JOHNSON, PHILIP B., M.A.. Patterns of Urban Stream Stability: Relaxation Times and the Conditions of (dis)Equilibrium in Low-Order Urban Watersheds. (2016).
Directed by Dr. Dan Royall. 78 pp.

There is a need to understand the drivers and process mechanisms by which urban stream channels change, to include the pathways through which they evolve. Finding appropriate criteria for accurate assessment of stream adjustment in urban environments has emerged as an important, but difficult endeavor. The overall goal of this study is to determine what morphological variables, if any, achieve a new equilibrium following the disturbance caused by urbanization as well as ascertain the relaxation period associated with this adjustment.

For this thesis a total of 19 channel reaches in North and South Buffalo Creek in Greensboro, NC, were studied in terms of several morphological characteristics, as well as the accompanying characteristics of each sub-basin these channels were within. The sub-basins were analyzed in terms of impervious cover, peak construction period, and topography. Plots of stream characteristics vs. time since peak construction period were used to track the relaxation trajectories of the characteristics. Statistical correlation analyses were used to study the relationships among all variables to assist with possible explanations for any patterns in the relaxation trends of morphological variables.

The overriding finding of this study was that only one morphological characteristic, the width/depth ratio, appears to display a relaxation trajectory, and this period is approximately 60 years, equilibrating at a value around 4.8. This is longer than many other urban adjustment periods cited in literature. Other variables are observed to adjust through time, but do not stabilize at final values.

PATTERNS OF URBAN STREAM STABILITY: RELAXATION TIMES AND THE CONDITIONS OF (DIS)EQUILIBRIUM IN LOW-ORDER URBAN WATERSHEDS

by

Philip B. Johnson

A Thesis Submitted to
the Faculty of The Graduate School at
The University of North Carolina at Greensboro
in Partial Fulfillment
of the Requirements for the Degree
Master of Arts

Greensboro
2016

Approved by

____
Committee Chair

APPROVAL PAGE

This thesis written by Philip B. Johnson has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

Committee Chair ___________________________

Committee Members ___________________________

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Date of Acceptance by Committee

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Date of Final Oral Examination

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CHAPTER I

INTRODUCTION

Introduction

Although it is widely assumed that the creation of impervious surface area in a watershed is the principle driver of stream channel change in the urban environment, simple correlations between the two are not always evident (Doyle et al., 2000). One important reason why this might be so is that urban stream studies have rarely been standardized with respect to time of evolution, and stream adjustments to urbanization are not instantaneous. Disequilibrium systems, as urban streams are frequently assumed to represent, progressively approach equilibrium over time following the stabilization of new boundary conditions or disturbance regimes, although they may never reach it (Doll et al., 2002; Chin, 2006). Thus, the time elapsed since the creation of the urban watershed condition is a critical variable affecting the stability of streams. It is possible that time elapsed is a more important stream stability variable than cover condition. Other variables such as connectivity between uplands and streams, the density and stature of stabilizing riparian vegetation, drainage area (which is positively correlated with the presence and size of floodplains and stream power in lower order streams, and negatively correlated with channel gradient), the characteristics of channel bank and bed materials, and constraints of infrastructure (rip-rap, vanes, culverts) on channel processes may also influence local specific responses of streams to urbanization, although not necessarily adjustment rates, and often only locally (Doyle et al., 2000).

It may be wrong to simply assign to any urban stream the characteristics of disequilibrium, especially without explaining in greater detail exactly what this term means in specific context. In order to be more explicit in defining a (dis)equilibrium stream channel state, more information is required on current states of modification and adjustment throughout stream networks and the evolution of watershed landcover over time. Although stream restoration professionals, predominantly engineers, typically use present channel form to assess a stream's dynamic status ("stable" or "unstable"), this is often done only at the reach scale, not always fully considered within the watershed system context (including history), and often to an extent that denies other indicators of adjustment. This can lead to both misdiagnosis of a stream's dynamic status and erroneous prescriptions for its rehabilitation.

A number of alternative (or complimentary) physical indices describing streams have been put forth as potentially meaningful (e.g. Doyle et al., 2000) with respect to adjustment and disequilibrium (Table 1). Some of these require simple measurements of form or structure along stream corridors, such as channel cross-section dimensions, presence or absence and size of inset alluvial benches, and various indices of bank erosion (Vietz et al., 2000). However, the relative value of individual indices for understanding the developmental state or stability status of a stream is frequently unknown, and furthermore may or may not vary greatly with environmental circumstances.

Table 1. Physical Channel Indices

Attribute	**Explanation/Calculation**	**Interpretation**
Channel Enlargement Ratio	**Bankfull channel capacity Divided by rural regional Curve capacity at the same Drainage area**	**<1 channel contraction >1 channel enlargement**
Relative Incision	**Terrace Height/ EffectiveFlow (EF = bar height/.71)**	**Values >1 Indicate Incision, Disconnection From Floodplain**
Width/Depth Ratio	**Width of Channel Divided By Channel Depth**	**Urban Regional Curve W/D Values =10 Reflecting Expected Value for Stable Urban Channel via Regional Curve, Doll et al.**
Bed Sediment Depth	**Field Measurement of Bed Sediment**	**Sediment Levels Reflect Both Local Erosion Activity and Transport Capacity Of Channel. Large Variations Correlate to (Dis)equilibrium**
Bank Erosion	**Field Observation and Measurement of Mass Wasting**	**Aggressive Erosion (both banks) Indicate Continued Adjustment, Single Bank Erosion a Result Of Local Variable or Natural Meander**
Bank Evaluation	**Bank Stability Determined By Field Assessment**	**Type/Amount of Vegetation on Channel Bank and Top of Bank Correlated to Level of Channel Erosion/Sediment Input**

Objective

In this study, a number of physical attributes that have been used for stream assessment are used to study the evolution and adjustment of low order urban streams in the Buffalo Creek watershed which heads in Greensboro, N.C. Values of these attributes are determined for a number of small (1st and 2nd order) watersheds, each having a different age of urban development. Individual attribute site-averaged values are plotted versus development age to estimate the equilibration age of the attribute. Stepwise multiple regression is used to find the combination of attributes most capable of predicting watershed development age, the latter assumed to be an index of progress towards equilibrium. The research has two principal objectives:

Objective 1: determine the relationships between stream geomorphological variables and watershed urbanization and the ages of stabilization (response times) for the different variables.

Objective 2: determine which variables together best predict watershed development age, and thus the progress of stream adjustment to urbanization.

A naturally stable stream, a channel in equilibrium, maintains its dimension, pattern, and profile over time so that the stream does not degrade or aggrade (NCSRI). Determining the time required to reach stabilization for a given channel characteristic will provide valuable information regarding the overall effects of urbanization to fluvial systems as well as potentially specify a trajectory for the stabilization of urban effects.

CHAPTER II

BACKGROUND STUDIES

Background

There is a need to understand the drivers and process mechanisms by which urban stream channels change, to include the pathways through which they evolve. This understanding is necessary for best management practices in storm water quality as directed by the Clean Water Act, as well as for infrastructure and flood management concerns in most municipalities. There are many interrelated components of change in streams that are potentially of ecological and resource consequence. One of the components usually deemed most critical is hydraulic geometry. Hydraulic geometry describes how channel dimensions change with discharge at one location (at-a-station geometry) or as average floodstage increases with drainage area (downstream geometry). The latter forms the basis for modern "natural channel design" approaches to stream restoration, and is represented by power functions of discharge for conditions of the stage of flow just reaching the top of the channel bank ("bankfull stage").

These are:

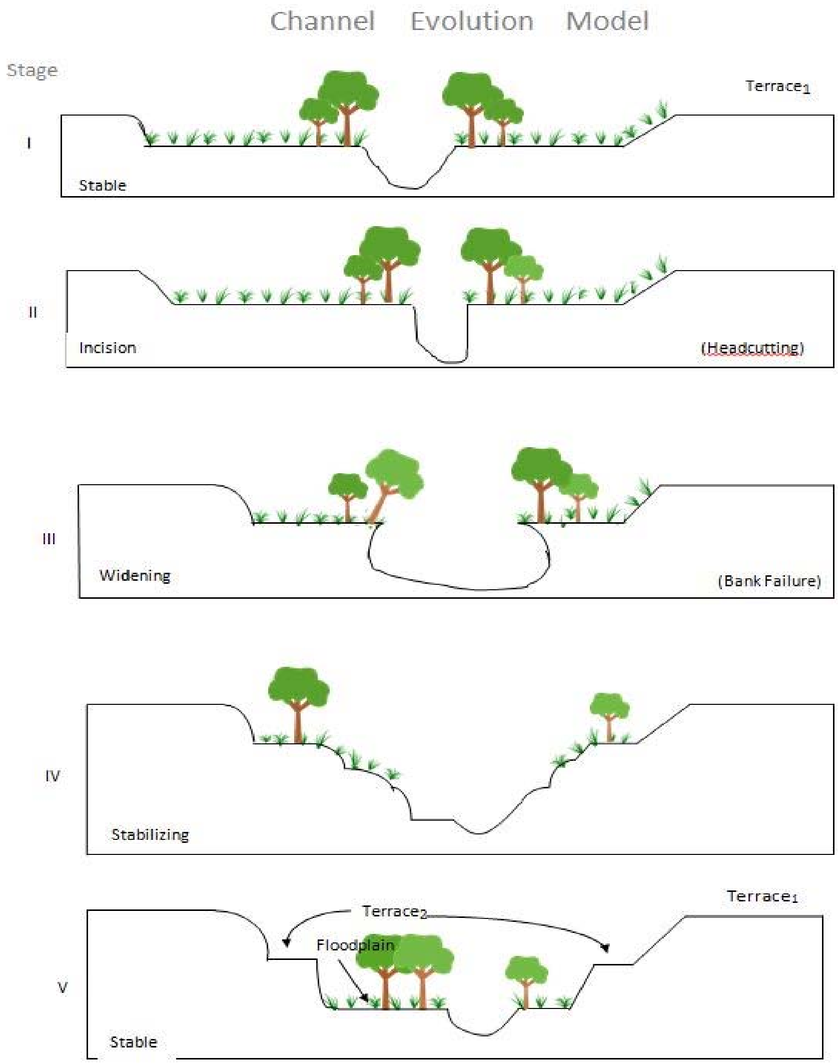
$W = aQ^l$

$D = bQ^m$

where W is bankfull channel width, D is bankfull channel depth, *a* and *b* are scaling constants, Q is water discharge, and *l* and *m* are the rates of growth of width and depth respectively.

Stream restoration, now a billion dollar business in the US, relies heavily on a form of hydraulic geometry equation in which drainage area is substituted for discharge to plot a "regional curve" depicting how stable channels are expected to change moving downstream (i.e., as drainage area grows). If a current stream reach does not conform to the expected regional curve for a given area (within the "region" from which the curves were empirically derived), then it may be judged unstable or potentially so within the system and targeted for remediation. Regional curves have been constructed for both rural and urban watersheds in many areas across the US, including North Carolina (Doll et al., 2002). According to regional curves, for a given drainage area, urban stream channels are both wider and deeper than rural ones, usually reflecting the larger peak storm discharges brought about by expansion of impervious surface area. The coefficients a and b are higher for urban streams, whereas the exponents l and m may or may not be. In North Carolina, the exponents appear to remain nearly constant (Doll et al., 2002).

General channel enlargement in urban settings reflects the broad consensus of geomorphologist world-wide. However, there is a need for more detailed descriptions of not only end states for urban streams, but also evolutionary pathways, and this need has rarely been met by empirical studies. As a result, simple conceptual models are often assumed to apply. Perhaps the most common is that of the channel evolution model of Simon and Hupp (1986) (Fig. 1) who describe the results of accelerated drainage from channelized rivers in western Tennessee.



Rendered from Simon & Hupp (1986)

Figure 1. Channel Evolution Model

Accelerated flow leads to deep incision and tall banks that, upon reaching a critical height, begin to backwaste, ultimately producing a new, lower channel, inset within the enlarged one. These changes propagate upstream via knickpoint migration starting a complex response of aggradation and degradation cycles throughout the system. Because increased runoff in urban watersheds leads to channel enlargement via similar incision and bank backwasting processes, the model has been applied in this context. However, the original authors never contended the model’s applicability to urban systems. The direct manipulation of a rural channel represents a very different and much less permanent change than watershed urbanization. Arguably, the rural channel has been merely disturbed and is free to return to some semblance of its original state over time, whereas the urban stream’s hydrology and water/sediment balance has been permanently altered. (Chin, 2006) Thus, the Simon and Hupp model may not be an adequate analog for tracking urban stream evolution. Regardless of its applicability, the model’s usefulness is limited by its high degree of generalization; it may be incapable of capturing the potential complexity of urban environmental transformations.

An implicit assumption in using regional curves is that the streams from which they have been derived are well-adjusted to their watershed conditions, a prerequisite for their being judged "stable". This is potentially problematic in many watersheds that have been strongly impacted by human activities, especially if these activities have been recent. Urban streams are so severely impacted by human activities that they are often assumed to be in disequilibrium (henceforth, DEQ) with their watershed environments. Disequilibrium is defined as a condition in which systems tend towards regaining particular equilibria after disturbance, but never reach it because their response times to disturbance are greater than the disturbance frequency. Response time is comprised of both reaction time, how long it takes for a channel to react to a given disturbance, and relaxation time, the amount of time required for the channel to recover from the disturbance and return to equilibrium.

The same concept regarding disequilibrium, the transient form ratio (TFR): TFR = *Mean Relaxation time(RT) / Mean Recurrence interval of disturbance(RID)* was devised by Brunsden and Thorne (1979) as a means of describing what they referred to as landscape *sensitivity*. When the TF >1, the landscape is considered sensitive, and is dominated by transient (temporary, ever-changing) forms. It is otherwise insensitive and dominated by permanent forms. The continuing condition of TF >1 (sensitive) over time is synonymous with DEQ (Renwick, 1992; Knighton, 1998) and one of its indicators is disproportionality between system inputs and outputs. Such a condition is clearly at odds with the ability to interpret stability and instability in the straightforward visual and qualitative way often used in restoration. One of the consequences is that even determining the bankfull stage of streams in disequilibrium is very difficult and the result may even be meaningless in many urban stream situations (Florsheim et al., 2013).

From a temporal perspective, there are two principal explanations for DEQ relative to urban streams based on which term in the TFR, the numerator or the denominator, is a greater control. These are:

(1) DEQ exists because streams are still adjusting to the rapid development of their watersheds, which was completed many years ago. That is, there was a period of major disturbance and streams have been adjusting to this "event" ever since; i.e., their RTs (response times) are very long. Thus urbanization is viewed as one large disturbance event, in the same way that early 20th century soil erosion and sediment input into streams is also considered as a single event to which streams continue to adjust.

(2) DEQ exists because, although modern streams would be well adjusted to the overall urban condition after a protracted period (e.g., 50+ years), continuing small pulses of disturbance as an old urbanized area is redeveloped, and/or as small infill development continues, maintains a very low RID (recurrence interval of disturbance).

When a perturbation does not last long enough for fundamental widespread system adjustments to occur, it is seen as a disturbance. If, as in the case of urbanization, the perturbation is permanent, then instead of a disturbance, a change in boundary conditions has occurred (Phillips 2009). That is the case in perspective 1, whereas perspective 2 considers the overprinting of subsequent smaller disturbances. Thus in reality, both conditions can exist at once. In general however, overprinting by frequent smaller post-development disturbances may not even be noticeable given the dominant impact of a change in boundary conditions. Thus the time elapsing since watershed development emerges as the fundamental control on stream adjustment. Given enough time, a system will equilibrate with even a large change in boundary conditions and effectively cease to be in disequilibrium, though smaller disturbances may continue to produce minor changes. The duration of this response time (reaction plus relaxation time) is difficult to predict. Preliminary data suggest a range from 1 to 4 decades for drainage areas less than 20 km^2, and perhaps much longer for larger basins (Chin, 2006). However, the means of establishing when equilibrium has been achieved in these studies is not always clear and there is variation in apparent response times in different environments. Furthermore, equilibration of one stream variable only implies, but does not prove, equilibration in any other, so that some aspects of stream channel morphology might adjust sooner than others.

This may be parallel with, or even an extension of, the problems with defining bankfull stage as the dominant channel-forming discharge; not all elements of stream channel form may be adjusted to a single discharge (Knighton, 1998).

Finding appropriate criteria for accurate assessment of stream adjustment in urban environments has emerged as an important, but difficult endeavor. Furthermore, a critical knowledge of how urban stream evolution is bound to time and space scales remains both elusive, and inadequately addressed in the literature. Several important questions exist:

1. How long does it take for urban streams in a given geological environment to equilibrate with their watershed conditions once these have stabilized? That is, if all other environmental attributes are equal, what are the response times for streams to urbanization?

2. Exactly how do streams equilibrate to the urban environment, and given that the urbanization represents a permanent disturbance (as opposed to, for example, logging), how might their mechanisms for adjustment be different from impermanent situations?

3. Although the amount of effective (connected) impervious area is recognized as the primary driver of urban channel change, what other physical watershed or stream channel corridor attributes influence channel response?

