37.938	37.719	38.000	37.656	38.750	38.625	38.750	38.688	89.063	89.063	89.063	89.063	51.234	0.0185	0.0221
1	4.0%	2.5%	0.99	0.99	0.99	0.99	0.00	0.00	0.00	0.00	0.99	0.143	0.145	0.143	0.145	37.844	37.688	37.938	37.781	38.813	38.656	38.719	38.719	102.906	102.906	102.906	102.906	65.094	0.0180	0.0214
3	4.0%	2.5%	2.98	2.98	2.98	2.98	0.00	0.00	0.00	0.00	2.98	0.215	0.223	0.223	0.223	37.563	37.375	37.563	37.438	38.594	38.438	38.719	38.531	138.375	138.375	138.344	138.375	100.883	0.0192	0.0228
5	4.0%	2.5%	5.00	5.00	5.00	5.00	0.00	0.00	0.00	0.00	5.00	0.260	0.268	0.260	0.268	37.375	37.281	37.438	37.219	38.531	38.375	38.563	38.406	150.438	153.438	150.438	153.438	114.609	0.0160	0.0191
7	4.0%	2.5%	0.80	0.80	0.80	0.80	6.24	6.24	6.24	6.24	7.04	0.285	0.295	0.285	0.295	37.250	37.063	37.281	37.094	38.406	38.250	38.344	38.250	168.406	173.969	168.406	173.969	134.016	0.0173	0.0206
9	4.0%	2.5%	2.78	2.78	2.78	2.78	6.23	6.23	6.23	6.23	9.01	0.320	0.328	0.320	0.328	37.375	37.219	37.406	37.281	38.594	38.469	38.656	38.531	184.875	189.188	184.875	189.188	149.711	0.0182	0.0216
10	4.0%	2.5%	3.78	3.78	3.78	3.78	6.19	6.19	6.20	6.19	9.97	0.320	0.335	0.320	0.335	37.281	37.188	37.375	37.188	38.594	38.406	38.625	38.500	190.563	194.563	190.563	194.563	155.305	0.0181	0.0216
11	4.0%	2.5%	4.79	4.79	4.79	4.79	6.20	6.20	6.20	6.20	10.99	0.350	0.360	0.350	0.360	37.063	36.875	37.125	36.938	38.563	38.406	38.563	38.563	202.625	206.219	202.656	206.281	167.445	0.0201	0.0239
0.5	4.0%	3.0%	0.51	0.51	0.51	0.51	0.00	0.00	0.00	0.00	0.51	0.108	0.113	0.108	0.113	37.781	37.688	37.875	37.688	38.469	38.406	38.531	38.438	81.719	81.719	81.719	81.719	43.961	0.0166	0.0197
1	4.0%	3.0%	1.01	1.01	1.01	1.01	0.00	0.00	0.00	0.00	1.01	0.135	0.145	0.135	0.145	37.656	37.469	37.719	37.531	38.281	38.219	38.281	38.250	93.063	93.063	93.188	93.188	55.531	0.0155	0.0185
3	4.0%	3.0%	3.02	3.02	3.02	3.02	0.00	0.00	0.00	0.00	3.02	0.235	0.245	0.245	0.245	37.438	37.313	37.500	37.375	38.125	37.969	38.156	38.031	126.594	126.594	126.656	126.657	89.219	0.0184	0.0219
5	4.0%	3.0%	5.00	4.99	4.99	4.99	0.00	0.00	0.00	0.00	4.99	0.290	0.290	0.291	0.291	37.313	37.125	37.250	37.156	37.969	38.031	37.969	38.063	140.344	140.344	140.344	140.344	103.133	0.0163	0.0194
7	4.0%	3.0%	0.77	0.78	0.77	0.77	6.29	6.29	6.29	6.30	7.07	0.320	0.330	0.320	0.330	36.875	36.781	36.969	36.875	37.781	37.781	37.813	37.875	149.250	152.781	149.250	152.781	114.141	0.0151	0.0180
9	4.0%	3.0%	2.80	2.80	2.80	2.80	6.26	6.26	6.26	6.26	9.06	0.360	0.370	0.360	0.370	37.094	36.844	37.156	36.969	37.375	37.750	37.406	37.813	163.563	168.625	163.625	168.688	129.109	0.0164	0.0195
10	4.0%	3.0%	3.78	3.78	3.78	3.77	6.24	6.24	6.24	6.24	10.02	0.365	0.375	0.365	0.375	36.813	36.750	36.906	36.813	38.000	37.875	38.094	37.938	170.750	176.594	170.750	176.594	136.852	0.0173	0.0206
11	4.0%	3.0%	4.72	4.72	4.71	4.71	6.24	6.24	6.24	6.23	10.95	0.400	0.410	0.400	0.410	36.750	36.500	36.750	36.531	38.031	37.813	38.125	37.844	175.969	181.313	175.969	181.313	142.008	0.0175	0.0208
0.5	4.0%	4.0%	0.50	0.50	0.50	0.50	0.00	0.00	0.00	0.00	0.50	0.115	0.125	0.115	0.125	37.781	37.656	37.813	37.688	37.938	38.375	37.969	38.406	75.625	75.625	75.688	75.688	37.922	0.0184	0.0219
1	4.0%	4.0%	1.01	1.01	1.01	1.01	0.00	0.00	0.00	0.00	1.01	0.165	0.173	0.166	0.173	37.531	37.375	37.563	37.406	38.281	38.063	38.313	38.000	87.188	87.188	87.250	87.250	49.750	0.0186	0.0221
3	4.0%	4.0%	3.02	3.02	3.02	3.02	0.00	0.00	0.00	0.00	3.02	0.250	0.255	0.255	0.255	37.219	37.125	37.281	37.188	37.969	37.875	38.031	38.000	111.313	111.313	111.375	111.375	74.141	0.0180	0.0214
5	4.0%	4.0%	5.01	5.01	5.01	5.01	0.00	0.00	0.00	0.00	5.01	0.295	0.325	0.295	0.325	37.625	37.500	37.688	37.563	37.188	37.563	37.219	37.656	123.125	128.281	123.250	128.375	88.164	0.0172	0.0205
7	4.0%	4.0%	0.77	0.77	0.77	0.77	6.27	6.27	6.27	6.27	7.04	0.350	0.360	0.350	0.360	36.688	36.563	36.781	36.625	37.844	37.719	37.844	37.781	130.563	135.563	130.625	135.688	96.445	0.0155	0.0184
9	4.0%	4.0%	2.79	2.79	2.79	2.79	6.26	6.26	6.27	6.27	9.05	0.400	0.400	0.400	0.400	36.563	36.531	36.688	36.094	37.438	37.250	37.563	37.375	138.813	146.000	138.875	146.000	105.953	0.0155	0.0185
10	4.0%	4.0%	3.80	3.80	3.80	3.80	6.22	6.22	6.22	6.22	10.02	0.410	0.420	0.410	0.420	36.469	36.406	36.188	35.844	38.031	38.156	38.000	38.125	145.313	148.750	145.344	148.781	110.820	0.0158	0.0188
11	4.0%	4.0%	4.77	4.77	4.75	4.75	6.20	6.20	6.21	6.21	10.97	0.440	0.450	0.440	0.450	37.375	36.406	37.406	36.781	37.875	37.719	37.844	37.750	147.000	151.281	146.000	151.313	111.906	0.0147	0.0175

Table B4.2 Asphalt treatment surface data

Discharg	SL (%)	SX (%)	QWALL (CFS)				Qfloor (CFS)				Qtotal	Depth (ft)				Spread Dist T1 (in)				Curb Distance (in)				Spread Dist T2 (in)				AVG	n value	
actual Q			Initial		Final		Initial		Final		AVG	Min		Max		T1min		T2max		Cmin		Cmax		T1min		T2max		Spread	Geometri	Integrated
cfs			1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	CFS	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	In		
0.5	3.0%	1.5%	0.50	0.50	0.50	0.50	0.00	0.00	0.00	0.00	0.50	0.100	0.105	0.100	0.105	38.125	38.000	38.188	37.938	38.969	38.938	39.063	38.938	114.438	114.438	114.438	114.438	76.375	0.0203	0.0242
1	3.0%	1.5%	0.99	0.99	0.99	0.99	0.00	0.00	0.00	0.00	0.99	0.115	0.125	0.115	0.125	38.156	38.031	38.188	38.094	39.156	39.063	39.188	39.000	135.156	135.156	135.156	135.156	97.039	0.0194	0.0231
3	3.0%	1.5%	3.00	3.01	3.01	3.00	0.00	0.00	0.00	0.00	3.00	0.200	0.210	0.210	0.210	37.813	37.688	37.875	37.781	38.938	38.813	38.969	38.875	179.250	179.250	179.313	179.313	141.492	0.0175	0.0208
5	3.0%	1.5%	5.01	5.01	5.01	5.01	0.00	0.00	0.00	0.00	5.01	0.215	0.225	0.215	0.225	37.656	37.531	37.719	37.563	38.844	38.553	38.906	38.750	223.563	223.563	223.594	223.594	185.961	0.0217	0.0259
7	3.0%	1.5%	0.80	0.80	0.80	0.80	6.22	6.22	6.22	6.22	7.02	0.255	0.265	0.255	0.265	37.750	37.594	37.813	37.656	38.969	38.813	38.969	38.875	243.563	243.531	243.656	243.563	205.875	0.0207	0.0247
9	3.0%	1.5%																												
10	3.0%	1.5%																												
11	3.0%	1.5%																												
0.5	3.0%	2.0%	0.50	0.49	0.50	0.50	0.00	0.00	0.00	0.00	0.50	0.110	0.120	0.111	0.120	37.875	37.656	37.906	37.656	38.906	38.813	39.000	38.781	95.469	95.469	95.594	95.531	57.742	0.0157	0.0187
1	3.0%	2.0%	0.99	0.99	0.99	0.99	0.00	0.00	0.00	0.00	0.99	0.135	0.145	0.136	0.146	37.844	37.531	37.875	37.594	38.625	38.688	38.688	38.781	123.688	123.688	123.750	123.750	86.008	0.0226	0.0269
3	3.0%	2.0%	2.96	2.97	2.96	2.96	0.00	0.00	0.00	0.00	2.96	0.205	0.215	0.215	0.215	37.500	37.375	37.594	37.469	38.563	38.500	38.594	38.625	143.094	151.531	143.188	151.594	109.867	0.0145	0.0173
5	3.0%	2.0%	4.98	4.97	4.97	4.97	0.00	0.00	0.00	0.00	4.97	0.250	0.258	0.251	0.258	37.469	37.219	37.531	37.313	38.625	38.500	38.625	38.469	169.063	177.844	168.563	177.875	135.953	0.0153	0.0182
7	3.0%	2.0%	0.79	0.78	0.78	0.78	6.23	6.22	6.22	6.22	7.01	0.285	0.295	0.285	0.295	37.188	37.031	37.250	37.063	38.313	38.500	38.375	38.531	192.625	201.156	192.656	201.188	159.773	0.0167	0.0198
9	3.0%	2.0%	2.79	2.79	2.79	2.79	6.21	6.21	6.20	6.21	9.00	0.315	0.325	0.315	0.325	37.375	37.250	37.406	37.344	38.594	38.688	38.594	38.781	218.500	227.844	218.531	227.875	185.844	0.0194	0.0231
10	3.0%	2.0%	3.80	3.80	3.80	3.80	6.20	6.21	6.20	6.20	10.00	0.335	0.345	0.335	0.345	37.156	36.750	37.094	36.750	38.094	38.313	38.156	38.406	223.813	232.750	223.875	232.781	191.367	0.0189	0.0225
11	3.0%	2.0%	4.77	4.76	4.77	4.76	6.19	6.19	6.18	6.18	10.95	0.345	0.355	0.345	0.355	37.156	36.938	37.250	37.000	38.219	38.375	38.313	38.469	230.875	239.375	230.938	239.438	198.070	0.0189	0.0225
0.5	3.0%	2.5%	0.56	0.56	0.56	0.56	0.00	0.00	0.00	0.00	0.56	0.115	0.115	0.114	0.115	38.344	38.219	38.375	38.219	39.375	39.031	39.406	39.344	89.906	89.906	89.906	89.906	51.617	0.0147	0.0175
1	3.0%	2.5%	1.04	1.04	1.04	1.04	0.00	0.00	0.00	0.00	1.04	0.133	0.133	0.133	0.133	38.438	38.281	38.438	38.281	39.438	39.313	39.438	39.313	103.188	103.188	103.188	103.188	64.828	0.0146	0.0174
3	3.0%	2.5%	3.09	3.09	3.09	3.09	0.00	0.00	0.00	0.00	3.09	0.210	0.210	0.210	0.210	38.031	37.906	37.719	37.906	39.000	38.969	39.000	38.969	142.375	142.375	142.375	142.375	104.484	0.0176	0.0210
5	3.0%	2.5%	5.00	5.00	5.00	5.00	0.00	0.00	0.00	0.00	5.00	0.253	0.258	0.253	0.258	37.875	37.750	37.875	37.813	38.906	38.875	38.906	38.844	147.219	156.063	147.219	156.063	113.813	0.0137	0.0163
7	3.0%	2.5%	0.74	0.74	0.74	0.74	6.22	6.21	6.21	6.21	6.95	0.278	0.283	0.280	0.285	37.844	37.688	37.844	37.719	38.844	38.813	38.875	38.844	165.531	176.906	165.531	176.906	133.445	0.0151	0.0180
9	3.0%	2.5%	2.77	2.76	2.76	2.76	6.19	6.19	6.19	6.18	8.95	0.318	0.323	0.323	0.328	37.625	37.469	37.625	37.469	38.688	38.594	38.625	36.094	181.594	193.906	181.594	193.906	150.203	0.0160	0.0191
10	3.0%	2.5%	3.75	3.76	3.76	3.76	6.16	6.15	6.15	6.15	9.91	0.333	0.343	0.333	0.343	37.406	37.250	37.406	37.250	38.531	38.594	38.531	38.594	191.094	206.250	191.094	206.250	161.344	0.0176	0.0209
11	3.0%	2.5%	4.84	4.84	4.84	4.84	6.15	6.14	6.14	6.14	10.98	0.360	0.370	0.360	0.370	37.469	37.344	37.500	37.344	38.625	38.625	38.625	38.656	199.031	217.531	199.031	217.531	170.867	0.0185	0.0220
0.5	3.0%	3.0%	0.57	0.57	0.57	0.57	0.00	0.00	0.00	0.00	0.57	0.114	0.115	0.113	0.116	37.844	37.750	37.969	37.844	38.813	38.875	38.813	38.969	86.281	86.281	86.281	86.281	48.430	0.0167	0.0199
1	3.0%	3.0%	1.06	1.06	1.06	1.06	0.00	0.00	0.00	0.00	1.06	0.160	0.165	0.162	0.164	37.688	37.594	37.781	37.688	38.563	38.594	38.594	38.594	98.906	98.906	98.906	98.906	61.219	0.0166	0.0198
3	3.0%	3.0%	3.04	3.04	3.04	3.03	0.00	0.00	0.00	0.00	3.04	0.235	0.240	0.241	0.241	37.406	37.313	37.375	37.250	38.563	38.469	38.594	38.438	124.594	137.688	124.594	137.375	93.727	0.0183	0.0218
5	3.0%	3.0%	4.97	4.97	4.98	4.98	0.00	0.00	0.00	0.00	4.97	0.275	0.283	0.276	0.281	37.313	37.156	37.344	37.219	38.500	38.500	38.563	38.563	138.750	147.469	138.813	147.563	105.891	0.0153	0.0182
7	3.0%	3.0%	0.73	0.73	0.73	0.73	6.24	6.24	6.25	6.25	6.98	0.313	0.320	0.315	0.323	37.031	36.938	36.969	36.875	38.094	38.156	38.156	38.219	149.250	161.500	149.313	161.563	118.453	0.0147	0.0175
9	3.0%	3.0%	2.81	2.82	2.82	2.82	6.22	6.22	6.22	6.22	9.04	0.338	0.343	0.343	0.348	37.000	36.875	37.063	36.875	38.094	38.125	38.156	38.125	163.531	175.000	163.500	175.000	132.305	0.0153	0.0182
10	3.0%	3.0%	3.79	3.79	3.79	3.79	6.23	6.21	6.21	6.21	10.00	0.348	0.353	0.353	0.358	36.844	36.719	36.875	36.750	38.063	38.000	38.094	38.031	170.469	180.094	170.531	180.156	138.516	0.0156	0.0186
11	3.0%	3.0%	4.75	4.75	4.75	4.75	6.22	6.21	6.20	6.21	10.96	0.380	0.390	0.380	0.390	36.719	36.563	36.813	36.656	38.188	38.188	38.219	38.313	176.594	189.438	176.594	189.438	146.328	0.0165	0.0196
0.5	3.0%	4.0%	0.53	0.53	0.53	0.53	0.00	0.00	0.00	0.00	0.53	0.128	0.128	0.128	0.128	38.531	38.375	38.594	38.438	39.156	39.000	39.219	39.063	78.688	78.688	78.750	78.750	40.234	0.0192	0.0192
1	3.0%	4.0%	1.05	1.05	1.05	1.05	0.00	0.00	0.00	0.00	1.05	0.176	0.175	0.177	0.177	38.094	37.969	38.156	37.969	39.188	38.813	39.250	38.844	89.188	89.188	89.281	89.281	51.188	0.0181	0.0183
3	3.0%	4.0%	2.97	2.97	2.97	2.97	0.00	0.00	0.00	0.00	2.97	0.258	0.260	0.260	0.260	37.844	37.719	37.938	37.750	38.781	38.656	38.844	38.719	112.875	112.875	112.969	112.969	75.109	0.0179	0.0181
5	3.0%	4.0%	5.01	5.01	5.01	5.01	0.00	0.00	0.00	0.00	5.01	0.308	0.313	0.308	0.314	38.031	37.875	38.094	37.906	38.750	38.625	38.781	38.719	123.750	129.438	133.844	129.500	91.156	0.0181	0.0173
7	3.0%	4.0%	0.77	0.77	0.77	0.77	6.26	6.27	6.26	6.26	7.03	0.348	0.358	0.348	0.358	38.000	37.531	37.938	37.625	39.063	38.969	39.156	39.063	134.844	139.625	134.531	139.938	99.461	0.0160	0.0165
9	3.0%	4.0%	2.73	2.73	2.73	2.73	6.24	6.24	6.24	6.24	8.97	0.373	0.380	0.373	0.380	37.625	38.094	37.625	38.156	38.531	39.031	38.563	39.156	140.313	147.938	140.406	148.000	106.289	0.0150	0.0156
10	3.0%	4.0%	3.78	3.78	3.77	3.77	6.25	6.24	6.25	6.26	10.02	0.398	0.413	0.398	0.413	37.344	38.219	37.344	38.281	37.906	38.281	38.500	38.438	144.594	154.375	144.656	154.406	111.711	0.0153	0.0162
11	3.0%	4.0%	4.75	4.75	4.75	4.75	6.25	6.24	6.26	6.25	11.00	0.418	0.428	0.418	0.428	37.500	37.219	37.531	37.281	38.594	38.438	38.688	38.531	151.406	161.188	151.469	161.281	118.953	0.0165	0.0175

Table B4.3 Asphalt treatment surface data

Discharg	SL (%)	SX (%)	QWALL (CFS)				Qfloor (CFS)				Qtotal	Depth (ft)				Spread Dist T1 (in)				Curb Distance (in)				Spread Dist T2 (in)				AVG	n value	
actual Q			Initial		Final		Initial		Final		AVG	Min		Max		T1min		T2max		Cmin		Cmax		T1min		T2max		Spread	Geometri	Integrated
cfs			1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	CFS	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	In		
0.5	2.0%	1.5%	0.50	0.50	0.50	0.50	0.00	0.00	0.00	0.00	0.50	0.103	0.103	0.103	0.103	39.375	39.219	39.344	39.281	40.219	40.313	40.250	40.344	117.500	117.500	117.563	117.563	78.227	0.0177	0.0211
1	2.0%	1.5%	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	1.00	0.140	0.140	0.141	0.141	38.250	38.313	37.969	38.313	39.063	38.906	39.031	38.813	143.125	143.125	143.250	143.250	104.977	0.0194	0.0231
3	2.0%	1.5%	3.02	3.02	3.02	3.02	0.00	0.00	0.00	0.00	3.02	0.196	0.196	0.196	0.196	38.375	38.125	38.406	38.219	39.063	38.969	39.156	39.000	182.625	193.969	182.688	193.969	150.031	0.0166	0.0198
5	2.0%	1.5%	4.99	4.99	4.99	4.99	0.00	0.00	0.00	0.00	4.99	0.255	0.260	0.256	0.261	38.000	37.875	38.094	37.844	38.969	38.906	38.969	38.875	218.719	229.563	218.656	229.813	186.234	0.0179	0.0213
7	2.0%	1.5%																												
9	2.0%	1.5%																												
10	2.0%	1.5%																												
11	2.0%	1.5%																												
0.5	2.0%	2.0%	0.50	0.50	0.50	0.50	0.00	0.00	0.00	0.00	0.50	0.118	0.118	0.119	0.119	38.281	38.188	38.313	38.250	38.875	38.938	38.906	38.969	101.688	101.688	101.688	101.688	63.430	0.0162	0.0192
1	2.0%	2.0%	1.01	1.01	1.00	1.01	0.00	0.00	0.00	0.00	1.01	0.148	0.148	0.149	0.149	38.063	38.094	38.063	38.094	38.531	39.063	38.531	39.063	125.125	125.125	125.094	125.125	87.039	0.0188	0.0224
3	2.0%	2.0%	3.01	3.01	3.01	3.01	0.00	0.00	0.00	0.00	3.01	0.223	0.230	0.230	0.230	37.813	37.688	37.906	37.719	39.000	38.875	39.063	38.969	151.156	158.875	151.219	158.938	117.266	0.0139	0.0165
5	2.0%	2.0%	5.00	5.00	5.01	5.00	0.00	0.00	0.00	0.00	5.00	0.265	0.275	0.265	0.275	37.719	37.594	37.813	37.531	38.781	38.875	38.781	38.906	180.375	189.531	180.375	189.563	147.297	0.0154	0.0183
7	2.0%	2.0%	0.76	0.76	0.76	0.76	6.26	6.26	6.26	6.25	7.01	0.295	0.305	0.295	0.305	37.438	37.500	37.500	37.563	38.625	38.656	38.313	38.719	207.281	222.250	207.281	222.344	177.289	0.0180	0.0215
9	2.0%	2.0%	2.76	2.76	2.76	2.75	6.25	6.25	6.25	6.25	9.01	0.325	0.335	0.325	0.335	37.500	37.281	37.469	37.344	38.531	38.594	38.531	38.688	227.250	238.844	226.313	238.844	195.414	0.0181	0.0216
10	2.0%	2.0%	3.80	3.80	3.80	3.80	6.23	6.23	6.23	6.23	10.04	0.348	0.358	0.348	0.358	37.500	37.281	37.625	37.313	38.781	38.688	38.688	38.750	236.500	242.094	236.406	242.000	201.820	0.0177	0.0211
11	2.0%	2.0%																												
0.5	2.0%	2.5%	0.49	0.49	0.49	0.49	0.00	0.00	0.00	0.00	0.49	0.153	0.153	0.153	0.153	37.969	37.844	37.906	37.813	38.250	38.509	38.375	38.478	90.000	90.000	90.000	85.500	50.992	0.0133	0.0158
1	2.0%	2.5%	1.05	1.05	1.05	1.05	0.00	0.00	0.00	0.00	1.05	0.178	0.178	0.178	0.178	38.219	38.094	38.281	38.188	38.875	38.906	38.813	38.875	113.281	113.281	113.250	113.281	75.078	0.0175	0.0208
3	2.0%	2.5%	2.98	2.98	2.62	2.97	0.00	0.00	0.00	0.00	2.89	0.288	0.288	0.288	0.288	38.000	37.813	38.031	37.750	38.844	38.906	38.844	38.938	146.813	148.313	148.344	148.344	110.055	0.0176	0.0210
5	2.0%	2.5%	4.95	4.95	4.96	4.96	0.00	0.00	0.00	0.00	4.95	0.324	0.328	0.324	0.328	36.969	36.875	37.000	36.875	39.000	39.000	39.000	39.031	163.156	167.469	163.031	167.500	128.359	0.0154	0.0184
7	2.0%	2.5%	0.80	0.80	0.81	0.80	6.24	6.25	6.24	6.24	7.05	0.350	0.340	0.350	0.340	36.875	36.719	36.875	36.781	38.781	38.844	38.813	38.875	177.469	187.406	177.500	187.438	145.641	0.0153	0.0182
9	2.0%	2.5%	2.83	2.83	2.83	2.83	6.18	6.18	6.18	6.18	9.01	0.393	0.400	0.393	0.400	36.781	36.656	36.844	36.750	38.750	38.813	38.750	38.813	200.438	206.938	200.469	206.938	166.938	0.0172	0.0204
10	2.0%	2.5%	3.73	3.73	3.72	3.72	6.19	6.19	6.21	6.21	9.93	0.420	0.428	0.420	0.428	36.781	36.625	36.656	36.469	38.813	38.813	38.844	38.844	207.500	214.000	207.625	214.188	174.195	0.0174	0.0208
11	2.0%	2.5%	4.80	4.80	4.81	4.82	6.18	6.18	6.17	6.18	10.99	0.443	0.450	0.443	0.450	36.625	36.531	36.656	36.563	38.875	38.813	38.875	38.750	213.344	220.719	213.344	220.813	180.461	0.0173	0.0206
0.5	2.0%	3.0%	0.53	0.53	0.53	0.53	0.00	0.00	0.00	0.00	0.53	0.143	0.143	0.143	0.143	37.938	37.813	38.000	37.844	38.938	38.875	39.031	38.875	87.906	87.906	87.906	87.906	50.008	0.0158	0.0188
1	2.0%	3.0%	1.04	1.04	1.05	1.04	0.00	0.00	0.00	0.00	1.04	0.173	0.173	0.173	0.173	37.813	37.688	37.844	37.750	39.063	39.000	39.094	39.000	103.750	103.750	103.750	103.781	65.984	0.0168	0.0200
3	2.0%	3.0%	3.02	3.03	3.02	3.02	0.00	0.00	0.00	0.00	3.02	0.245	0.250	0.250	0.250	37.281	37.188	37.344	37.125	38.625	38.625	38.688	38.688	138.281	144.469	138.281	144.500	104.148	0.0197	0.0234
5	2.0%	3.0%	4.96	4.96	4.95	4.95	0.00	0.00	0.00	0.00	4.95	0.290	0.300	0.290	0.300	37.000	36.906	37.063	36.906	38.656	38.563	38.719	38.563	150.750	155.156	150.781	155.156	115.992	0.0160	0.0190
7	2.0%	3.0%	0.76	0.76	0.76	0.76	6.20	6.20	6.20	6.20	6.96	0.330	0.338	0.330	0.338	36.938	36.781	36.906	36.781	38.594	38.531	38.625	38.563	162.469	170.063	162.656	170.094	129.469	0.0153	0.0182
9	2.0%	3.0%	2.82	2.82	2.82	2.82	6.19	6.19	6.20	6.20	9.02	0.385	0.393	0.385	0.393	36.625	36.469	36.719	36.500	38.656	38.531	37.688	38.563	175.438	180.063	175.469	180.156	141.203	0.0148	0.0176
10	2.0%	3.0%	3.84	3.84	3.83	3.84	6.16	6.16	6.16	6.16	10.00	0.403	0.413	0.403	0.413	36.500	36.344	36.563	36.375	38.500	38.406	38.563	38.469	180.281	189.906	180.281	189.906	148.648	0.0153	0.0182
11	2.0%	3.0%	5.08	5.08	5.08	5.08	6.15	6.13	6.14	6.13	11.22	0.413	0.423	0.413	0.423	36.500	36.313	36.563	36.375	38.125	38.031	38.188	38.031	188.094	196.625	188.125	196.656	155.938	0.0155	0.0185
0.5	2.0%	4.0%	0.53	0.53	0.53	0.53	0.00	0.00	0.00	0.00	0.53	0.148	0.148	0.148	0.148	37.750	37.594	37.750	37.625	38.813	38.750	38.844	38.781	79.906	79.906	79.906	79.906	42.227	0.0161	0.0192
1	2.0%	4.0%	0.99	0.99	0.99	0.99	0.00	0.00	0.00	0.00	0.99	0.200	0.200	0.200	0.200	37.219	37.000	37.156	36.969	38.688	38.750	38.656	39.000	89.219	89.219	89.219	89.219	52.133	0.0151	0.0179
3	2.0%	4.0%	3.04	3.04	3.04	3.04	0.00	0.00	0.00	0.00	3.04	0.273	0.275	0.275	0.275	37.063	36.813	37.031	36.875	38.563	38.438	38.563	38.000	122.750	122.750	122.750	122.750	85.805	0.0186	0.0222
5	2.0%	4.0%	5.01	5.01	5.01	5.02	0.00	0.00	0.00	0.00	5.01	0.333	0.333	0.333	0.333	36.750	36.656	36.781	36.969	38.594	38.500	38.656	38.500	134.313	139.094	134.375	139.094	99.930	0.0170	0.0202
7	2.0%	4.0%	0.85	0.85	0.85	0.85	6.16	6.15	6.14	6.14	7.00	0.405	0.410	0.405	0.410	45.875	46.813	45.813	45.750	47.875	47.938	47.938	47.875	152.063	159.000	152.063	159.063	109.484	0.0155	0.0184
9	2.0%	4.0%	2.82	2.83	2.83	2.83	6.14	6.14	6.14	6.14	8.97	0.433	0.443	0.433	0.443	36.438	36.250	36.438	36.281	38.438	38.406	38.469	38.406	150.313	160.625	150.281	160.563	119.094	0.0151	0.0180
10	2.0%	4.0%	3.95	3.96	3.95	3.95	6.11	6.12	6.12	6.12	10.07	0.460	0.475	0.460	0.475	36.344	36.344	36.313	36.406	38.344	38.250	38.313	38.281	154.188	163.500	154.250	163.438	122.492	0.0145	0.0173
11	2.0%	4.0%																												

Table B4.4 Asphalt treatment surface data

Discharg	SL (%)	SX (%)	QWALL (CFS)				Qfloor (CFS)				Qtotal	Depth (ft)				Spread Dist T1 (in)				Curb Distance (in)				Spread Dist T2 (in)				AVG	n value	
actual Q			Initial		Final		Initial		Final		AVG	Min		Max		T1min		T2max		Cmin		Cmax		T1min		T2max		Spread	Geometri	Integrated
cfs			1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	CFS	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	In		
0.5	1.0%	1.5%	0.49	0.49	0.49	0.49	0.00	0.00	0.00	0.00	0.49	0.145	0.145	0.145	0.145	38.500	38.250	38.406	38.281	38.781	39.094	38.781	39.031	118.750	118.750	118.719	118.750	80.383	0.0141	0.0167
1	1.0%	1.5%	0.99	0.99	0.99	0.99	0.00	0.00	0.00	0.00	0.99	0.180	0.180	0.180	0.180	38.500	38.250	38.531	38.250	39.438	39.281	39.438	39.344	148.031	148.000	148.063	148.063	109.656	0.0155	0.0184
3	1.0%	1.5%	2.99	2.99	2.99	2.99	0.00	0.00	0.00	0.00	2.99	0.240	0.250	0.250	0.250	38.031	37.938	38.125	38.031	39.188	39.250	39.219	39.313	215.094	215.094	215.094	215.094	177.063	0.0184	0.0219
5	1.0%	1.5%																												
7	1.0%	1.5%																												
9	1.0%	1.5%																												
10	1.0%	1.5%																												
11	1.0%	1.5%																												
0.5	1.0%	2.0%	0.50	0.50	0.50	0.50	0.00	0.00	0.00	0.00	0.50	0.120	0.130	0.120	0.130	38.313	38.031	37.844	38.000	39.250	38.969	39.281	39.063	109.969	109.969	110.000	110.000	71.938	0.0161	0.0192
1	1.0%	2.0%	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	1.00	0.155	0.160	0.155	0.160	38.625	38.500	38.688	38.531	39.813	39.500	39.844	39.563	132.500	132.500	132.563	132.563	93.945	0.0164	0.0195
3	1.0%	2.0%	3.01	3.01	3.01	3.01	0.00	0.00	0.00	0.00	3.01	0.263	0.270	0.271	0.271	38.156	38.063	38.250	38.125	39.531	39.406	39.625	39.469	173.594	173.594	173.656	173.656	135.477	0.0144	0.0171
5	1.0%	2.0%	5.02	5.02	5.01	5.01	0.00	0.00	0.00	0.00	5.02	0.315	0.325	0.315	0.325	37.844	37.719	37.844	37.719	39.188	39.156	39.188	39.156	218.688	221.125	218.688	221.156	182.133	0.0191	0.0227
7	1.0%	2.0%	0.75	0.75	0.76	0.75	6.19	6.19	6.19	6.19	6.94	0.345	0.355	0.345	0.355	38.000	37.781	38.094	37.844	39.688	39.500	39.750	39.625	235.500	242.125	235.531	242.156	200.898	0.0179	0.0213
9	1.0%	2.0%																												
10	1.0%	2.0%																												
11	1.0%	2.0%																												
0.5	1.0%	2.5%	0.50	0.50	0.50	0.50	0.00	0.00	0.00	0.00	0.50	0.123	0.123	0.123	0.123	38.156	38.094	38.219	38.125	39.094	39.125	39.125	39.125	99.125	99.125	99.406	99.406	61.117	0.0150	0.0178
1	1.0%	2.5%	0.99	0.99	0.98	0.98	0.00	0.00	0.00	0.00	0.98	0.193	0.197	0.194	0.197	37.844	37.688	37.906	37.688	38.813	39.031	38.813	39.031	121.125	121.125	121.125	121.125	83.344	0.0174	0.0207
3	1.0%	2.5%	3.01	3.01	3.00	3.00	0.00	0.00	0.00	0.00	3.01	0.271	0.276	0.276	0.276	37.469	37.375	37.500	37.813	38.969	38.781	38.969	38.875	161.063	162.688	161.688	163.156	124.609	0.0167	0.0198
5	1.0%	2.5%	4.98	4.98	4.98	4.97	0.00	0.00	0.00	0.00	4.98	0.309	0.313	0.310	0.312	37.281	37.188	37.281	37.656	38.813	38.844	38.781	38.875	185.000	192.094	185.063	192.156	151.227	0.0169	0.0201
7	1.0%	2.5%	0.75	0.75	0.75	0.75	6.22	6.22	6.23	6.22	6.97	0.353	0.358	0.353	0.358	37.094	36.969	37.156	37.000	38.500	38.656	38.531	38.719	202.750	214.188	202.844	214.188	171.438	0.0169	0.0201
9	1.0%	2.5%	2.79	2.79	2.79	2.79	6.18	6.18	6.18	6.18	8.97	0.394	0.399	0.393	0.398	36.938	36.813	37.000	36.781	38.719	38.656	38.750	38.781	223.063	229.875	223.094	230.000	189.625	0.0172	0.0204
10	1.0%	2.5%	3.83	3.83	3.82	3.81	6.18	6.18	6.19	6.19	10.01	0.405	0.410	0.406	0.410	36.875	36.688	36.906	37.781	38.625	38.750	38.656	38.781	230.625	237.656	230.656	237.656	197.086	0.0170	0.0203
11	1.0%	2.5%																												
0.5	1.0%	3.0%	0.49	0.49	0.49	0.49	0.00	0.00	0.00	0.00	0.49	0.158	0.158	0.153	0.158	37.750	38.031	37.938	38.031	38.875	38.844	38.875	38.844	90.281	90.281	90.281	90.281	52.344	0.0135	0.0161
1	1.0%	3.0%	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	1.00	0.193	0.194	0.193	0.194	37.750	37.594	37.688	37.531	38.844	38.313	38.844	38.844	113.031	113.031	113.031	113.031	75.391	0.0177	0.0211
3	1.0%	3.0%	2.98	2.97	2.96	2.97	0.00	0.00	0.00	0.00	2.97	0.275	0.276	0.277	0.277	37.531	37.469	37.563	37.469	38.750	38.813	38.750	38.906	147.188	147.188	147.188	147.219	109.688	0.0162	0.0193
5	1.0%	3.0%	4.99	4.98	4.99	4.98	0.00	0.00	0.00	0.00	4.98	0.313	0.315	0.312	0.315	37.219	37.188	37.219	37.188	38.781	38.688	38.844	38.688	165.281	171.000	165.281	171.000	130.938	0.0155	0.0185
7	1.0%	3.0%	0.82	0.82	0.82	0.82	6.22	6.23	6.25	6.25	7.05	0.400	0.401	0.399	0.401	37.094	36.969	37.063	36.969	38.781	38.625	38.781	38.594	177.563	190.625	177.594	190.656	147.086	0.0150	0.0178
9	1.0%	3.0%	2.84	2.84	2.84	2.84	6.22	6.22	6.22	6.23	9.06	0.427	0.430	0.428	0.430	36.750	36.688	36.813	36.781	38.438	38.500	38.469	38.563	200.875	209.406	200.844	209.469	168.391	0.0167	0.0199
10	1.0%	3.0%	3.81	3.80	3.80	3.81	6.19	6.19	6.21	6.21	10.00	0.450	0.455	0.451	0.455	36.625	36.531	36.625	36.563	38.188	38.188	38.219	38.219	203.563	214.750	203.594	214.750	172.578	0.0161	0.0192
11	1.0%	3.0%	4.82	4.83	4.81	4.82	6.19	6.19	6.19	6.19	11.01	0.480	0.488	0.482	0.487	36.656	36.531	36.719	36.594	38.469	38.313	38.500	38.313	211.531	221.906	211.469	221.875	180.070	0.0164	0.0195
0.5	1.0%	4.0%	0.50	0.50	0.50	0.50	0.00	0.00	0.00	0.00	0.50	0.155	0.155	0.156	0.156	38.188	38.094	38.250	38.063	39.156	39.125	39.188	38.688	83.406	83.406	83.438	83.500	45.289	0.0145	0.0173
1	1.0%	4.0%	1.01	1.01	1.01	1.01	0.00	0.00	0.00	0.00	1.01	0.238	0.238	0.239	0.239	38.219	38.000	38.219	38.094	39.344	39.250	39.313	39.313	98.281	98.281	98.375	98.375	60.195	0.0153	0.0182
3	1.0%	4.0%	2.99	2.99	2.98	2.98	0.00	0.00	0.00	0.00	2.99	0.329	0.332	0.332	0.332	37.531	37.500	37.688	37.469	38.625	38.813	38.594	38.938	126.469	129.406	126.594	129.469	90.438	0.0154	0.0183
5	1.0%	4.0%	4.98	4.98	4.98	4.99	0.00	0.00	0.00	0.00	4.98	0.403	0.408	0.404	0.408	37.188	37.188	36.875	37.188	38.875	39.063	38.875	39.188	147.094	148.781	147.219	148.844	110.875	0.0159	0.0189
7	1.0%	4.0%	0.82	0.82	0.81	0.81	6.23	6.23	6.24	6.25	7.05	0.440	0.445	0.441	0.445	36.875	36.750	36.875	36.719	38.719	38.438	37.750	38.500	157.563	162.500	157.688	162.625	123.289	0.0149	0.0177
9	1.0%	4.0%	2.84	2.84	2.84	2.84	6.22	6.23	6.20	6.20	9.05	0.489	0.493	0.489	0.493	36.844	36.750	36.938	36.813	38.750	38.719	37.750	37.844	167.750	174.406	167.750	174.594	134.289	0.0146	0.0174
10	1.0%	4.0%																												
11	1.0%	4.0%																												

Table B4.5 Asphalt treatment surface data

Discharg	SL (%)	SX (%)	QWALL (CFS)				Qfloor (CFS)				Qtotal	Depth (ft)				Spread Dist T1 (in)				Curb Distance (in)				Spread Dist T2 (in)				AVG	n value	
actual Q			Initial		Final		Initial		Final		AVG	Min		Max		T1min		T2max		Cmin		Cmax		T1min		T2max		Spread	Geometri	Integrated
cfs			1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	CFS	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	1st run	2nd run	In		
0.5	0.5%	1.5%	0.48	0.48	0.49	0.48	0.00	0.00	0.00	0.00	0.48	0.133	0.133	0.136	0.136	38.219	39.281	38.344	39.313	38.156	39.344	38.156	39.469	123.625	128.438	128.563	128.563	88.508	0.0127	0.0151
1	0.5%	1.5%	1.01	1.01	1.01	1.01	0.00	0.00	0.00	0.00	1.01	0.180	0.180	0.182	0.182	38.656	39.375	38.219	39.063	38.063	38.406	38.031	39.406	159.938	159.938	160.031	160.156	121.188	0.0140	0.0167
3	0.5%	1.5%																												
5	0.5%	1.5%																												
7	0.5%	1.5%																												
9	0.5%	1.5%																												
10	0.5%	1.5%																												
11	0.5%	1.5%																												
0.5	0.5%	2.0%	0.49	0.49	0.49	0.49	0.00	0.00	0.00	0.00	0.49	0.153	0.153	0.153	0.153	37.719	37.844	37.719	37.969	38.375	38.156	38.438	38.656	121.375	121.375	121.313	121.344	83.539	0.0172	0.0204
1	0.5%	2.0%	1.05	1.05	1.05	1.05	0.00	0.00	0.00	0.00	1.05	0.198	0.203	0.198	0.203	37.656	38.094	37.906	38.125	38.438	38.625	38.375	38.625	143.969	146.281	144.094	146.375	107.234	0.0157	0.0187
3	0.5%	2.0%	2.95	2.95	2.95	2.96	0.00	0.00	0.00	0.00	2.95	0.308	0.313	0.310	0.310	37.281	37.625	37.344	37.813	38.094	38.688	38.094	38.688	192.188	198.094	192.250	198.188	157.664	0.0156	0.0185
5	0.5%	2.0%																												
7	0.5%	2.0%																												
9	0.5%	2.0%																												
10	0.5%	2.0%																												
11	0.5%	2.0%																												
0.5	0.5%	2.5%	0.50	0.50	0.50	0.50	0.00	0.00	0.00	0.00	0.50	0.173	0.173	0.172	0.172	37.688	37.781	37.688	37.813	38.719	39.219	38.719	39.188	104.531	104.531	104.094	104.094	66.570	0.0133	0.0159
1	0.5%	2.5%	1.03	1.03	1.03	1.03	0.00	0.00	0.00	0.00	1.03	0.220	0.225	0.220	0.225	37.469	37.938	37.688	38.000	38.906	39.188	38.969	39.156	135.500	135.531	135.500	135.438	97.719	0.0181	0.0215
3	0.5%	2.5%	2.99	2.99	2.98	2.98	0.00	0.00	0.00	0.00	2.99	0.368	0.373	0.373	0.373	37.031	37.375	37.031	37.063	38.094	39.063	38.063	39.000	172.719	177.094	172.719	176.906	137.734	0.0154	0.0184
5	0.5%	2.5%	5.01	5.01	5.01	5.01	0.00	0.00	0.00	0.00	5.01	0.398	0.405	0.398	0.405	37.031	37.438	37.063	37.438	38.719	39.125	38.906	39.156	213.688	216.969	243.750	216.500	185.484	0.0210	0.0250
7	0.5%	2.5%	0.88	0.88	0.87	0.87	6.15	6.15	6.17	6.17	7.03	0.455	0.460	0.455	0.460	36.250	37.125	36.156	37.156	38.313	39.000	38.375	39.031	229.688	237.313	229.625	237.344	196.820	0.0170	0.0203
9	0.5%	2.5%																												
10	0.5%	2.5%																												
11	0.5%	2.5%																												
0.5	0.5%	3.0%	0.49	0.49	0.50	0.49	0.00	0.00	0.00	0.00	0.49	0.180	0.180	0.180	0.180	37.938	36.781	37.906	36.781	38.500	38.656	38.531	38.656	98.781	98.781	98.750	98.781	61.422	0.0147	0.0175
1	0.5%	3.0%	1.00	1.01	1.00	1.00	0.00	0.00	0.00	0.00	1.00	0.240	0.243	0.241	0.244	37.500	38.063	37.563	38.156	38.344	38.688	38.438	38.688	125.750	125.750	125.875	125.875	87.992	0.0188	0.0224
3	0.5%	3.0%	3.02	3.01	3.03	3.03	0.00	0.00	0.00	0.00	3.02	0.338	0.343	0.343	0.343	36.969	37.344	37.013	38.313	38.500	38.813	38.406	38.844	162.375	162.375	162.406	162.406	124.981	0.0159	0.0190
5	0.5%	3.0%	4.99	4.99	4.99	4.99	0.00	0.00	0.00	0.00	4.99	0.408	0.415	0.408	0.415	36.375	37.094	36.406	36.969	38.031	38.688	37.969	38.625	187.688	194.000	187.719	194.094	154.164	0.0169	0.0201
7	0.5%	3.0%	0.82	0.82	0.82	0.82	6.15	6.15	6.18	6.19	6.99	0.473	0.480	0.474	0.481	36.375	36.313	36.525	36.406	38.906	39.000	38.719	39.063	208.563	210.375	208.625	210.469	173.103	0.0164	0.0196
9	0.5%	3.0%																												
10	0.5%	3.0%																												
11	0.5%	3.0%																												
0.5	0.5%	4.0%	0.50	0.50	0.49	0.49	0.00	0.00	0.00	0.00	0.49	0.203	0.203	0.203	0.203	37.688	38.031	37.688	38.031	38.469	38.688	38.469	38.656	89.375	89.375	89.406	89.375	51.523	0.0146	0.0174
1	0.5%	4.0%	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	1.00	0.245	0.248	0.245	0.248	37.406	38.000	37.469	37.938	38.531	38.875	38.594	38.375	107.719	107.719	107.719	107.719	70.016	0.0164	0.0195
3	0.5%	4.0%	3.03	3.03	3.03	3.03	0.00	0.00	0.00	0.00	3.03	0.370	0.375	0.375	0.375	36.781	37.688	36.625	37.719	38.375	38.844	38.438	38.844	147.625	150.188	147.625	150.125	111.688	0.0189	0.0225
5	0.5%	4.0%	4.99	4.99	5.00	5.00	0.00	0.00	0.00	0.00	4.99	0.455	0.460	0.455	0.460	36.281	37.375	36.281	37.656	38.313	38.938	38.313	38.938	165.813	170.125	165.813	170.125	131.070	0.0175	0.0209
7	0.5%	4.0%																												
9	0.5%	4.0%																												
10	0.5%	4.0%																												
11	0.5%	4.0%																												

APPENDIX C

MANNING'S N-VALUES ESTIMATED BY PRANDTL-VON KARMAN VELOCITY METHOD

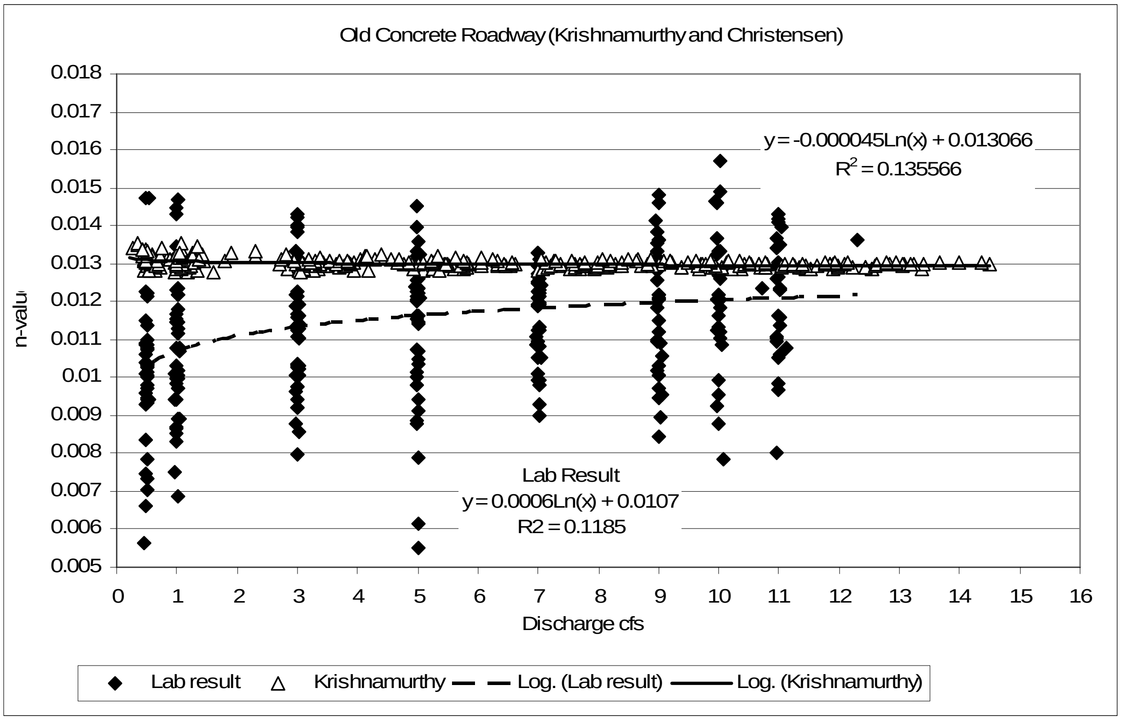


Figure C1.1 Manning's n-value and discharge of smooth concrete surface estimated by Krishnamurthy and Christensen's equation

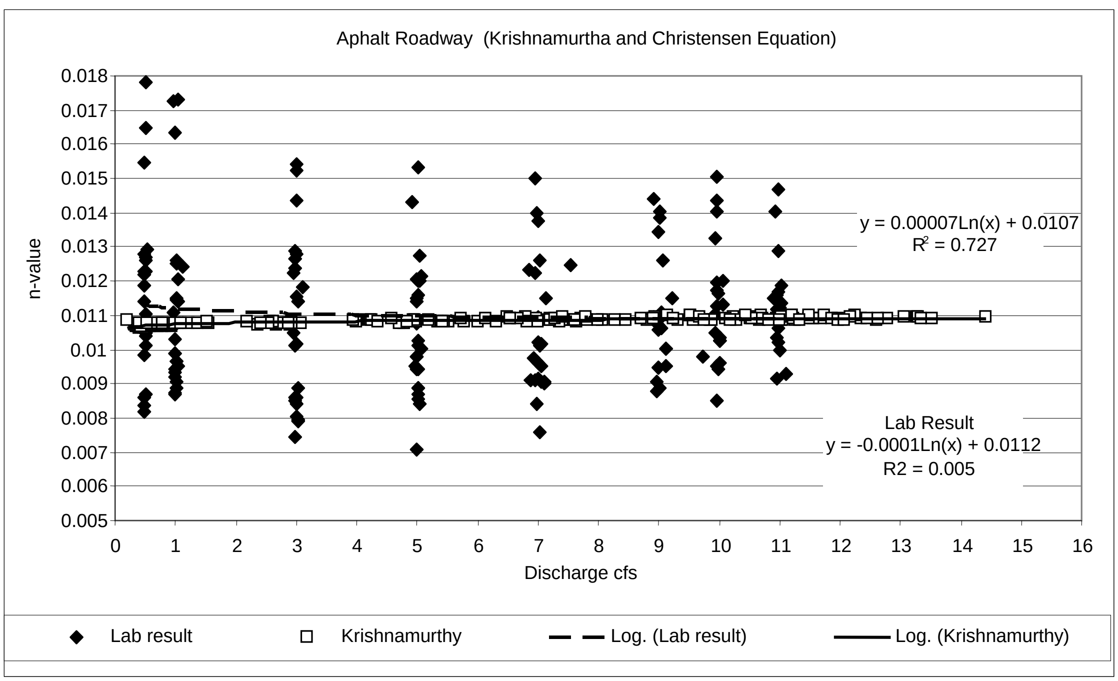


Figure C1.2 Manning's n-value and discharge of asphalt surface estimated by Krishnamurthy and Christensen's equation

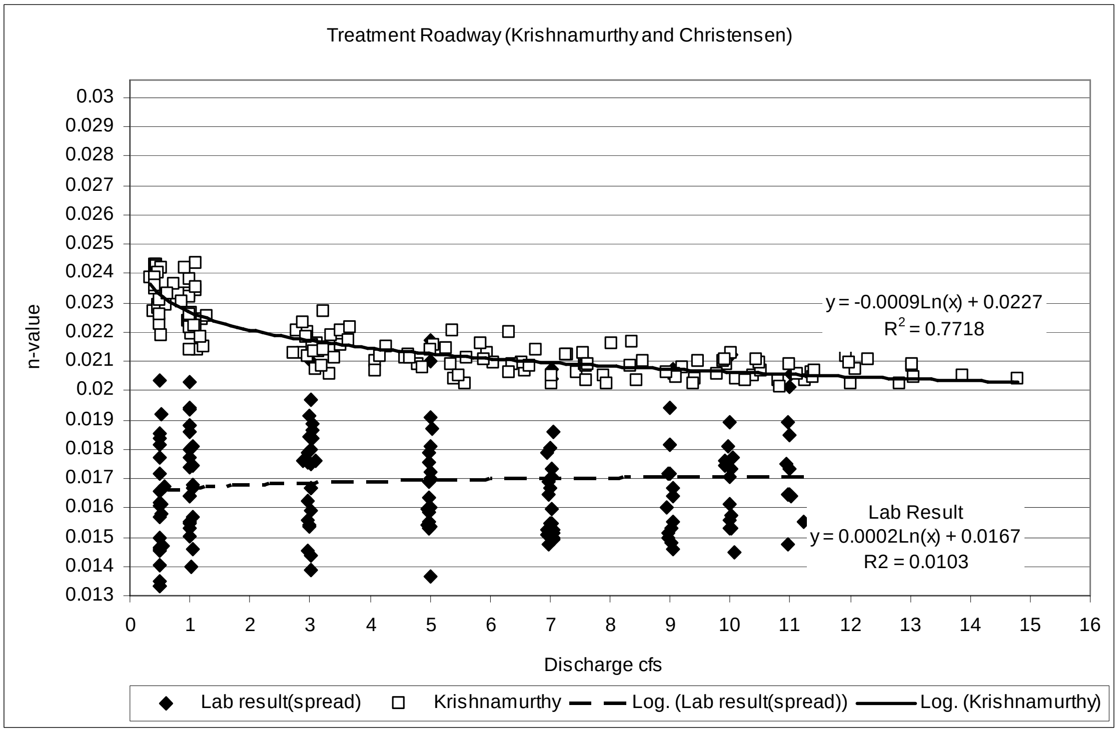


Figure C1.3 Manning's n-value and discharge of asphalt treatment surface estimated by Krishnamurthy and Christensen's equation

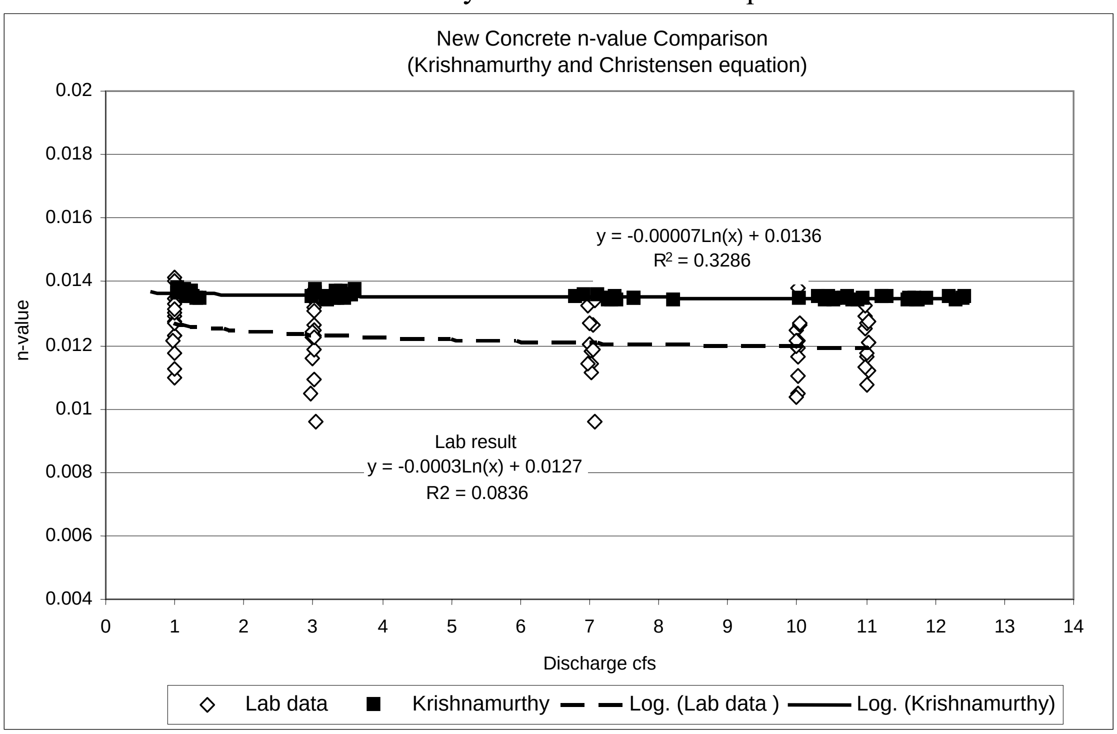


Figure C1.4 Manning's n-value and discharge of TxDOT concrete surface estimated by Krishnamurthy and Christensen's equation

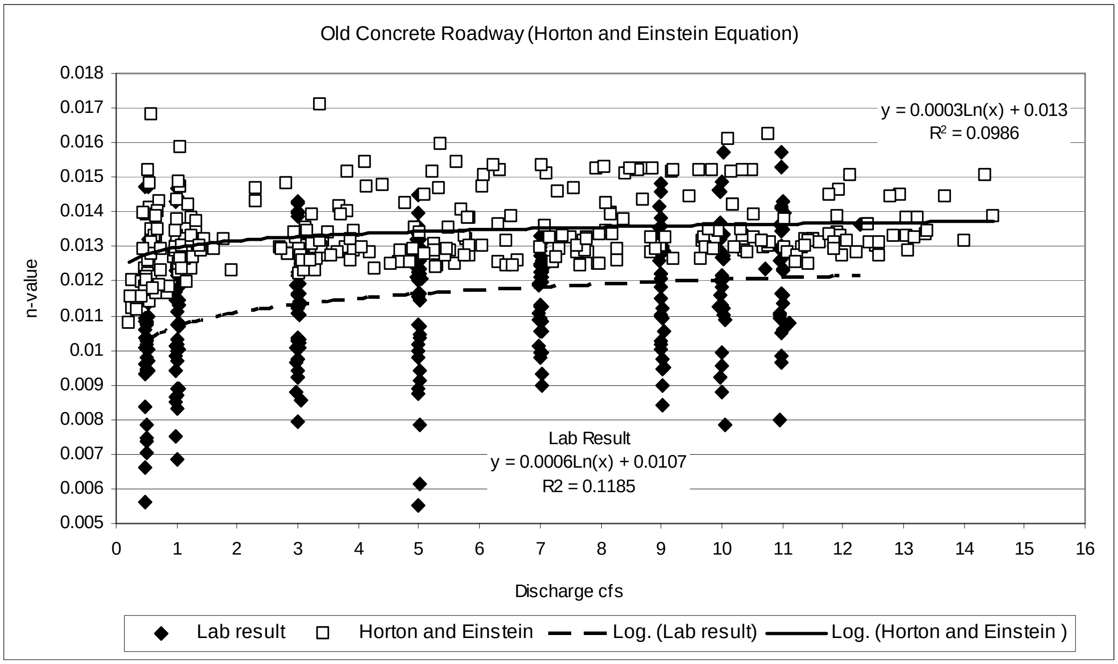


Figure C2.1 Manning's n-value and discharge of smooth concrete surface estimated by Horton and Einstein's equation

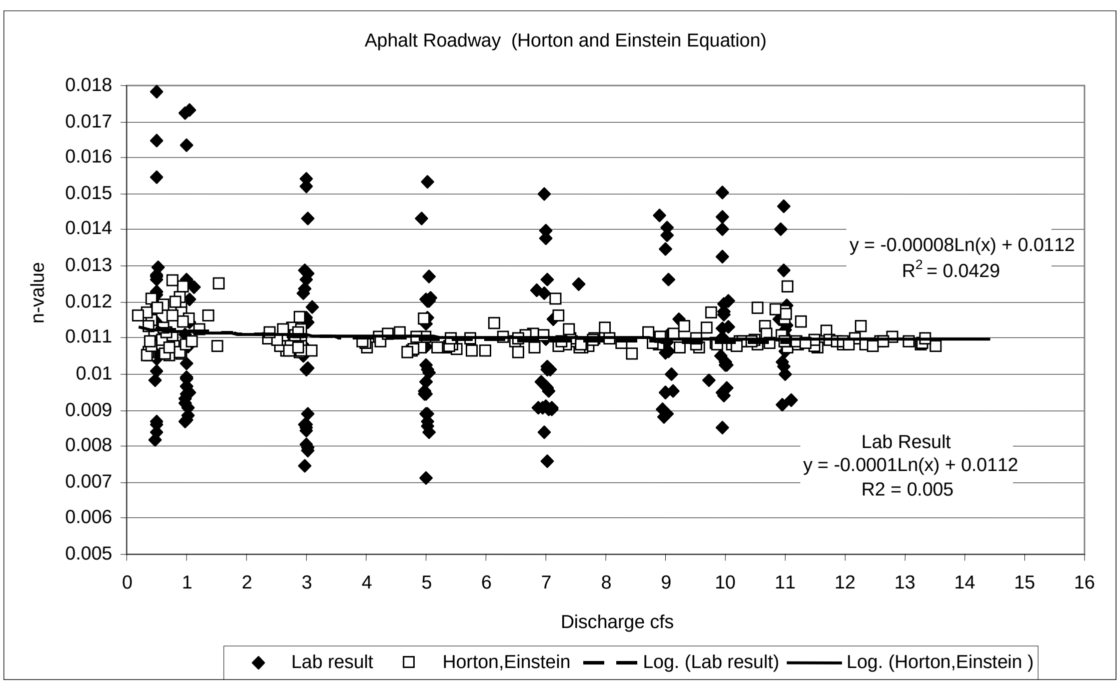


Figure C2.2 Manning's n-value and discharge of asphalt surface estimated by Horton and Einstein's equation

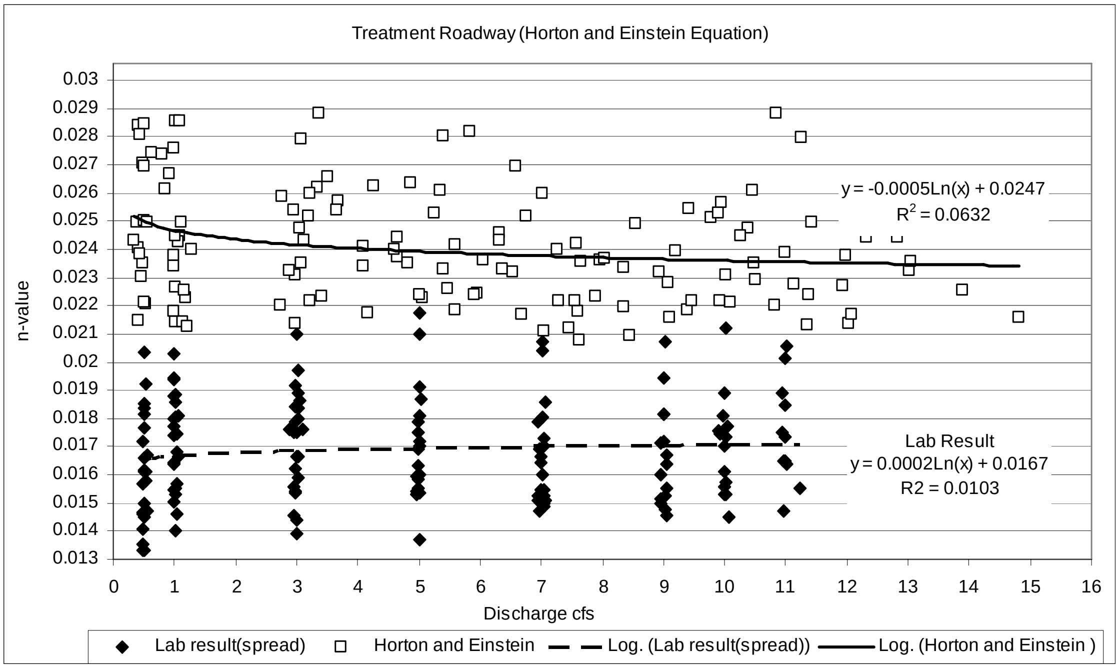


Figure C2.3 Manning's n-value and discharge of asphalt treatment surface estimated by Horton and Einstein's equation