4. What are the best indices for recognizing disequilibrium in particular stream channels?

5. How does spatial scale (essentially, drainage area) influence the answers to all of these questions?

Although no single study can definitively answer these questions for all circumstances, there is a need for case studies from which generalizations may eventually be recognized, and the dearth of these motivates this proposal. The project described herein addresses, to varying extents, the first four of these questions for a restricted set of conditions and locations: the headwaters of Buffalo Creek in Guilford County, NC. It focuses on the relaxation pathways of stream variables over time, seeking the durations of adjustment for different stream variables, and a knowledge of which variables are the best indicators of adjustment. There are two hypotheses:

Hypothesis 1: Indications of instability will strongly correlate with age of watershed development, with stability being reached after approximately 35 years elapsed time since cessation of major development (based on results given by Chin, 2006).

Hypothesis 2: Watershed variables that are directly related to bank erosion in particular (e.g. channel width, bank erosion indices and size of inset benches) will be the most robust predictors of development age. The importance of bank erosion (and depositional accretion via fluvial bar and bench formation) in determining the channel cross-section, and its conspicuousness relative to, for example, streambed elevation change, suggest its usefulness in stream stability analyses.

CHAPTER III

METHODS

Study Watersheds

This research requires the observation and measurement of stream channel form on selected 1st and 2nd order channels in 19 select subwatersheds of the North and South Buffalo Creek watersheds in Greensboro, N.C. (Fig 1, Table 2) and provides an analysis similar to that of Vietz et al. (2014) for urbanizing watersheds in Australia. The selected subwatersheds reflect various ages of urban development, and are typical of the study area and common to many other southern Piedmont cities. The sites selected are primarily intended to cover a range of urban development ages because time elapsed following disturbance is presumed in this research to be the key adjustment variable. Variations in land cover and impervious surface area results as a byproduct of the primary selection criterion and these attributes are also analyzed. It became increasingly difficult to find appropriate sites due to both accessibility and study parameter requirements, leading to fewer sites than would be statistically ideal.

Table 2. Watershed Characteristics

Site Name	Coordinates(dd) Lower End	Drainage Area Km²	TIA %	EIA%	Development Age	Relief (m)	Relief Ratio
Assembly	N36.13885° W-79.74228°	0.34	5	1.1	24	21.33	0.029
Big Tree	N36.06628° W-79.90008°	1.01	30	16.4	46	28.04	0.02
Campus	N36.0725° W-79.81321°	1.7	60	46.5	69	35.35	0.019
Elmsley	N36.00332°	1.1	5	1.1	51	31.69	0.022

	W-79.78831°						
Forest Valley	N36.10765° W-79.84511°	0.35	40	25.3	43	26.21	0.032
Frazier	N36.02829° W-79.85056°	2.55	15	5.8	36	30.48	0.019
Greenway	N36.07738° W-79.82415°	0.56	35	20.7	76	23.16	0.02
Kenview	N36.07417° W-79.87832°	2.5	35	20.7	40	35.35	0.027
Kettering	N36.0764° W-79.86293°	0.95	40	25.3	37	27.43	0.025
Lakefield	N36.0174° W-79.80057°	0.85	25	12.5	38	29.26	0.016
Nanotech	N36.05876° W-79.74430°	3.7	15	5.8	40	36.57	0.014
Normandy	N36.11576° W-79.81755°	.18	15	5.8	55	21.33	0.039
Random	N36.04590° W-79.86574°	1.8	30	16.4	46	28.65	0.013
Robinhood	N36.1118° W-79.84143°	0.79	35	20.7	52	33.52	0.035
Sharing	N36.07166° W-79.72881°	2.6	20	8.9	41	33.52	0.015
Waldron	N36.11961° W-79.80471°	0.78	30	16.4	31	29.87	0.026
Watauga	N36.09773° W-79.85078°	1.4	25	12.5	45	34.74	0.023
Willowbrook	N36.06711° W-79.8394°	0.64	35	20.7	70	27.43	0.028
Willow	N36.09544° W-79.70169°	3.9	10	3.2	39	34.74	0.012

Stream variables for each of the 19 watersheds analyzed are derived from a representative 100m reach of stream. For each 100m reach, a minimum of 6 locations were used in the measurement and evaluation of stream morphology. These locations were at 20m intervals along each reach with additional measurements obtained in locations where mass wasting was evident. A total of 119 cross sections (total across all 19 sites) were evaluated for the various metrics included in this study. Grid coordinates were obtained for every location using a Garmin 62stc with accuracy at +/- 3 meters.

GIS Model

For this study a map of Guilford County was created in ArcGIS (ESRI, 2015). There were several layers required to analyze all of the criteria included in this project. A DEM was created from USGS 1/9 arc National Elevation Dataset tiles. (USGS) The DEM was then overlain with orthoimagery, roads and boundaries, tax parcel information, contour lines, and hydrology flowlines. The grid coordinates of each study site were input into the model by way of an excel sheet. These points were used as a reference from which to determine the sub-basin for each reach through ArcGIS hydrology tools. Each sub-basin, a raster layer, was then converted into a polygon which was used to clip the tax parcel layer.

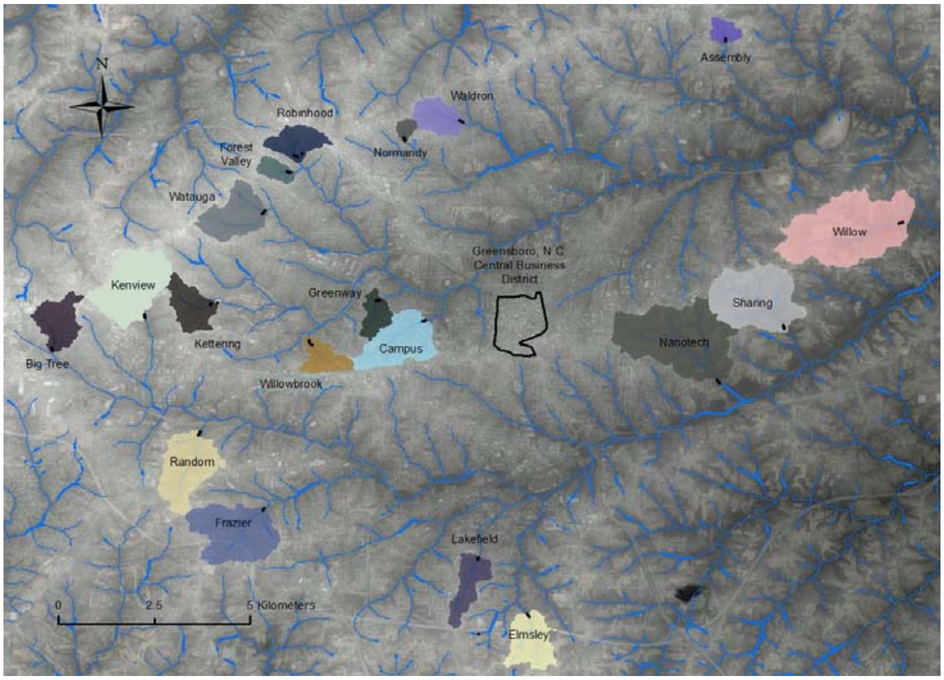


Figure 2. Watershed Map

The tax layer contained dates of construction for every parcel within the polygon, and the arithmetic mean of these dates were used as the construction age for each watershed. The area of the polygons were calculated and used to indicate basin size. These area calculations were cross-referenced with both pixel size (3.08m^2) times pixel count and manual graphing techniques. Manual graphing techniques and model outcomes differed by only .02km^2.

Orthoimagery within this GIS model was analyzed to estimate the total impervious area (TIA) inside of the individual watersheds. These estimates were then converted to effective impervious area (EIA) according to the equation developed by Sutherland (1995). Channel slope and relief were determined by observation of USGS contour lines, and the length of each watershed determined by measurement tools in ArcGIS. These measurements were used in determining the relief ratio as described by Strahler (1957).

Field Data

The observations and measurements used in this study describe various attributes of channel shape, size, sediment compositions, vegetation characteristics, and zones of channel banks showing mass wasting. (Table 3) All measurements were made by the author to ensure consistency throughout the study. Cross sectional measurements were taken at regular intervals of 20m to determine channel width and depth, normal flow water width, and channel cross-sectional area. The presence of bench and bar formations was noted to include size and frequency. Effective flow and relative incision was calculated in accordance with Florsheim et. al. (2013). Any obvious variations in bed sediment texture or quantity were described in terms of the textural classification of the deposit by the percentage of cobble, gravel, sand and bedrock. Also noted were the presence/absence, type and stature of vegetation cover on any in-channel bench and all bank top surfaces. Vegetation cover density and stature were quantified using a simple rating index from 1-5, with 5 being closed canopy riparian forest, 1 being bare ground, 2 as full but low herbaceous cover (mown grass), 3 as dense tall grasses and weeds with deep rooting zones, and 4 a mix of tall, dense grasses and weeds with trees without closed canopy.

A Bank Stabilization Index was assessed with a metric of 1-5, with 1 being a completely stable, well vegetated bank, 2 still stable though less vegetated, 3 showing some sign of recent instability and sparse vegetation, 4 having minimal vegetation and signs of recent scour, and 5 an instance of active mass wasting. Sites showing active mass wasting were analyzed in terms of bank erosion hazard index (BEHI) variables which are bank angle, root density, root depth, and erosion area. Only 7 of the 19 reaches studied exhibited active bank failure, and were measured for the BEHI values (henceforth termed 'BEHI' in further writings). For mass wasting, affected bank surface area and failure depth were the most important indices of failure size. All eroding banks were described and photographed so that stratification, bank slope angle, and root depth and density could be further assessed later from a computer screen as necessary. Type, size, and location of engineering structures (such as rip rap or vanes) were noted whenever they occurred. Field observations of flood events were observed in an attempt to constrain the frequencies at which bank and bench tops are inundated. Although no event completely came to benchfull, much less bankfull stage during the time frame of this study some relevant observations were made.

Watershed Variables

Development age was ascertained for each watershed using data from the Greensboro GIS center and Planning/Development Department. Data on ages of urban development were determined for each watershed, including dates for the earliest, most recent, and average age of development. Modal age of urban development was used as the index of elapsed time for plots of time vs. stream attribute values. Data from the USGS were analyzed within ESRI ArcGIS (USGS) to determine total impervious area (TIA), channel slope and local relief, land use type and extent, and drainage area per study site. Effective impervious area (EIA) values, representing that portion of the TIA fully connected to the drainage network, were estimated using empirical equations derived from previous studies (Sutherland, 1995; Exum et al., 2005).

The regional curve values of bankfull width, depth, and cross-sectional area for each sub-basin were calculated according to equations provided by Doll et al., (2002) for the North Carolina Piedmont. Bankfull areas were not determined in fieldwork, although estimates of it as the simple product of width and depth for top-of-bank and top-of-bench (if present)was calculated. All variables were entered into an excel spreadsheet for further mathematical calculations. A total of 45 variables were analyzed in the final analysis.

The original Excel spreadsheet contained 116 rows and 48 columns, representing data from each individual cross section. Several of these columns, or attributes, were calculated secondarily from the primary data. Width/Depth ratio would be an example, as well as cross-sectional area, enlargement ratio, and relative incision.

These data were then averaged to their mean values for each variable per watershed, creating a second Excel spreadsheet which was used to compare watershed values. The bank stabilization metric values were averaged for each side (lft. bank, rt. Bank) and added together to create an overall assessment for each reach. The same was performed for bank vegetation. Some attribute values were converted to a natural log base signified by ‘*ln*’ before the variable name.

Table 3. Study Variables

BnkWdth- Bankfull Channel Width	Measurement of distance between top of banks in meters
Depth- Channel Depth	Vertical distance between top of bank and channel bed in meters
WetWdth- Wet Width	Width of the submerged bed when surveyed
W/D- Width to Depth Ratio	Width measurement divided by Depth
lnW/D- log base of W/D	Conversion of W/D to a natural log
BnkAngle-Bank Angle	Angle of the channel bank in degrees
RtDpth- Root Depth	Percentage of bank height that roots penetrate
RtDnsty- Root Density	Percentage of bank face root systems occupy
ErosArea- Erosion Area (BEHI Sites)	Width times height of erosion observed
BarHgt-Bar Height	Measurement of bar height above the channel bed in meters
BarVol- Bar Volume	Average width x length x max height of bar
BnchHgt-Bench Height	Measurement of bench height above channel bed in meters
BnchVol- Bench Volume	Average width x length x max height of bench
BnchFreq- Bench Frequency	Number of benches observed per reach
EffFlow- Effective Flow	Bar height divided by 0.71 (Florsheim, 2013)
RelIncis- Relative Incision	Bank height divided by effective flow (Florsheim, 2013)
BasinKm2- Basin Area	Basin Area in square kilometers
lnBasin- log base of basin area	Basin Area converted to natural log
Age- construction age	Mean age of construction in basin

lnAge-construction age	Natural log value of mean age of construction
Relief- Relief	Overall relief within basin
lnRelief- log base of relief	Natural log of basin relief
RelRatio- Relief Ratio	Basin relief divided by basin length
ChnlSlope-Channel Slope	Change in bed elevation per unit distance
TIA- Total Impervious Area	Percentage of impervious area in basin
EIA- Effective Impervious Area	Conversion of TIA to EIA
lnEIA- log base of EIA	Natural log of EIA
Cobble (64-256mm)	Percent of cobble in channel bed
Gravel (2-64mm)	Percent of gravel in channel bed
Sand (0.5-2mm)	Percent of sand in channel bed
Bedrock	Percent of bedrock in channel bed
RtAct- Right Activity	Bank stabilization index for rt. bank 1=most stable-5=least stable
LftAct- Left Activity	Bank stabilization index for lft. Bank 1=most stable-5=least stable
LandRAct- Left and Right Activity	Average of left and right bank stabilization index values by reach
RVeg- Right Vegetation	Right bank vegetation cover by index 1=most vegetated-5=least vegetated
LReg- Left Vegetation	Left bank vegetation cover by index 1=most vegetated-5=least vegetated
LandRVeg- Left and Right Vegetation	Average of left and right vegetation cover by reach
CSArea- Cross Section Area	Area of channel cross section
BnchArea- Bench Area	Cross sectional area of channel within benches
CSAENlR- Enlargement Ratio	Cross Section area divided by Doll Area
DollArea- Doll Area	Bankfull cross-sectional area predicted by regional curve of Doll et. al. (2002)
DollWdth- Doll Width	Channel width predicted by regional curve of Doll et. al. (2002)
DollDpth- Doll Depth	Channel depth predicted by regional curve of Doll et. al. (2002)

Quantitative Analysis

The quantitative analysis consists first of performing a bivariate correlation in order to determine which variables have the strongest relationship with one another, and particularly what watershed averaged variable correlates best with urbanization age. The next analysis performed consisted of plotting each stream variable having a good correlation with age, as a function of urban development age in a scatter plot, and fitting linear, log-linear trendlines to determine at what age (if any) that variable reaches a steady value. For that variable, the indicated age represents the end of relaxation (and response) time. Although this may be different for every variable (and many may never stabilize), it is hypothesized that an average value of relaxation time with small standard deviation will emerge at around 35 years, based on Chin (2006).

A similar analysis was conducted for impervious area to see if there are any variables, especially those that proved to be insensitive to development age, which might be primarily responding to this second watershed variable.

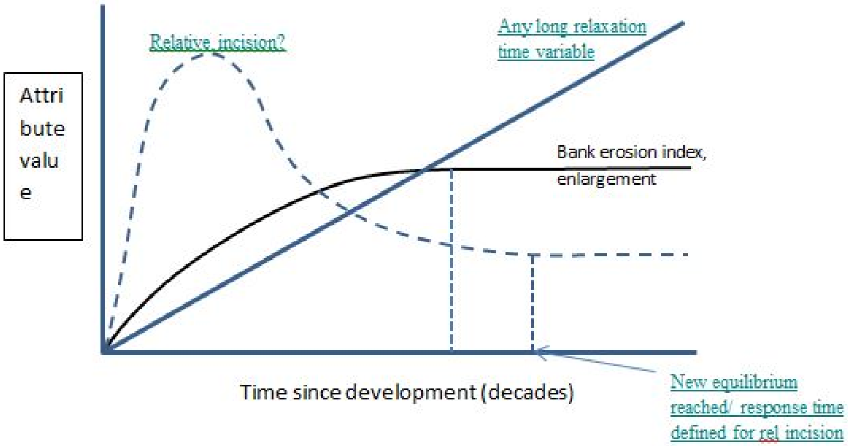


Figure 3. Example Plots of Relationships between Attributes and Development Age.

Variables would not be expected to approach equilibrium values as impervious cover increases as streams would be in a constant state of renewed adjustment. Instead, both the strength and slope of any relationship, between a stream variable and impervious cover would suggest sensitivity to cover conditions and might help explain why a particular stream variable might be insensitive to development age. However, the range of variation in impervious cover between watersheds may not be sufficient to provide good results. The study site selection is geared more towards determining the effects of elapsed age rather than cover characteristics. Given more time, a larger number of watersheds might be chosen to reflect all kinds of age and cover conditions, and the cover control analysis made more robust. In particular, it is possible that the magnitude of effect, primarily a product of cover characteristics and connectivity, may be correlated with its relaxation time. (Although such reasoning may seem logical, it is not necessarily correct. It would depend on the rate of initial stream response as reflected in the steepness of the adjustment time curve, and this has not been systematically studied by others.

The final analyses performed with these data were Stepwise multiple regressions in order to determine the most prominent stream variables that when combined, statistically explain development age. That is, given limited time and resources, which combination of variables are most sensitive to age, and thus best evaluated for purposes of estimating the degree of channel adjustment or equilibrium.

CHAPTER IV

RESULTS AND INTERPRETATIONS

Individual Cross-Section Scale Correlations

The Pearson correlation matrix for individual cross-section variables was analyzed with a threshold absolute value of R value = 0.6 to be the lowest value that indicates a probable relationship. The p values for all of these correlations are below 0.05 and designated by an asterisk in the appendix. Relationships lower than this would produce an R^2 of 0.25 or below and were not considered as a useful level of correlation. Relationships that are likely to be intrinsically auto-correlative are also not presented. This primarily includes correlations for variable pairs in which one variable is a composite (aggregate) variable incorporating the other.

For individual cross-section sites, 16 out of 544 total correlations had absolute value of r > 0.6 (Table 4). The most commonly correlated measure was Erosion Area, which is correlated at absolute value r>0.6 for 5 different variables. Root density (correlated with 3 variables) and root depth (correlated with 3 variables) were the only other non-autocorrelated variables having more than one absolute value r>0.6 correlation. Two of the four variables correlated to Erosion Area are channel cross-section dimension variables, and the other two are related to bank vegetation. Of the 16 total correlations with r=>0.6 five have r values>=0.8:Channel Depth Erosion Area, Root Density:Channel Depth, Root Density: Erosion Area, Root Depth: Left Bank Vegetation, and Root Depth: Right Bank Vegetation.

Table 4. Pearson Correlation Values for Non-Autocorrelated Variables

Primary Variable	Correlating Variable w/ R value
Channel Width	ChnDepth (0.607)
Wet Width	Relief (0.625)
Channel Depth	ErosArea (0.8), ChnWdth (0.607), RtDensity (0.803)
Channel Area	RtDensity (0.722)
Bench Volume	Cobble (.664)
Bar Height	RelRatio (-0.619)
Sand	BnkAngle (0.678)
Left and Right Vegetation	ErosArea (-0.705)
Bank Angle	RtDepth (-0.65), Sand (0.678)
RtDensity	ChnlDepth (0.803), ErosArea (0.824), ChnArea (0.722)
RtDepth	LftVeg (-0.829), RtVeg (-0.827), BnkAngle (-0.65)
Erosion Area	RtDensity (0.824), LftVeg (-0.705), RtVeg (-0.717), ChnlDepth (0.607), LandRVeg (-0.705)

Individual Scale Interpretations

Channel depth and root density correlate with an R value of 0.803. This could be explained as a greater root density would increase bank cohesion and inhibit channel widening, leading to a larger amount of incision. Channel depth and erosion area returned a correlation value of 0.8. This can be explained by the fact that the erosion area variable represents mass wasting erosion only, which tended to encompass the entire bank. Therefore in erosion area calculations bank height, or channel depth, would be part of the equation, so autocorrelated to some extent. Furthermore, according to the CEM mass wasting occurs once a critical bank height is reached, meaning this relationship is expected.

The correlation between bench volume and cobble proportion in channel bed returned an R value of 0.664. This could be explained by the presence of larger, stable benches indicating some advanced level of stream adjustment and possible equilibrium of sediment input vs. output. This being the case there would likely be a lesser amount of sand evident, it being washed out of channel beds, leaving more cobble which requires a larger flow event to transport.

Sand and bank angle returned an R value of 0.678. This could indicate that a large amount of sediment is present in channels which have reached Simon and Hupp's (1986) critical bank height and are mass wasting, leading to a larger amount of sand as channels widen following incision.

The top of bank vegetation has an apparently negative correlation with erosion area, but that is due to the metric utilized in this study. The lower the number used to describe the bank vegetation, the less vegetated the surrounding area. This being the case, as top of bank vegetation went down (the index number), the erosion area went up. That would be the logical result of non-vegetated floodplains as there is little root protection in the adjacent floodplain, leading to more active bank erosion.

Bank angle and root depth correlate with a negative value of r=-0.65. This could be explained by increased root depth inhibiting channel widening via mass wasting, assuming that high (near vertical) bank angles are maintained by mass wasting. It could be argued that a channel less inclined to widen would be forced to incise, potentially increasing the bank angle.

Erosion area and root density correlate at an R value of 0.824. Erosion Area represents instances of mass wasting such as slumps caused by undercutting, not general scour. A greater root density could decrease bank widening leading to greater incision. This incision could increase the bank height, leading to a larger measurable area from channel bed to the top of the bank, which could in turn explain the positive correlation between erosion area and root density.

Watershed Scale Correlations

The Pearson correlation matrix for watershed variables showed higher correlation values than those of the individual cross sections resulting in a much larger number of correlations with R>0.6 values (Table 5). Construction age correlation values ranged between .735 and .365 with W/D showing the strongest relationship. The correlations for EIA and lnEIA were also studied in this matrix is an effort to ascertain whether or not they represent a stronger control over stream morphology than age. The strongest correlation to lnEIA is the bank stability erosion index which has a value of 0.650, compared to that of 0.365 for age and bank activity. The W/D and EIA relationship returned an R of only 0.347.

Table 5. Pearson Correlation Values of Watershed-Scale Variables

Primary Variable-	Correlation variable w/ R value-
lnAge	W/D (0.735), BnkAngle (0.628), ErosArea (-0.744)
Channel Width	WetWdth (0.783), BarVol (0.617), Relief (0.636), BnkDepth (0.826)
Bank Depth	BnkWdth (0.826), WetWdth (0.695)
Wet Width	BnkAngle (-0.667), lnBasin (0.717), Relief (0.803)
Width to depth ratio	ErosArea (-0.743), RelInc (-0.755), lnAge(0.735)

Bank Angle	LandRVeg (0.853), Relief (-0.831), lnAge (0.628), BasinArea (-0.805), WetWdth (-0.667)
Erosion Area	W/D (-0.743), Age (-0.744), LandRVeg (-0.696), RelInc (0.895)
Bar Height	RelRatio (-0.811), Gravel (-0.651), Chnl Width, (0.6612), BasinKm2 (0.607)
Relative Incision	ErosArea (0.895), RelRatio (0.628)
Basin Area	BnkAngle (-0.805), BarVol (0.756), RelRatio (-0.688), Relief (0.739)
Relief	BnkAngle (-0.831), BasinKm^2 (0.739)
lnEIA	RtDepth (-0.611), LandRAct (0.650)
Sand	RtDepth (-0.686), RtDensity (-0.693)
Left and Right Vegetation	RtDepth (-0.875), ErosArea (-0.696), BnkAngle ((0.853)

Watershed Scale Interpretations

The Pearson correlation matrix for watershed variables and the average values for each individual variable per reach provided a different view of the study sites. The primary variable of this study, construction age, returned an R=0.735 value when converted to a natural log base and correlated to the width to depth ratio. This indicates that as age increases, width, the numerator, increases at a higher rate, or the channel has aggraded, and the denominator, depth, has decreased. Following a peak construction event an increase in sediment would be expected, leading to aggradation and a decreased depth. This aggradation would occur early in the post-construction channel adjustment and is likely not represented in this study as the youngest site, Assembly, is 24 years old. Over time, the higher peak discharges caused by urbanization would remove this sediment and accelerate erosion, eventually surpassing the critical bank height proposed by Simon and Hupp (1986), leading to an accelerated bank erosion and an increased width to depth ratio.

The r value for ln(age) vs. bank angle was 0.628. This is consistent with progressive channel widening in the mid to late stages of the Simon and Hupp (1986) model, which is caused by continual bank erosion. For this to hold true there would likely be a time period between bank failure and the inherent sediment input being removed, leading to further channel widening. Bank failure could in some instances cause a slump to fall only to a mid-bank position, leading to a decrease in overall bank angle. The more likely explanation is that of channel incision creating a greater bank height which eventually results in bank failure creating higher bank angles.

There was a negative correlation between construction age and erosion area. If bank mass wasting erosion decreases over time it would seem that there is some level of 'recovery' for urban streams. It further indicates that although EIA is a continuing disturbance, with urbanization as a disturbance type, the affected system can eventually adjust in a coherent manner. This would not necessarily relate to scour erosion, but more likely to mass wasting on the level of true bank failure.

Channel width has an R value of 0.636 when correlated to relief. The reasons for this likely vary between watersheds. In some cases, such as the Nanotech site, the relief was comparatively high at 36ft with a bank width of 8.62m, though it was also one of the larger watersheds at 3.7Km^2. As such, the reach was a larger second order stream, therefore a greater channel size would be expected due to basic hydraulic geometry considerations. In contrast, the Waldron site had a relief of 29ft and a bank width of 8.48 meters, but a basin area of only

0.78Km². This site was a 1st order stream in an area of higher urbanization and fed by stormwater culverts. The EIA for the Nanotech site was only 5.8% compared to an EIA of 16.4% for the Waldron site. As such the Waldron site likely has a larger cross-section due to increased impervious surface area and the associated higher peak discharges. This is further magnified by the high, local relief, as Waldron has a relief ratio of 0.026 compared to that of 0.014 for Nanotech. Still, as relief has a Pearson correlation of R=0.739 with basin area, the probable cause of a relationship between relief and channel width is due to watershed size and general hydraulic geometry.

The relationship between channel width and bar height (0.661) and bar volume (0.617) is suspect due to two primary outliers in terms of bar height and volume. These were the Willowlake site and the Random site which differed greatly in many ways. The Willowlake site was on the outskirt of the county and fairly rural in character with a basin size of 3.66Km² and EIA of only 3.2%. The site is connected to farmlands which were likely contributors of sediment. As well, this channel was relatively unaffected by urban activity and still displayed good sinuosity with point bars and cutbank. As such there was a large volume of sand bars recorded, as well as wide channels due to having one of the larger drainage areas. In contrast, the Random site is in a medium size basin at 1.8Km² with 16.4% EIA and displayed minimal sinuosity. A common characteristic of urban streams are that they tend to be straighter than rural channels, as evidenced in the differences noticed between the Random and Willow site. (Chin, 2006) The Random site was fed from a large culvert and deeply incised with roadways on either side. The bars at Random differed from those at Willowlake in that they were large cobble bars upwards of 10m long and .5m tall. This was likely due to local geography and high incision.

Wet width correlated with channel width with an R value of 0.826, channel depth at 0.695, basin size (ln) at 0.717, and relief with 0.803, all of which can be explained by arguments similar to those mentioned above regarding channel width and each variable. The anomaly to the wetted width variable is the negative relationship found with bank angle at an R=-0.667. One explanation could involve the early stages of the Simon and Hupp model (1986) with a channel initially incising, prior to the critical bank height. At this stage a channel would likely have a smaller wetted width and steeper bank angles than those found in an older channel. Another explanation could involve the consistency of a given banks soil profile. The angle of repose should reflect the banks composition such that a sandy soil would tend to settle at a lower angle than that of clay due to the latter's high cohesion. If this were the case then one would expect a narrower, steeper profile in a clay rich soil bank found in smaller drainages, and a gentler one further downstream in larger basins where larger wetted widths occur, and where floodplain sediments making up the channel banks would consist of coarser sands and silts.

Bank angle correlates with relief at an R value of -0.831 and watershed area at -0.805. The implication of this is that as basin areas increase in size, which entails an increase in relief, bank angles decrease, or put another way, lower order streams tend towards steeper banks. This relationship likely skewed due to the low n values in mass wasting. The lowest bank angle value was 57° which was found in the largest basin of 2.5km^2, while the two highest bank angles are 70° and 67° with basin areas of 0.56km^2 and 0.35km^2. Representing nearly half of the bank angle values this is the most likely explanation for the relationship.

The erosion area of channels (wrought by mass wasting) had a negative relationship with width to depth ratio at R=-0.743. This seems to be an expected dynamic given that there is a direct relationship between Age and W/D ratio. Once a channel has reached a width capable of containing the stream following the urban disturbance erosion would tend to decrease. This is consistent with the correlation between erosion area and construction age which also shows a negative correlation of R=-0.744, indicating that over time channel width reaches an equilibrium with channel depth and again the erosion process decreases. The other correlation for erosion is with bank vegetation at an R value of -0.696. This simply implies that less vegetation creates an environment for greater bank mass wasting erosion.

The Pearson correlations for bar height not previously mentioned are with relief ratio at R=-0.811 and gravel at an R=-0.651. The negative relationship with relief ratio indicates that a lower stream channel slope, which is typical for a basin of low relief ratio, is more likely to create an environment conducive to sediment deposition and the formation of bars. Another explanation is that a high relief ratio generally means a smaller basin and channel which would constrain the size of bar that could form. As for the negative relationship with gravel, most bars observed in this study were composed of sand. In this situation a prevalence of sand would necessitate a reduction in gravel, at least by simple observation.

Relative Incision and mass wasting Erosion Area have a relationship with an R value of 0.895. This would be expected as the act of incising would create higher, steeper banks, more conducive to erosion and mass wasting. The other aspect to consider is that to calculate relative incision there must be some bar formation present in order to calculate effective flow. Furthermore, a high rate of relative incision indicates disconnection from a flood plain. The presence of benches and bars, in conjunction with disconnection from flood plains and active erosion seem to indicate the process of creating of an inset channel. Another explanation would be that the presence of mass wasting would be expected to contribute large amounts of sediment in the channel, leading to the formation of bars and reducing the relative incision value. As such it would seem that a given channels level of adjustment following urbanization, or at what stage of evolution it has reached, would dictate which explanation is most appropriate.

Sand has a negative correlation with both root depth and root density with R values of -0.686 and -0.693 respectively. This is possibly an indicator of the relationship between the presence of well rooted vegetation and erosion control. Stable banks would likely contribute less sediment to the channel, decreasing the percentage of sand in the bed material.

EIA (ln) and root depth have a correlation with an R value of -0.611. One cause for this could be that many of the channels close to the downtown area are bordered by walking paths and have mown grass up to the streams edge. There have been attempts to remedy this by leaving an untended border to these channels, but this still leaves only a thin, herbaceous cover. What trees that are found tend to be relatively new growth and spread several meters apart. The farther basins are from high EIA areas the deeper the canopy of bank vegetation, as a general rule. EIA (ln) and bank stabilization index correlate with an R=0.650 value. The apparent reason for this would be that impervious surface increases bank erosion. A similar statement would be that denser urban areas increase channel erosion, which may be more accurate as included in this would be the increase in drainage density and connectivity due to stormwater systems. In this study Sutherland (1995) calculations to translate TIA to EIA were utilized in an attempt to include the level of connectivity in local stormwater infrastructure.

Trendlines

Scatterplots for watershed scale correlations with an R=>0.8 value were plotted and trendlines were fitted to determine if attributes such as shape of trendlines, including slope and intercept, and possibly patterns in residuals, would provide useful information on the nature of correlations, and in the case of Age as the independent variable, the relaxation trajectories for adjusting form variables. The linear and logarithmic trendlines were analyzed for each pair of variables. The polynomial trendline was also entered for the relationship between construction age and the width to depth ratio. This was done as a means of better visualizing the timeline associated with the relaxation period between the disturbance caused by urbanization and the possible equilibrium of the W/D ratio. A total of six relationships were plotted (Figs. 4-11), and the variables covered are Bar Height: Relief Ratio, Bank Angle: Relief, EIA: Bank Stabilization Index, Construction Age, Relative Incision: Erosion Area, Age: Width to Depth Ratio.