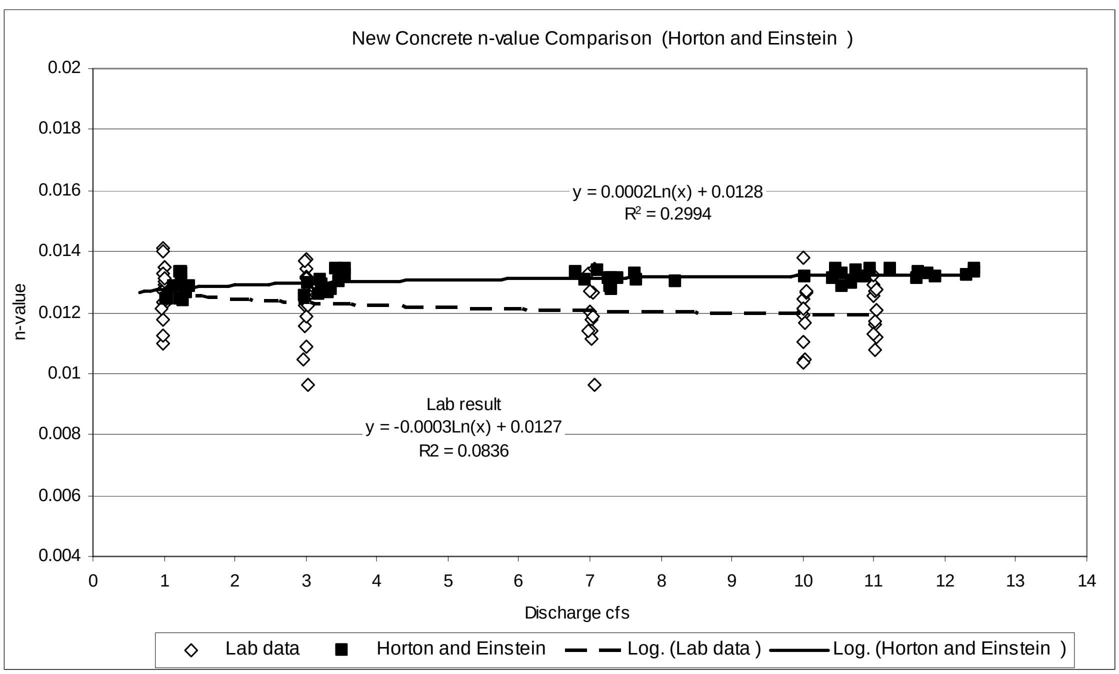


Figure C2.4 Manning's n-value and discharge of TxDOT concrete surface estimated by Horton and Einstein's equation

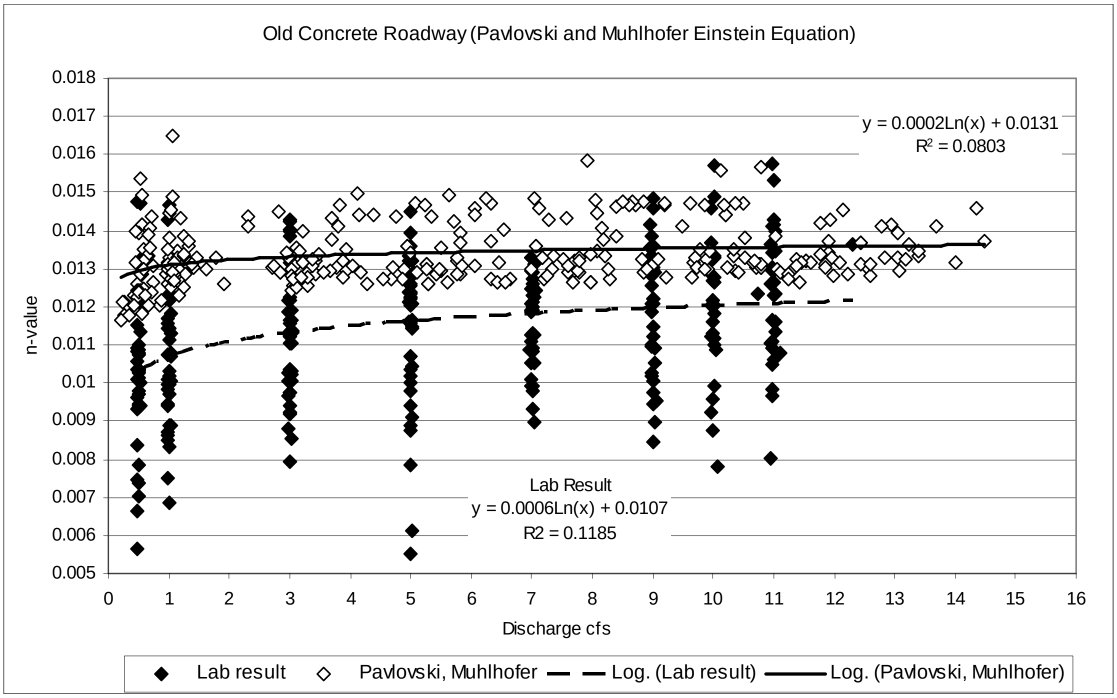


Figure C3.1 Manning's n-value and discharge of smooth concrete roadway estimated by Pavlovski, Muhlhofer, Einstein and Banks's equation

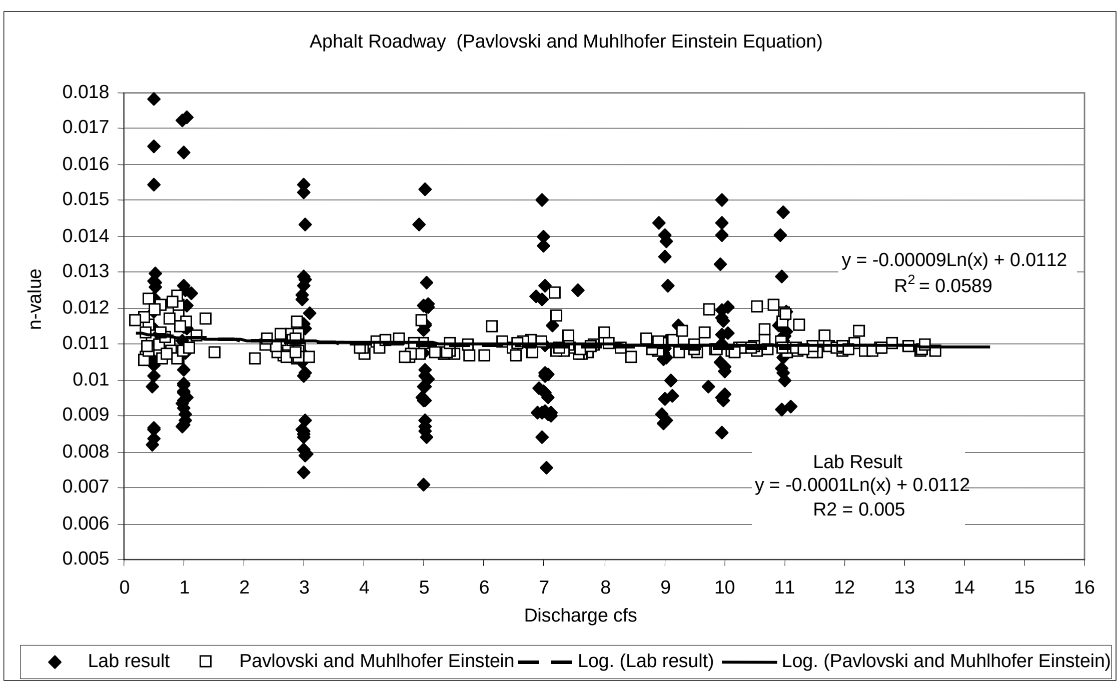


Figure C3.2 Manning's n-values and discharges of asphalt Roadway estimated by Pavlovski, Muhlhofer, Einstein and Banks's equation

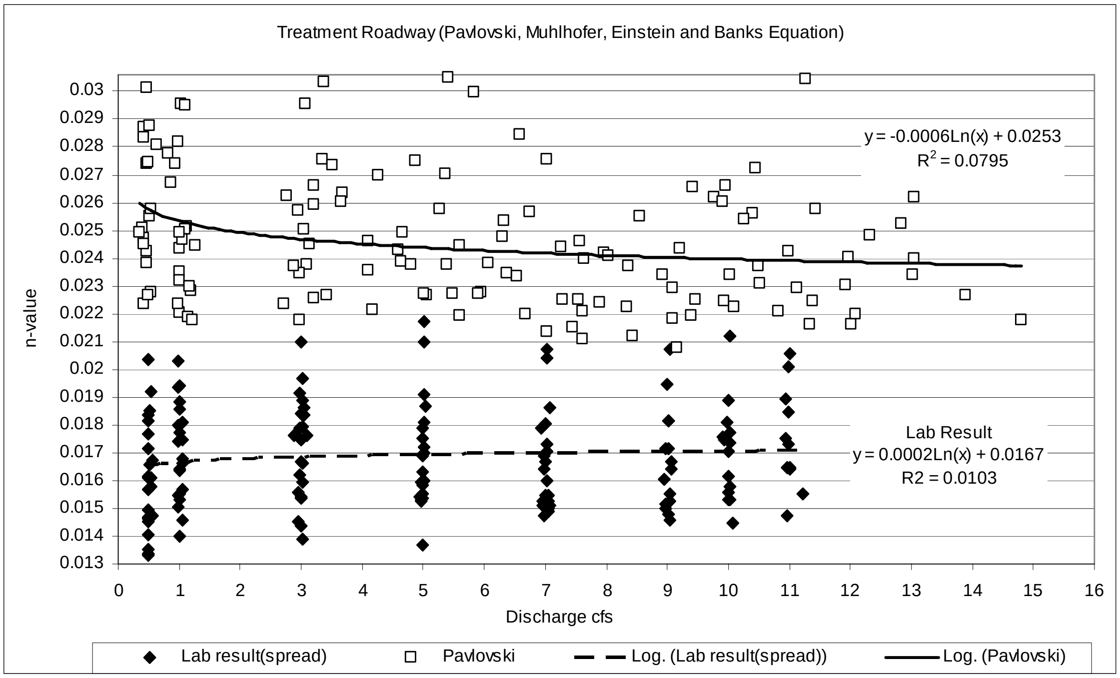


Figure C3.3 Manning's n-values and discharges of asphalt treatment roadway estimated by Pavlovski, Muhlhofer, Einstein and Banks's equation

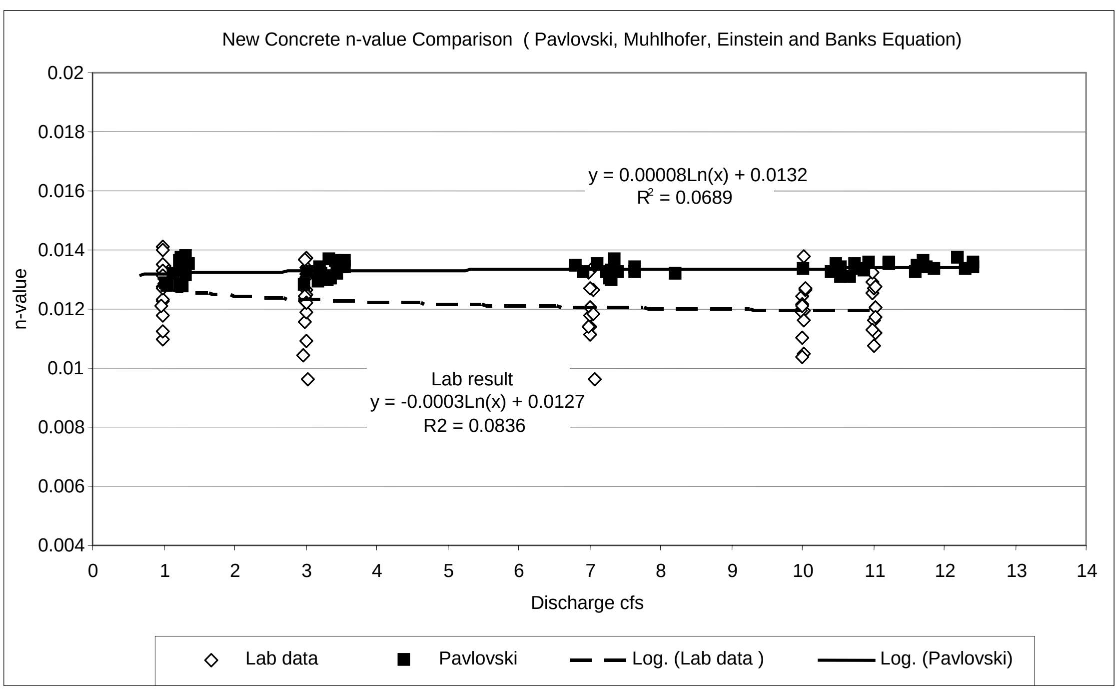


Figure C3.4 Manning's n-values and discharges of TxDOT concrete roadway estimated by Pavlovski, Muhlhofer, Einstein and Banks's equation

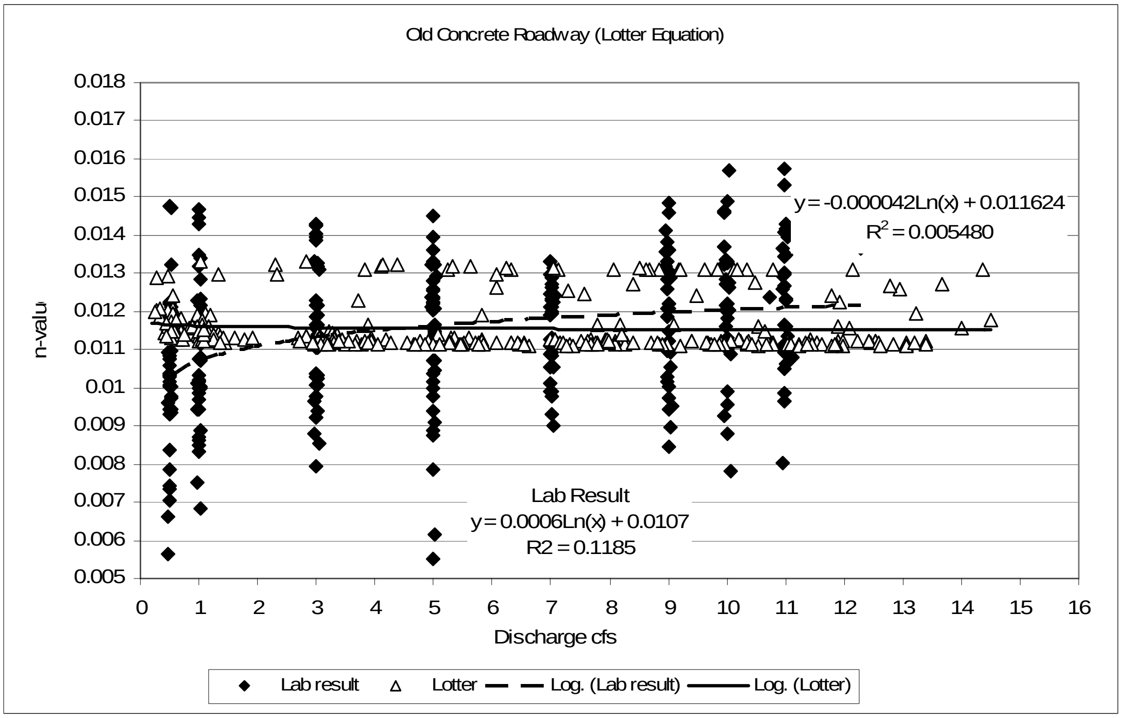


Figure C4.1 Manning's n-values and discharges of smooth concrete roadway estimated by Lotter's equation

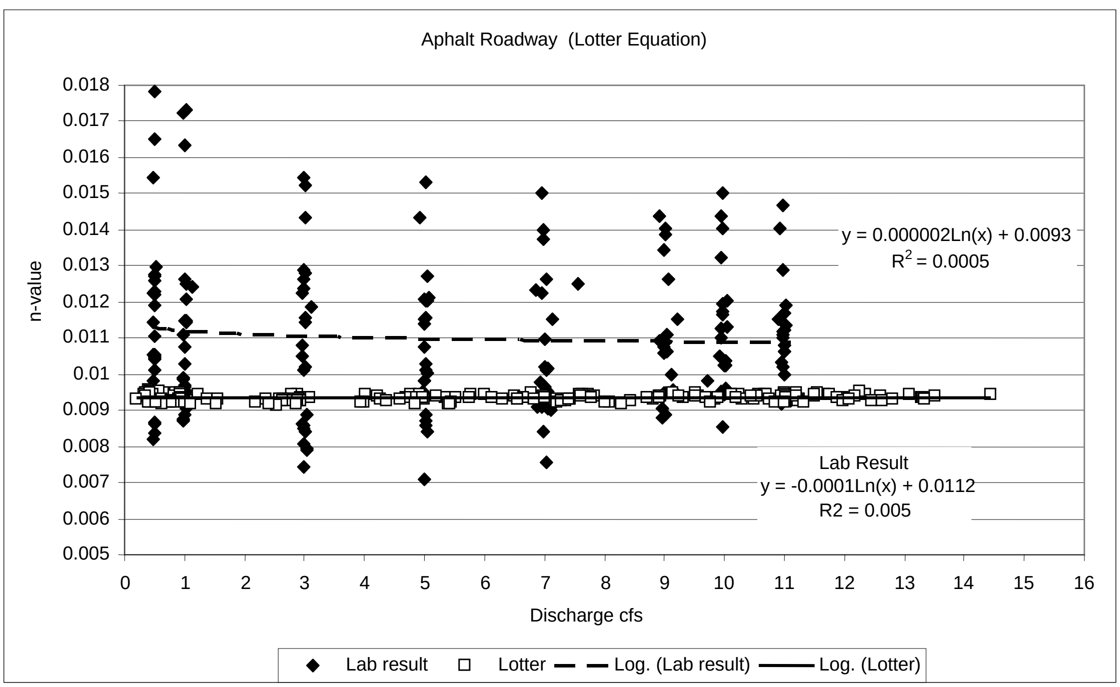


Figure C4.2 Manning's n-values and discharges of asphalt roadway estimated by Lotter's equation

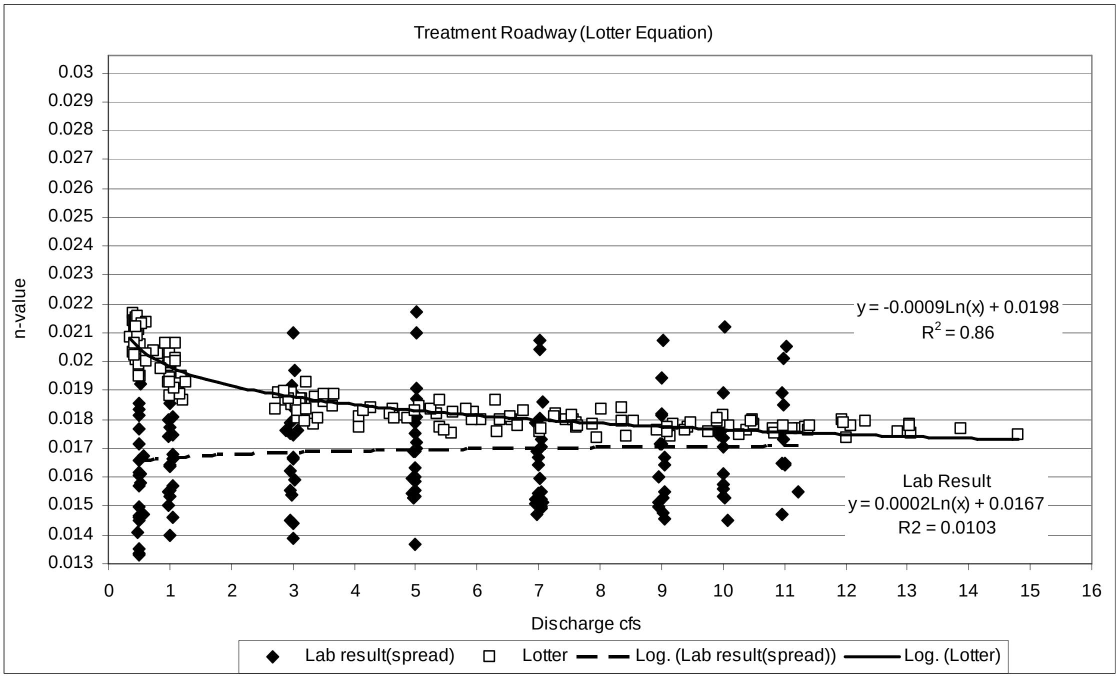


Figure C4.3 Manning's n-values and discharges of asphalt treatment roadway estimated by Lotter's equation

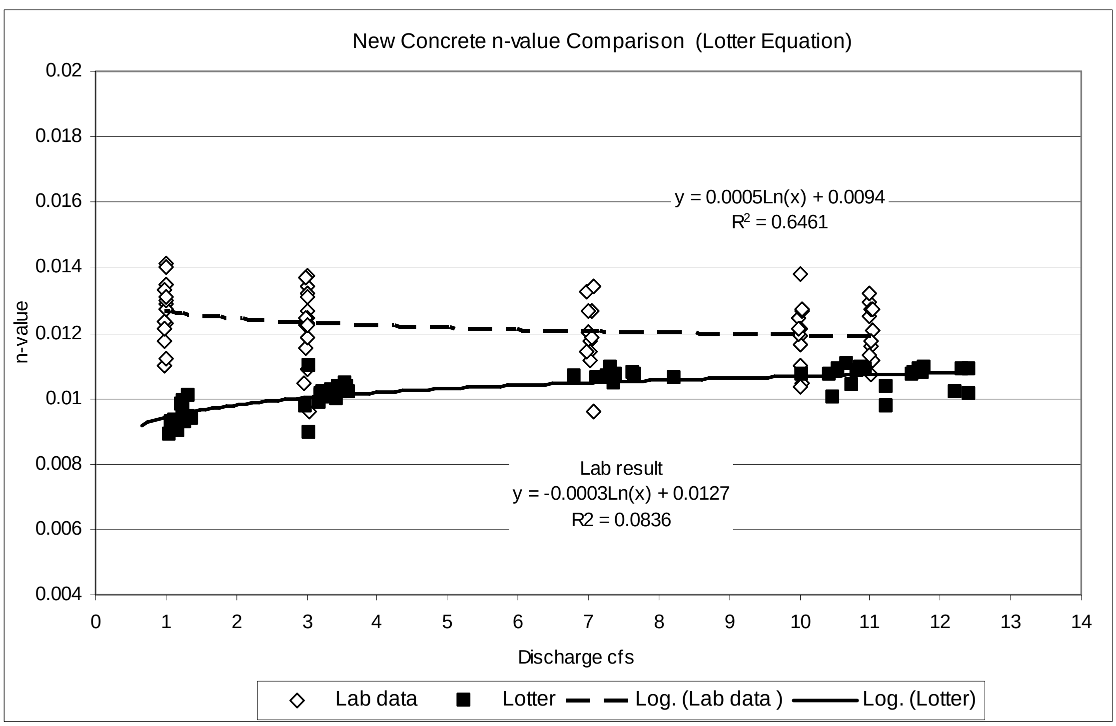


Figure C4.4 Manning's n-values and discharges of TxDOT concrete roadway estimated by Lotter's equation

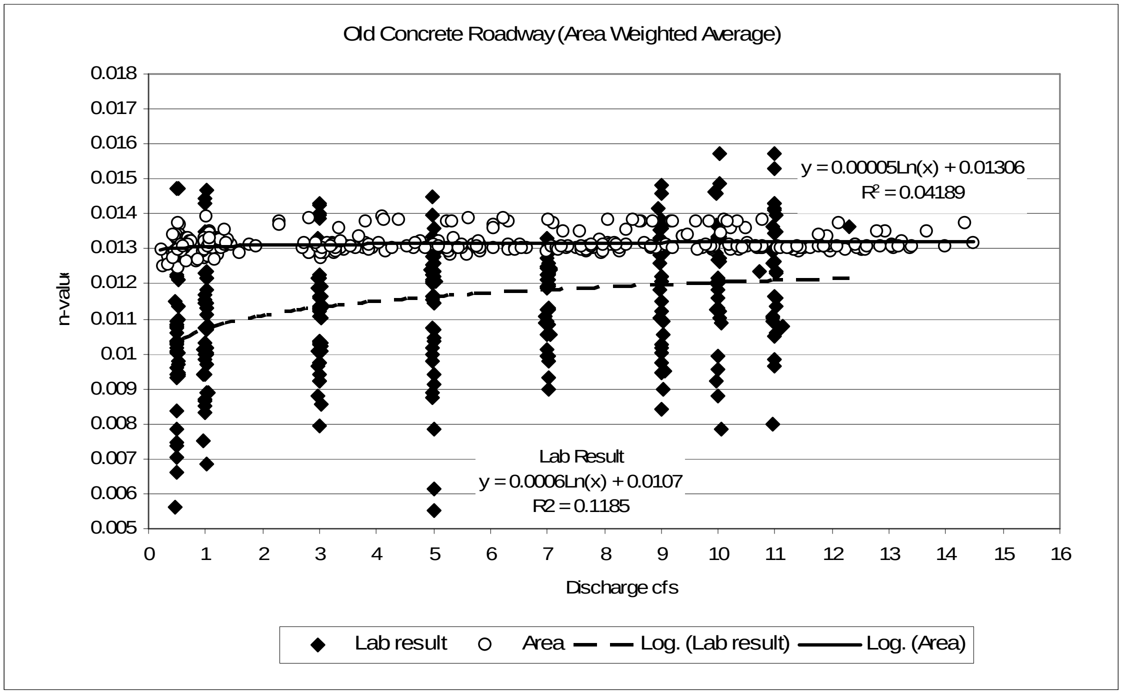


Figure C5.1 Manning's n-values and discharges of smooth concrete surface estimated by Area-Weight averaging method

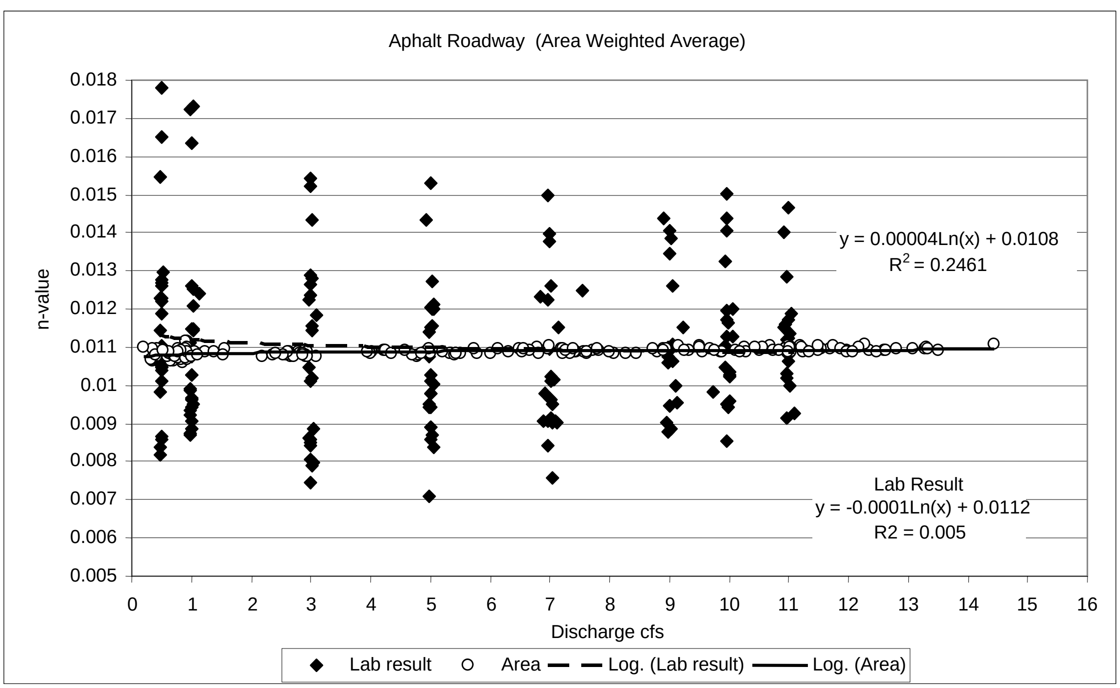


Figure C5.2 Manning's n-values and discharges of asphalt surface estimated by area-weight averaging method

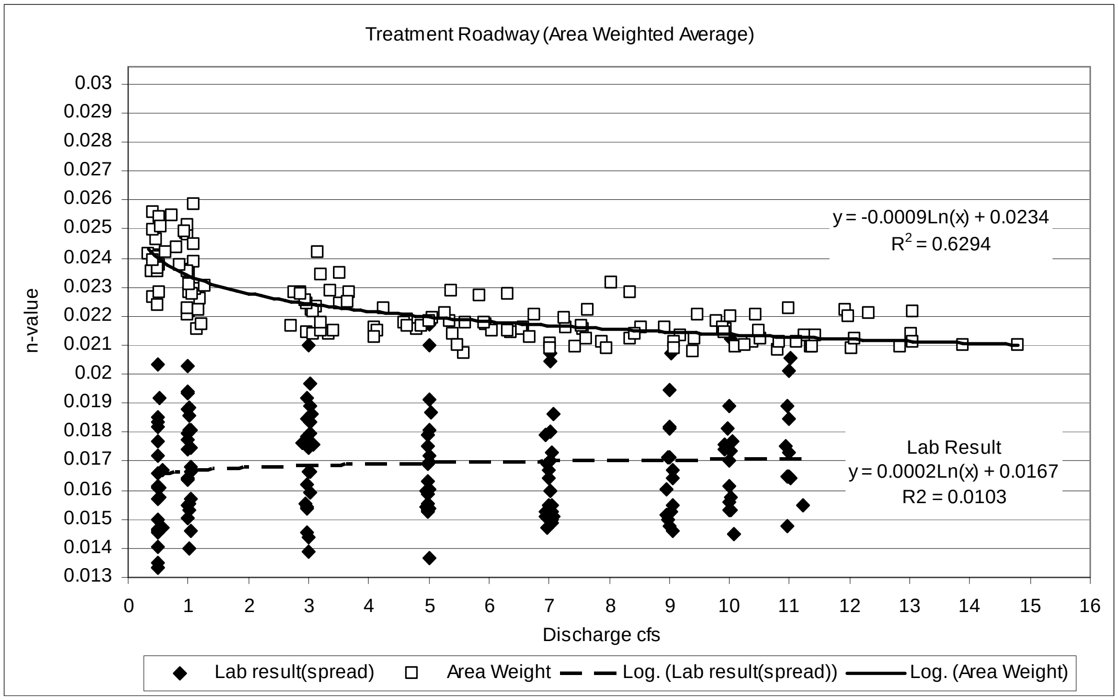


Figure C5.3 Manning's n-values and discharges of asphalt treatment surface estimated by area-weight averaging method