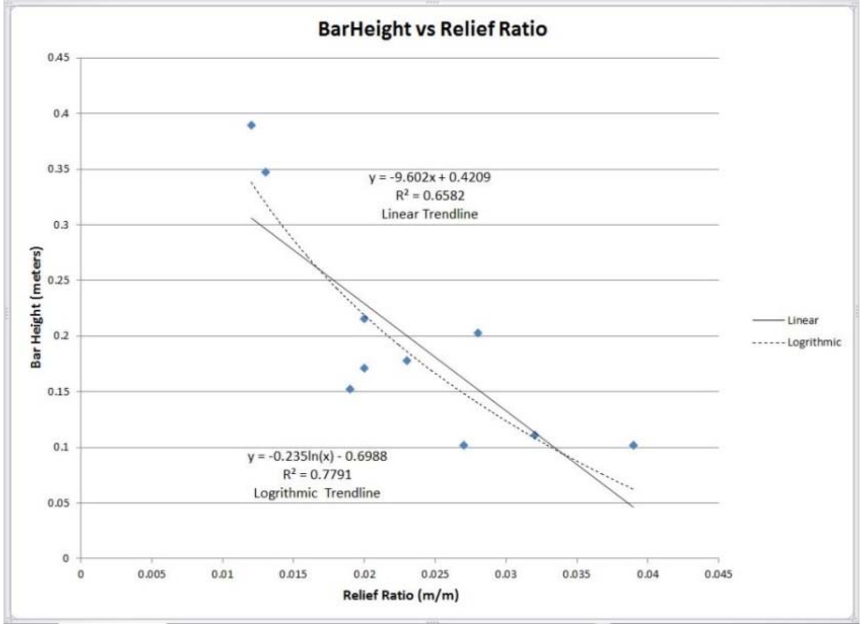


Figure 4. Bar Height vs. Relief Ratio Trendline

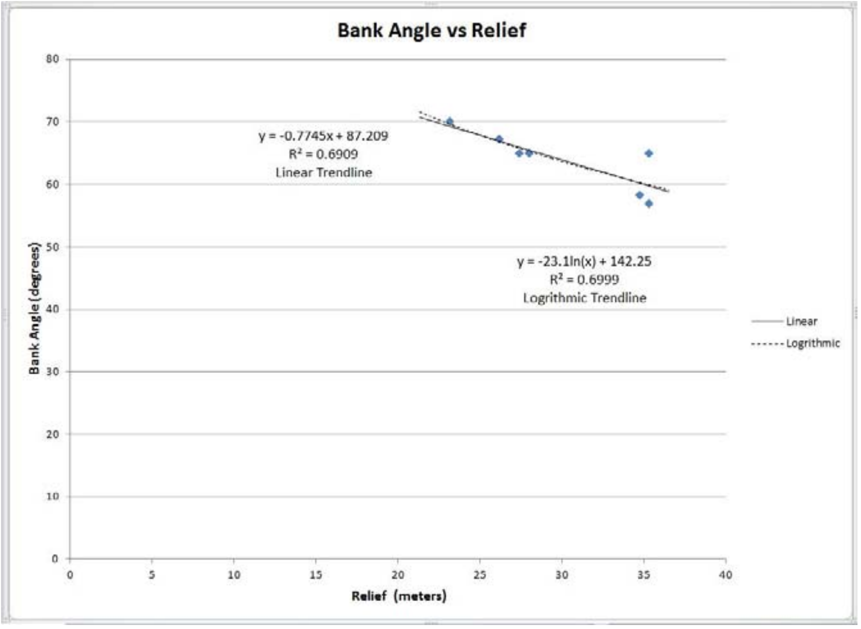


Figure 5. Bank Angle vs. Relief Trendline

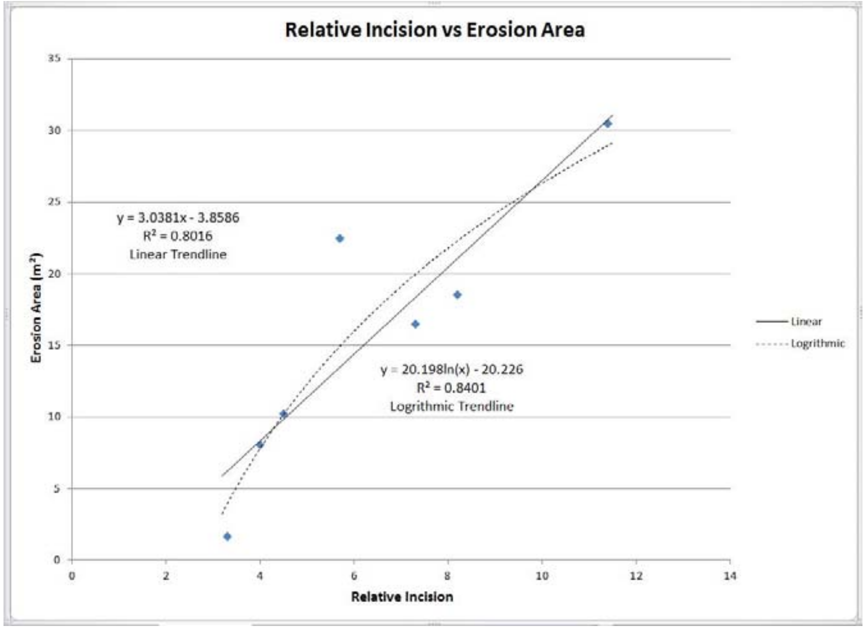


Figure 6. Relative Incision vs. Erosion Area Trendline

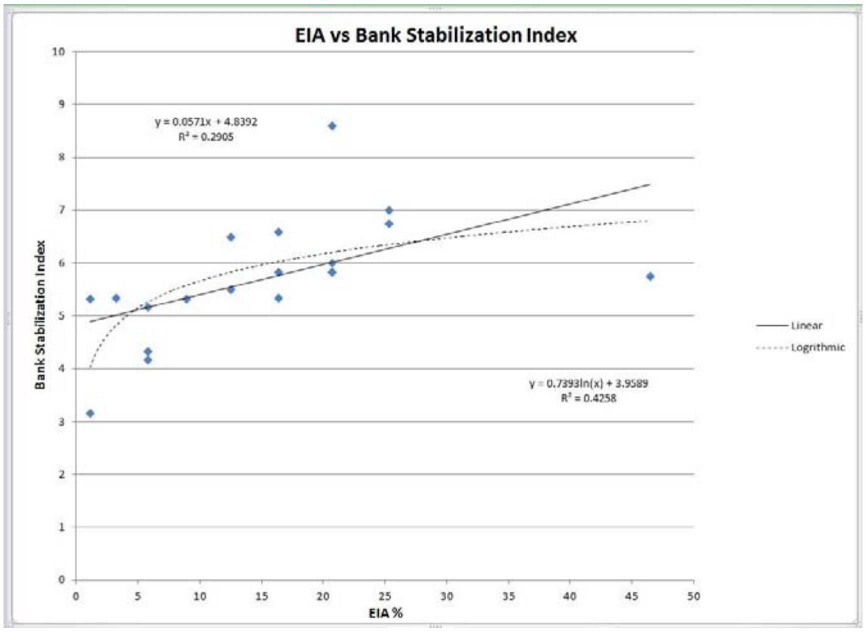


Figure 7. EIA vs. Bank Stabilization Index Trendline

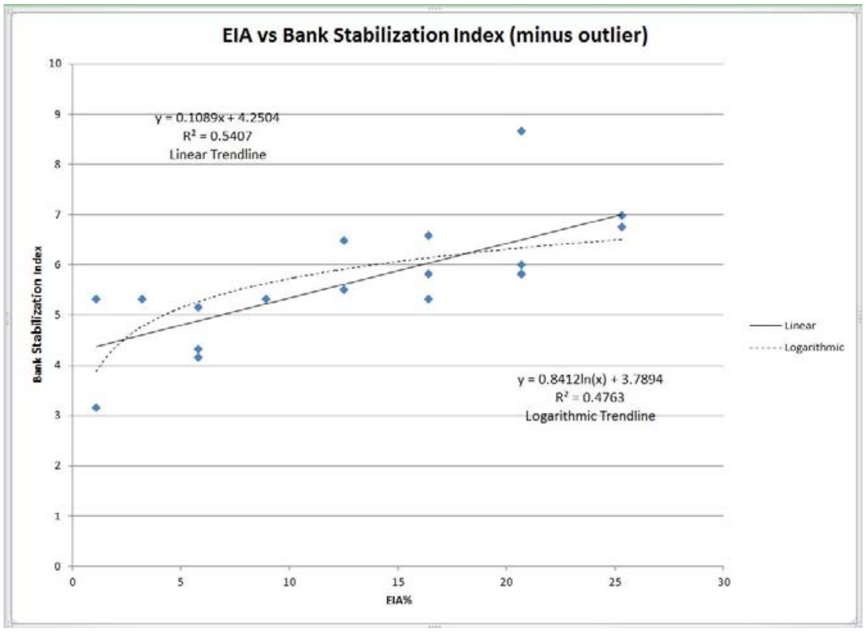


Figure 8. EIA vs. Bank Stabilization Index (minus outlier) Trendline

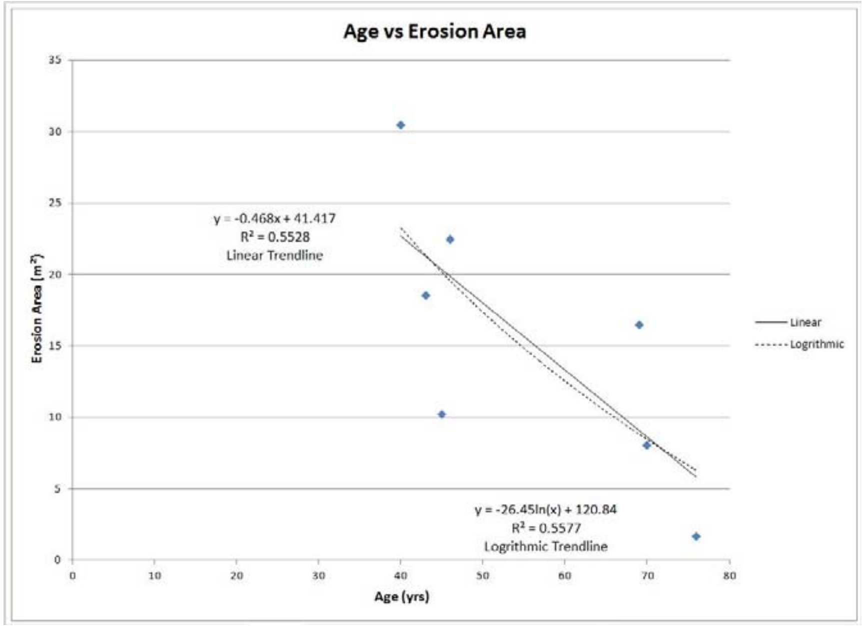


Figure 9. Age vs. Erosion Area Trendline

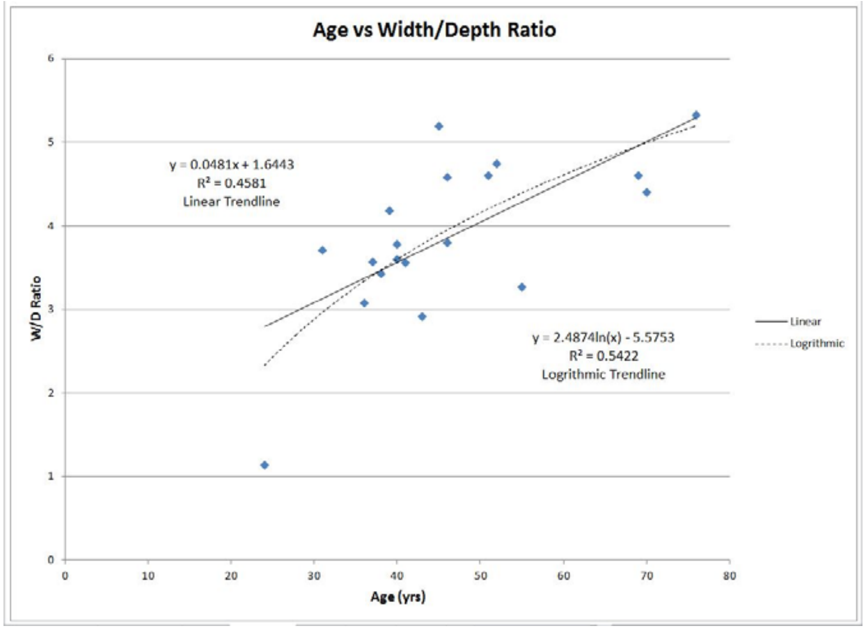


Figure 10. Age vs. Width/Depth Ratio Trendline

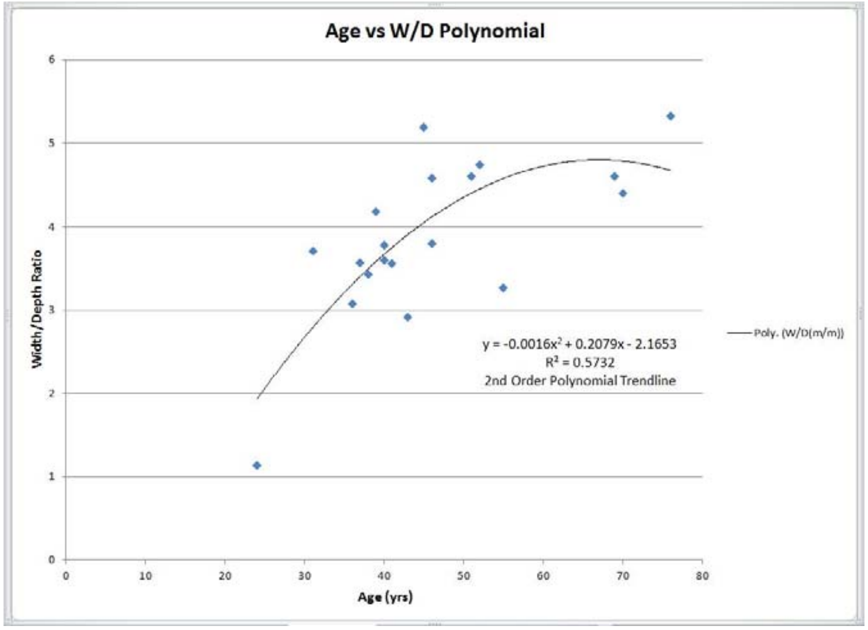


Figure 11. Age vs. Width/Depth Polynomial Trendline

Three of the six relationships, bank angle:relief, relative incision:erosion area, and age:erosion area, are represented by only 7 data points because erosion area and bank angle were only collected at 7 sites where recent bank failures were observed; this was only at 7 or the 19 sites. In these three relationships, linear and log-linear trendline fits gave similar coefficients of determination. However, the small number of data points requires that these relationships be viewed as potentially unreliable.

The remaining three relationships are bar height:relief ratio, EIA:bank stabilization index, and age:width/depth ratio. The plot of bar height vs.relief ratio is only represented by 10 points as bars were only observed at 10 of the 19 survey sites. Zero values for bar height were not assumed for sites not exhibiting bars because it is unusual for a stream to contain no bars, raising the question of the controls on bar formation at such sites being the same as those that do have bars. Of the 10 points charted the linear equation returned an R^2 of 0.658 with a slope of -9.6, and the logarithmic equation had an $R^2=0.779$ .This is the strongest negative slope observed in this study, and the strength of the relationship seems more than expected.

The plot of EIA vs. bank stabilization index returned an R^2 of 0.28 and a slope of 0.05. In this correlation there was an obvious outlier, the Campus site, which had an EIA nearly twice the value of any other watershed. When this outlier was removed the linear trendline returned an $R^2= 0.54$ and the slope increased to 0.108. Both the R^2 and the slope nearly double in this case. It should also be noted that the linear R^2 is greater than that of the logarithmic in this case. As the bank stabilization index used higher numbers to indicate lower stability it can be seen that stabilization decreases with increased EIA percentages. As the linear trendline is the better fit, this indicates a proportionality between the two variables, and EIA may be viewed as a continual disturbance which increases bank instability, regardless of age. As an ever present disturbance factor related to flashy hydrographs, the increased stream power could be such that the increased level of bank instability, or at least a decreased level of stability, is a long term property of the new regime following the change in boundary conditions imposed by urbanization.

The plot of age vs. W/D ratio has an $R^2=0.458$ with a slope of 0.048 and the logarithmic trendline has an R^2 of 0.542. This was the best overall correlation for age, the independent variable necessary for analyzing relaxation times which is the principal focus of the study. A polynomial trendline was fitted with an R^2 to 0.573. This polynomial trendline appears to level out at approximately 65 years at the W/D value of 4.8, suggestive of the possible response time for this morphological variable.

Multiple Regressions

Stepwise multiple regressions were performed within SPSS on all data with several combinations of variables, both independent and dependent, in an attempt to best understand and explain the dataset. A 95% confidence interval was used in all regressions.

The first stepwise regression ran used Age as the dependent variable and all other variables as independent variables. (Table 6) The outcome was a model using W/D and lnRelief as independent variables with an R^2 of .629. The equation provided is Age=123.55+12.31(W/D)-36.88(lnRelief).

Table 6. Model Summary: Dependent Variable-Construction Age

Independent Variables	R Value	R^2 Value	Coefficients	T-Score	P-Value
W/D	0.677	0.458	Constant- 9.39 W/D- 9.53	0.939 3.791	0.361 0.001
W/D Relief(ln)	0.793	0.629	Constant- 123.55 W/D- 12.31 Relief(ln)- -36.88	2 .875 5.177 -2.71	0.011 0.000 0.015

The second stepwise regression used the natural log of age as the dependent variable with all other study variables again input as independent variables. (Table 7) The result was a model with an R^2 of 0.661, again entering W/D as the first independent variable, though this time lnBasin area was entered as the second variable. The equation provided is (ln)Age=2.84+0.248(W/D)-0.122(lnBasin).

Table 7. Model Summary: Dependent Variable-Construction Age(ln)

Independent Variables	R Value	R² Value	Coefficients	T-Score	P-Value
W/D	0.735	0.513	Constant- 2.95 W/D- .218	15.234 4.467	0.000 0.000
W/D Basin(ln)	0.813	0.661	Constant- 2.842 W/D- .248 Relief(ln)- -122	16.008 5.517 -2.385	0.000 0.000 0.030

The outcome of these regressions provides an insight into which variable, or variables in combination, may be a function of age. The variables most commonly included are perhaps best suited to the assessment of stream adjustment states.