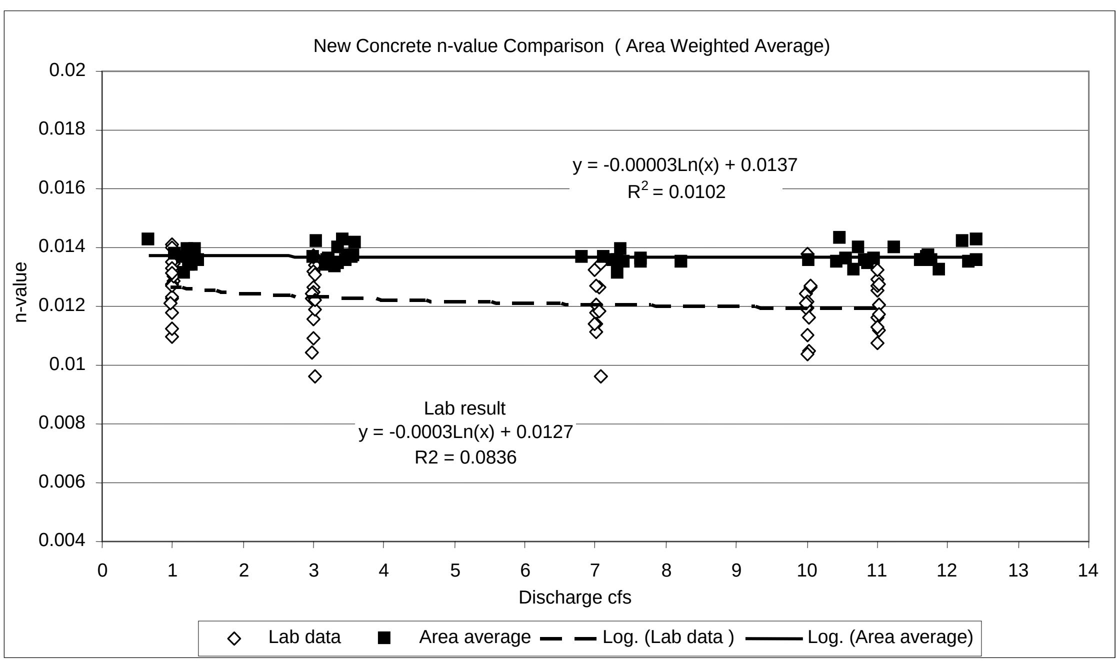


Figure C5.4 Manning's n-values and discharges of TxDOT concrete surface estimated by area-weight averaging method

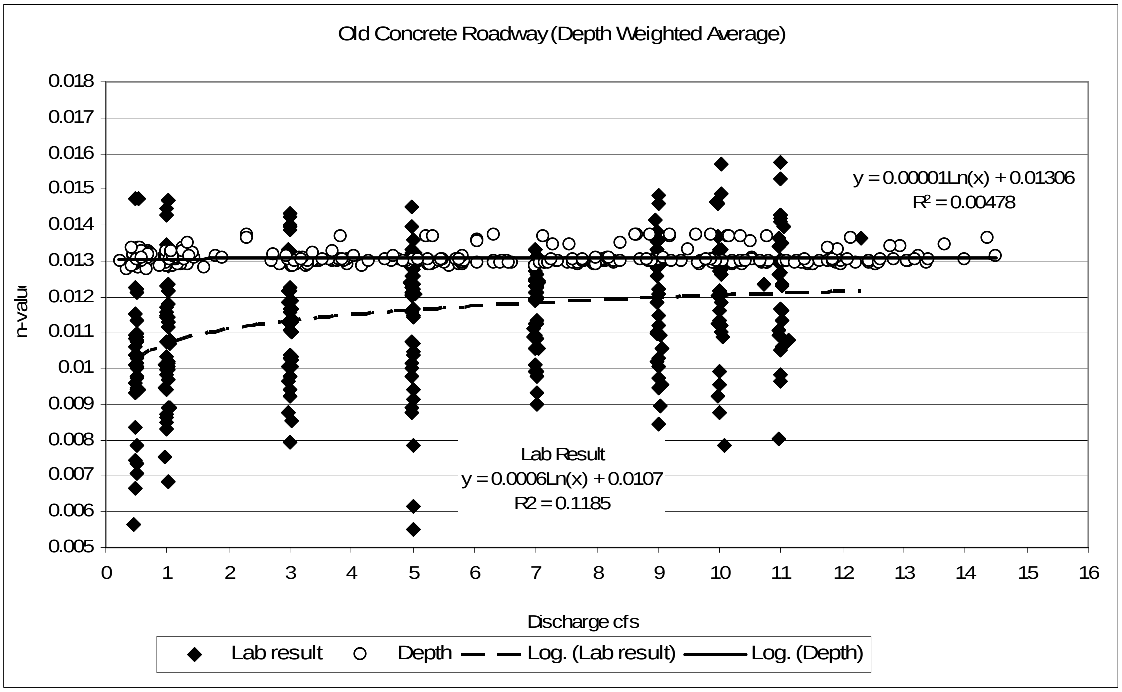


Figure C6.1 Manning's n-values and discharges of smooth concrete surface estimated by depth-weight averaging method

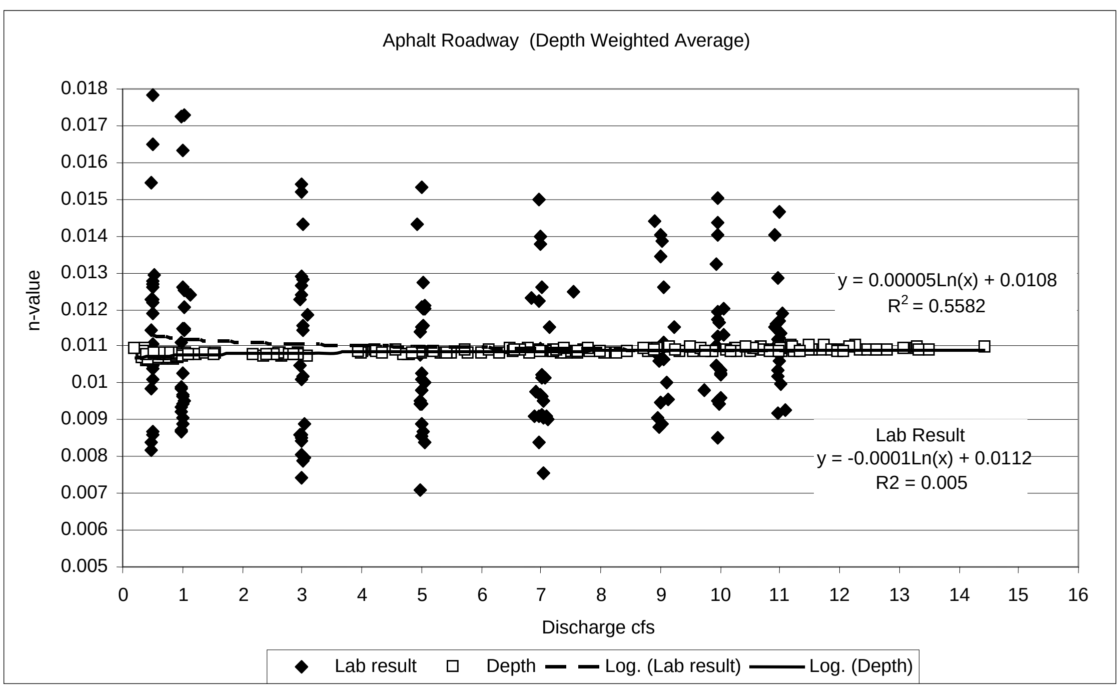


Figure C6.2 Manning's n-values and discharges of asphalt surface estimated by depth-weight averaging method

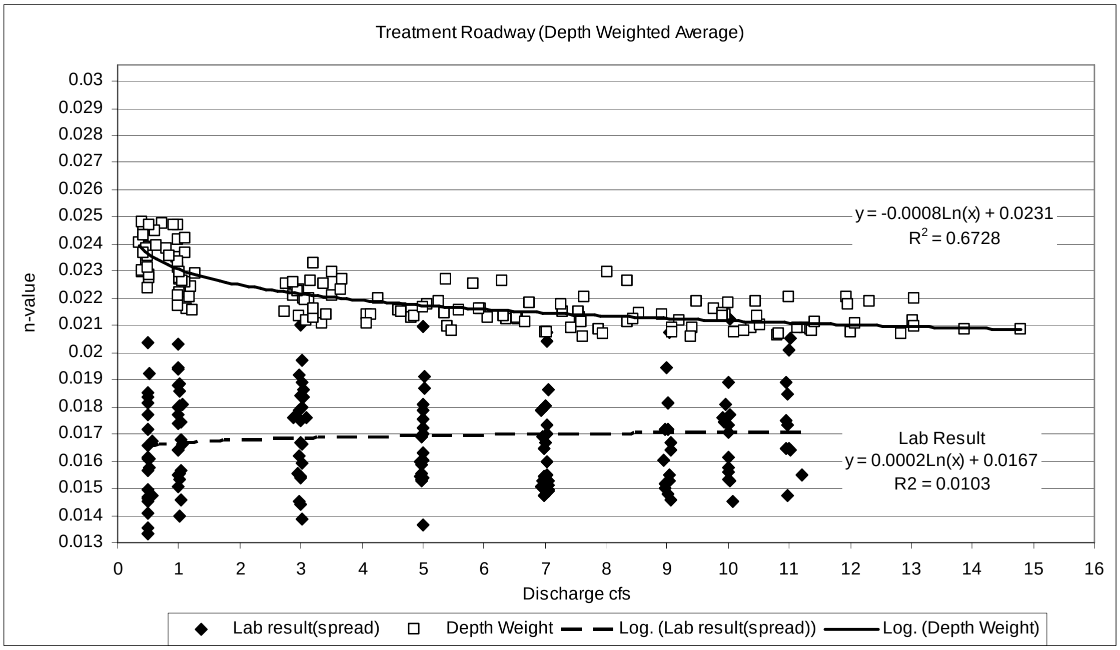


Figure C6.3 Manning's n-values and discharges of asphalt treatment surface estimated by depth-weight averaging method

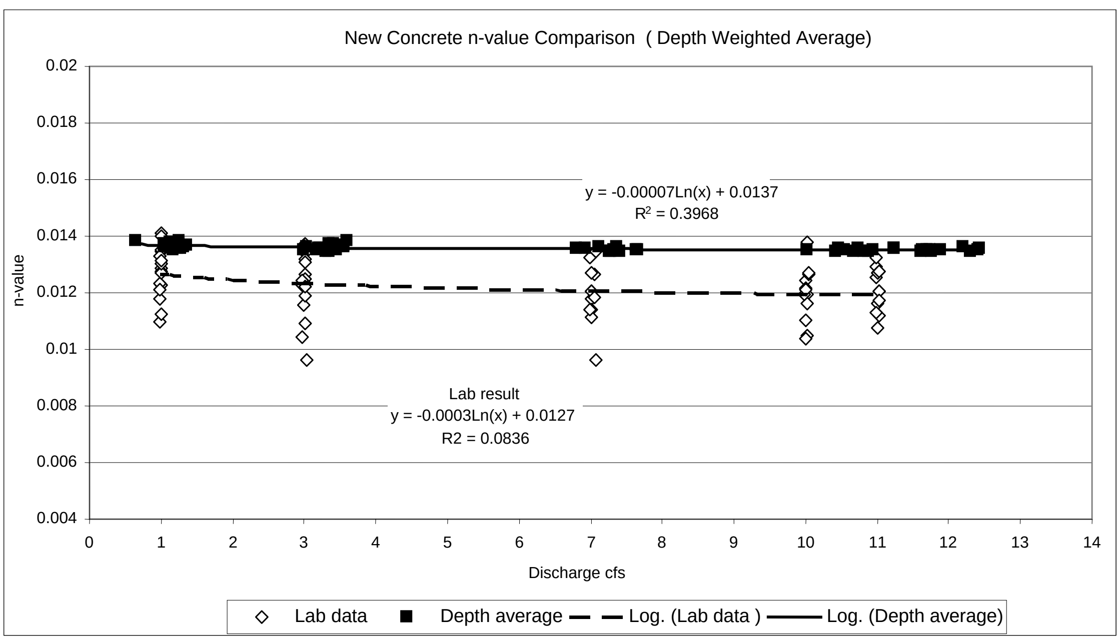


Figure C6.4 Manning's n-values and discharges of TxDOT concrete surface estimated by depth-weight averaging method

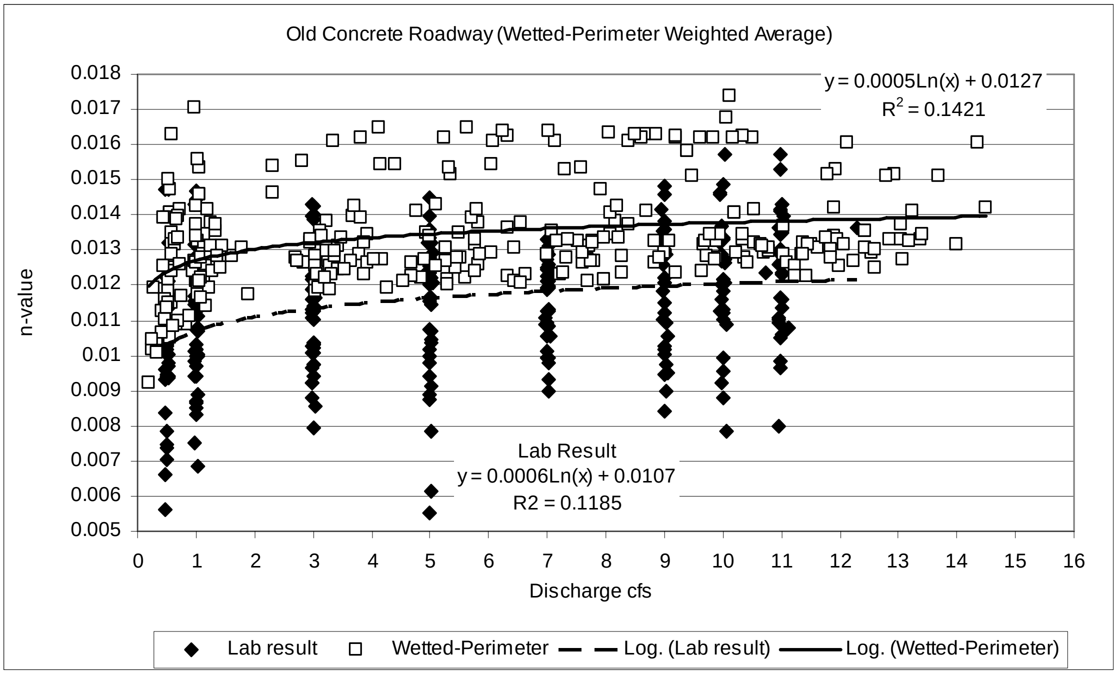


Figure C7.1 Manning's n-values and discharges of smooth concrete surface estimated by wetted-perimeter weighted averaging method

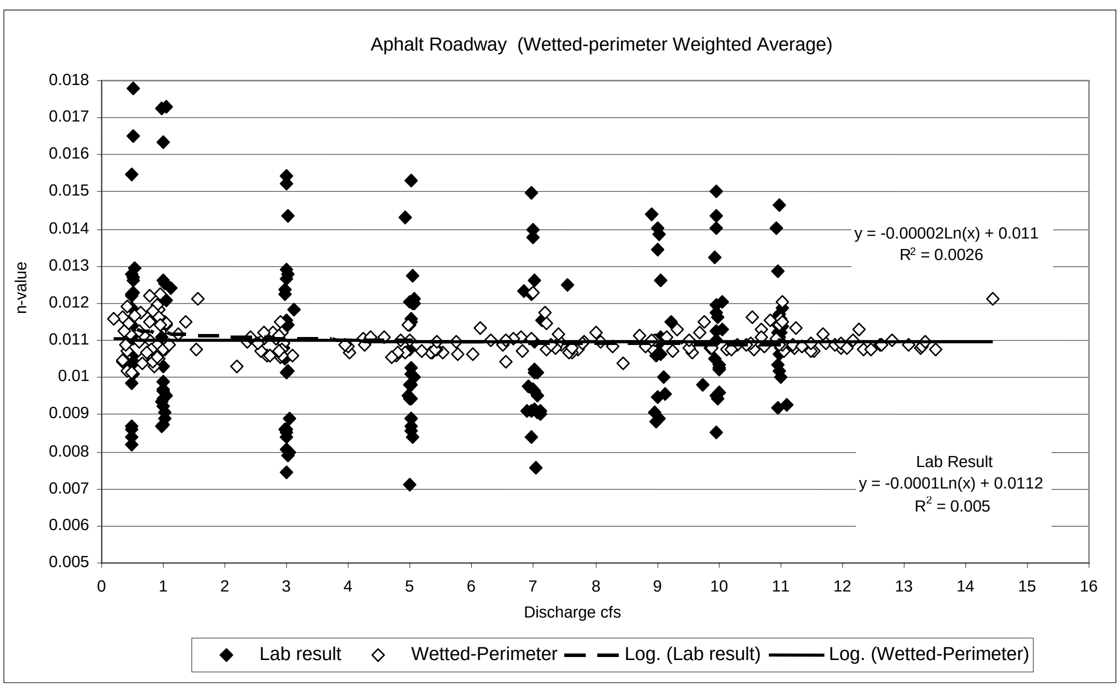


Figure C7.2 Manning's n-values and discharges of asphalt surface estimated by wetted-perimeter weighted averaging method

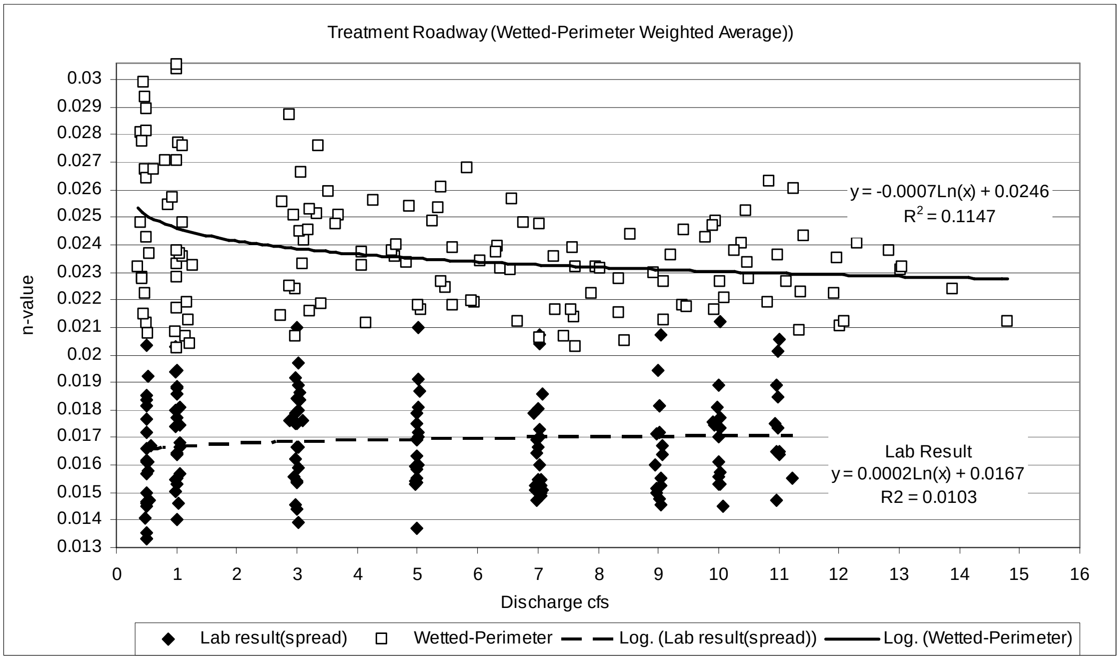


Figure C7.3 Manning's n-values and discharges of asphalt treatment surface estimated by wetted-perimeter weighted averaging method

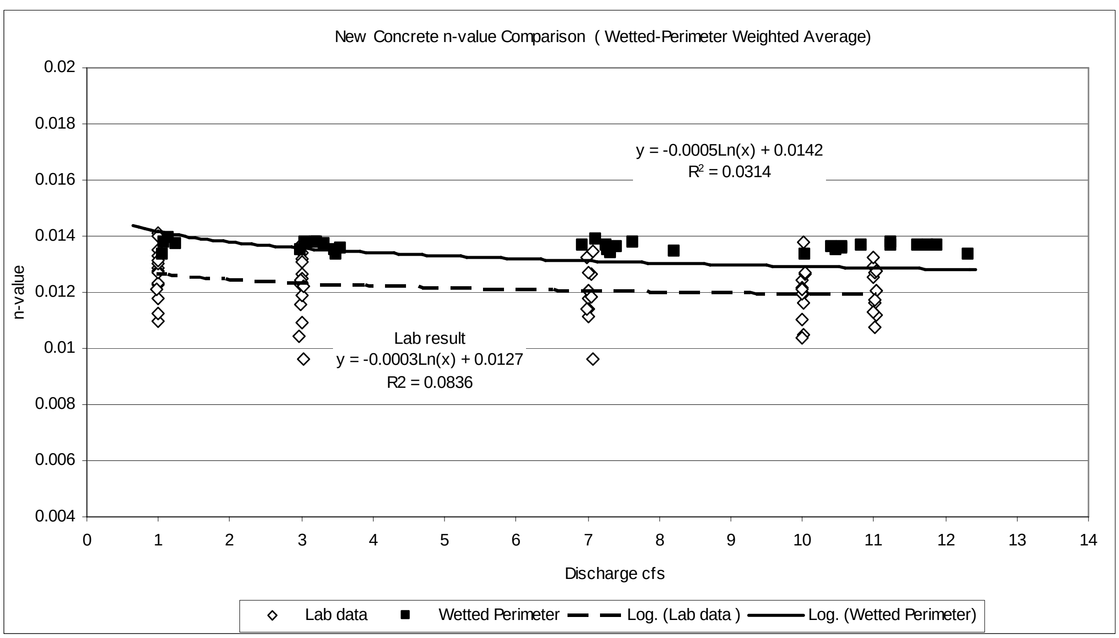


Figure C7.4 Manning's n-values and discharges of TxDOT concrete surface estimated by wetted-perimeter weighted averaging method

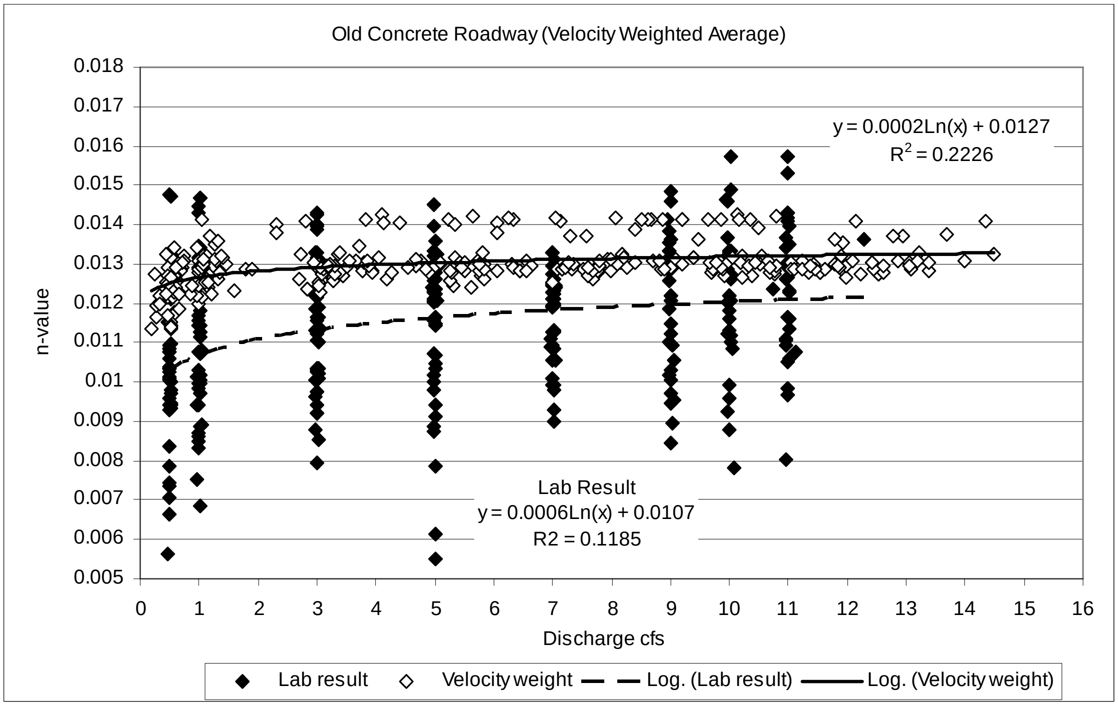


Figure C8.1 Manning's n-values and discharges of smooth concrete surface estimated by velocity-weight averaging method

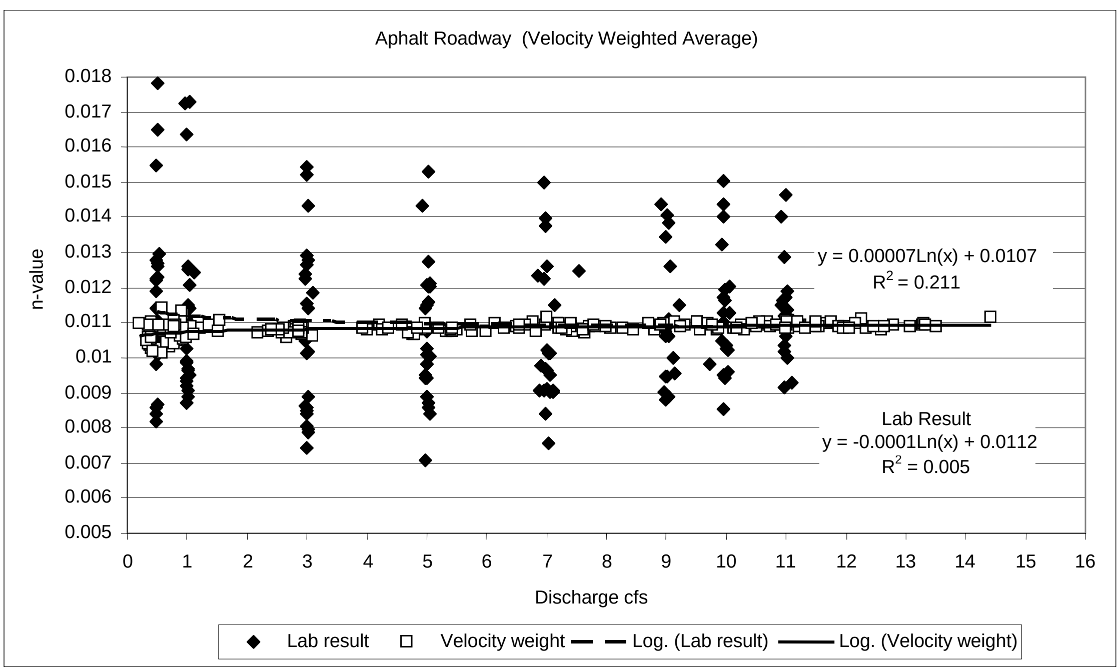


Figure C8.2 Manning's n-values and discharges of asphalt surface estimated by velocity-weight averaging method

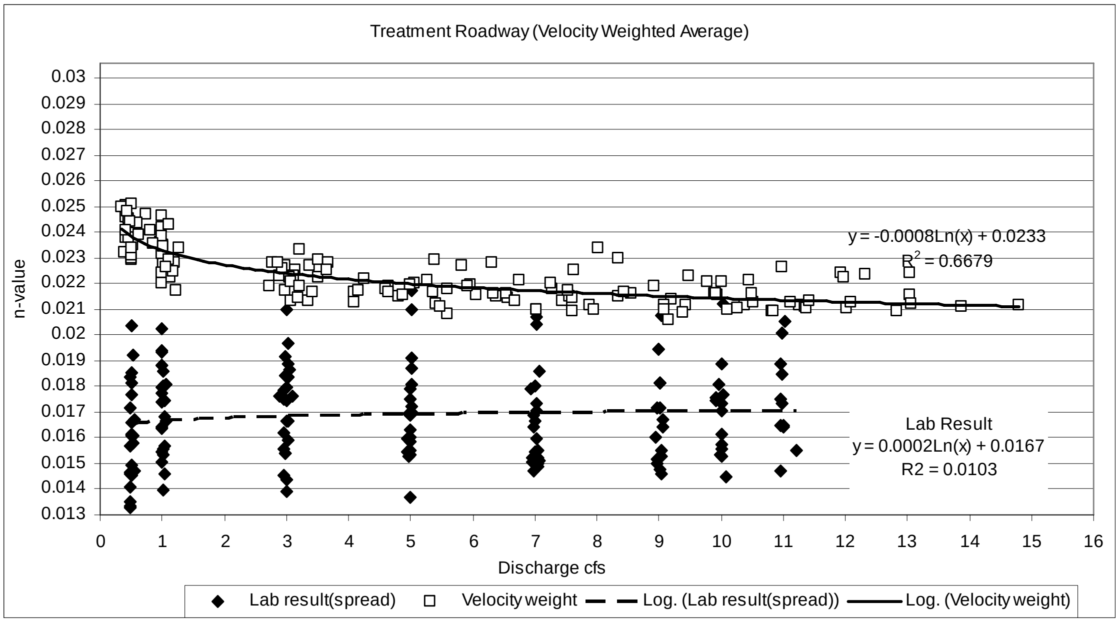


Figure C8.3 Manning's n-values and discharges of asphalt treatment surface estimated by velocity-weight averaging method

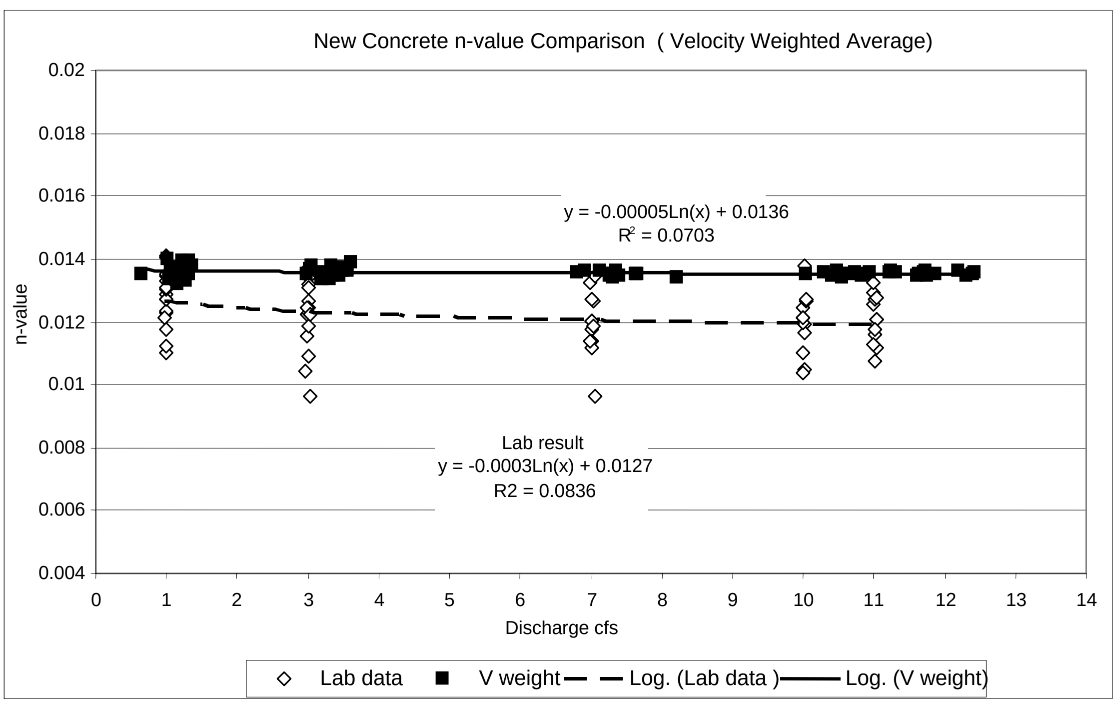


Figure C8.4 Manning's n-values and discharges of TxDOT concrete surface estimated by velocity-weight averaging method