CHAPTER V

DISCUSSION

Overview

The overall goal of this study was to determine what morphological variables if any achieve a new equilibrium following the disturbance caused by urbanization as well as ascertain the relaxation period associated with this adjustment. As urbanization may or may not be viewed as a continuing disturbance due to the dramatic change imposed by impervious surfaces, as well as the continuing re-development of urban areas, it is still hoped that some evidence of stabilization can be observed, possibly describing a new equilibrium following a change in boundary conditions. It is likely that different morphological variables will adjust over varying time periods and the ability to discern these differences would greatly enhance one's ability as regards stream restoration. If it could be determined that there is a 'normal' relaxation period for a particular variable it would serve as a valuable guide towards ascertaining a channels level of equilibrium, at least as concerns the morphological trait in question. This being the case, restoration efforts could be directed accordingly and focused on variables other than those which have reached equilibrium. Furthermore, the information might be used to resection streams that are being rehabilitated using channel dimensions known to reflect what the final equilibrium will look like. Understanding of urban channel evolution is far from complete in general and a greater knowledge of relaxation periods should lead to a better understanding of the human impact on these transient geomorphic systems.

Trends in Correlations

A large number of correlations with R values greater than the 0.6 threshold were found in this study, and an attempt was made to interpret most in a straightforward way. There were few however which correlated with Age, and only one which had an n=19 representation, that being Age vs. W/D ratio. This one relationship does appear to suggest a relaxation period and signs of stabilization within the age range of the analysis at an approximate value of 4.8 in 60 years. The lowest point in the scatterplot is the Assembly site which is by far the youngest at 24yrs of age, and the lowest W/D ratio at 1.14, and there is a large gap between points to the next higher value. If this point were assumed to be an outlier, and removed from the plot, the linear and logarithmic coefficients of determination drop to $R^2= 0.36$. As there is poor point representation in the lower age values, and few if any local sites constructed in this timeframe, it becomes difficult to better establish this trend.

The large number of correlations around R=+/- 0.6 show the amount of scatter that may be typical of highly variable urban environments. This is also true of the Age/W/D Ratio plot. Although the majority of the plots which had R>=0.8 also had low n values, the coherent, explainable relationships present, regardless of the amount of scatter, suggest the multi-variate controls on urban channel form. Much of that variety, such as riparian vegetation, bank composition, percentage of EIA and connectivity, could come from the highly variable nature of the urban stream environment as has been remarked upon in some urban literature. (Chin, 2006, Paul & Meyer, 2001, Hammer, 1972) Some variables that might have been expected to correlate did not do so at a noticeable lovel. For example, channel cross-sectional area normally correlates with drainage area, in parallel with regional hydraulic geometry curves. Hunt and

Royall (2012) have analyzed this for the Buffalo Creek watershed and demonstrate this trend in particular for North Buffalo Creek. However, their minimum drainage area was about 19 Km², much larger than in the current study. Smaller watersheds, which are less likely to contain fully alluvial streams, may be more sensitive to upland soil properties (with upland soils forming the channel boundary in more instances), and might be likely to more frequently reflect the great variations in urban environments.

Thus it is that some of the scatter in the Age vs. W/D plot could be due to the large number of influential variables. Drainage area (DA) and EIA were two important watershed variables in particular that were in need of control so as to isolate Age as a control as much as possible. In fact, both turned out to vary over a potentially influential range, although neither is well correlated with the W/D ratio. Lower drainage areas show some tendency to have the lowest W/D ratios. (Fig. 12)

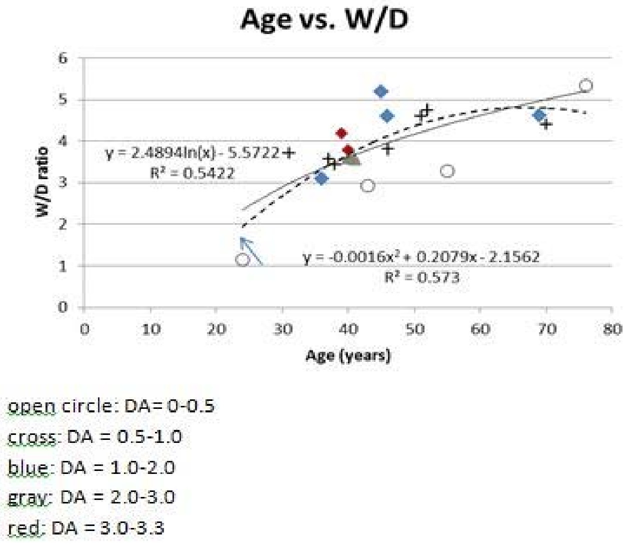
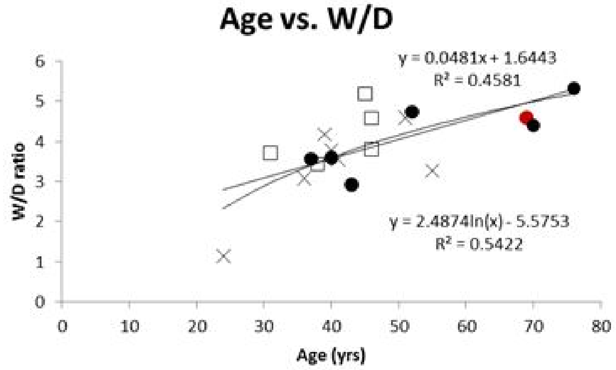


Figure 12. Age vs. W/D Ratio Distinguished by Drainage Area

Lower W/D ratios for smaller DAs might be expected on the simple basis of hydraulic geometry curves sine DA is proportional to bankfull discharge (Q). (Knighton, 1998, Doll et al., 2002) The exponent to which Q is raised to predict channel width is always greater than that for predicting channel depth, averaging 0.5 vs. 0.37 respectively (Knighton, 1998), with similar values reported for the North Carolina Piedmont. (Doll, 2002) These exponents indicate that width grows faster than depth as bankfull discharge (and also drainage area) increases, thus at lower DAs W/D ratio would also tend to be lower, assuming that there was plenty of time for adjustment to changing runoff volume.

EIA also varied more than originally thought. However, this variability shows no clear pattern with to the W/D ratio plot. (Fig 13)



EIA 0-10	X
EIA 10-20	open box
EIA 20-30	closed circle
EIA 30-40	closed box
EIA 40-50	red circle

Figure 13. Age vs. W/D Ratio Distinguished by EIA

This is a little unexpected given the good correlation between EIA and Bank Stabilization Index. At younger and middle ages, there is some indication that watersheds with high EIA (30-40%) tend towards higher W/D ratios that plot above trendlines (closed box points in Fig 13). Otherwise, a mix of EIA values are found throughout the scatter.

Stabilizing Variables and Channel Evolution

The largest R^2 value obtained from the stepwise multiple regressions was 0.661, which used the natural log of construction age as the dependent variable. The independent variables returned were W/D ratio and the natural log of basin size, which entered the equation in this order. This was expected, given that W/D ratio hasin the previous sections, been demonstrated to have the strongest relationship with construction age, and might be used as a means of determining the level of equilibrium/disequilibrium present in a given channel. This could be useful in stream restoration as a metric from which to determine a channels level of stability as well as provide a template to work from, possibly more appropriate than using the channel dimensions from regional curves as a guideline.

The channel evolution model (CEM) of Simon and Hupp (1986) is believed by many to apply to urban as well as the channelized for rural channels for which it is formulated, and in turn is often used as a guideline for stream restoration. (NCSRI) The results of this relative to the importance of the W/D ratio can be usefully compared to this CEM because it prominently features predictions of how channel width and depth might evolve after disturbance. Urban steam evolution begins with a short-lived pulse of sediment eroded from construction sites, which leads to a short aggradation phase. (Wolman, 1967) Once the initial sediment fill caused by the construction process has been removed incision will become prevalent until a critical bank height is reached, at which point lateral adjustment via bank failure dominates. When the channel has widened and enlarged enough to accommodate the high peak discharges, distributing the stream power over a larger channel bed area, a loss of unit stream power will occur. At this point, according to the Simon and Hupp CEM aggradation will again occur. This process will eventually stabilize at a point which will presumably dictate a new width to depth ratio, matching the discharge energy and sediment demands which coincide with the new boundary condition, although W/D ratios are not explicitly predicted by the model. As the width to depth ratio emerged as the primary variable correlated with development age it would appear that trend in this morphological variable over time best represents a possible relaxation trajectory to a new equilibrium. The polynomial trendline reveals a relaxation period of approximately 65 years, at which point the channel has widened to a point nearly 5 times greater than its depth. The original CEM model states that a truly adjusted channel is represented by an inset channel able to meander within its own alluvium and the channel benches serve as the new floodplain. (Simon and Hupp, 1986) In this scenario the new inset floodplain will eventually contain a channel similar to the pre-disturbance channel. This seems to coincide with the large width to depth ratio as a sign of equilibration, if these variables are measured from the historic terrace, but in urban systems the discharge is permanently altered leading to a change in boundary conditions. This is evidenced by regional curve values which always show greater values for width, depth, channel area, and discharge in urban systems as compared to rural systems of the same drainage area. Chin (2006) states that W/D ratios are reported to have increased after urbanization in 100% of urban streammorphology published studies. This tendency is also found in downstream hydraulic geometry equations as bankfull width increases faster than depth downstream, leading to a higher W/D ratio. (Knighton, 1998; Charlton, 2008) As discharge increases downstream in most humid environments, the higher W/D ratios of urban systems which likely result from the increased discharge may follow a similar paradigm.

Methodological Issues

The primary shortcoming to this study is that the only sites which recorded the BEHI variables of bank angle, root depth, root density, and erosion area were channel reaches which displayed bank failure. In retrospect, the values for bank angle, root depth and density would have been valuable in determining many of the morphological characteristics of channels regardless of the presence of bank failure erosion and should have been recorded at every cross section. An index for soil profiles in respect to cohesion properties would also be informative. As well, all active erosion could be recorded, and natural scour included in the dataset. Due to time constraints this was not accomplished and the study is lacking in several pertinent dimensions. The inclusion of soil profiles for each site would provide a means of determining some type of metric from which to determine the stability of banks based on more than mere visual inspection of morphology and vegetation. Recording root depth and density at each cross section would provide similar benefits. These in turn could be correlated to bank angles providing an accurate portrayal of the evolution of channels through time based on more than just the single value for time elapsed since the peak construction event and percentage of impervious area within the watershed.

During the time this study was ongoing there were no rain events large enough to inundate benches, much less overflow channel banks onto historical floodplains. One event in particular had the potential to reach runoff levels necessary to provide important information for the study, though this unfortunately did not take place. It did lead to the conclusion that when studying 1st and 2nd order streams downstream gauging stations may not provide accurate information. This is based on the assumption that a given rain band could have the ability to inundate a channel in a small basin. The highest gauging station located in the study area of this project covers a drainage area of 24.6 Km². The average basin size for the channels in this study is only 1.45Km². Rain bands could easily affect basins of this size, creating a scenario in which one watershed could be inundated to the point of breaking channel banks while another does not. This being the case several large rain events could be necessary to evaluate every reach in the study.

A final shortcoming to this study is the lack of sites surveyed. A greater number of watersheds, the minimum being 30, would provide a higher degree of confidence in the findings reported here. Again due to time constraints, this was not achieved. As stated earlier, it became increasingly difficult to locate suitable streams due to the constraints of study intentions, but all possibilities were not exhausted. Given time it is possible that 11 more sites could be located and incorporated into the data set, reaching the minimum of 30 sites, the number commonly referred to as that which achieves statistical reliability.

Conclusion

The first hypothesis of this study stated that channels would begin to show signs of stability after approximately 35yrs based on the results given by Chin. (2006) Hypothesis 2 proposed that variables directly related to bank erosion would be the most robust predictors of development age. In the final assessment neither of these hypotheses stands up to the conclusions derived from field data. The multiple variables influencing the morphology of urban headwater streams create a large amount of scatter in data between sites, leading to low values for the individual correlations. As such, only 3 variables correlated strongly with age, and of those only 1, W/D Ratio, had both a strong correlation and large enough n value to be considered reliable. The relaxation period for this variable appears to be closer to 60yrs, longer than that proposed by Chin (2006). The fact that the W/D ratio also entered the Stepwise multiple regression first reinforces the idea that this variable is most sensitive to time. As regards the second hypothesis, bank stabilization index correlates with EIA to a greater extent than Age. This is a reasonable expectation as greater EIA produces a higher discharge, which means more stream power with which to erode existing channels, as well as requiring a larger channel to contain the high discharge. This higher discharge created by EIA can possibly be viewed as a substitute for basin area in hydraulic down-stream-geometry. Given enough time to equilibrate, an urban channel may reach a particular W/D ratio based on the level of discharge associated with the basins EIA, similar to that of the higher discharge and channel size found in a reach further downstream without a high EIA. In this situation both EIA and Age would be strong contributors to urban channel dimensions, complicating the model to the point of requiring trendlines for both variables, resulting in a ‘window’ within which the W/D value should fall. The complexity involved in two variables contributing equally to channel evolution, though contributing at differing levels between sites, is one explanation of the high scatter and low correlation values observed in the field data provided in this study.

The value of this study to stream restoration science lies in the ability to determine a morphological variable that best indexes the equilibration of a channel in an urban setting, compared to calculating a presumed channel dimensions based on regional curve values.

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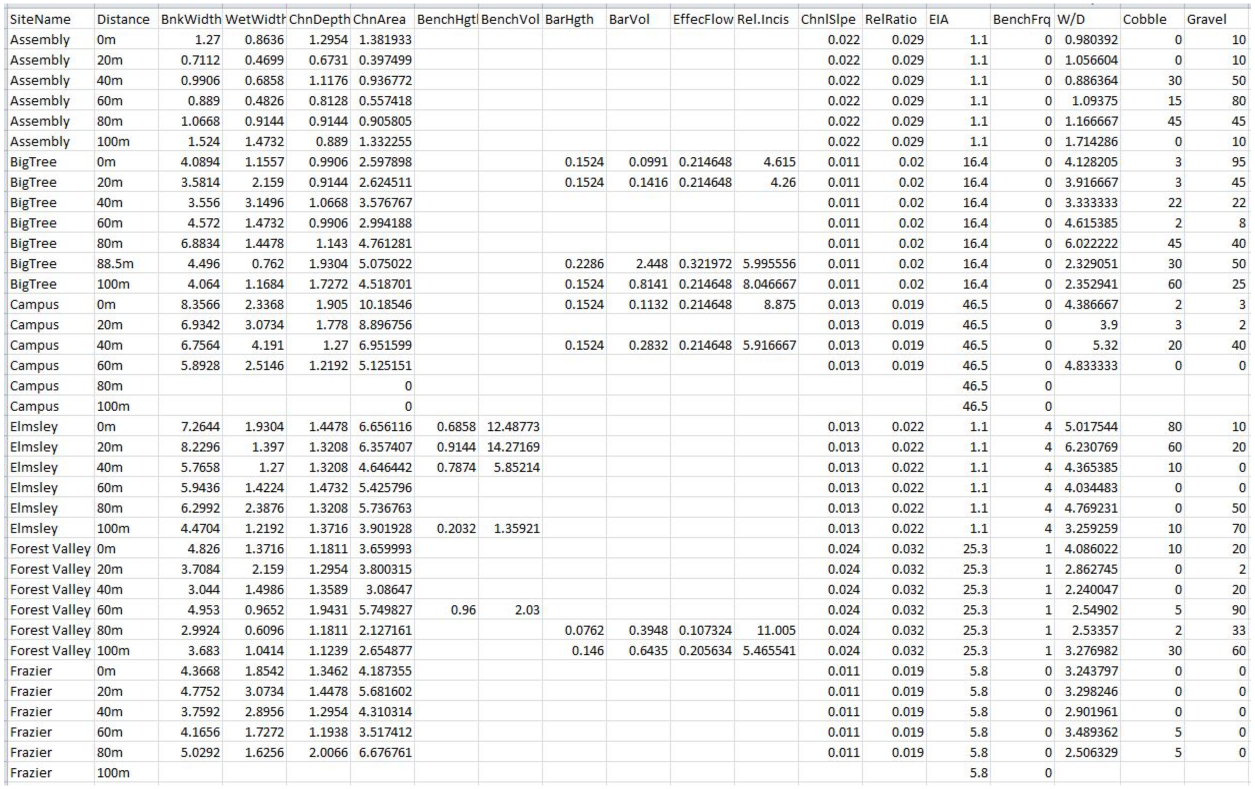
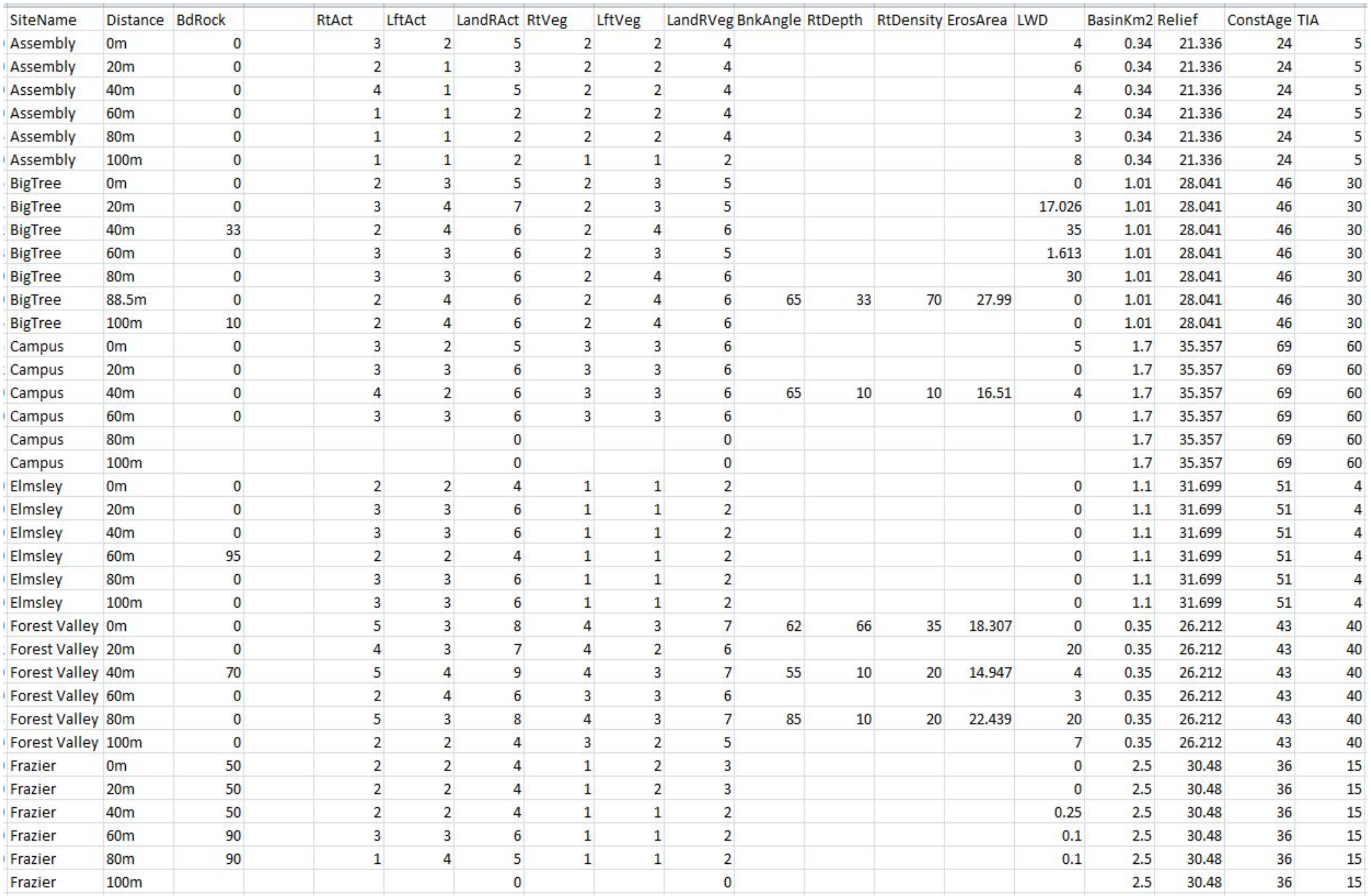
APPENDIX A