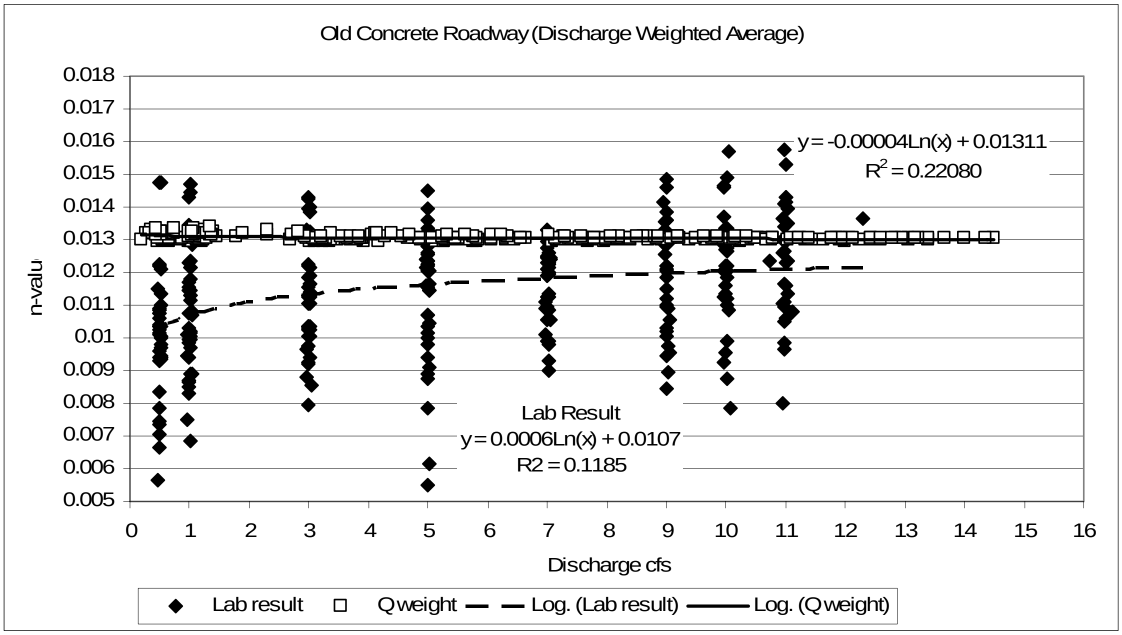


Figure C9.1 Manning's n-values and discharges of smooth concrete surface estimated by discharge-weight averaging method

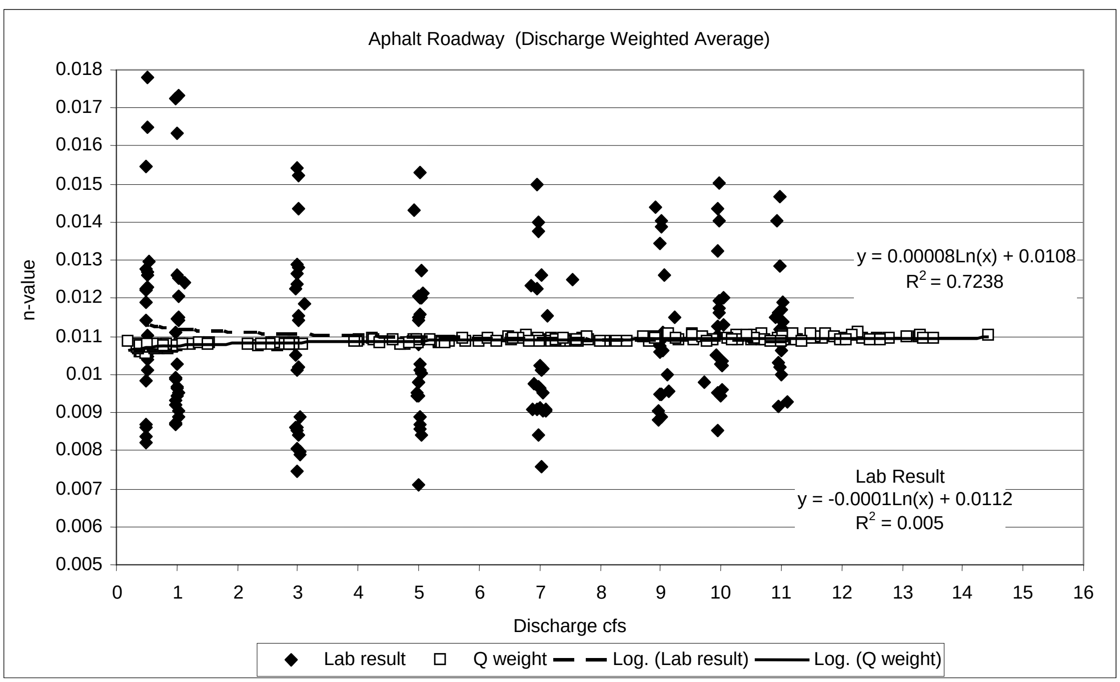


Figure C9.2 Manning's n-values and discharges of asphalt surface estimated by discharge-weight averaging method

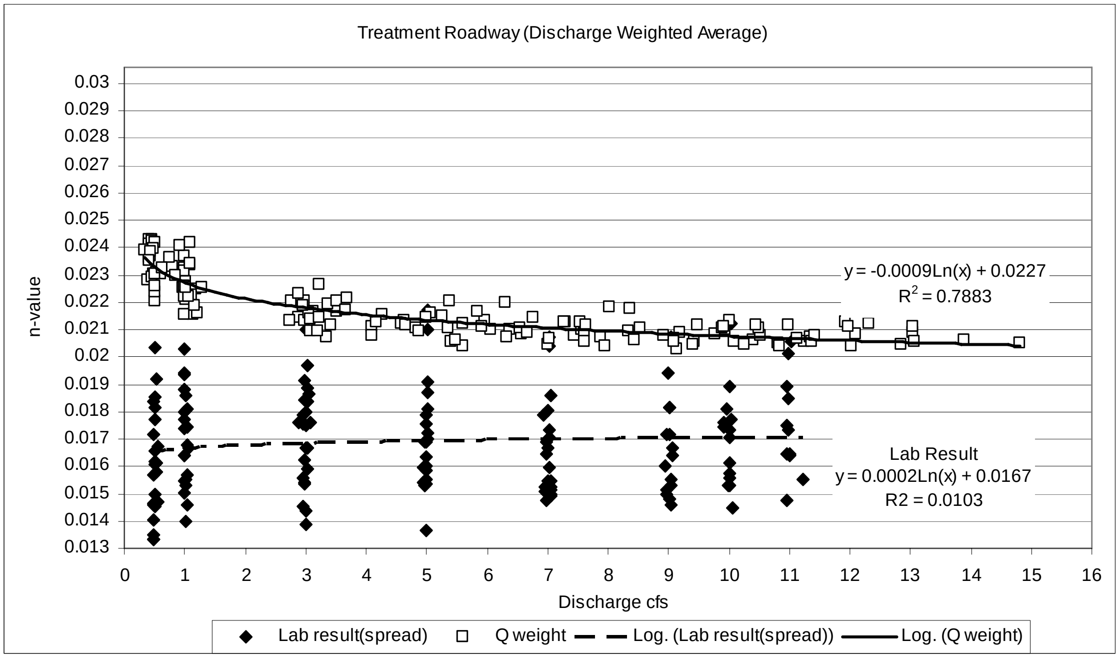


Figure C9.3 Manning's n-values and discharges of asphalt treatment surface estimated by discharge-weight averaging method

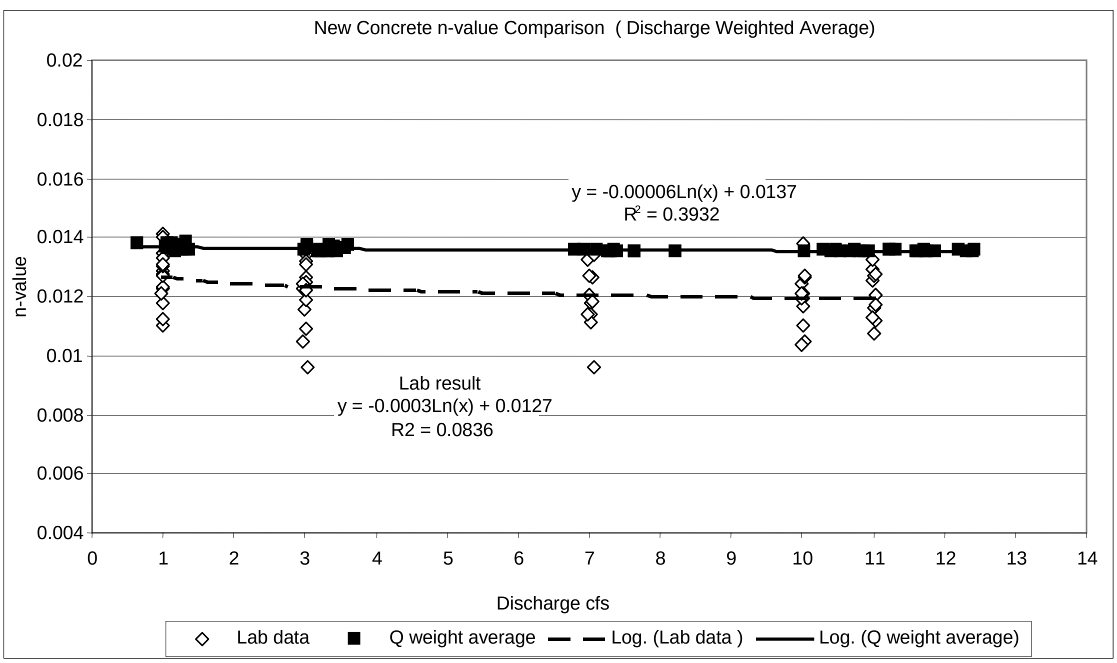


Figure C9.4 Manning's n-values and discharges of TxDOT concrete surface estimated by discharge-weight averaging method

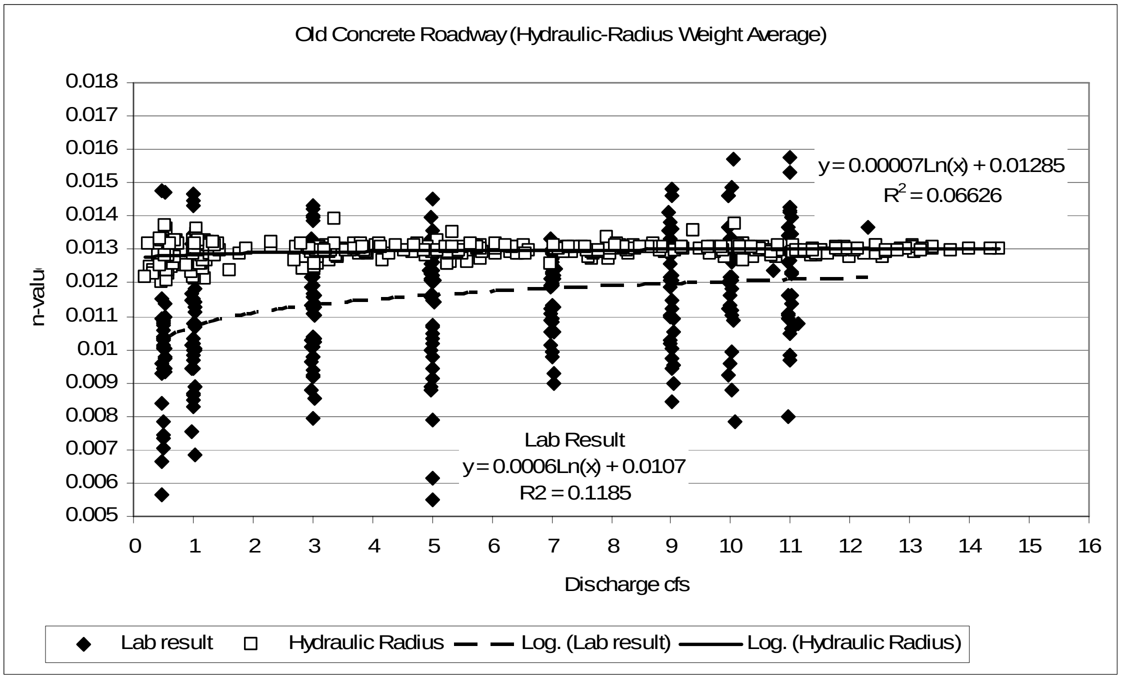


Figure C10.1 Manning's n-values and discharges of smooth concrete surface estimated by hydraulic-radius weighted averaging method

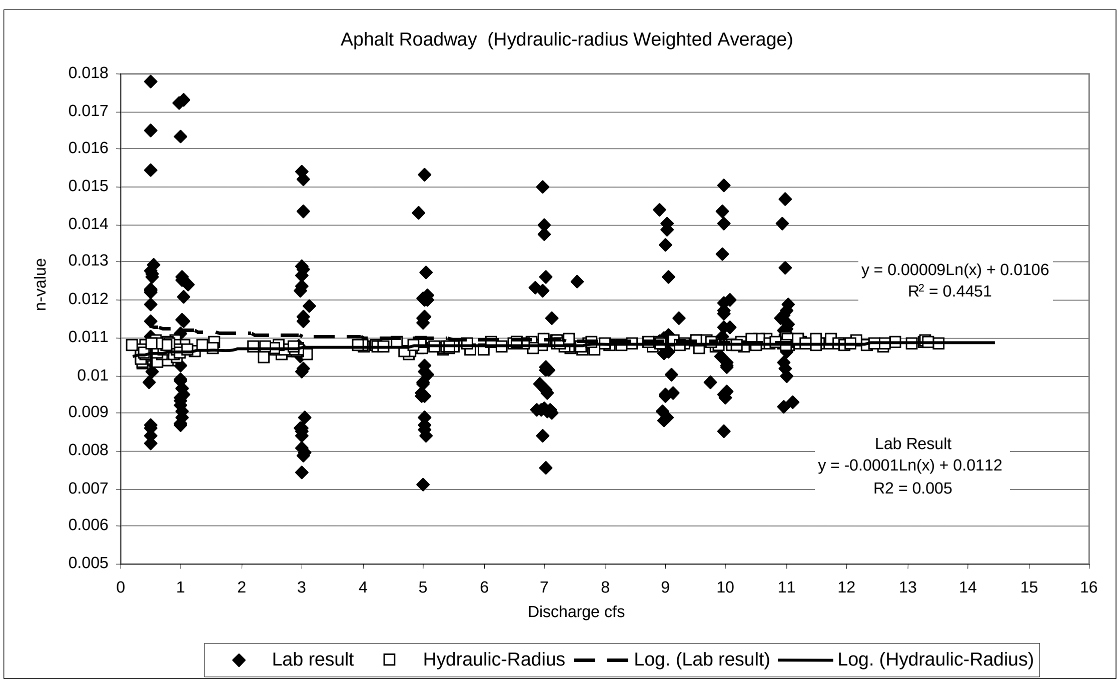


Figure C10.2 Manning's n-values and discharges of asphalt surface estimated by hydraulic-radius weighted averaging method

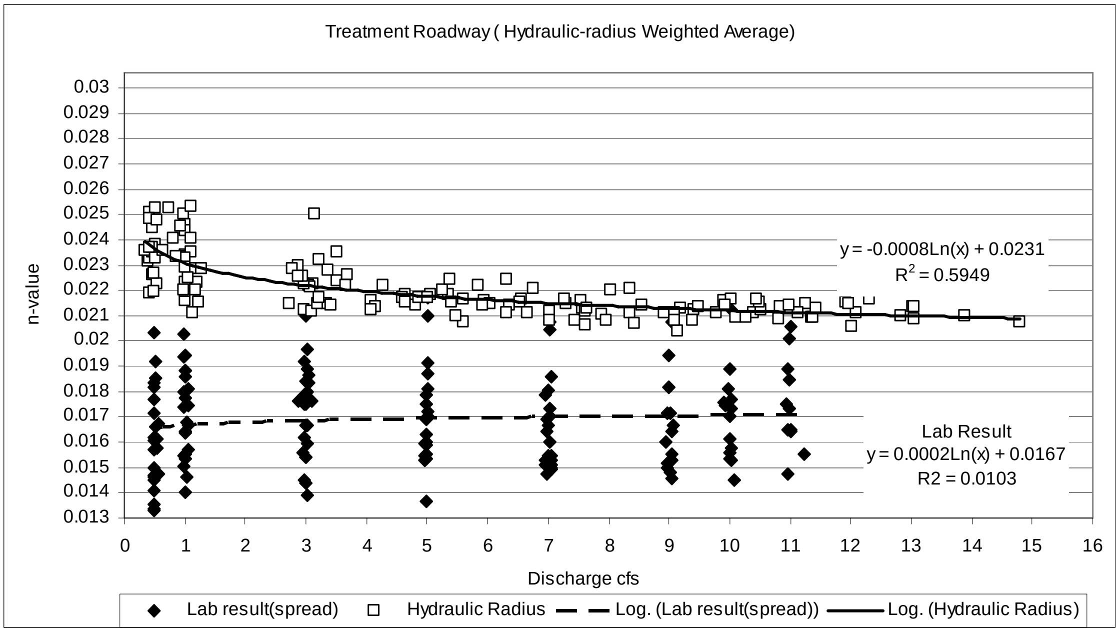


Figure C10.3 Manning’s n-values and discharges of asphalt treatment surface estimated by hydraulic-radius weighted averaging method

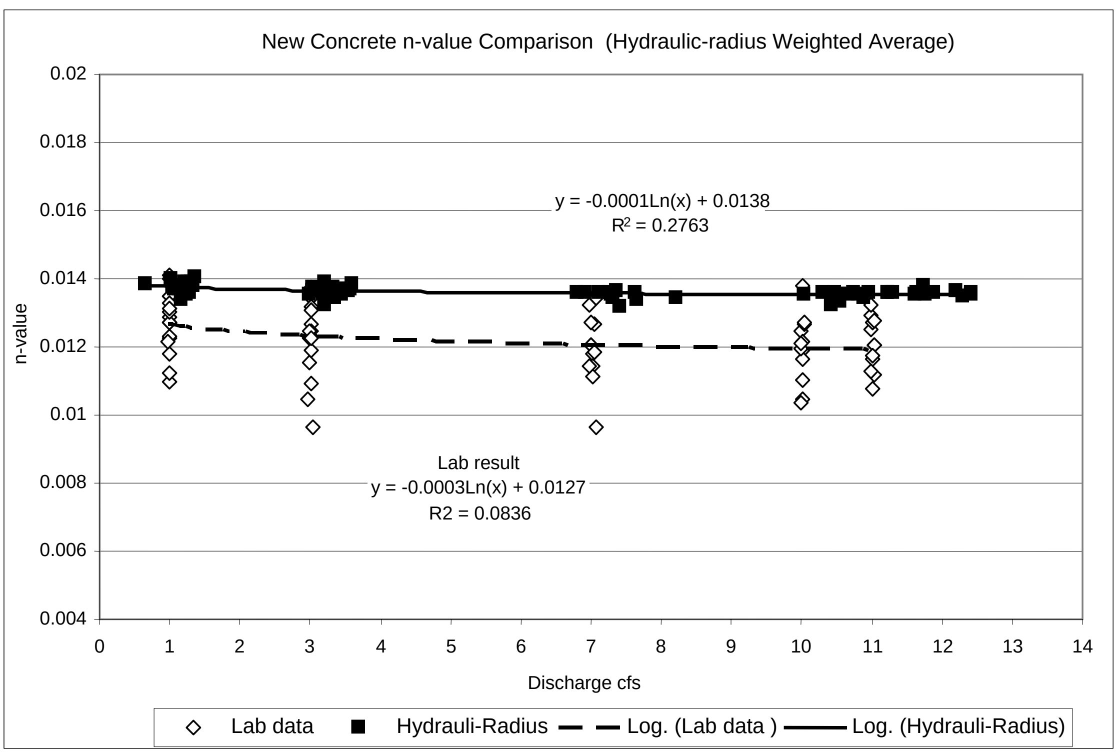


Figure C10.4 Manning’s n-values and discharges of TxDOT concrete surface estimated by hydraulic-radius weighted averaging method

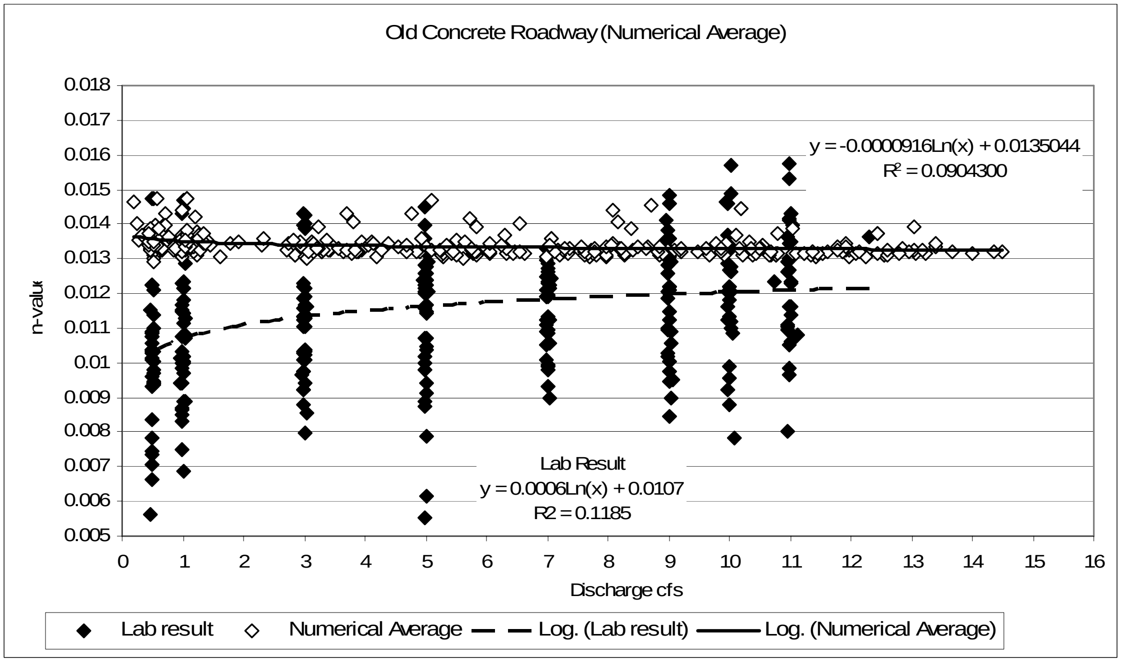


Figure C11.1 Manning's n-values and discharges of smooth concrete surface estimated by numerical average

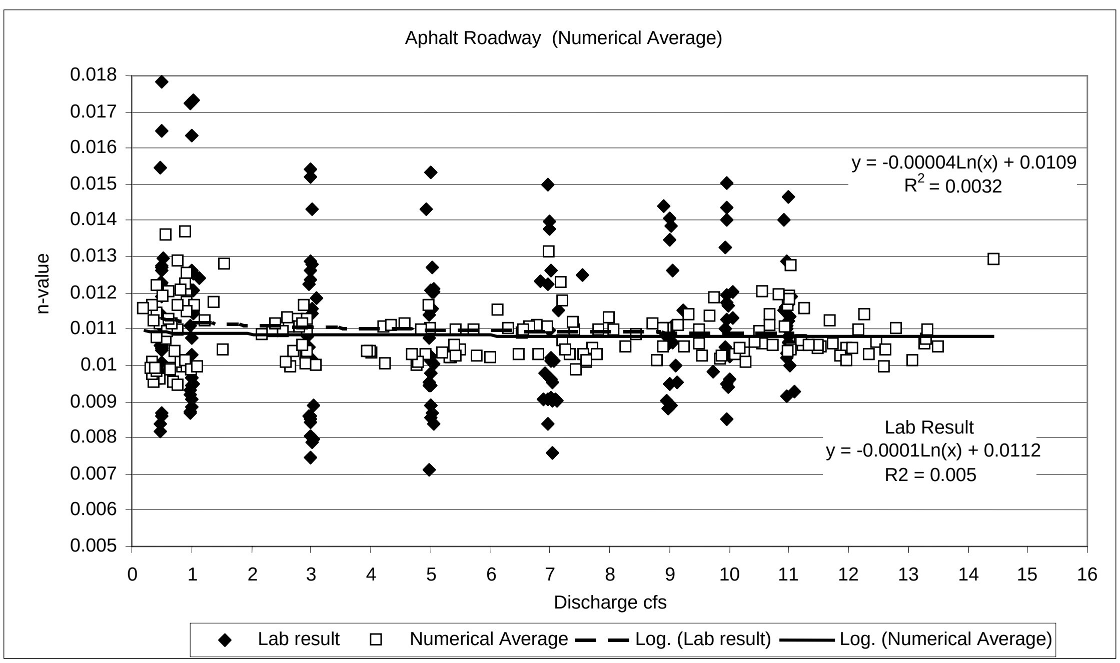


Figure C11.2 Manning's n-values and discharges of asphalt surface estimated by numerical average

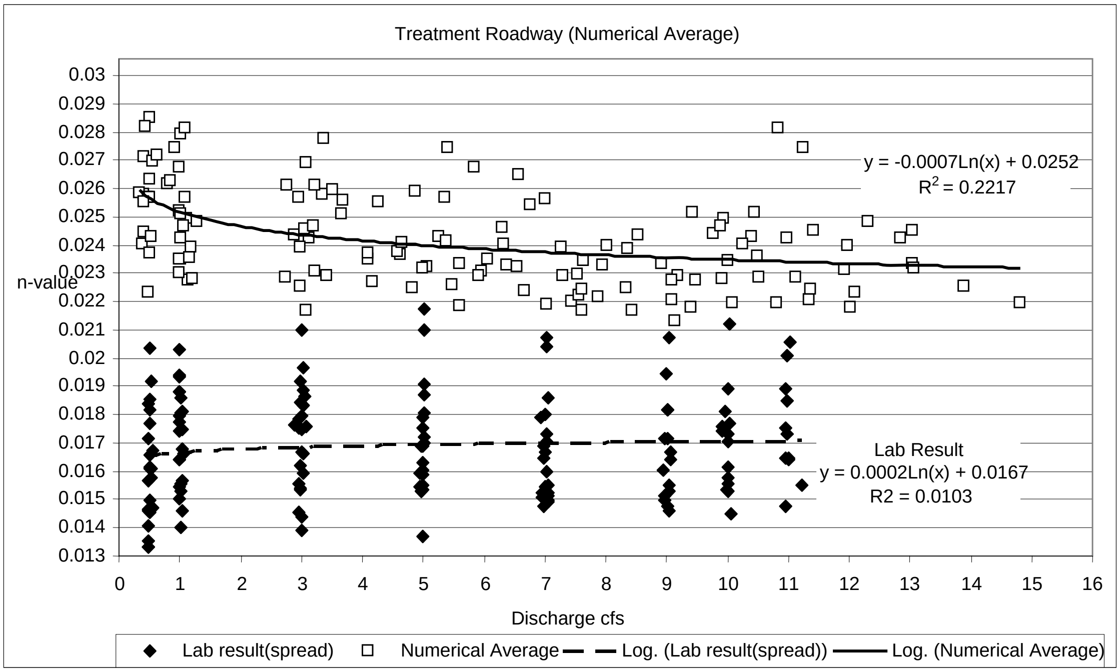


Figure C11.3 Manning's n-values and discharges of asphalt treatment surface estimated by numerical average

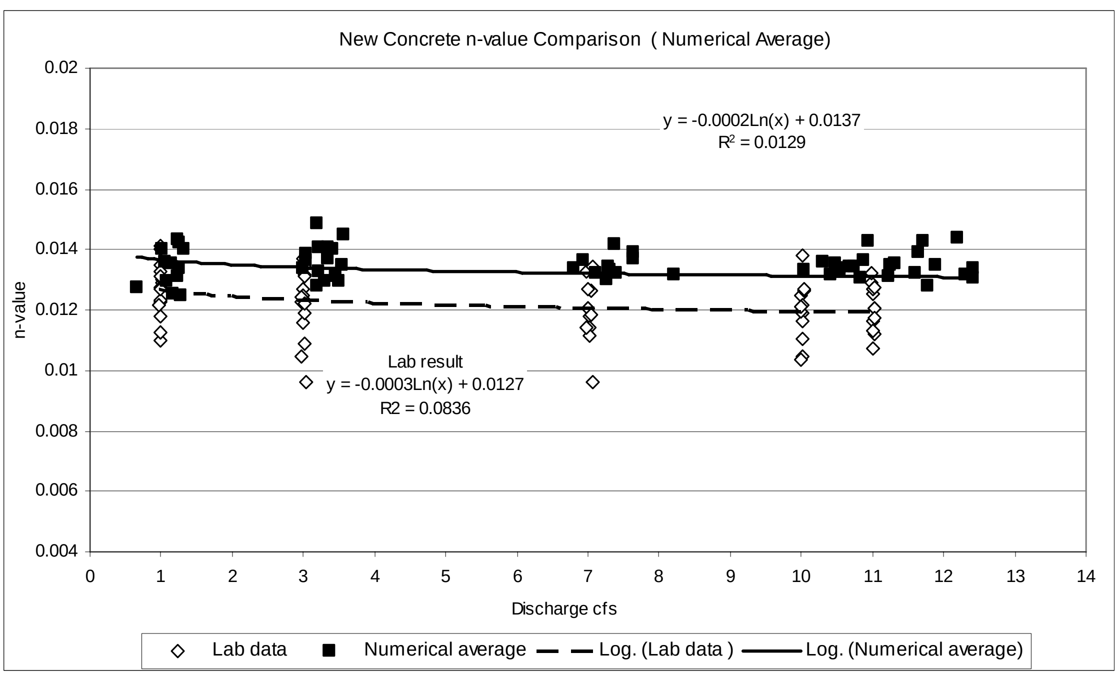


Figure C11.4 Manning's n-values and discharges of TxDOT concrete surface estimated by numerical average

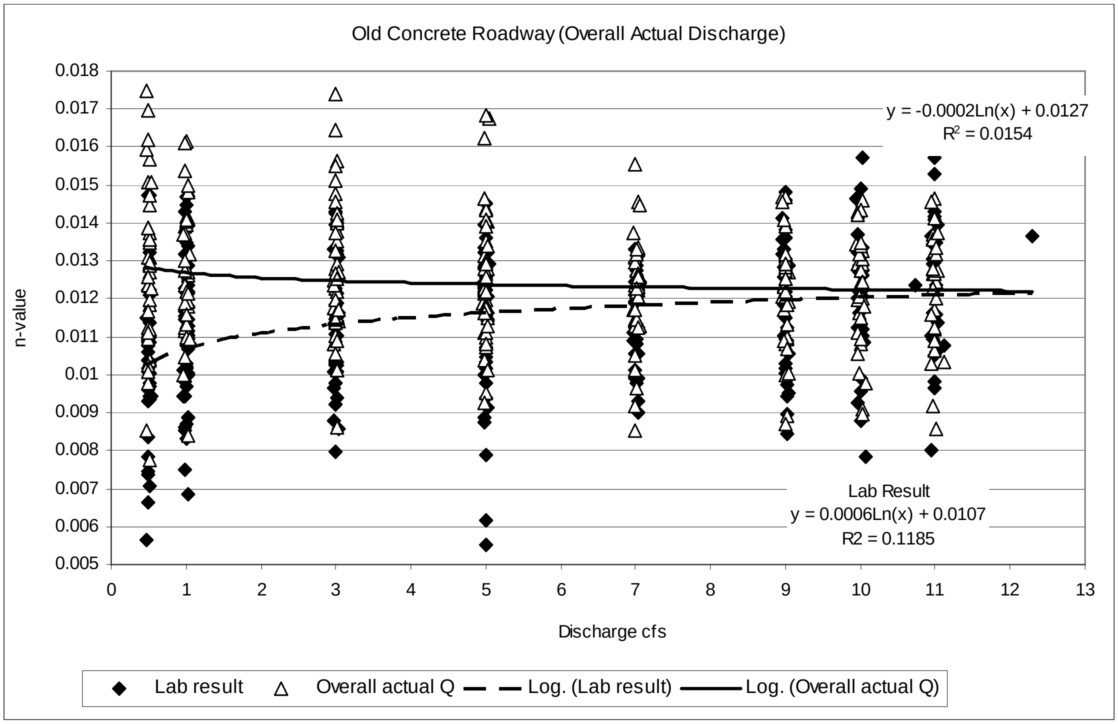


Figure C12.1 Manning's n-values and discharges of smooth concrete surface estimated by Manning's equation and using measured discharge

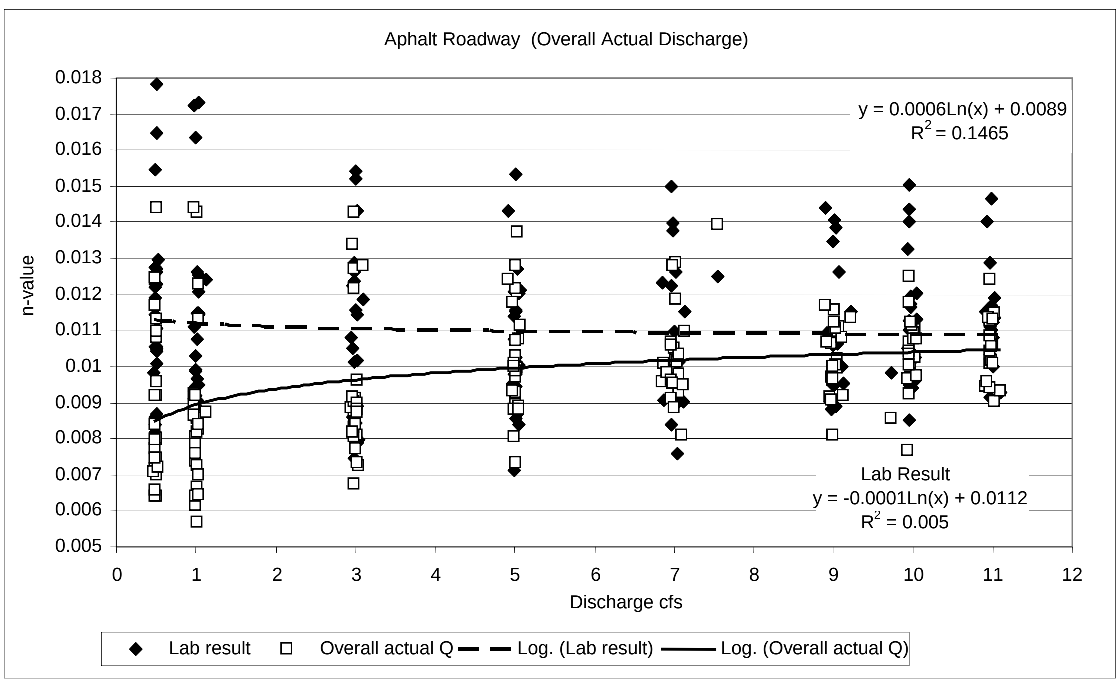


Figure C12.2 Manning's n-values and discharges of asphalt surface estimated by Manning's equation and using measured discharge

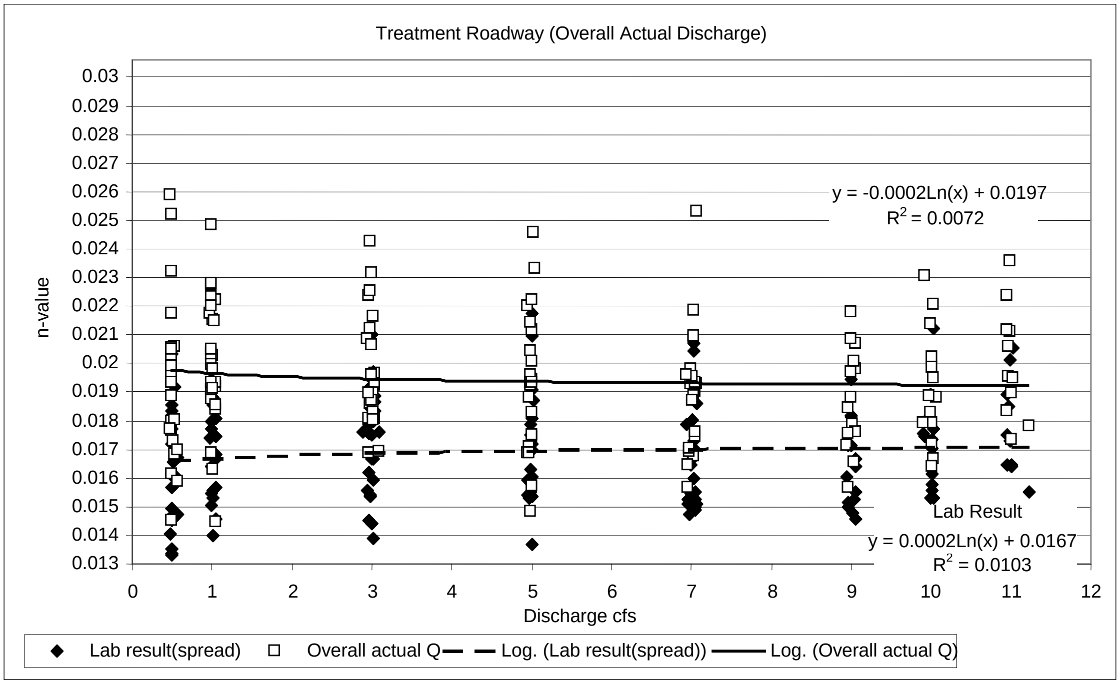


Figure C12.3 Manning's n-values and discharges of asphalt treatment surface estimated by Manning's equation and using measured discharge

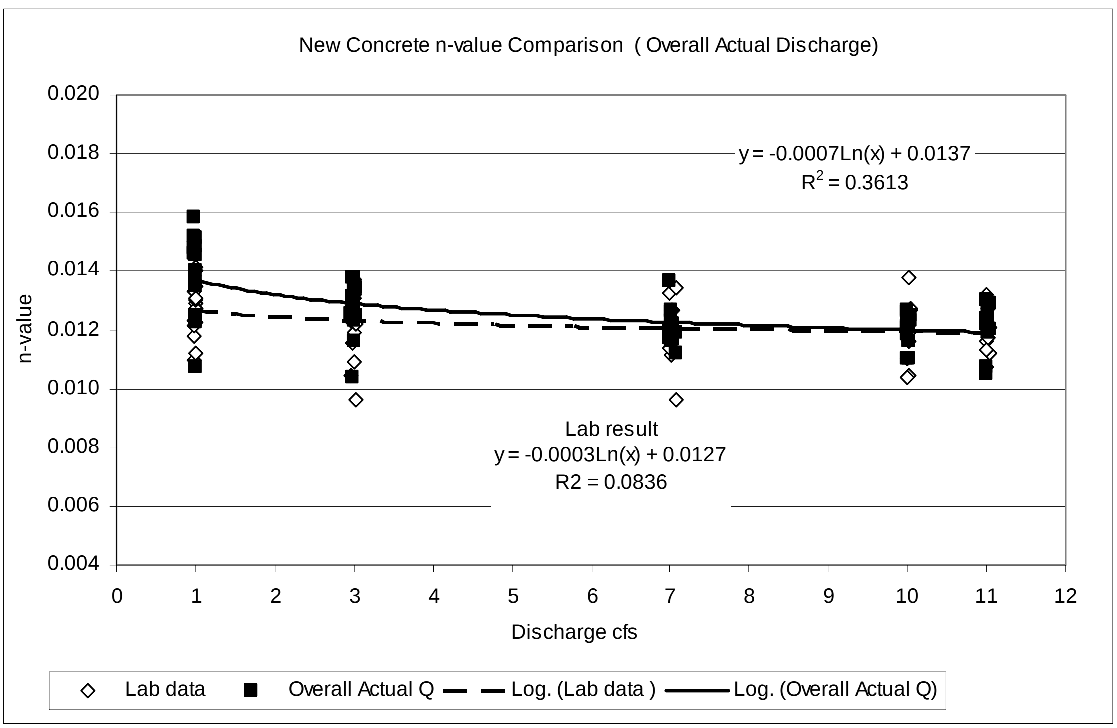


Figure C12.4 Manning's n-values and discharges of TxDOT concrete surface estimated by Manning's equation and using measured discharge

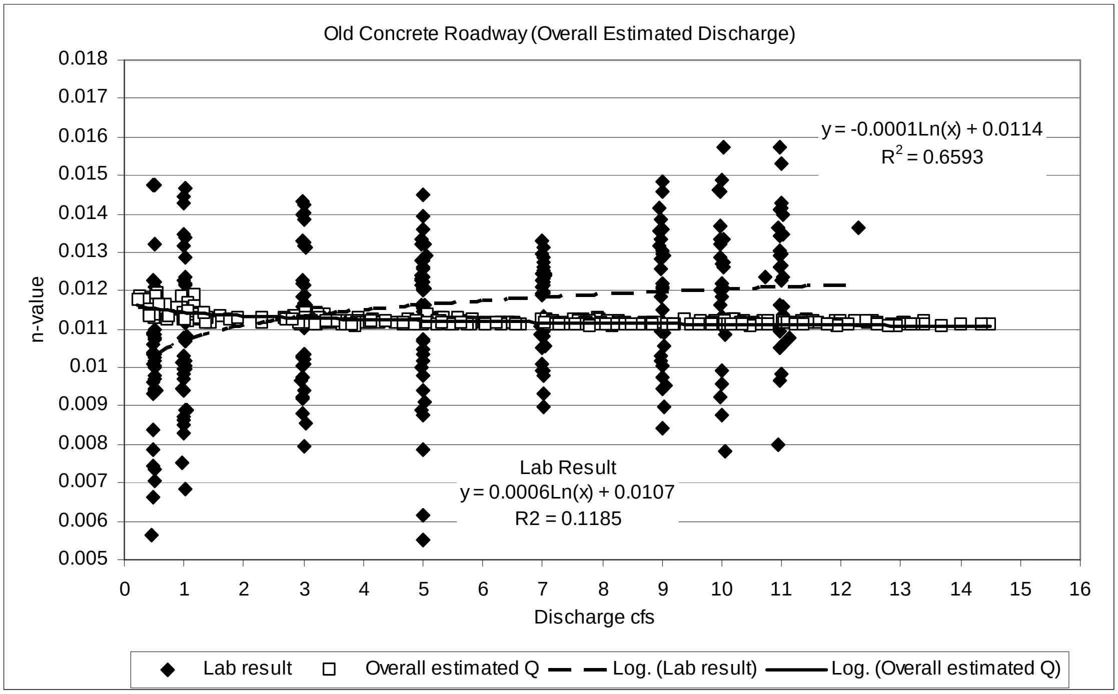


Figure C13.1 Manning's n-values and discharges of smooth concrete surface estimated by Manning's equation and using Prandtl-von Karman estimated discharge

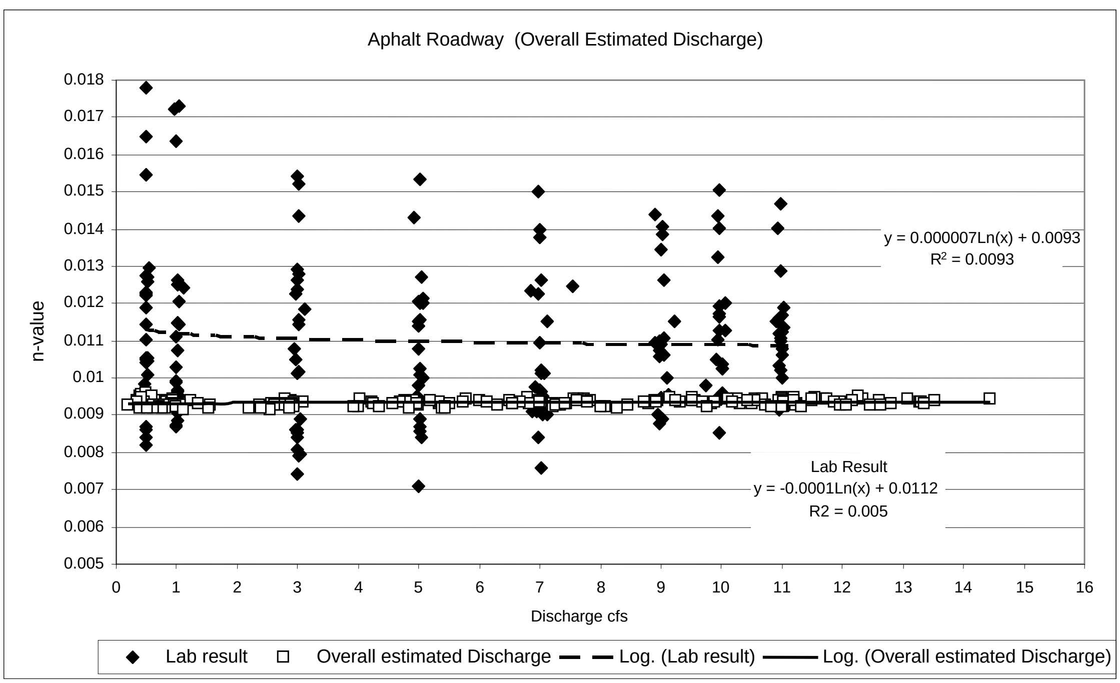


Figure C13.2 Manning's n-values and discharges of asphalt surface estimated by Manning's equation and using Prandtl-von Karman estimated discharge

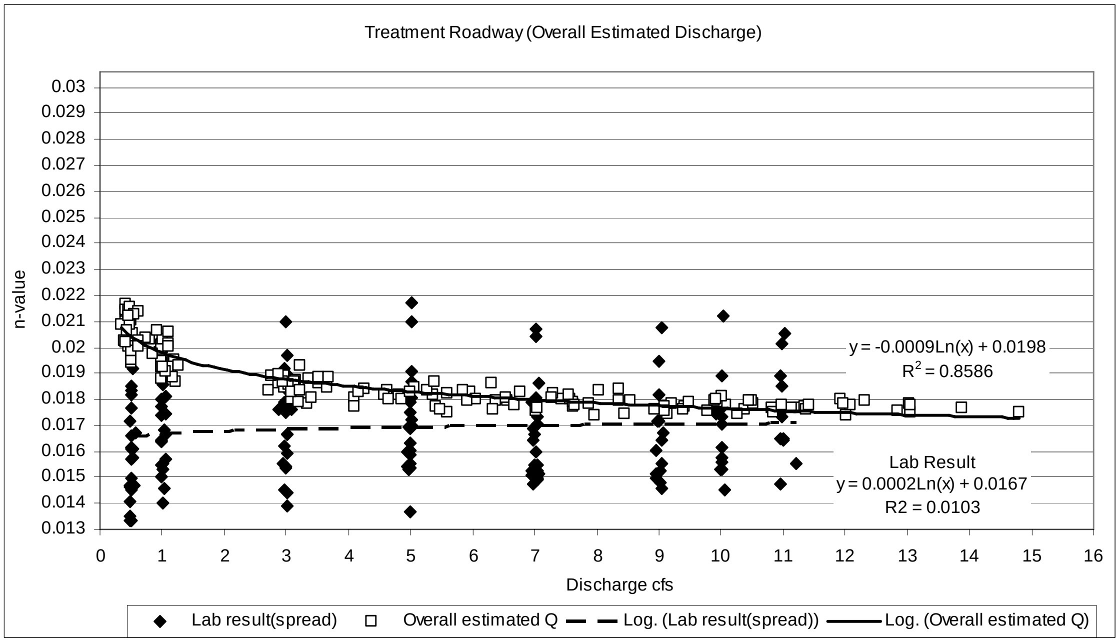


Figure C13.3 Manning's n-values and discharges of asphalt treatment surface estimated by Manning's equation and using Prandtl-von Karman estimated discharge

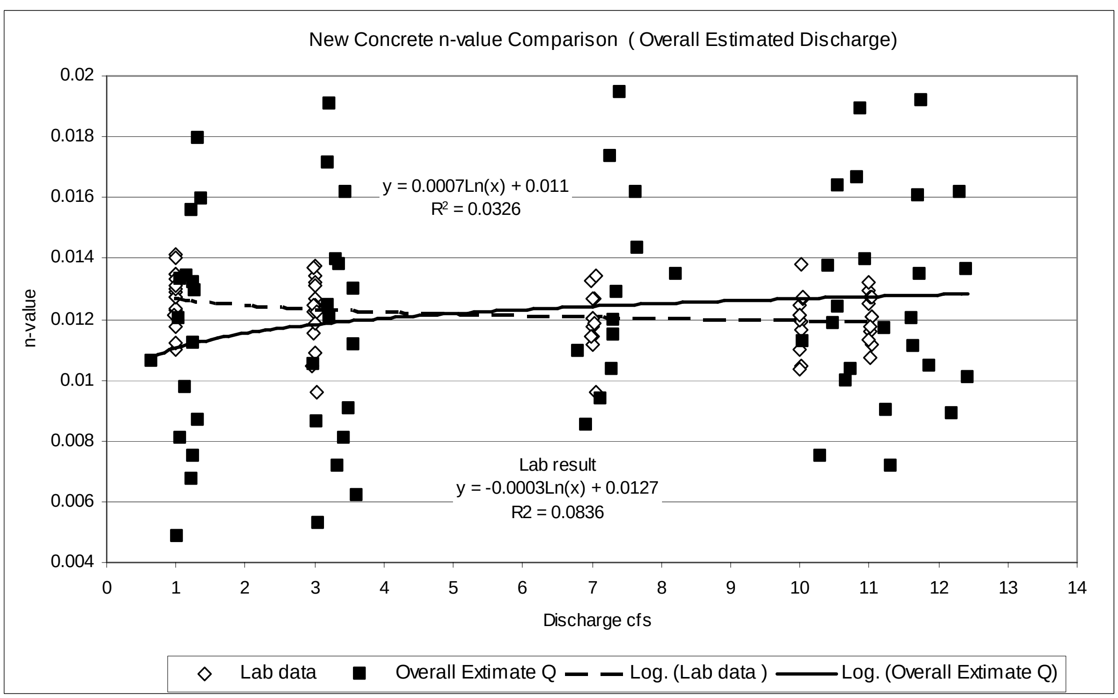


Figure C13. 4 Manning's n-values and discharges of TxDOT concrete surface estimated by Manning's equation and using Prandtl-von Karman estimated discharge

APPENDIX D

COMPARISON BETWEEN MEASURD AND PRANDTL-VON KARMAN VELOCITY METHOD DISCAHRGES

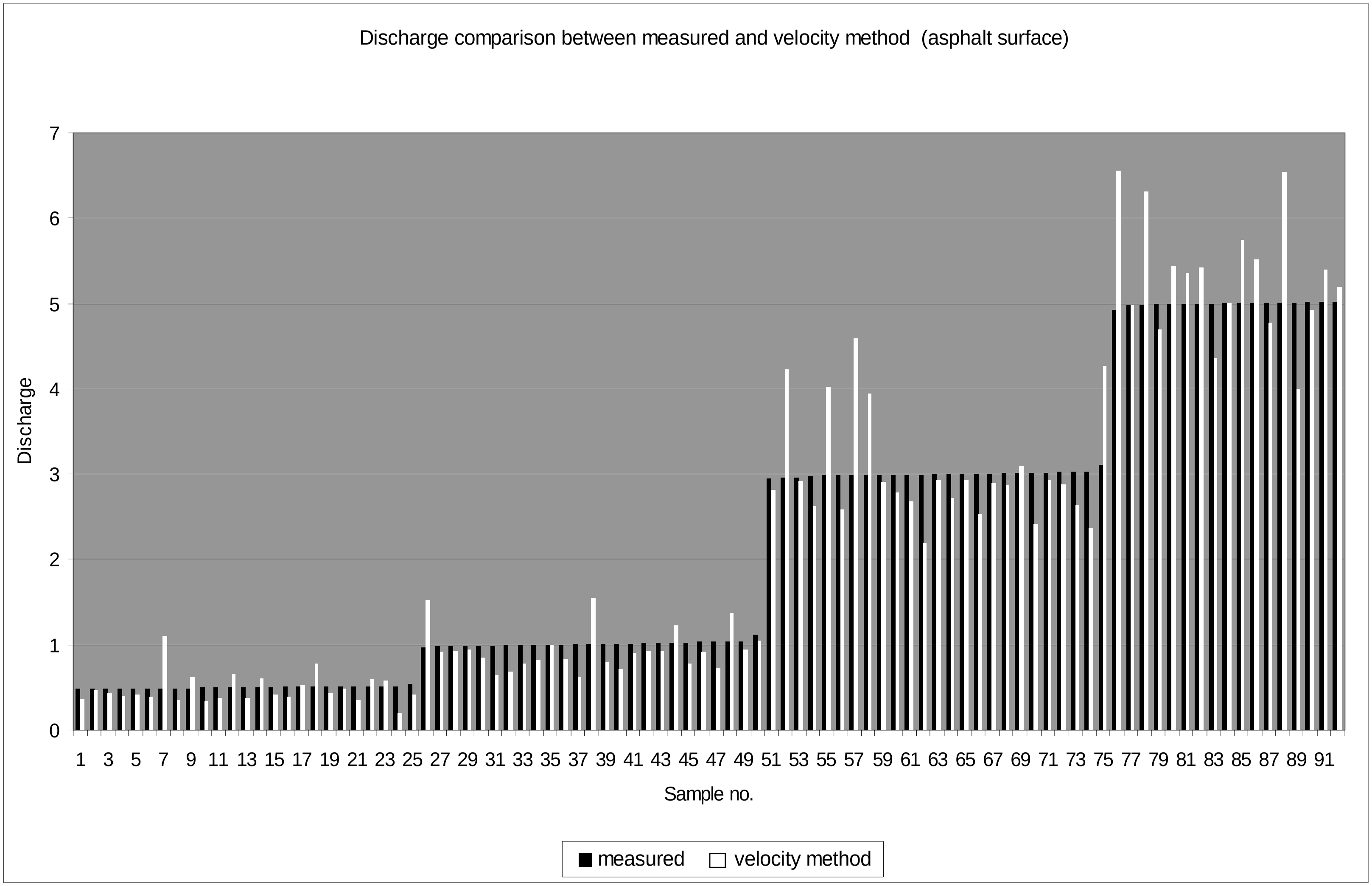


Figure D1.1 Comparison between measured and Prandtl and Von Karman velocity method discharges for asphalt surface (before remove outliers)

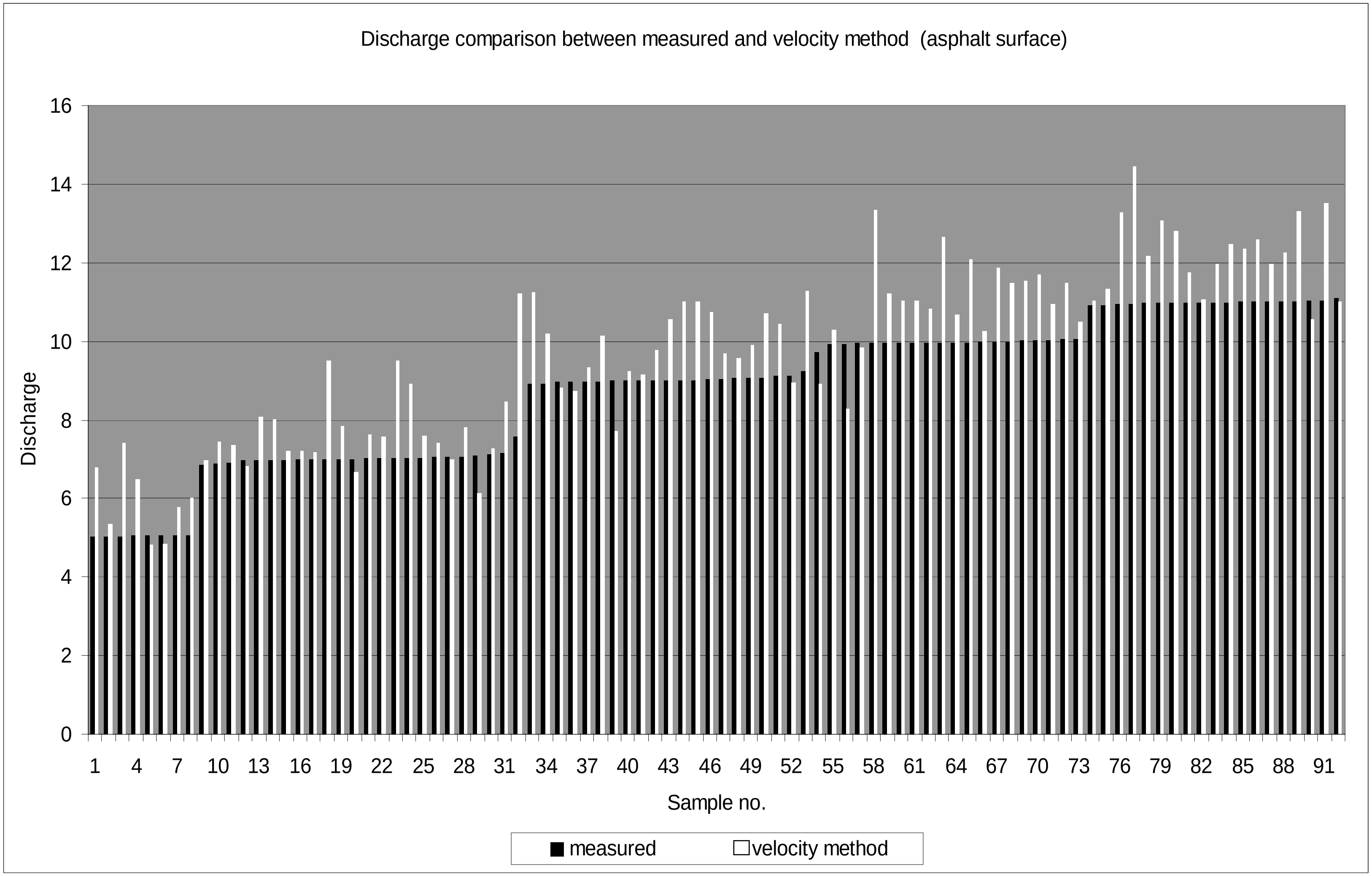


Figure D1.2 Comparison of discharge between measured and Prandtl and Von Karman velocity method for asphalt surface (before remove outliers)

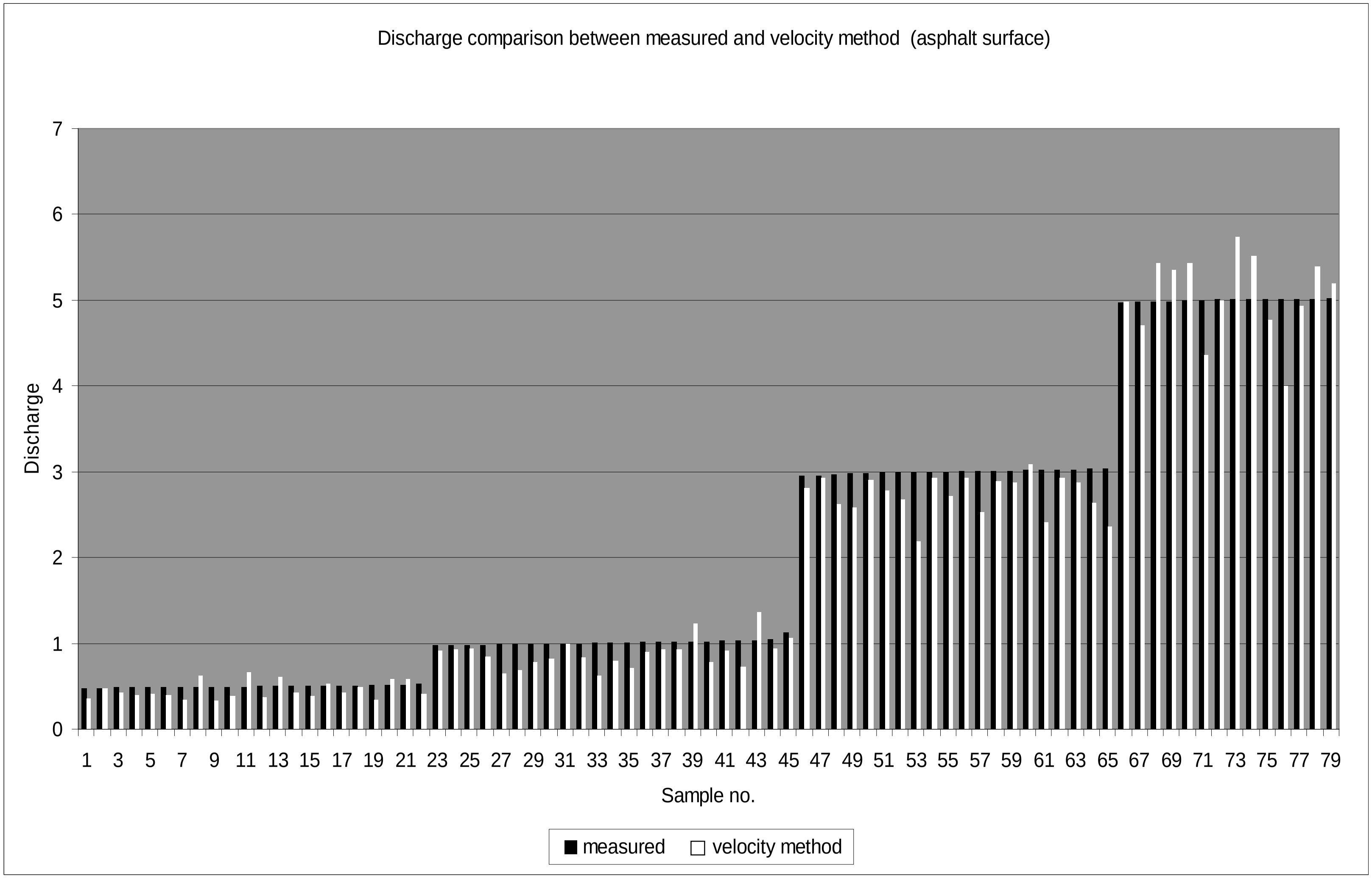


Figure D1.3 Comparison of discharge between measured and Prandtl and Von Karman velocity method for asphalt surface (after remove outliers)

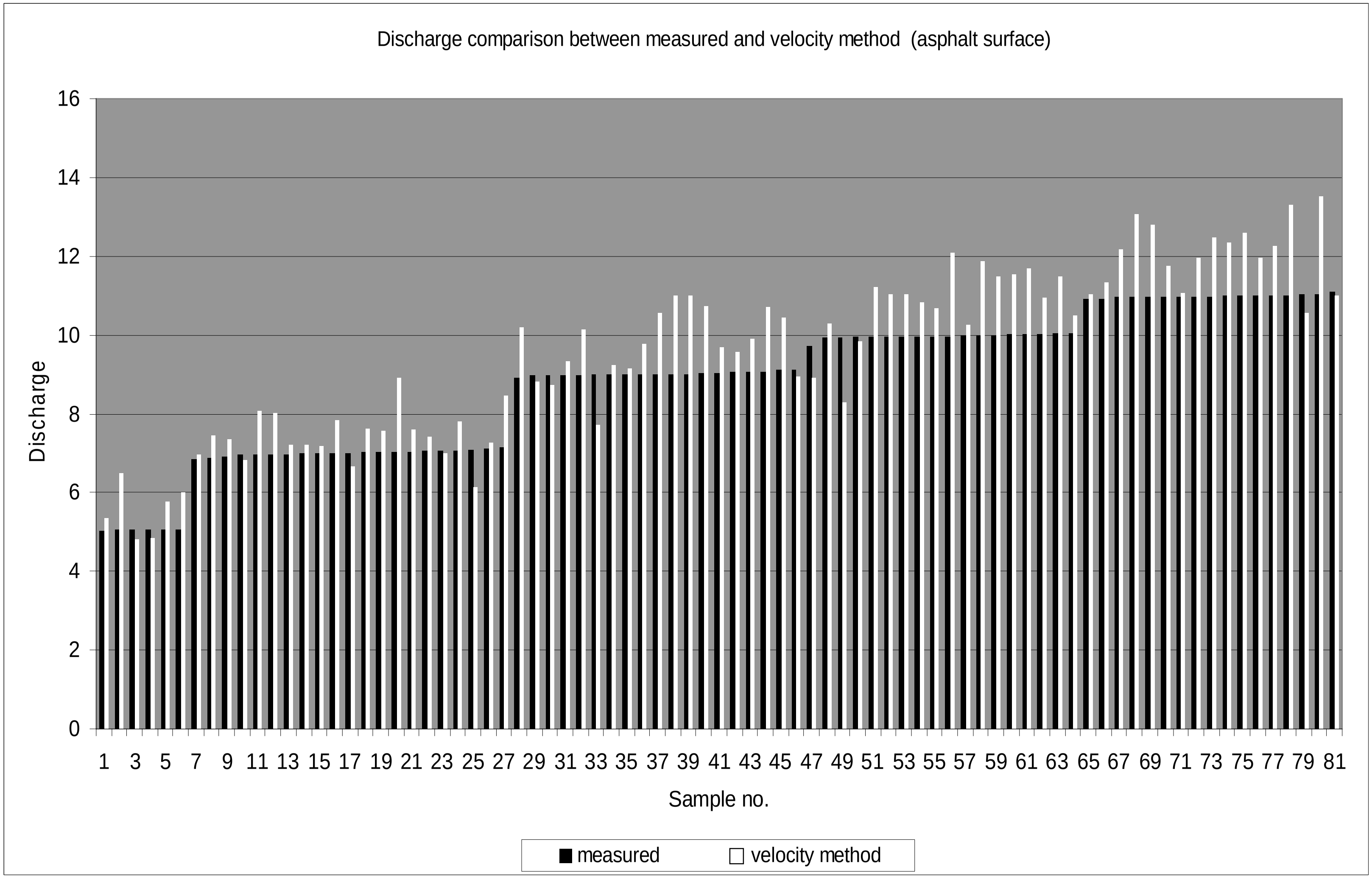


Figure D1.4 Comparison of discharge between measured and Prandtl and Von Karman velocity method for asphalt surface (after remove outliers)