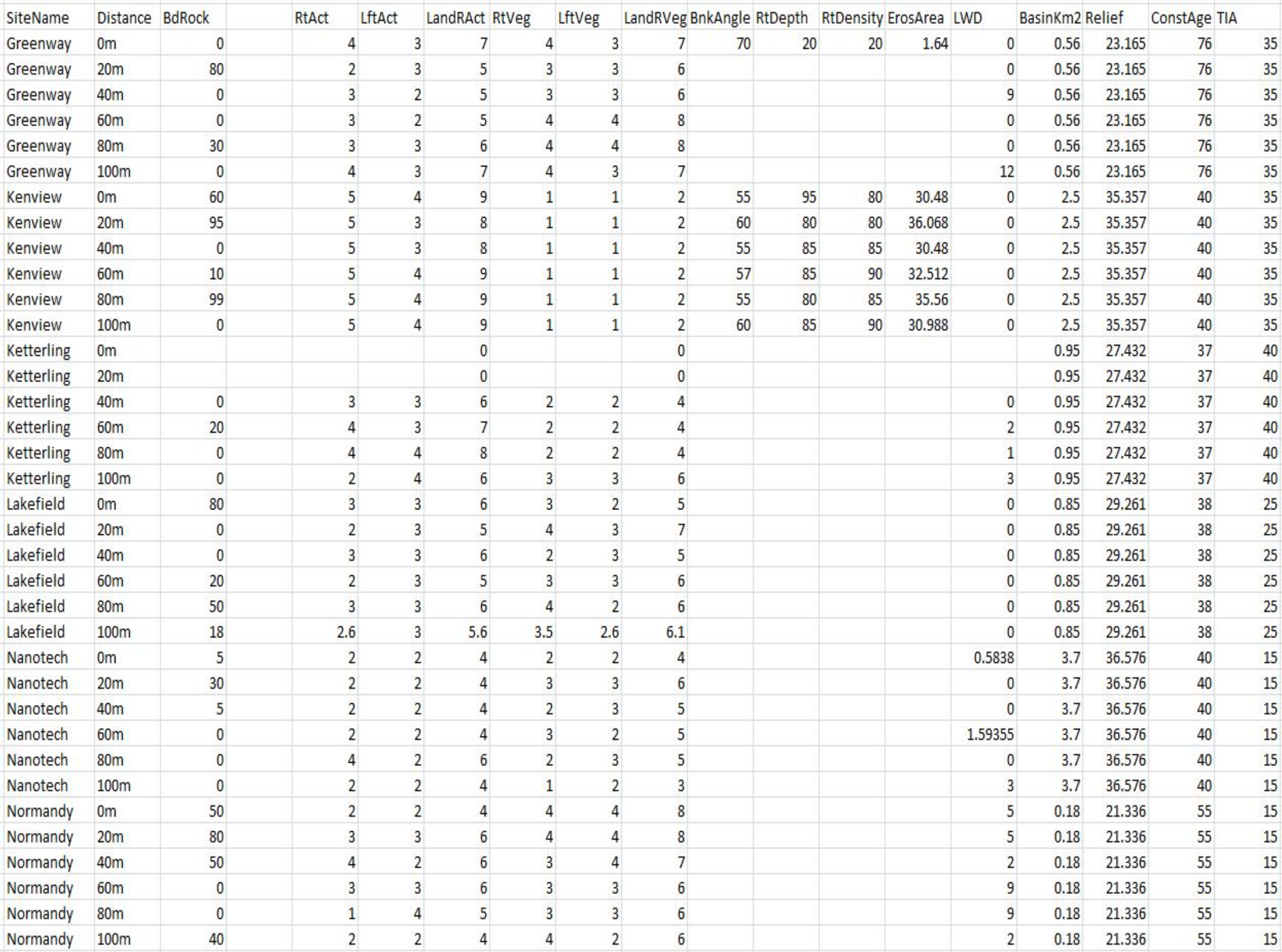
CROSS SECTION SCALE EXCEL DATA



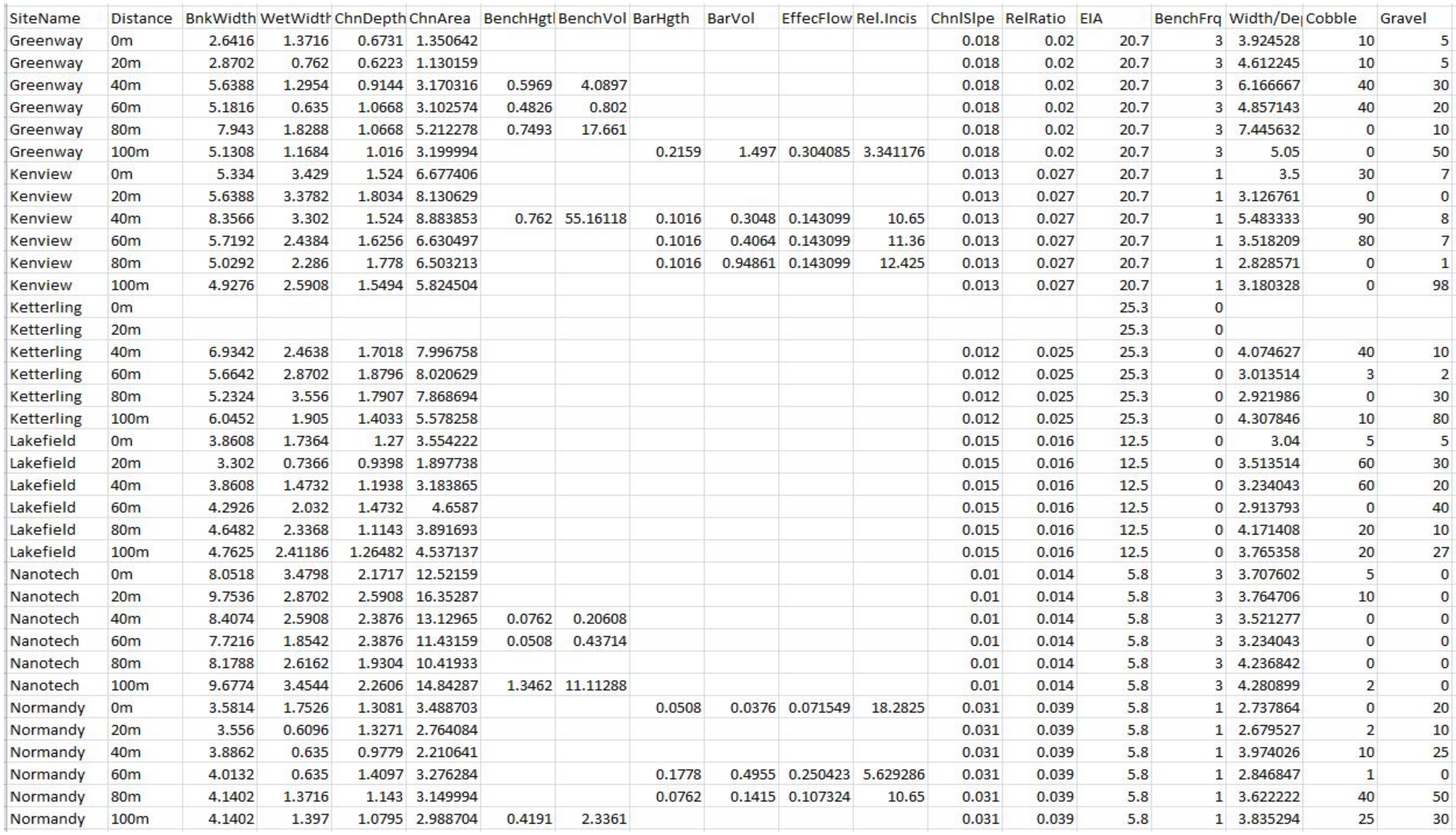
SiteName	Distance	BnkWidth	WetWidth	ChnDepth	ChnArea	BenchHgt	BenchVol	BarHgth	BarVol	EffecFlow	Rel.Incis	ChnlSlpe	RelRatio	EIA	BenchFrq	W/D	Cobble	Gravel
Assembly	0m	1.27	0.8636	1.2954	1.381933							0.022	0.029	1.1	0	0.980392	0	10
Assembly	20m	0.7112	0.4699	0.6731	0.397499							0.022	0.029	1.1	0	1.056604	0	10
Assembly	40m	0.9906	0.6858	1.1176	0.936772							0.022	0.029	1.1	0	0.886364	30	50
Assembly	60m	0.889	0.4826	0.8128	0.557418							0.022	0.029	1.1	0	1.09375	15	80
Assembly	80m	1.0668	0.9144	0.9144	0.905805							0.022	0.029	1.1	0	1.166667	45	45
Assembly	100m	1.524	1.4732	0.889	1.332255							0.022	0.029	1.1	0	1.714286	0	10
BigTree	0m	4.0894	1.1557	0.9906	2.597898			0.1524	0.0991	0.214648	4.615	0.011	0.02	16.4	0	4.128205	3	95
BigTree	20m	3.5814	2.159	0.9144	2.624511			0.1524	0.1416	0.214648	4.26	0.011	0.02	16.4	0	3.916667	3	45
BigTree	40m	3.556	3.1496	1.0668	3.576767							0.011	0.02	16.4	0	3.333333	22	22
BigTree	60m	4.572	1.4732	0.9906	2.994188							0.011	0.02	16.4	0	4.615385	2	8
BigTree	80m	6.8834	1.4478	1.143	4.761281							0.011	0.02	16.4	0	6.022222	45	40
BigTree	88.5m	4.496	0.762	1.9304	5.075022			0.2286	2.448	0.321972	5.995556	0.011	0.02	16.4	0	2.329051	30	50
BigTree	100m	4.064	1.1684	1.7272	4.518701			0.1524	0.8141	0.214648	8.046667	0.011	0.02	16.4	0	2.352941	60	25
Campus	0m	8.3566	2.3368	1.905	10.18546			0.1524	0.1132	0.214648	8.875	0.013	0.019	46.5	0	4.386667	2	3
Campus	20m	6.9342	3.0734	1.778	8.896756							0.013	0.019	46.5	0	3.9	3	2
Campus	40m	6.7564	4.191	1.27	6.951599			0.1524	0.2832	0.214648	5.916667	0.013	0.019	46.5	0	5.32	20	40
Campus	60m	5.8928	2.5146	1.2192	5.125151							0.013	0.019	46.5	0	4.833333	0	0
Campus	80m				0									46.5	0			
Campus	100m				0									46.5	0			
Elmsley	0m	7.2644	1.9304	1.4478	6.656116	0.6858	12.48773					0.013	0.022	1.1	4	5.017544	80	10
Elmsley	20m	8.2296	1.397	1.3208	6.357407	0.9144	14.27169					0.013	0.022	1.1	4	6.230769	60	20
Elmsley	40m	5.7658	1.27	1.3208	4.646442	0.7874	5.85214					0.013	0.022	1.1	4	4.365385	10	0
Elmsley	60m	5.9436	1.4224	1.4732	5.425796							0.013	0.022	1.1	4	4.034483	0	0
Elmsley	80m	6.2992	2.3876	1.3208	5.736763							0.013	0.022	1.1	4	4.769231	0	50
Elmsley	100m	4.4704	1.2192	1.3716	3.901928	0.2032	1.35921					0.013	0.022	1.1	4	3.259259	10	70
Forest Valley	0m	4.826	1.3716	1.1811	3.659993							0.024	0.032	25.3	1	4.086022	10	20
Forest Valley	20m	3.7084	2.159	1.2954	3.800315							0.024	0.032	25.3	1	2.862745	0	2
Forest Valley	40m	3.044	1.4986	1.3589	3.08647							0.024	0.032	25.3	1	2.240047	0	20
Forest Valley	60m	4.953	0.9652	1.9431	5.749827	0.96	2.03					0.024	0.032	25.3	1	2.54902	5	90
Forest Valley	80m	2.9924	0.6096	1.1811	2.127161			0.0762	0.3948	0.107324	11.005	0.024	0.032	25.3	1	2.53357	2	33
Forest Valley	100m	3.683	1.0414	1.1239	2.654877			0.146	0.6435	0.205634	5.465541	0.024	0.032	25.3	1	3.276982	30	60
Frazier	0m	4.3668	1.8542	1.3462	4.187355							0.011	0.019	5.8	0	3.243797	0	0
Frazier	20m	4.7752	3.0734	1.4478	5.681602							0.011	0.019	5.8	0	3.298246	0	0
Frazier	40m	3.7592	2.8956	1.2954	4.310314							0.011	0.019	5.8	0	2.901961	0	0
Frazier	60m	4.1656	1.7272	1.1938	3.517412							0.011	0.019	5.8	0	3.489362	5	0
Frazier	80m	5.0292	1.6256	2.0066	6.676761							0.011	0.019	5.8	0	2.506329	5	0
Frazier	100m													5.8	0			