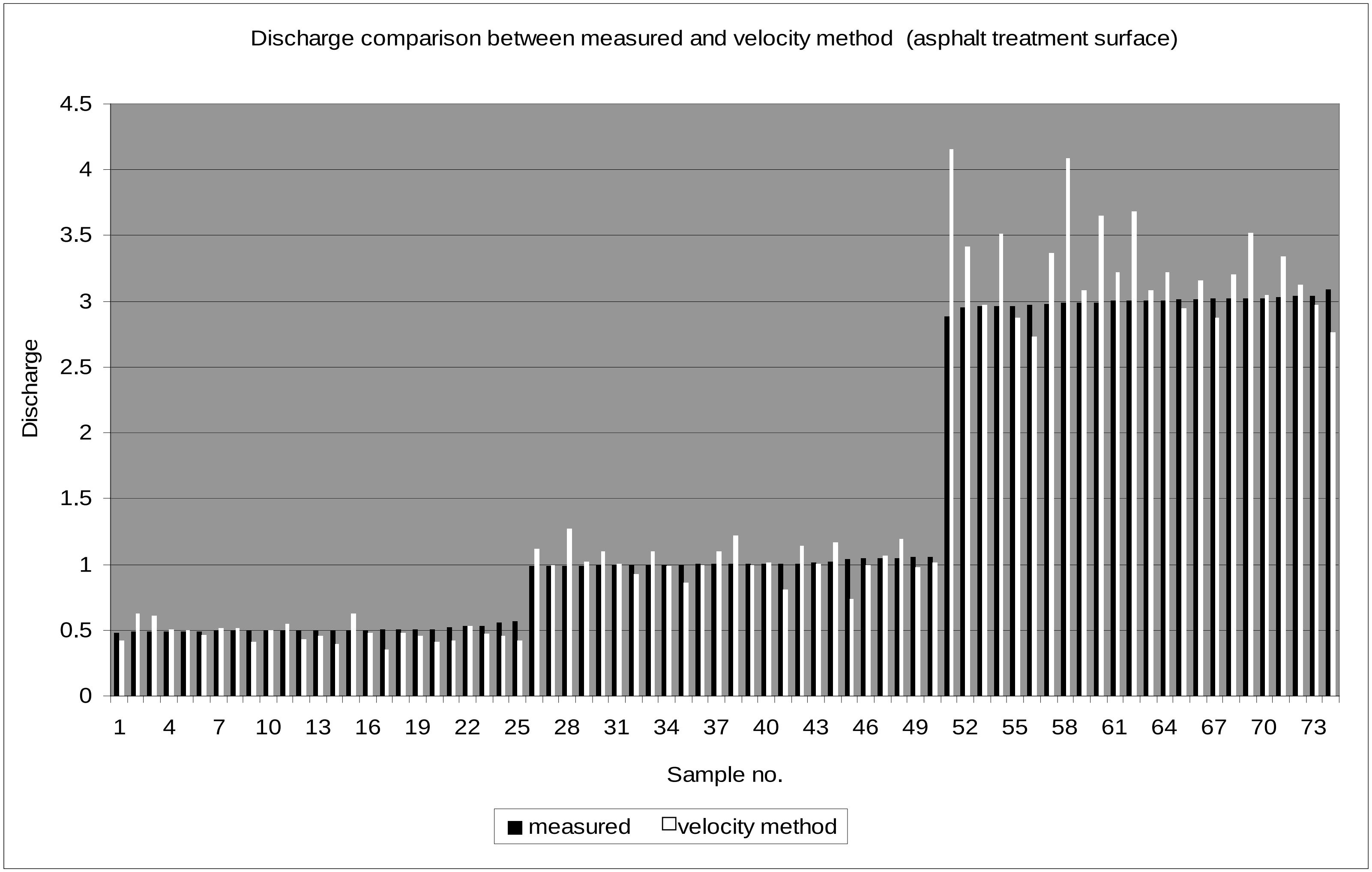


Figure D2.1 Comparison of discharge between measured and Prandtl and Von Karman velocity method for asphalt treatment surface (before remove outliers)

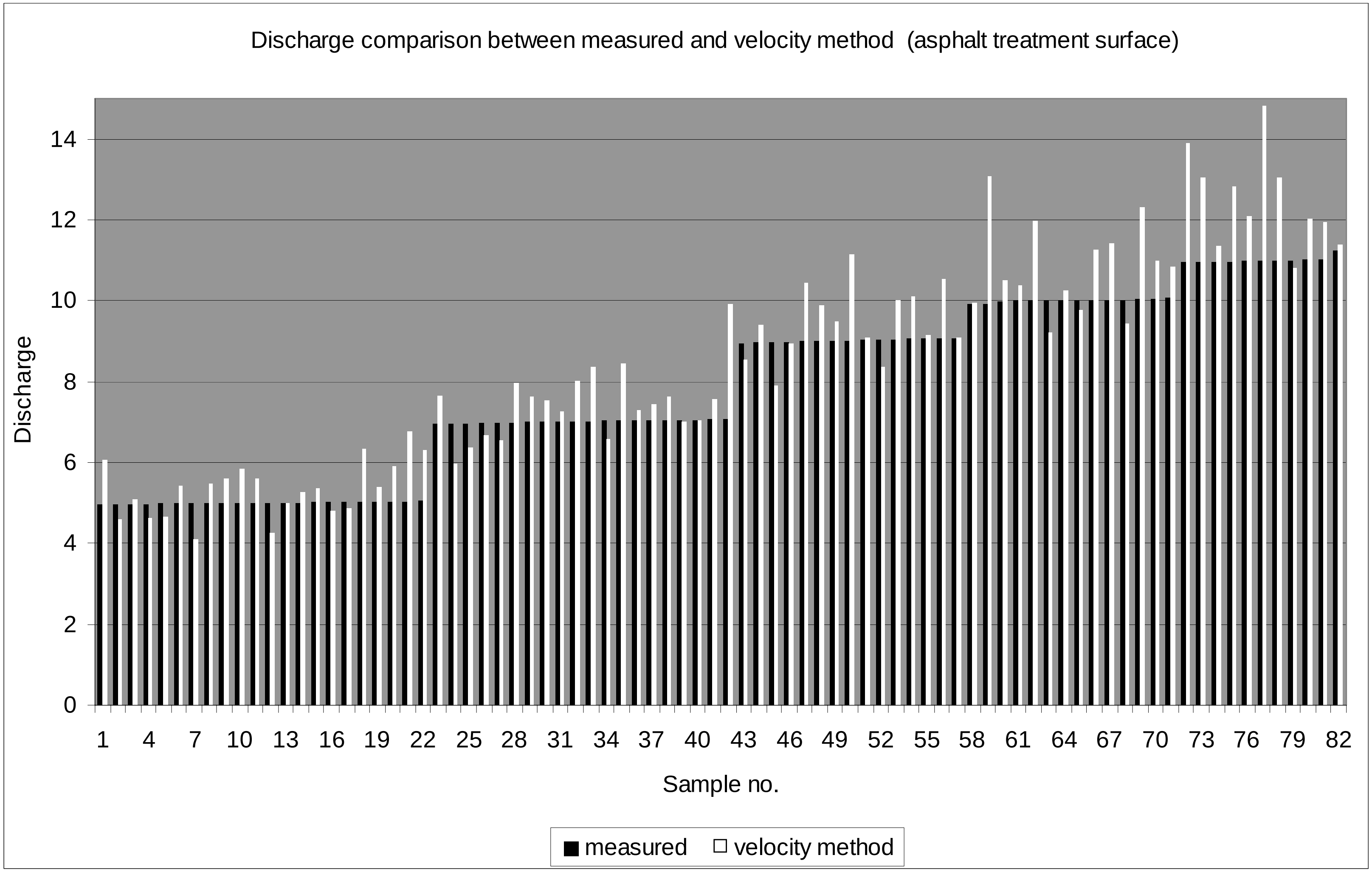


Figure D2.2 Comparison of discharge between measured and Prandtl and Von Karman velocity method for asphalt treatment surface (before remove outliers)

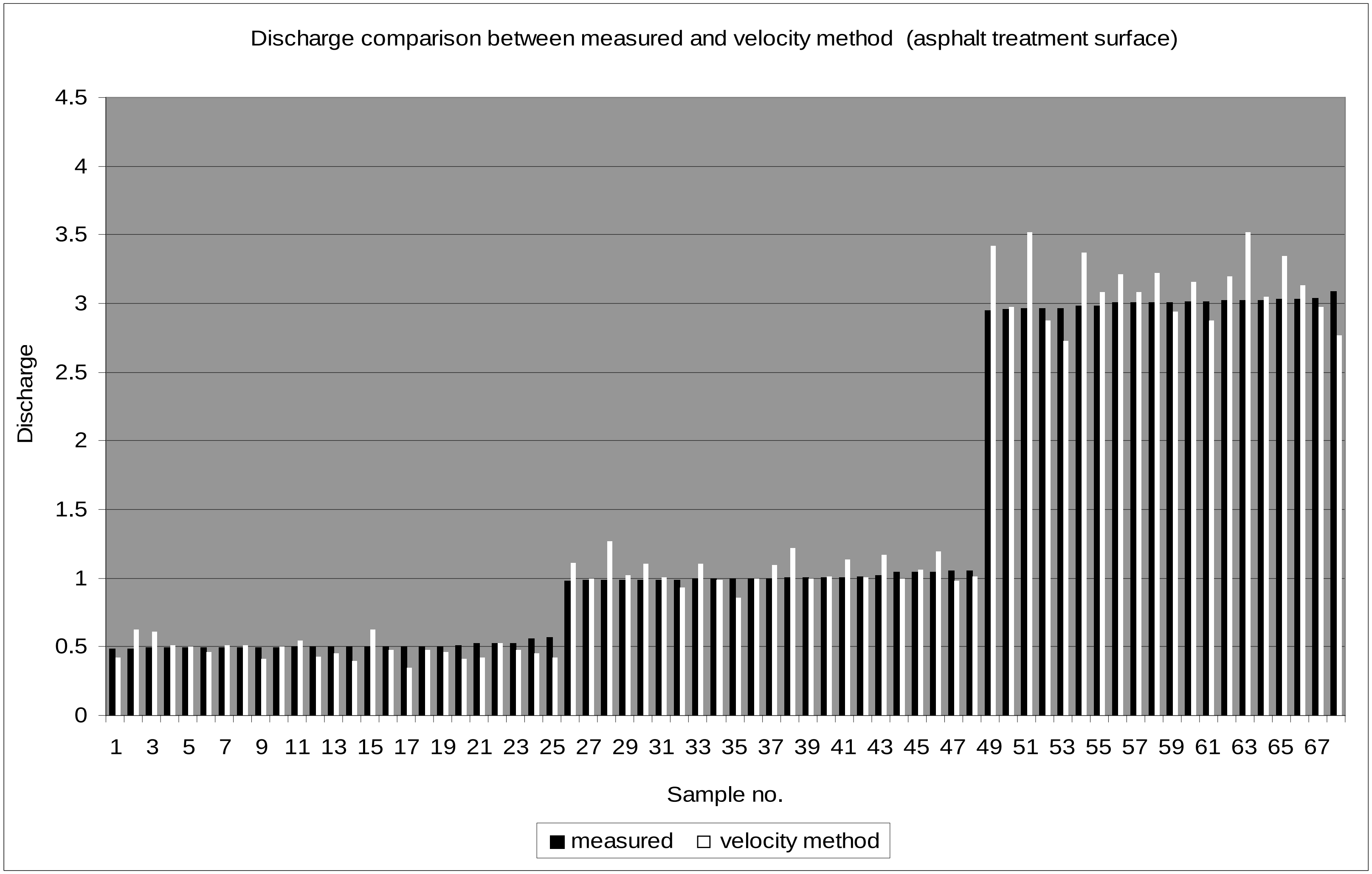


Figure D2.3 Comparison of discharge between measured and Prandtl and Von Karman velocity method for asphalt treatment surface (after remove outliers)

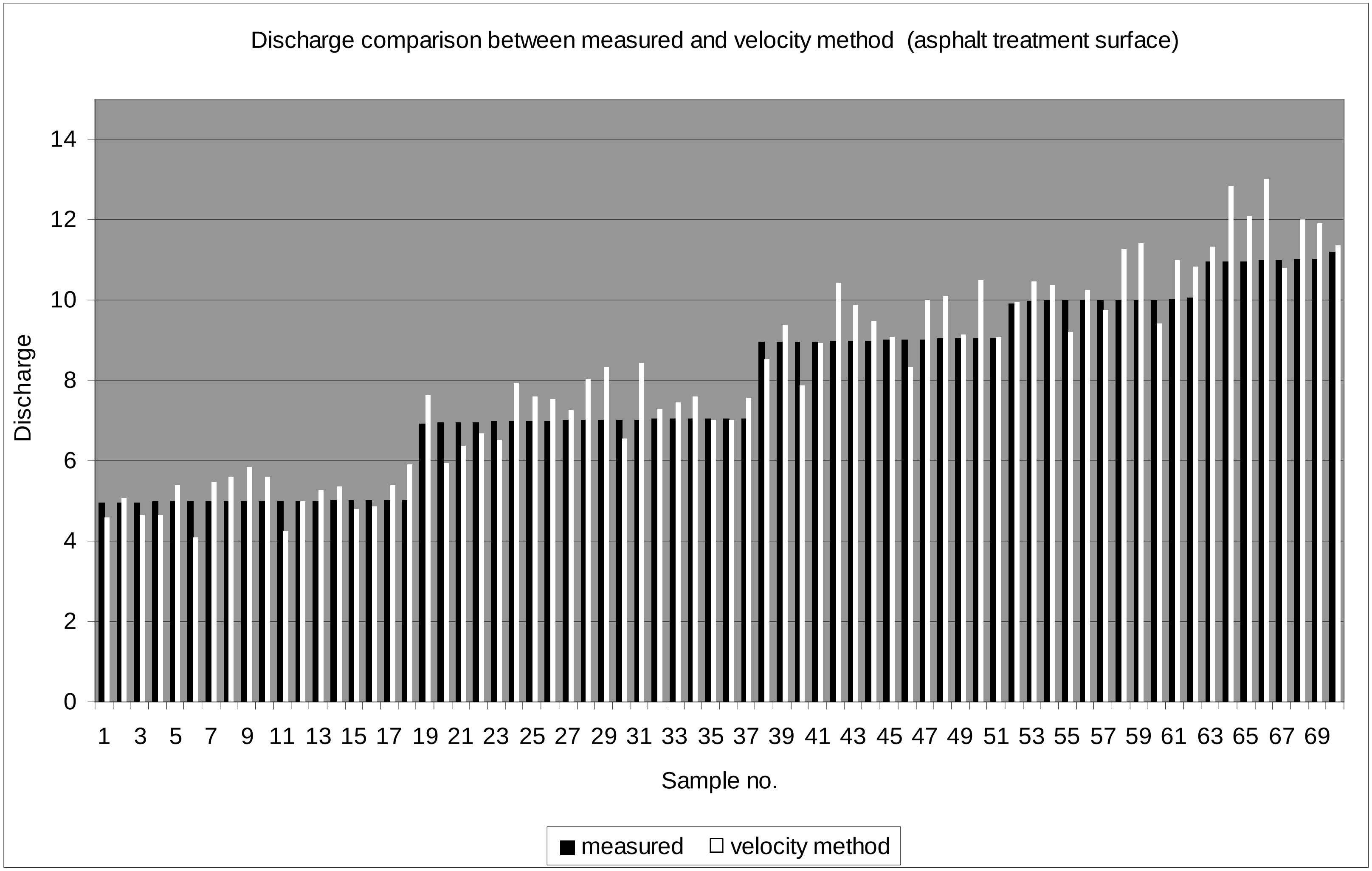


Figure D2.4 Comparison of discharge between measured and Prandtl and Von Karman velocity method for asphalt treatment surface (after remove outliers)

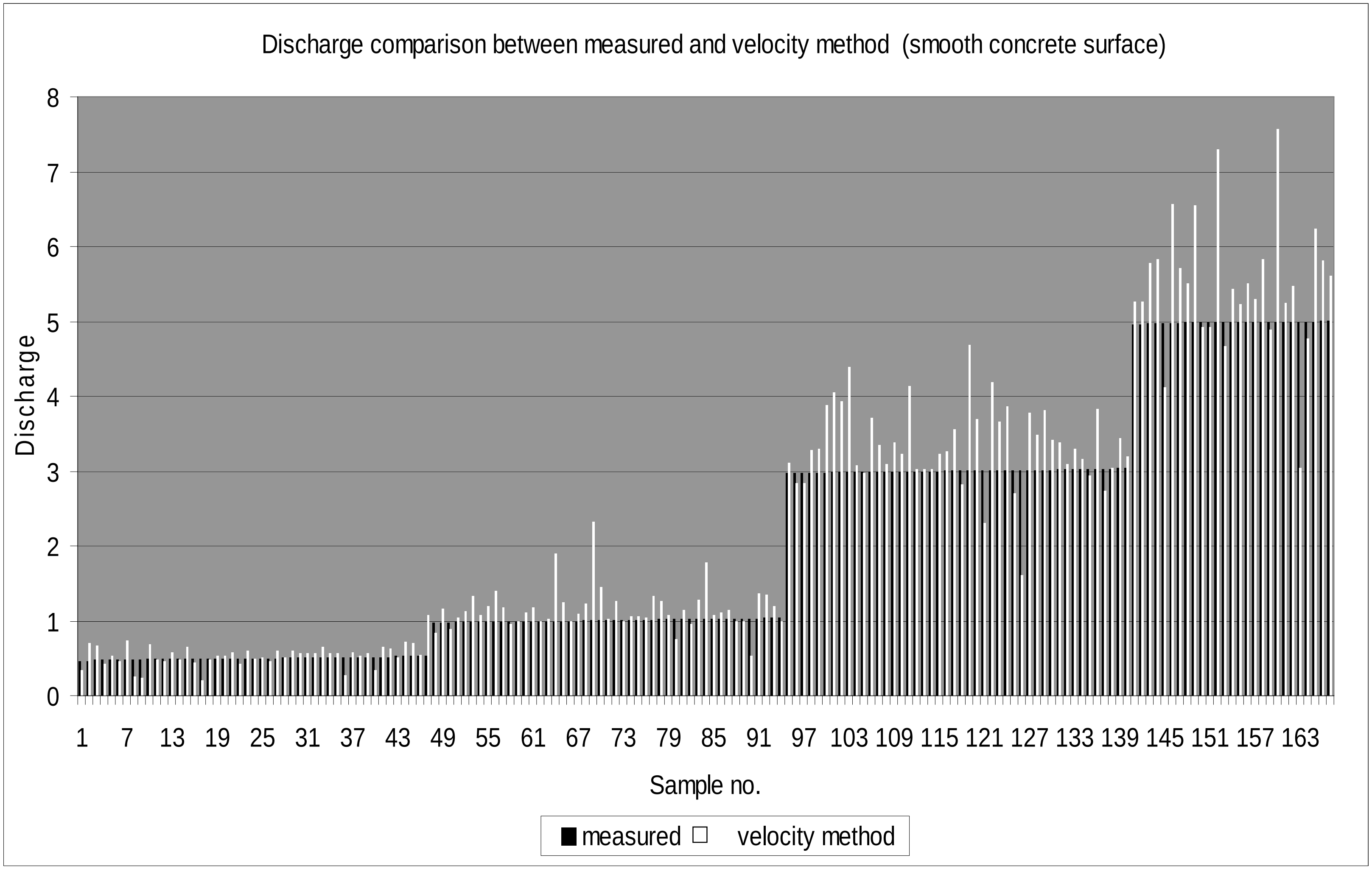


Figure D3.1 Comparison of discharge between measured and Prandtl and Von Karman velocity method for smooth concrete surface (before remove outliers)

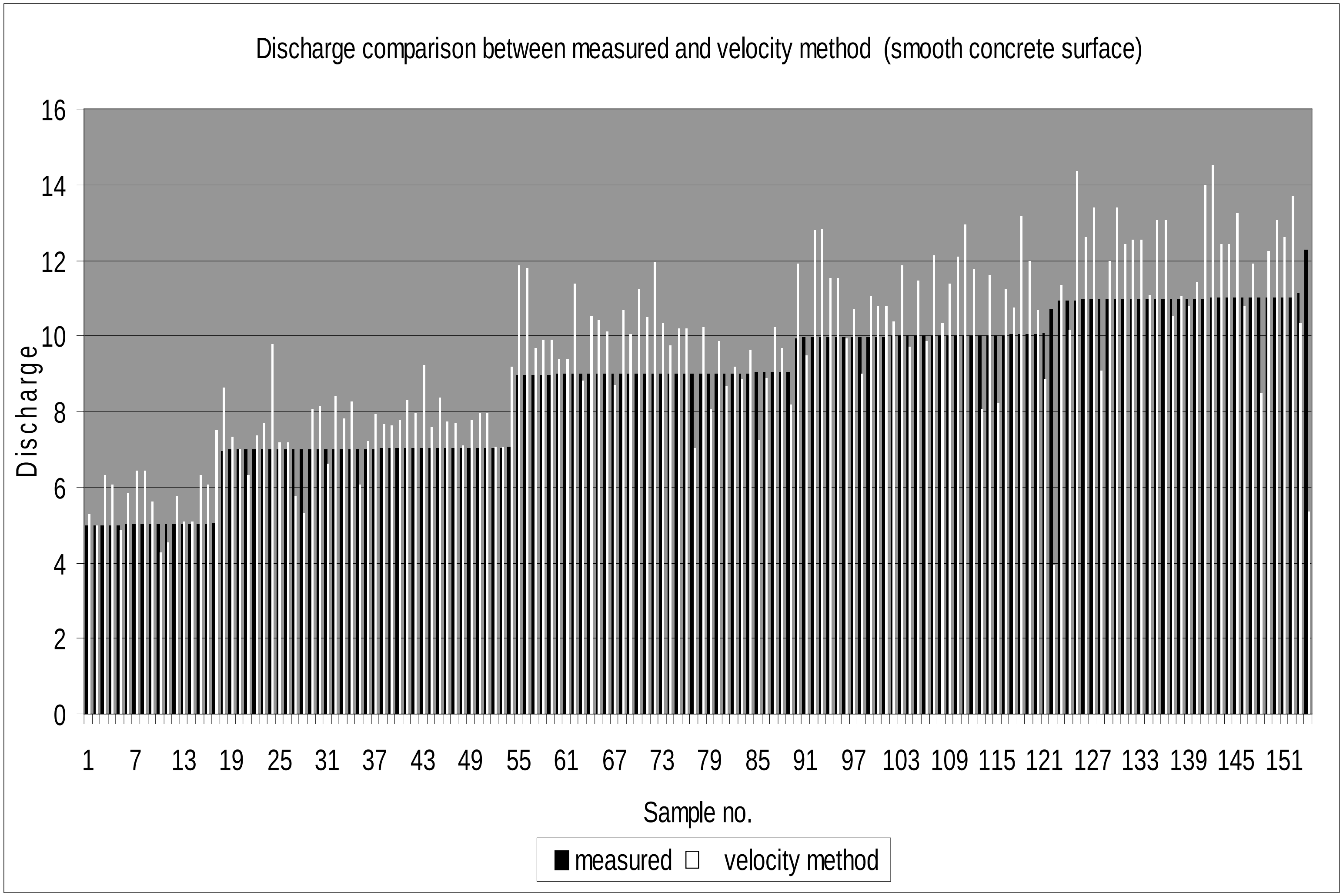


Figure D3.2 Comparison of discharge between measured and Prandtl and Von Karman velocity method for smooth concrete surface (before remove outliers)

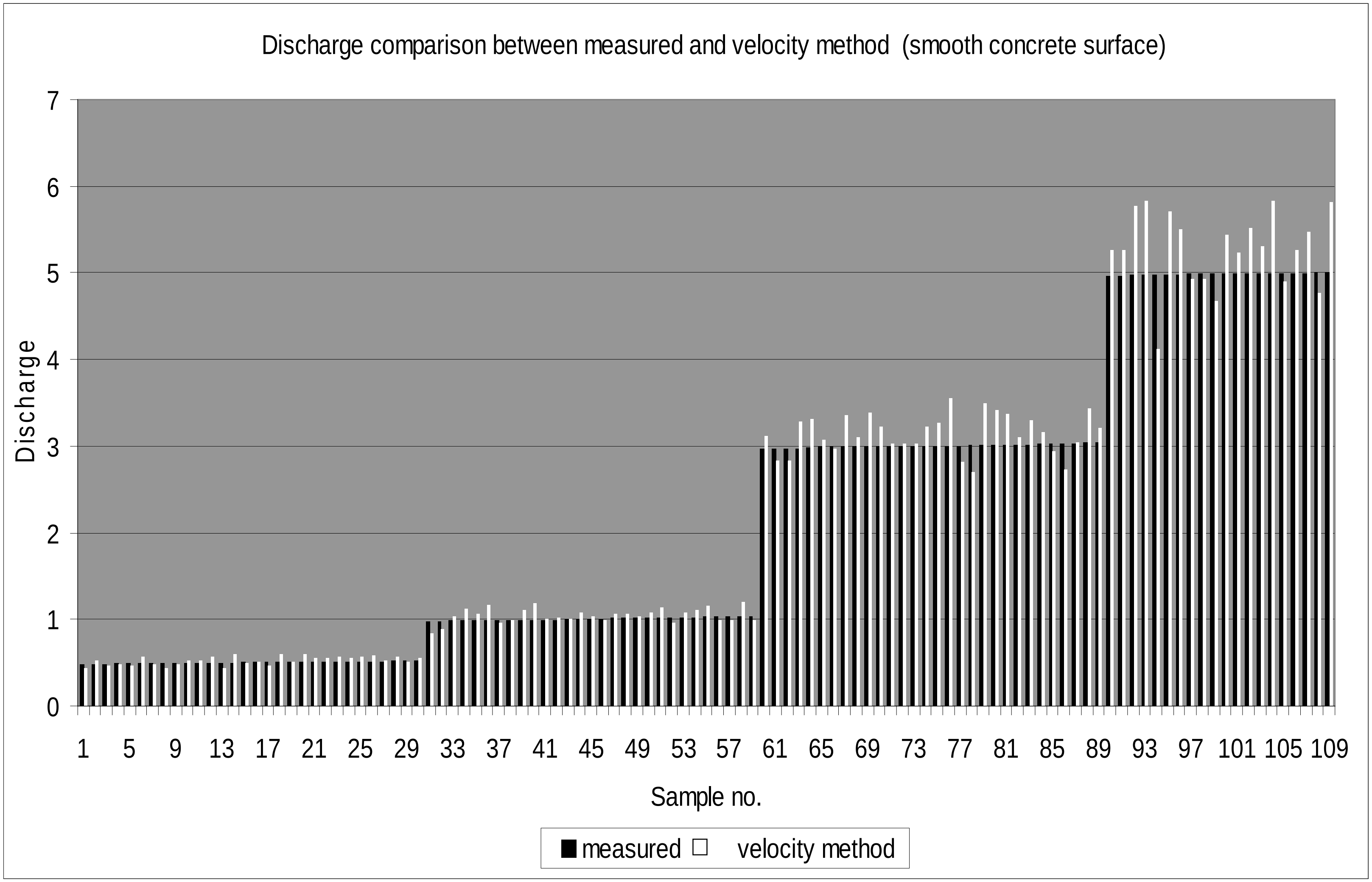


Figure D3.3 Comparison of discharge between measured and Prandtl and Von Karman velocity method for smooth concrete surface (after remove outliers)

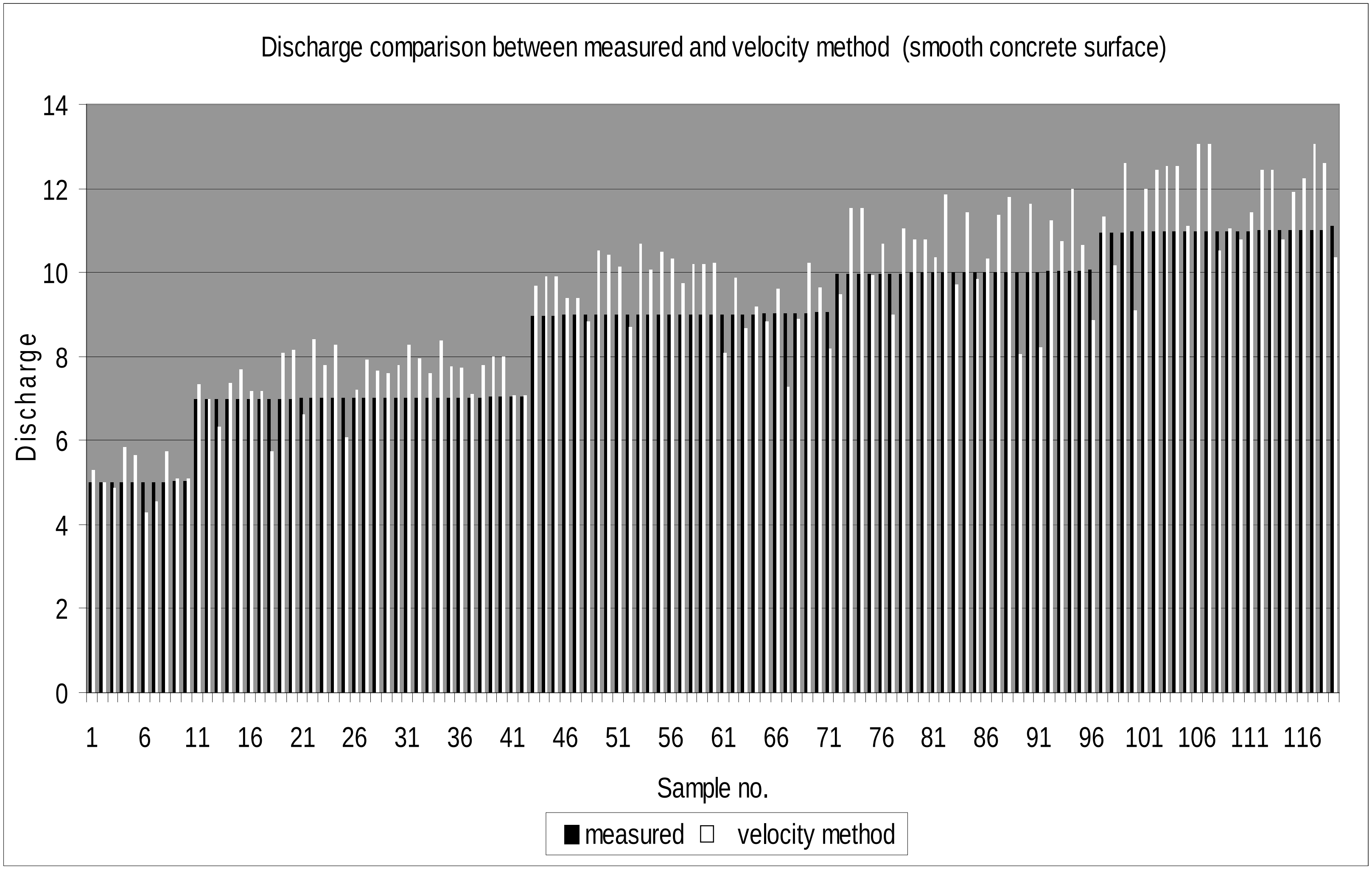


Figure D3.4 Comparison of discharge between measured and Prandtl and Von Karman velocity method for smooth concrete surface (after remove outliers)