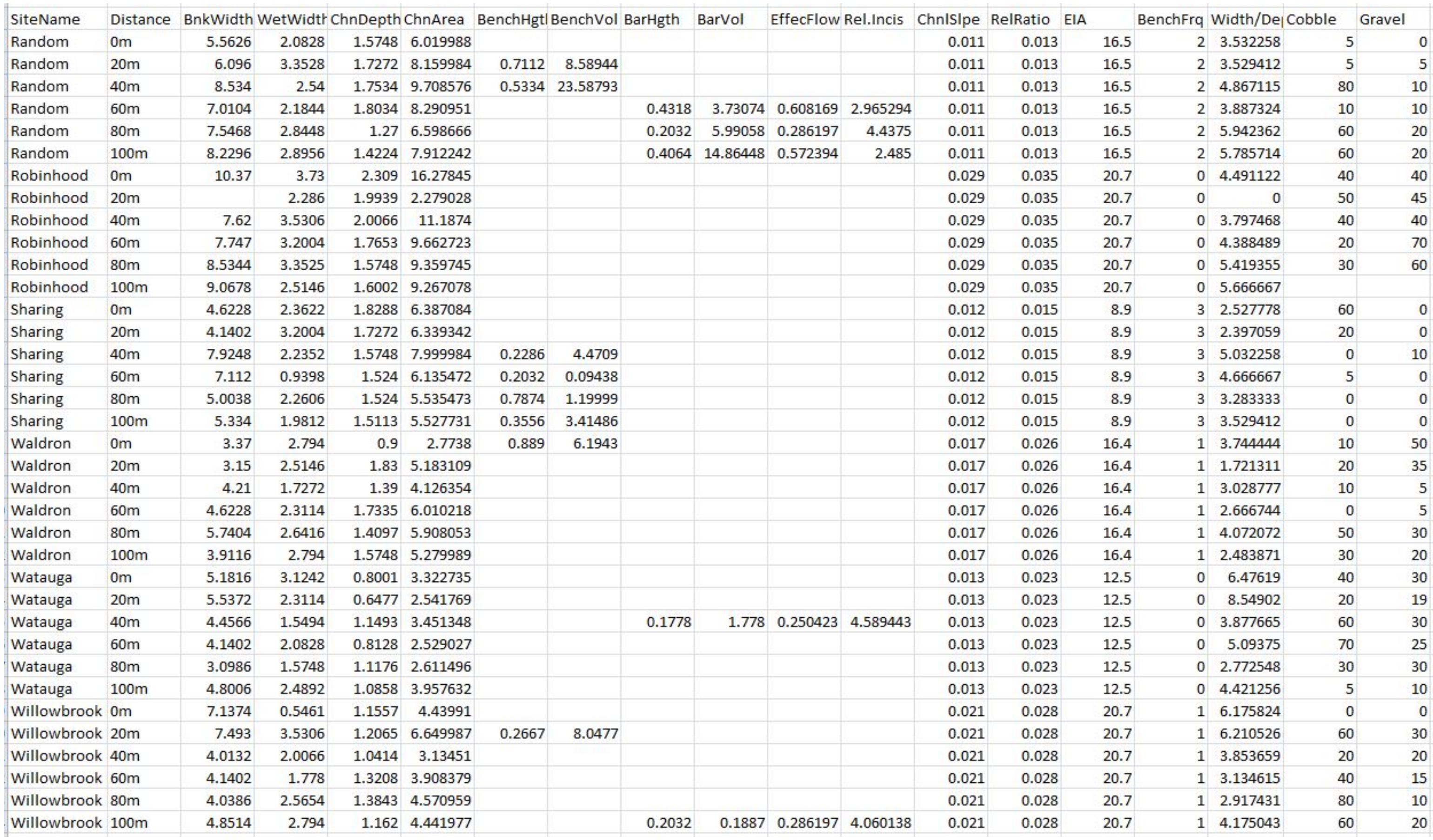
SiteName	Distance	BdRock		RtAct	LftAct	LandRAct	RtVeg	LftVeg	LandRVeg	BnkAngle	RtDepth	RtDensity	ErosArea	LWD	BasinKm2	Relief	ConstAge	TIA
Assembly	0m	0		3	2	5	2	2	4					4	0.34	21.336	24	5
Assembly	20m	0		2	1	3	2	2	4					6	0.34	21.336	24	5
Assembly	40m	0		4	1	5	2	2	4					4	0.34	21.336	24	5
Assembly	60m	0		1	1	2	2	2	4					2	0.34	21.336	24	5
Assembly	80m	0		1	1	2	2	2	4					3	0.34	21.336	24	5
Assembly	100m	0		1	1	2	1	1	2					8	0.34	21.336	24	5
BigTree	0m	0		2	3	5	2	3	5					0	1.01	28.041	46	30
BigTree	20m	0		3	4	7	2	3	5					17.026	1.01	28.041	46	30
BigTree	40m	33		2	4	6	2	4	6					35	1.01	28.041	46	30
BigTree	60m	0		3	3	6	2	3	5					1.613	1.01	28.041	46	30
BigTree	80m	0		3	3	6	2	4	6					30	1.01	28.041	46	30
BigTree	88.5m	0		2	4	6	2	4	6	65	33	70	27.99	0	1.01	28.041	46	30
BigTree	100m	10		2	4	6	2	4	6					0	1.01	28.041	46	30
Campus	0m	0		3	2	5	3	3	6					5	1.7	35.357	69	60
Campus	20m	0		3	3	6	3	3	6					0	1.7	35.357	69	60
Campus	40m	0		4	2	6	3	3	6	65	10	10	16.51	4	1.7	35.357	69	60
Campus	60m	0		3	3	6	3	3	6					0	1.7	35.357	69	60
Campus	80m					0			0						1.7	35.357	69	60
Campus	100m					0			0						1.7	35.357	69	60
Elmsley	0m	0		2	2	4	1	1	2					0	1.1	31.699	51	4
Elmsley	20m	0		3	3	6	1	1	2					0	1.1	31.699	51	4
Elmsley	40m	0		3	3	6	1	1	2					0	1.1	31.699	51	4
Elmsley	60m	95		2	2	4	1	1	2					0	1.1	31.699	51	4
Elmsley	80m	0		3	3	6	1	1	2					0	1.1	31.699	51	4
Elmsley	100m	0		3	3	6	1	1	2					0	1.1	31.699	51	4
Forest Valley	0m	0		5	3	8	4	3	7	62	66	35	18.307	0	0.35	26.212	43	40
Forest Valley	20m	0		4	3	7	4	2	6					20	0.35	26.212	43	40
Forest Valley	40m	70		5	4	9	4	3	7	55	10	20	14.947	4	0.35	26.212	43	40
Forest Valley	60m	0		2	4	6	3	3	6					3	0.35	26.212	43	40
Forest Valley	80m	0		5	3	8	4	3	7	85	10	20	22.439	20	0.35	26.212	43	40
Forest Valley	100m	0		2	2	4	3	2	5					7	0.35	26.212	43	40
Frazier	0m	50		2	2	4	1	2	3					0	2.5	30.48	36	15
Frazier	20m	50		2	2	4	1	2	3					0	2.5	30.48	36	15
Frazier	40m	50		2	2	4	1	1	2					0.25	2.5	30.48	36	15
Frazier	60m	90		3	3	6	1	1	2					0.1	2.5	30.48	36	15
Frazier	80m	90		1	4	5	1	1	2					0.1	2.5	30.48	36	15
Frazier	100m					0			0						2.5	30.48	36	15



SiteName	Distance	BdRock		RtAct	LftAct	LandRAct	RtVeg	LftVeg	LandRVeg	BnkAngle	RtDepth	RtDensity	ErosArea	LWD	BasinKm2	Relief	ConstAge	TIA
Greenway	0m	0		4	3	7	4	3	7	70	20	20	1.64	0	0.56	23.165	76	35
Greenway	20m	80		2	3	5	3	3	6					0	0.56	23.165	76	35
Greenway	40m	0		3	2	5	3	3	6					9	0.56	23.165	76	35
Greenway	60m	0		3	2	5	4	4	8					0	0.56	23.165	76	35
Greenway	80m	30		3	3	6	4	4	8					0	0.56	23.165	76	35
Greenway	100m	0		4	3	7	4	3	7					12	0.56	23.165	76	35
Kenview	0m	60		5	4	9	1	1	2	55	95	80	30.48	0	2.5	35.357	40	35
Kenview	20m	95		5	3	8	1	1	2	60	80	80	36.068	0	2.5	35.357	40	35
Kenview	40m	0		5	3	8	1	1	2	55	85	85	30.48	0	2.5	35.357	40	35
Kenview	60m	10		5	4	9	1	1	2	57	85	90	32.512	0	2.5	35.357	40	35
Kenview	80m	99		5	4	9	1	1	2	55	80	85	35.56	0	2.5	35.357	40	35
Kenview	100m	0		5	4	9	1	1	2	60	85	90	30.988	0	2.5	35.357	40	35
Ketterling	0m					0			0						0.95	27.432	37	40
Ketterling	20m					0			0						0.95	27.432	37	40
Ketterling	40m	0		3	3	6	2	2	4					0	0.95	27.432	37	40
Ketterling	60m	20		4	3	7	2	2	4					2	0.95	27.432	37	40
Ketterling	80m	0		4	4	8	2	2	4					1	0.95	27.432	37	40
Ketterling	100m	0		2	4	6	3	3	6					3	0.95	27.432	37	40
Lakefield	0m	80		3	3	6	3	2	5					0	0.85	29.261	38	25
Lakefield	20m	0		2	3	5	4	3	7					0	0.85	29.261	38	25
Lakefield	40m	0		3	3	6	2	3	5					0	0.85	29.261	38	25
Lakefield	60m	20		2	3	5	3	3	6					0	0.85	29.261	38	25
Lakefield	80m	50		3	3	6	4	2	6					0	0.85	29.261	38	25
Lakefield	100m	18		2.6	3	5.6	3.5	2.6	6.1					0	0.85	29.261	38	25
Nanotech	0m	5		2	2	4	2	2	4					0.5838	3.7	36.576	40	15
Nanotech	20m	30		2	2	4	3	3	6					0	3.7	36.576	40	15
Nanotech	40m	5		2	2	4	2	3	5					0	3.7	36.576	40	15
Nanotech	60m	0		2	2	4	3	2	5					1.59355	3.7	36.576	40	15
Nanotech	80m	0		4	2	6	2	3	5					0	3.7	36.576	40	15
Nanotech	100m	0		2	2	4	1	2	3					3	3.7	36.576	40	15
Normandy	0m	50		2	2	4	4	4	8					5	0.18	21.336	55	15
Normandy	20m	80		3	3	6	4	4	8					5	0.18	21.336	55	15
Normandy	40m	50		4	2	6	3	4	7					2	0.18	21.336	55	15
Normandy	60m	0		3	3	6	3	3	6					9	0.18	21.336	55	15
Normandy	80m	0		1	4	5	3	3	6					9	0.18	21.336	55	15
Normandy	100m	40		2	2	4	4	2	6					2	0.18	21.336	55	15



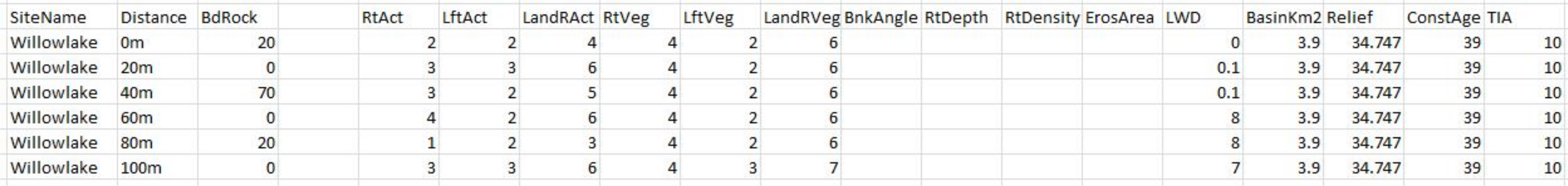
SiteName	Distance	BnkWidth	WetWidth	ChnDepth	ChnArea	BenchHgt	BenchVol	BarHgth	BarVol	EffecFlow	Rel.Incis	ChnlSlpe	RelRatio	EIA	BenchFrq	Width/De	Cobble	Gravel
Greenway	0m	2.6416	1.3716	0.6731	1.350642							0.018	0.02	20.7	3	3.924528	10	5
Greenway	20m	2.8702	0.762	0.6223	1.130159							0.018	0.02	20.7	3	4.612245	10	5
Greenway	40m	5.6388	1.2954	0.9144	3.170316	0.5969	4.0897					0.018	0.02	20.7	3	6.166667	40	30
Greenway	60m	5.1816	0.635	1.0668	3.102574	0.4826	0.802					0.018	0.02	20.7	3	4.857143	40	20
Greenway	80m	7.943	1.8288	1.0668	5.212278	0.7493	17.661					0.018	0.02	20.7	3	7.445632	0	10
Greenway	100m	5.1308	1.1684	1.016	3.199994			0.2159	1.497	0.304085	3.341176	0.018	0.02	20.7	3	5.05	0	50
Kenview	0m	5.334	3.429	1.524	6.677406							0.013	0.027	20.7	1	3.5	30	7
Kenview	20m	5.6388	3.3782	1.8034	8.130629							0.013	0.027	20.7	1	3.126761	0	0
Kenview	40m	8.3566	3.302	1.524	8.883853	0.762	55.16118	0.1016	0.3048	0.143099	10.65	0.013	0.027	20.7	1	5.483333	90	8
Kenview	60m	5.7192	2.4384	1.6256	6.630497			0.1016	0.4064	0.143099	11.36	0.013	0.027	20.7	1	3.518209	80	7
Kenview	80m	5.0292	2.286	1.778	6.503213			0.1016	0.94861	0.143099	12.425	0.013	0.027	20.7	1	2.828571	0	1
Kenview	100m	4.9276	2.5908	1.5494	5.824504							0.013	0.027	20.7	1	3.180328	0	98
Ketterling	0m													25.3	0			
Ketterling	20m													25.3	0			
Ketterling	40m	6.9342	2.4638	1.7018	7.996758							0.012	0.025	25.3	0	4.074627	40	10
Ketterling	60m	5.6642	2.8702	1.8796	8.020629							0.012	0.025	25.3	0	3.013514	3	2
Ketterling	80m	5.2324	3.556	1.7907	7.868694							0.012	0.025	25.3	0	2.921986	0	30
Ketterling	100m	6.0452	1.905	1.4033	5.578258							0.012	0.025	25.3	0	4.307846	10	80
Lakefield	0m	3.8608	1.7364	1.27	3.554222							0.015	0.016	12.5	0	3.04	5	5
Lakefield	20m	3.302	0.7366	0.9398	1.897738							0.015	0.016	12.5	0	3.513514	60	30
Lakefield	40m	3.8608	1.4732	1.1938	3.183865							0.015	0.016	12.5	0	3.234043	60	20
Lakefield	60m	4.2926	2.032	1.4732	4.6587							0.015	0.016	12.5	0	2.913793	0	40
Lakefield	80m	4.6482	2.3368	1.1143	3.891693							0.015	0.016	12.5	0	4.171408	20	10
Lakefield	100m	4.7625	2.41186	1.26482	4.537137							0.015	0.016	12.5	0	3.765358	20	27
Nanotech	0m	8.0518	3.4798	2.1717	12.52159							0.01	0.014	5.8	3	3.707602	5	0
Nanotech	20m	9.7536	2.8702	2.5908	16.35287							0.01	0.014	5.8	3	3.764706	10	0
Nanotech	40m	8.4074	2.5908	2.3876	13.12965	0.0762	0.20608					0.01	0.014	5.8	3	3.521277	0	0
Nanotech	60m	7.7216	1.8542	2.3876	11.43159	0.0508	0.43714					0.01	0.014	5.8	3	3.234043	0	0
Nanotech	80m	8.1788	2.6162	1.9304	10.41933							0.01	0.014	5.8	3	4.236842	0	0
Nanotech	100m	9.6774	3.4544	2.2606	14.84287	1.3462	11.11288					0.01	0.014	5.8	3	4.280899	2	0
Normandy	0m	3.5814	1.7526	1.3081	3.488703			0.0508	0.0376	0.071549	18.2825	0.031	0.039	5.8	1	2.737864	0	20
Normandy	20m	3.556	0.6096	1.3271	2.764084							0.031	0.039	5.8	1	2.679527	2	10
Normandy	40m	3.8862	0.635	0.9779	2.210641							0.031	0.039	5.8	1	3.974026	10	25
Normandy	60m	4.0132	0.635	1.4097	3.276284			0.1778	0.4955	0.250423	5.629286	0.031	0.039	5.8	1	2.846847	1	0
Normandy	80m	4.1402	1.3716	1.143	3.149994			0.0762	0.1415	0.107324	10.65	0.031	0.039	5.8	1	3.622222	40	50
Normandy	100m	4.1402	1.397	1.0795	2.988704	0.4191	2.3361					0.031	0.039	5.8	1	3.835294	25	30