APPENDIX E

HISTOGRAM PLOTS OF MANNING'S N-VALUES

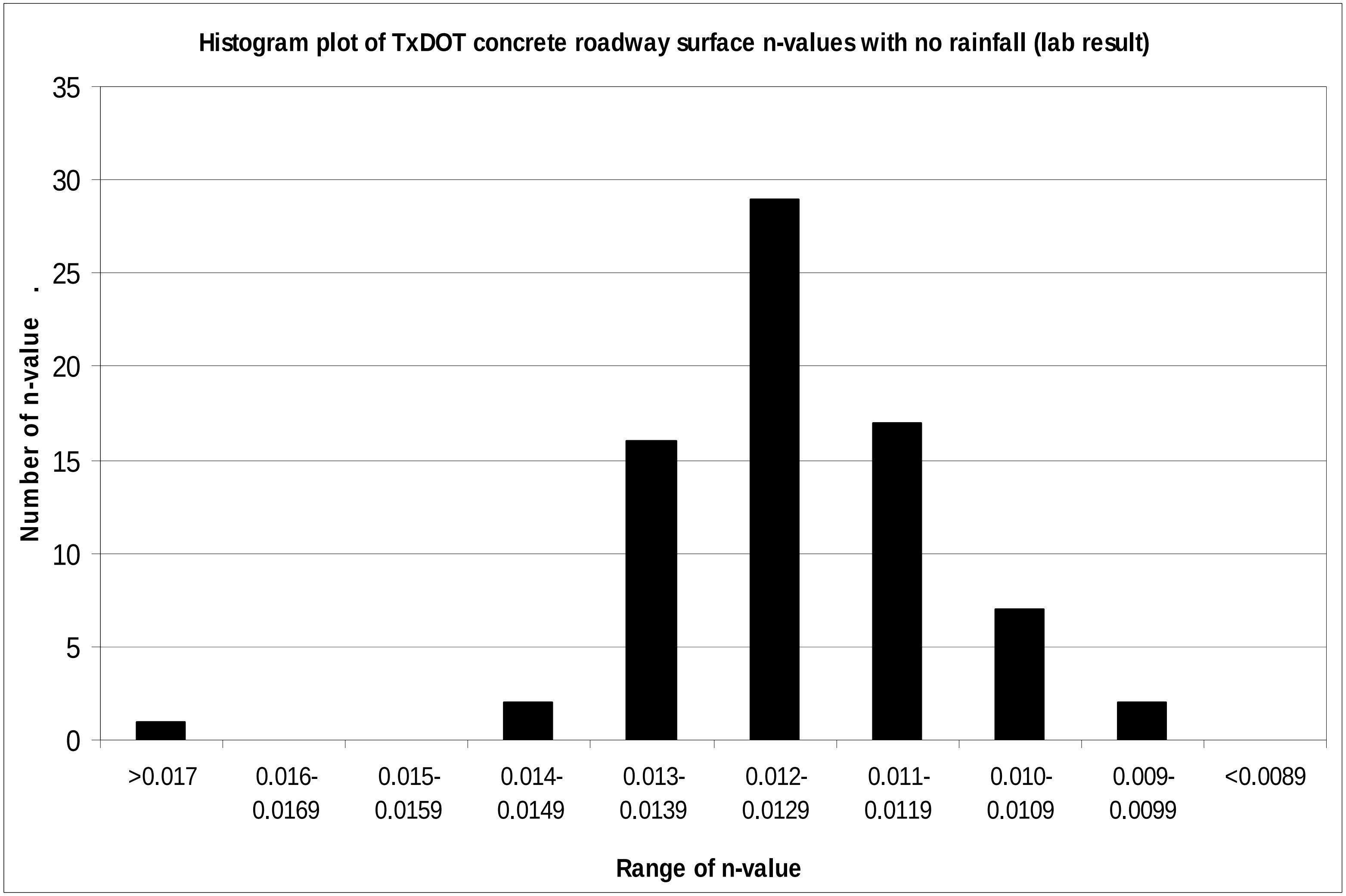


Figure E1.1 Histogram plot of TxDOT concrete roadway surface n-values with no-rainfall (lab result)

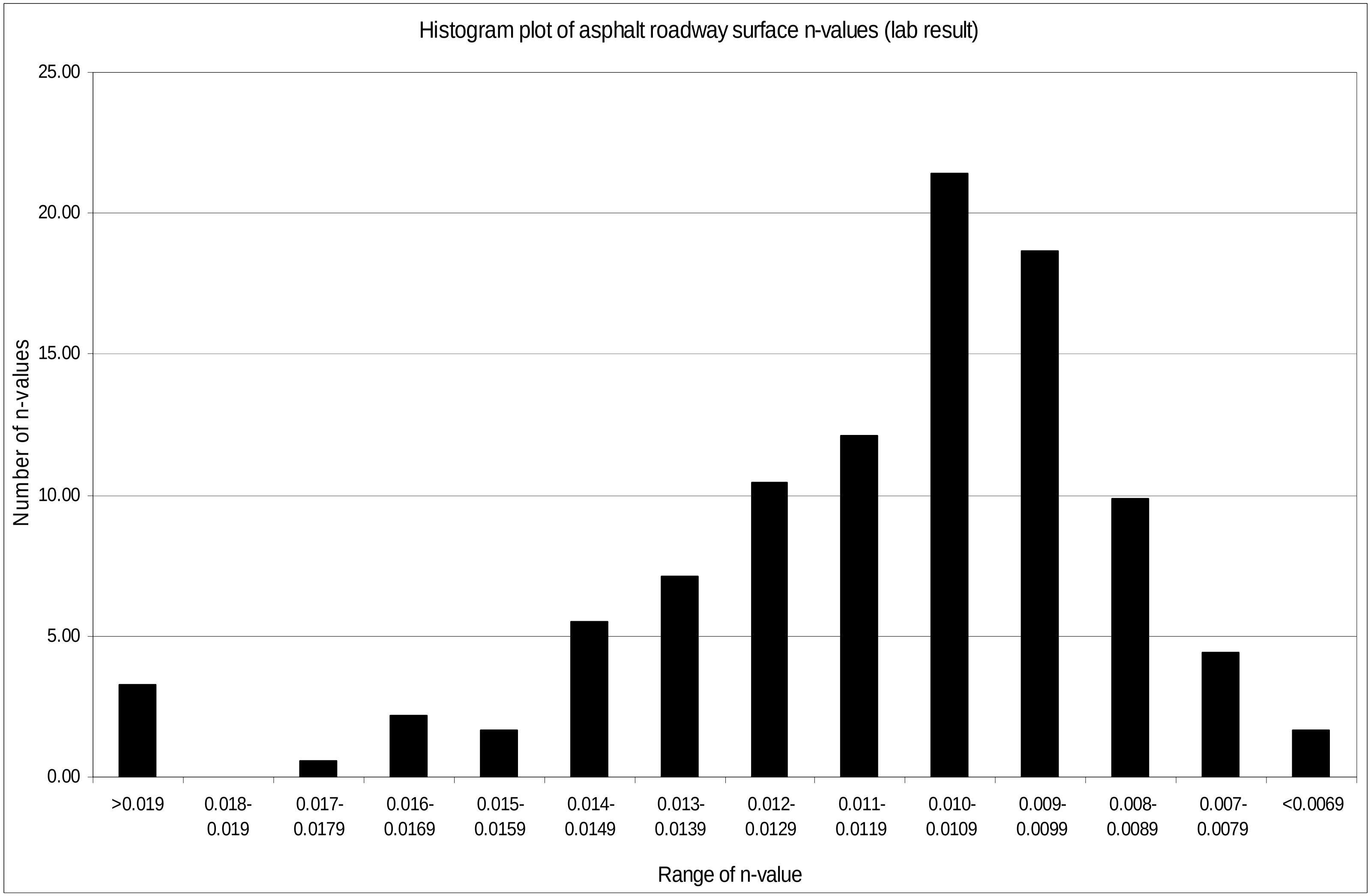


Figure E1.2 Histogram plot of asphalt roadway surface n-values (lab result)

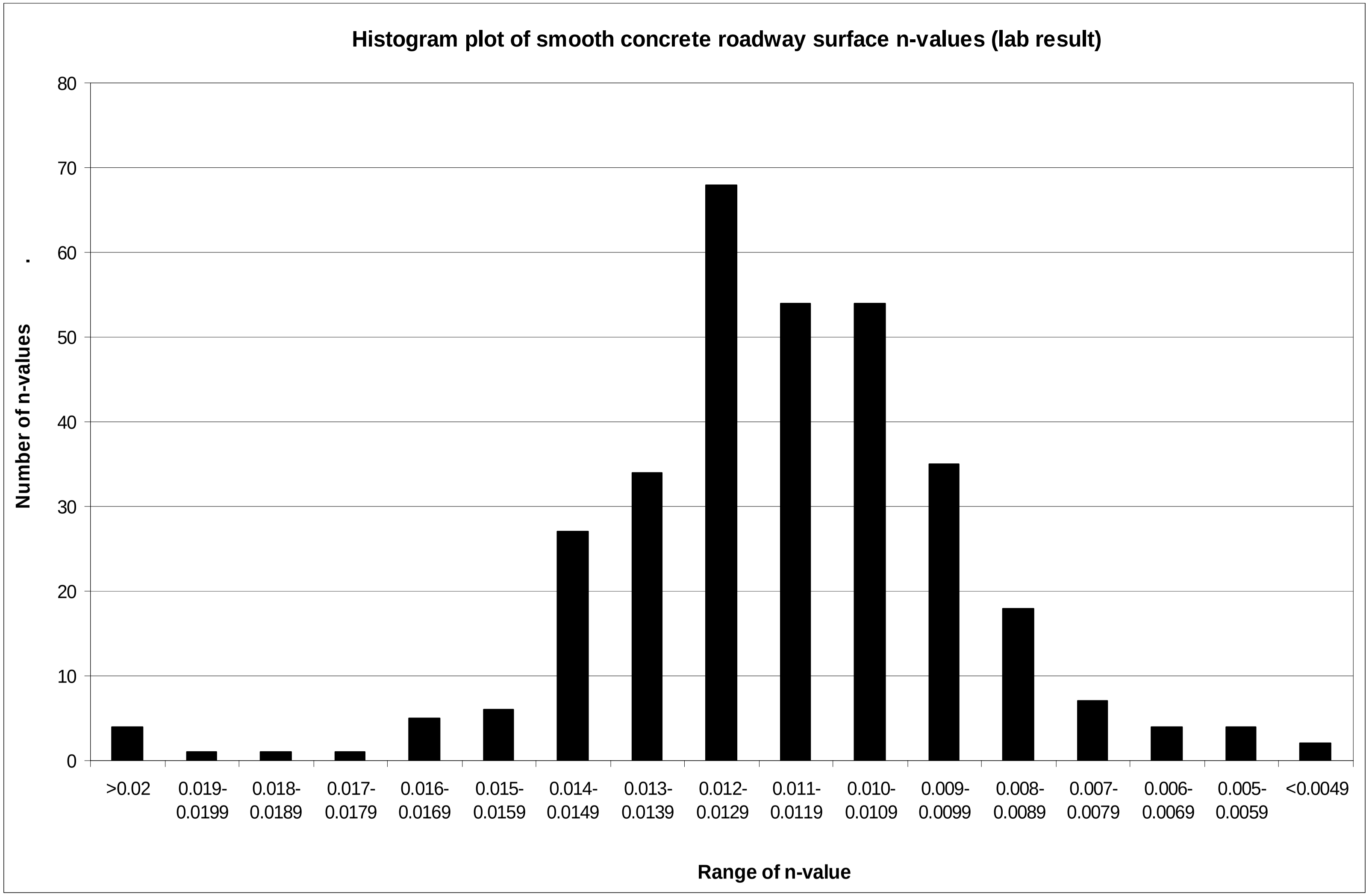


Figure E1.3 Histogram plot of smooth concrete roadway surface n-values (lab result)

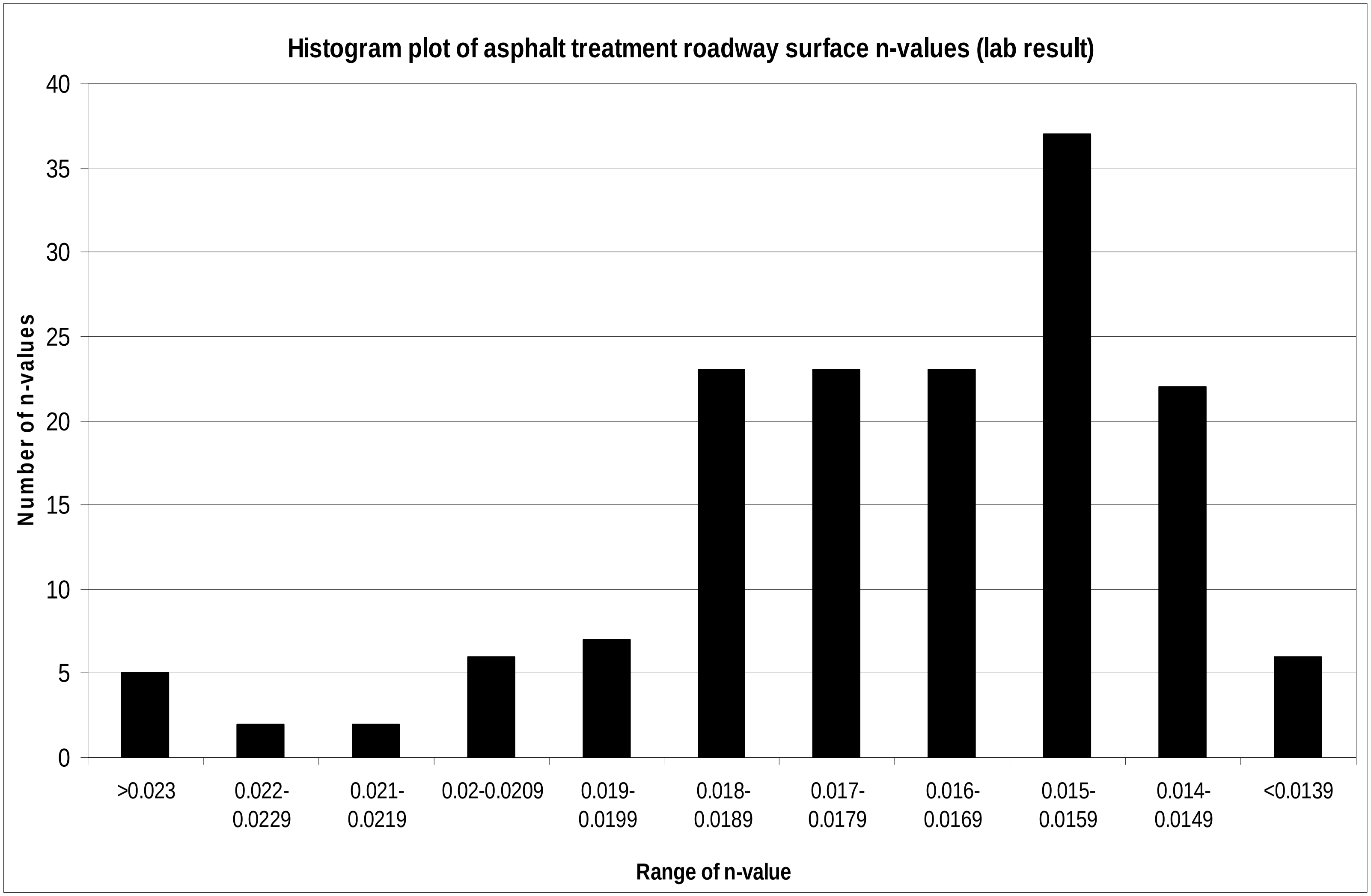


Figure E1.4 Histogram plot of asphalt treatment roadway surface n-values (lab result)

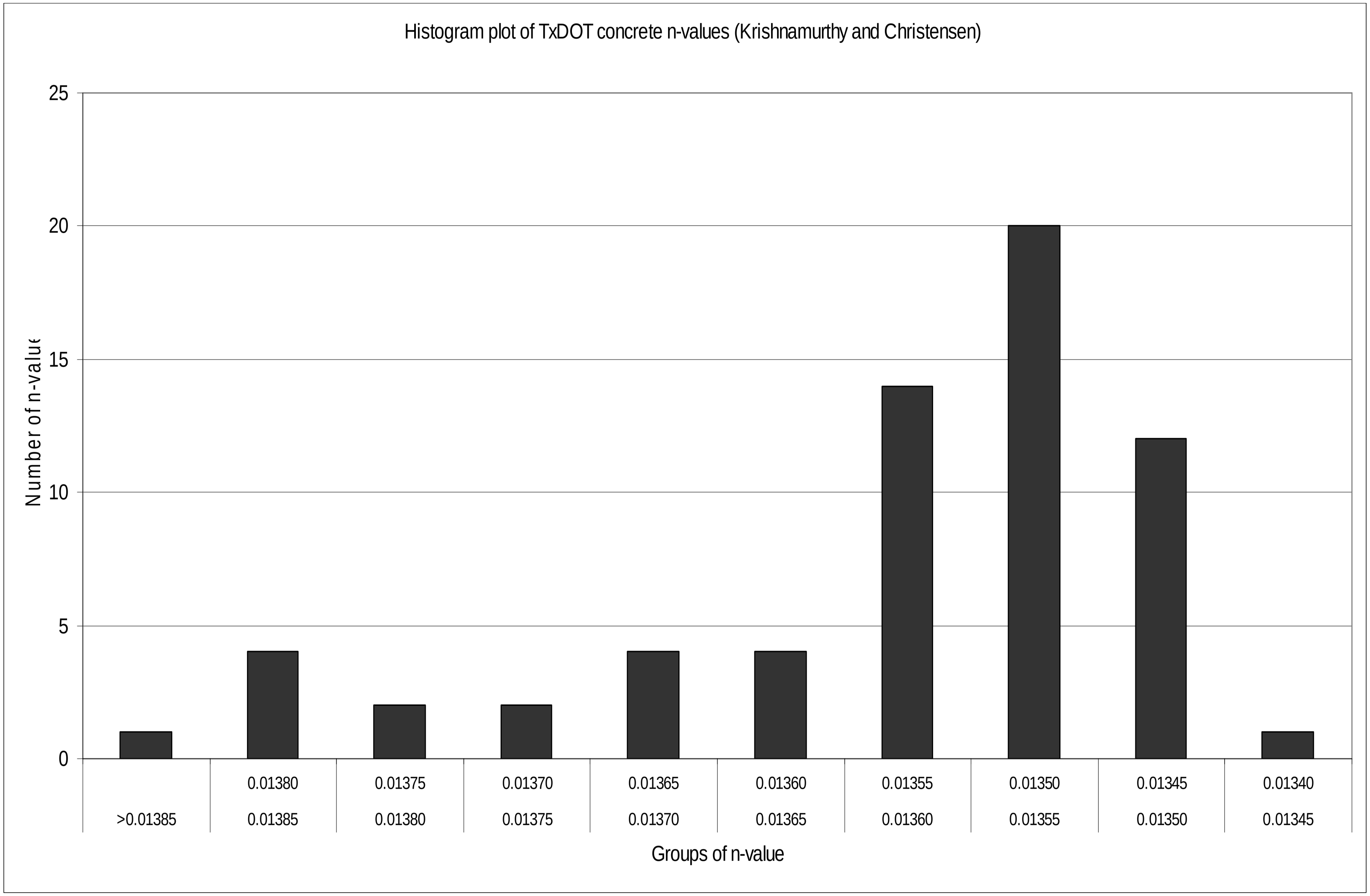


Figure E2.1 Histogram plot of TxDOT roadway surface n-values (Krishnamurthy and Christensen)

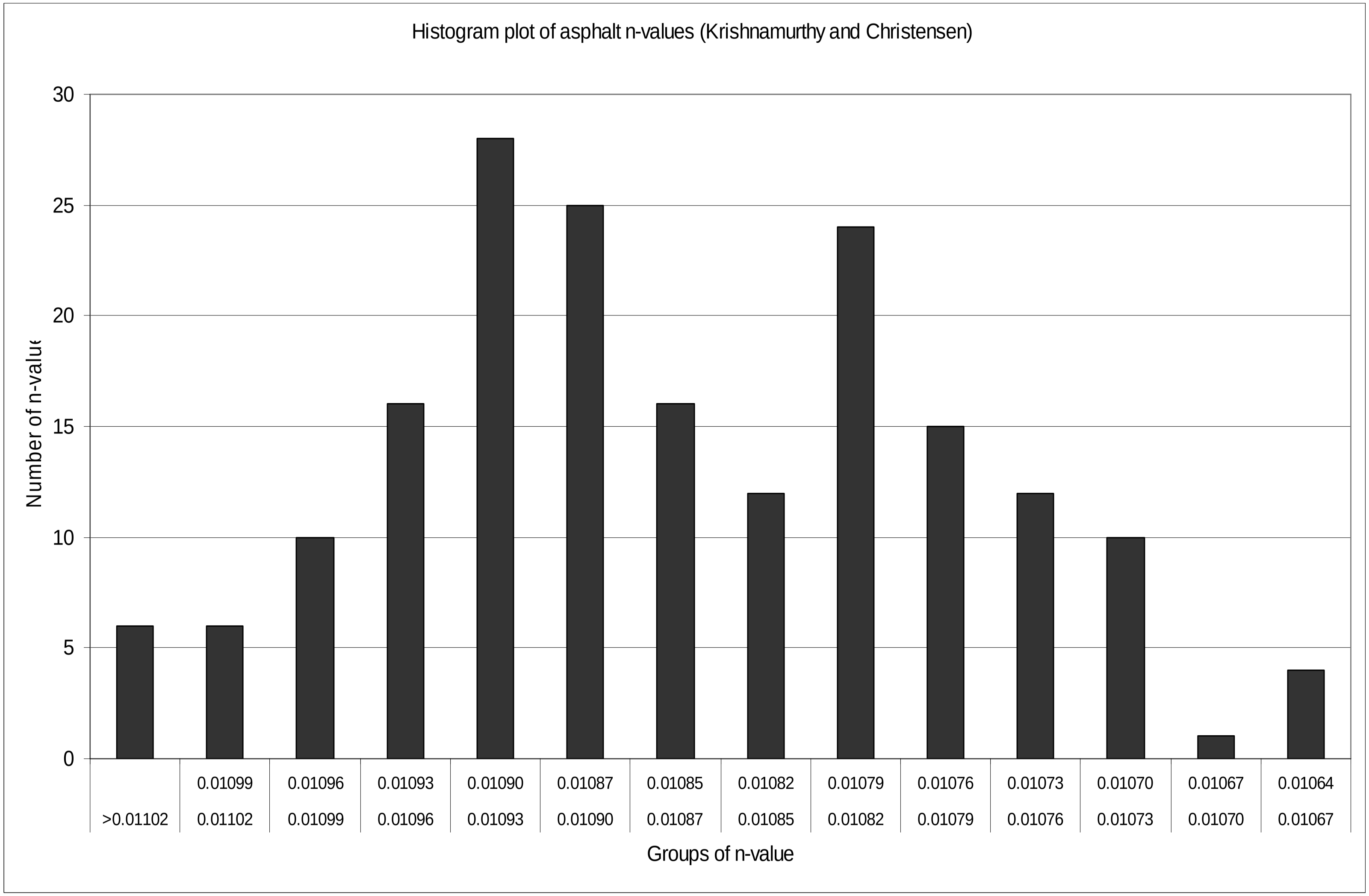


Figure E2.2 Histogram plot of asphalt roadway surface n-values (Krishnamurthy and Christensen)

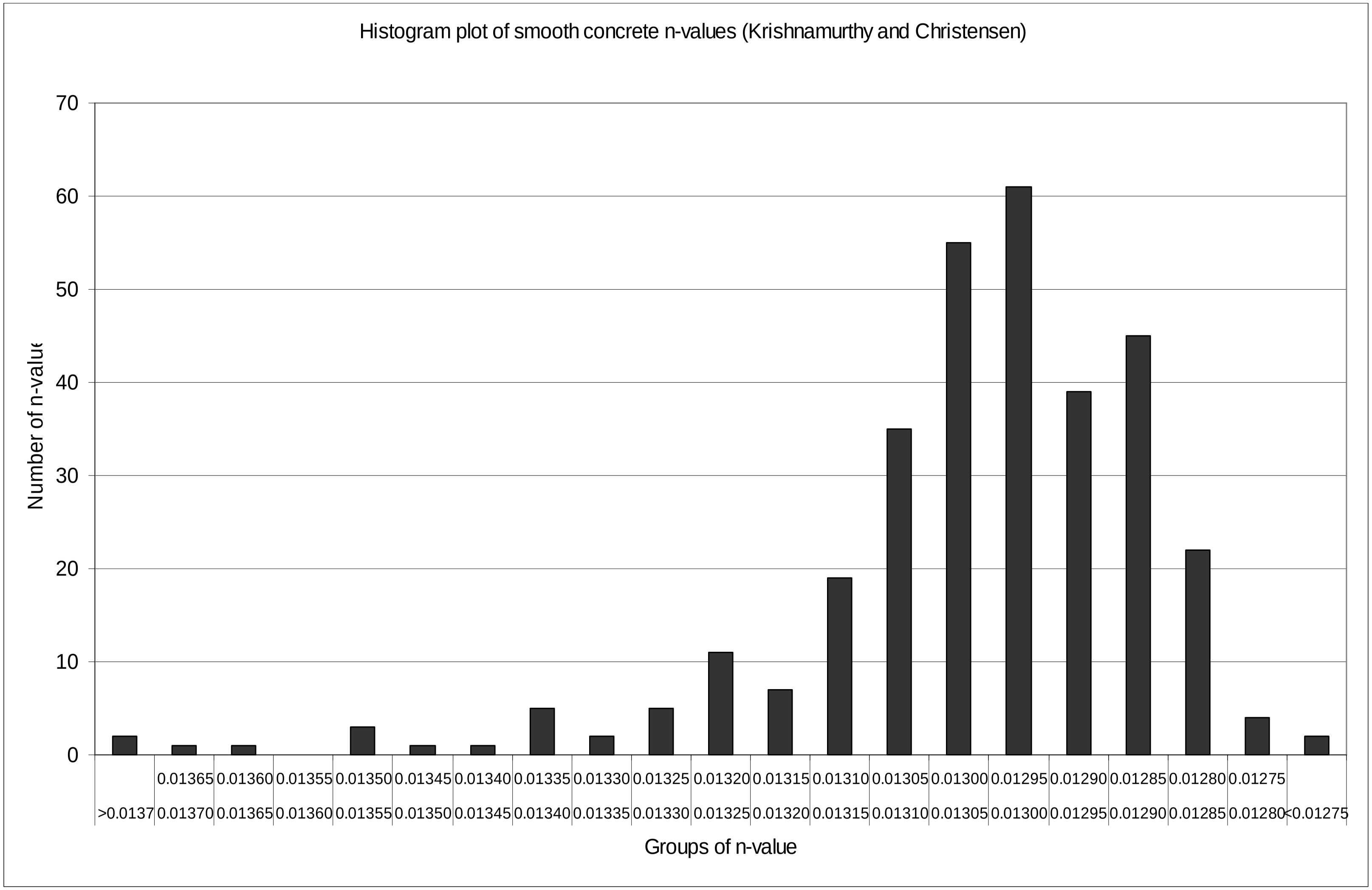


Figure E2.3 Histogram plot of smooth concrete roadway surface n-values (Krishnamurthy and Christensen)

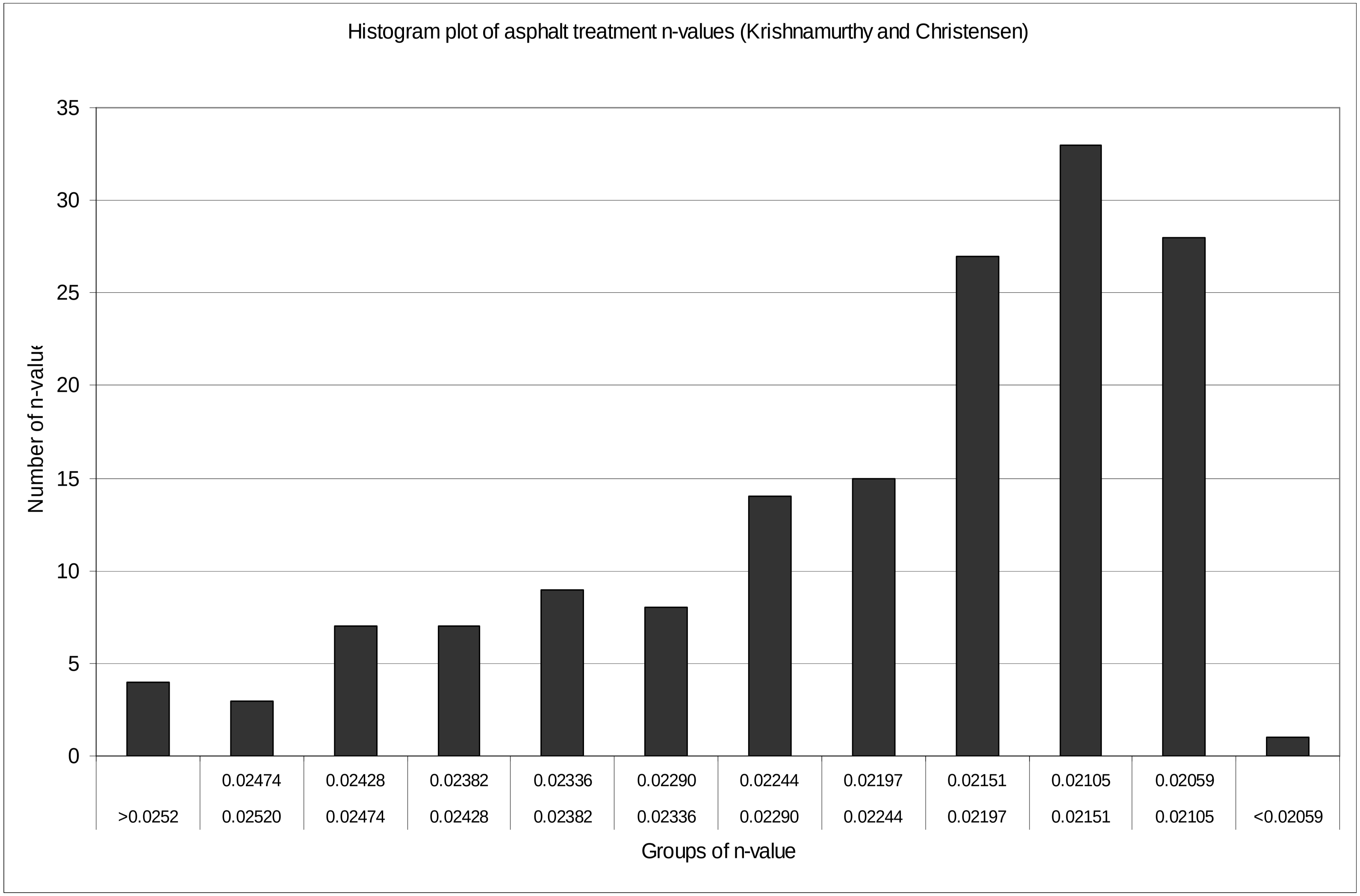


Figure E2.4 Histogram plot of asphalt treatment roadway surface n-values (Krishnamurthy and Christensen)

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