SiteName	Distance	BnkWidth	WetWidtł	ChnDepth	ChnArea	BenchHgtl	BenchVol	BarHgth	BarVol	EffecFlow	Rel.Incis	ChnlSlpe	RelRatio	EIA	BenchFrq	Width/De	Cobble	Gravel
Random	0m	5.5626	2.0828	1.5748	6.019988							0.011	0.013	16.5	2	3.532258	5	0
Random	20m	6.096	3.3528	1.7272	8.159984	0.7112	8.58944					0.011	0.013	16.5	2	3.529412	5	5
Random	40m	8.534	2.54	1.7534	9.708576	0.5334	23.58793					0.011	0.013	16.5	2	4.867115	80	10
Random	60m	7.0104	2.1844	1.8034	8.290951			0.4318	3.73074	0.608169	2.965294	0.011	0.013	16.5	2	3.887324	10	10
Random	80m	7.5468	2.8448	1.27	6.598666			0.2032	5.99058	0.286197	4.4375	0.011	0.013	16.5	2	5.942362	60	20
Random	100m	8.2296	2.8956	1.4224	7.912242			0.4064	14.86448	0.572394	2.485	0.011	0.013	16.5	2	5.785714	60	20
Robinhood	0m	10.37	3.73	2.309	16.27845							0.029	0.035	20.7	0	4.491122	40	40
Robinhood	20m		2.286	1.9939	2.279028							0.029	0.035	20.7	0	0	50	45
Robinhood	40m	7.62	3.5306	2.0066	11.1874							0.029	0.035	20.7	0	3.797468	40	40
Robinhood	60m	7.747	3.2004	1.7653	9.662723							0.029	0.035	20.7	0	4.388489	20	70
Robinhood	80m	8.5344	3.3525	1.5748	9.359745							0.029	0.035	20.7	0	5.419355	30	60
Robinhood	100m	9.0678	2.5146	1.6002	9.267078							0.029	0.035	20.7	0	5.666667		
Sharing	0m	4.6228	2.3622	1.8288	6.387084							0.012	0.015	8.9	3	2.527778	60	0
Sharing	20m	4.1402	3.2004	1.7272	6.339342							0.012	0.015	8.9	3	2.397059	20	0
Sharing	40m	7.9248	2.2352	1.5748	7.999984	0.2286	4.4709					0.012	0.015	8.9	3	5.032258	0	10
Sharing	60m	7.112	0.9398	1.524	6.135472	0.2032	0.09438					0.012	0.015	8.9	3	4.666667	5	0
Sharing	80m	5.0038	2.2606	1.524	5.535473	0.7874	1.19999					0.012	0.015	8.9	3	3.283333	0	0
Sharing	100m	5.334	1.9812	1.5113	5.527731	0.3556	3.41486					0.012	0.015	8.9	3	3.529412	0	0
Waldron	0m	3.37	2.794	0.9	2.7738	0.889	6.1943					0.017	0.026	16.4	1	3.744444	10	50
Waldron	20m	3.15	2.5146	1.83	5.183109							0.017	0.026	16.4	1	1.721311	20	35
Waldron	40m	4.21	1.7272	1.39	4.126354							0.017	0.026	16.4	1	3.028777	10	5
Waldron	60m	4.6228	2.3114	1.7335	6.010218							0.017	0.026	16.4	1	2.666744	0	5
Waldron	80m	5.7404	2.6416	1.4097	5.908053							0.017	0.026	16.4	1	4.072072	50	30
Waldron	100m	3.9116	2.794	1.5748	5.279989							0.017	0.026	16.4	1	2.483871	30	20
Watauga	0m	5.1816	3.1242	0.8001	3.322735							0.013	0.023	12.5	0	6.47619	40	30
Watauga	20m	5.5372	2.3114	0.6477	2.541769							0.013	0.023	12.5	0	8.54902	20	19
Watauga	40m	4.4566	1.5494	1.1493	3.451348			0.1778	1.778	0.250423	4.589443	0.013	0.023	12.5	0	3.877665	60	30
Watauga	60m	4.1402	2.0828	0.8128	2.529027							0.013	0.023	12.5	0	5.09375	70	25
Watauga	80m	3.0986	1.5748	1.1176	2.611496							0.013	0.023	12.5	0	2.772548	30	30
Watauga	100m	4.8006	2.4892	1.0858	3.957632							0.013	0.023	12.5	0	4.421256	5	10
Willowbrook	0m	7.1374	0.5461	1.1557	4.43991							0.021	0.028	20.7	1	6.175824	0	0
Willowbrook	20m	7.493	3.5306	1.2065	6.649987	0.2667	8.0477					0.021	0.028	20.7	1	6.210526	60	30
Willowbrook	40m	4.0132	2.0066	1.0414	3.13451							0.021	0.028	20.7	1	3.853659	20	20
Willowbrook	60m	4.1402	1.778	1.3208	3.908379							0.021	0.028	20.7	1	3.134615	40	15
Willowbrook	80m	4.0386	2.5654	1.3843	4.570959							0.021	0.028	20.7	1	2.917431	80	10
Willowbrook	100m	4.8514	2.794	1.162	4.441977			0.2032	0.1887	0.286197	4.060138	0.021	0.028	20.7	1	4.175043	60	20

SiteName	Distance	BdRock		RtAct	LftAct	LandRAct	RtVeg	LftVeg	LandRVeg	BnkAngle	RtDepth	RtDensity	ErosArea	LWD	BasinKm2	Relief	ConstAge	TIA
Random	0m	90		2	2	4	2	3	5					0.1	1.8	28.651	46	30
Random	20m	0		3	2	5	2	2	4					0	1.8	28.651	46	30
Random	40m	0		2	2	4	3	2	5					0	1.8	28.651	46	30
Random	60m	10		4	3	7	2	2	4					0	1.8	28.651	46	30
Random	80m	10		3	3	6	3	3	6					0	1.8	28.651	46	30
Random	100m	0		4	2	6	4	2	6					0	1.8	28.651	46	30
Robinhood	0m	0		2	4	6	4	2	6						0.79	33.528	52	35
Robinhood	20m	0		2	4	6	4	2	6						0.79	33.528	52	35
Robinhood	40m	0		2	4	6	4	2	6						0.79	33.528	52	35
Robinhood	60m	0		2	4	6	4	2	6						0.79	33.528	52	35
Robinhood	80m	0		2	4	6	4	2	6						0.79	33.528	52	35
Robinhood	100m			2	4	6	4	2	6						0.79	33.528	52	35
Sharing	0m	10		3	3	6	3	1	4					0	2.6	33.528	41	20
Sharing	20m	0		2	2	4	2	2	4					3	2.6	33.528	41	20
Sharing	40m	0		2	2	4	3	1	4					1	2.6	33.528	41	20
Sharing	60m	0		4	2	6	3	1	4					0	2.6	33.528	41	20
Sharing	80m	0		4	1	5	2	2	4					1	2.6	33.528	41	20
Sharing	100m	0		4	3	7	2	2	4					0.5	2.6	33.528	41	20
Waldron	0m	0		3	3	6	3	3	6					0	0.78	29.87	31	30
Waldron	20m	40		3	3	6	3	3	6					4	0.78	29.87	31	30
Waldron	40m	80		3	3	6	3	3	6					0	0.78	29.87	31	30
Waldron	60m	90		2	2	4	3	3	6					0	0.78	29.87	31	30
Waldron	80m	0		4	3	7	2	2	4					2	0.78	29.87	31	30
Waldron	100m	30		3	3	6	3	3	6					0	0.78	29.87	31	30
Watauga	0m	0		4	4	8	2	2	4	60	60	10	9.51	0	1.4	34.747	45	25
Watauga	20m	60		3	3	6	2	2	4					7	1.4	34.747	45	25
Watauga	40m	0		4	3	7	2	2	4	52	90	30	3.852	0	1.4	34.747	45	25
Watauga	60m	2		4	4	8	2	2	4	63	80	15	17.36	6	1.4	34.747	45	25
Watauga	80m	20		2	2	4	2	2	4					5	1.4	34.747	45	25
Watauga	100m	0		3	3	6	2	2	4					0	1.4	34.747	45	25
Willowbrook	0m	98		3	3	6	4	4	8					0	0.64	27.432	70	35
Willowbrook	20m	0		2	4	6	4	4	8					10	0.64	27.432	70	35
Willowbrook	40m	40		3	2	5	4	4	8					9	0.64	27.432	70	35
Willowbrook	60m	30		2	3	5	4	4	8					0	0.64	27.432	70	35
Willowbrook	80m	0		4	3	7	4	4	8	65	30	30	9.69	0	0.64	27.432	70	35
Willowbrook	100m	0		3	5	8	4	4	8	65	20	40	6.374	5	0.64	27.432	70	35

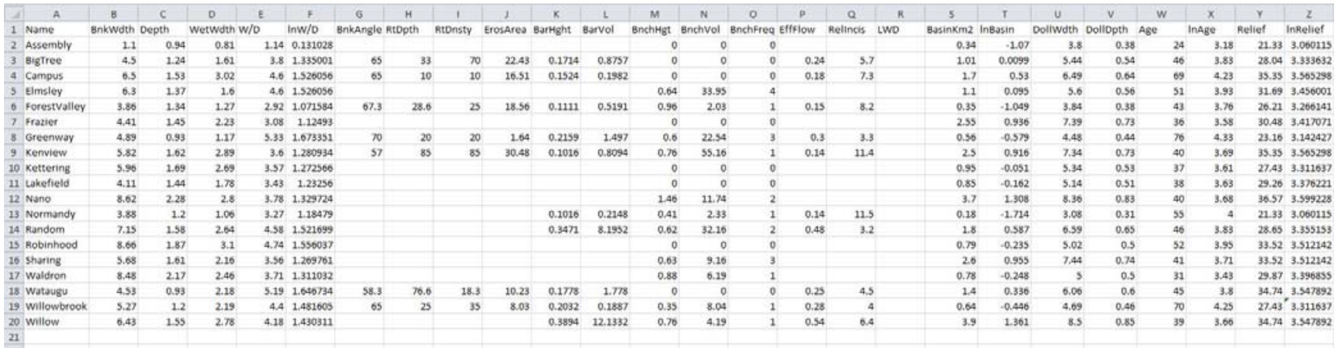
SiteName	Distance	BnkWidth	WetWidtl	ChnDepth	ChnArea	BenchHgtl	BenchVol	BarHgth	BarVol	EffecFlow	Rel.Incis	ChnlSlpe	RelRatio	EIA	BenchFrq	Width/De	Cobble	Gravel
Willowlake	0m	7.574	3.15	1.63	8.74006	0.762	4.19138	0.0762	0.56662	0.107324	15.18766	0.01	0.012	3.2	1	4.646626	15	5
Willowlake	20m	5.815	3.8348	1.854	8.945365							0.01	0.012	3.2	1	3.136462	0	0
Willowlake	40m	5.7912	2.3876	1.1684	4.778055							0.01	0.012	3.2	1	4.956522	10	5
Willowlake	60m	5.5118	1.6256	1.6256	5.801279			0.4826	15.44513	0.679718	2.391579	0.01	0.012	3.2	1	3.390625	0	0
Willowlake	80m	8.636	2.3368	1.6256	8.918692			0.6096	20.38813	0.858592	1.893333	0.01	0.012	3.2	1	5.3125	0	0
Willowlake	100m	5.2832	3.429	1.4224	6.196117							0.01	0.012	3.2	1	3.714286	0	0



SiteName	Distance	BdRock		RtAct	LftAct	LandRAct	RtVeg	LftVeg	LandRVeg	BnkAngle	RtDepth	RtDensity	ErosArea	LWD	BasinKm2	Relief	ConstAge	TIA
Willowlake	0m	20		2	2	4	4	2	6					0	3.9	34.747	39	10
Willowlake	20m	0		3	3	6	4	2	6					0.1	3.9	34.747	39	10
Willowlake	40m	70		3	2	5	4	2	6					0.1	3.9	34.747	39	10
Willowlake	60m	0		4	2	6	4	2	6					8	3.9	34.747	39	10
Willowlake	80m	20		1	2	3	4	2	6					8	3.9	34.747	39	10
Willowlake	100m	0		3	3	6	4	3	7					7	3.9	34.747	39	10

APPENDIX B

WATERSHED SCALE EXCEL DATA

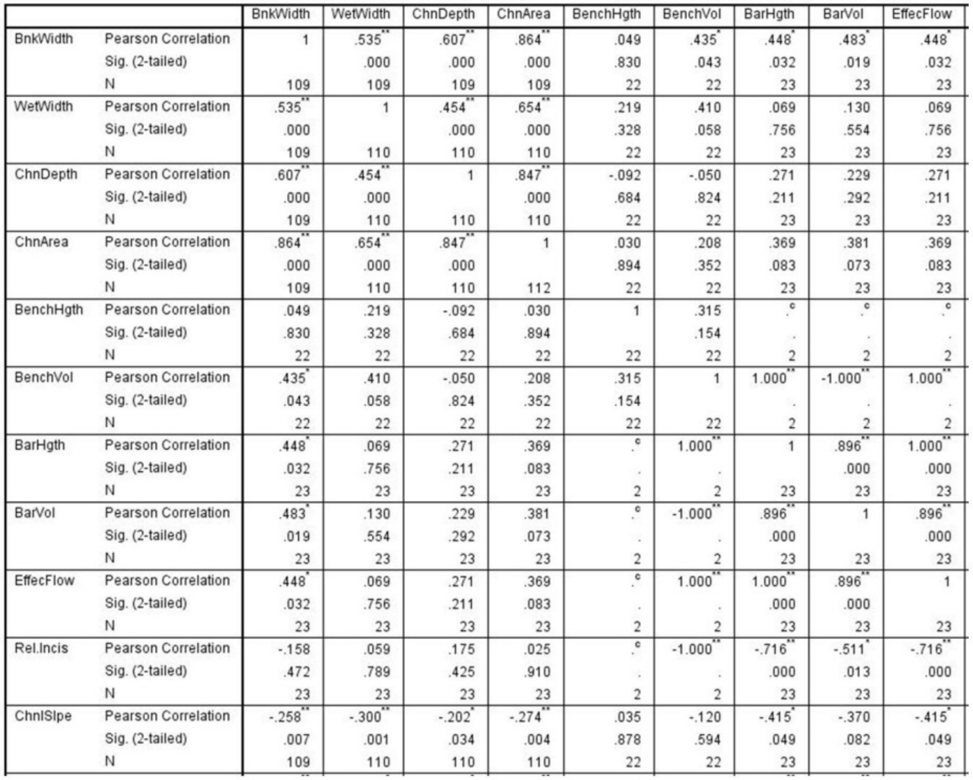


	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1	Name	BnkWdth	Depth	WetWdth	W/D	lnW/D	BnkAngle	RtDpth	RtDnsty	ErosArea	BarHght	BarVol	BnchHgt	BnchVol	BnchFreq	EffFlow	RelIncis	LWD	BasinKm2	lnBasin	DollWdth	DollDpth	Age	lnAge	Relief	lnRelief
2	Assembly	1.1	0.94	0.81	1.14	0.131028							0	0	0				0.34	-1.07	3.8	0.38	24	3.18	21.33	3.060115
3	BigTree	4.5	1.24	1.61	3.8	1.335001	65	33	70	22.43	0.1714	0.8757	0	0	0	0.24	5.7		1.01	0.0099	5.44	0.54	46	3.83	28.04	3.333632
4	Campus	6.5	1.53	3.02	4.6	1.526056	65	10	10	16.51	0.1524	0.1982	0	0	0	0.18	7.3		1.7	0.53	6.49	0.64	69	4.23	35.35	3.565298
5	Elmsley	6.3	1.37	1.6	4.6	1.526056							0.64	33.95	4				1.1	0.095	5.6	0.56	51	3.93	31.69	3.456001
6	ForestValley	3.86	1.34	1.27	2.92	1.071584	67.3	28.6	25	18.56	0.1111	0.5191	0.96	2.03	1	0.15	8.2		0.35	-1.049	3.84	0.38	43	3.76	26.21	3.266141
7	Frazier	4.41	1.45	2.23	3.08	1.12493							0	0	0				2.55	0.936	7.39	0.73	36	3.58	30.48	3.417071
8	Greenway	4.89	0.93	1.17	5.33	1.673351	70	20	20	1.64	0.2159	1.497	0.6	22.54	3	0.3	3.3		0.56	-0.579	4.48	0.44	76	4.33	23.16	3.142427
9	Kenview	5.82	1.62	2.89	3.6	1.280934	57	85	85	30.48	0.1016	0.8094	0.76	55.16	1	0.14	11.4		2.5	0.916	7.34	0.73	40	3.69	35.35	3.565298
10	Kettering	5.96	1.69	2.69	3.57	1.272566							0	0	0				0.95	-0.051	5.34	0.53	37	3.61	27.43	3.311637
11	Lakefield	4.11	1.44	1.78	3.43	1.23256							0	0	0				0.85	-0.162	5.14	0.51	38	3.63	29.26	3.376221
12	Nano	8.62	2.28	2.8	3.78	1.329724							1.46	11.74	2				3.7	1.308	8.36	0.83	40	3.68	36.57	3.599228
13	Normandy	3.88	1.2	1.06	3.27	1.18479					0.1016	0.2148	0.41	2.33	1	0.14	11.5		0.18	-1.714	3.08	0.31	55	4	21.33	3.060115
14	Random	7.15	1.58	2.64	4.58	1.521699					0.3471	8.1952	0.62	32.16	2	0.48	3.2		1.8	0.587	6.59	0.65	46	3.83	28.65	3.355153
15	Robinhood	8.66	1.87	3.1	4.74	1.556037							0	0	0				0.79	-0.235	5.02	0.5	52	3.95	33.52	3.512142
16	Sharing	5.68	1.61	2.16	3.56	1.269761							0.63	9.16	3				2.6	0.955	7.44	0.74	41	3.71	33.52	3.512142
17	Waldron	8.48	2.17	2.46	3.71	1.311032							0.88	6.19	1				0.78	-0.248	5	0.5	31	3.43	29.87	3.396855
18	Wataugu	4.53	0.93	2.18	5.19	1.646734	58.3	76.6	18.3	10.23	0.1778	1.778	0	0	0	0.25	4.5		1.4	0.336	6.06	0.6	45	3.8	34.74	3.547892
19	Willowbrook	5.27	1.2	2.19	4.4	1.481605	65	25	35	8.03	0.2032	0.1887	0.35	8.04	1	0.28	4		0.64	-0.446	4.69	0.46	70	4.25	27.43	3.311637
20	Willow	6.43	1.55	2.78	4.18	1.430311					0.3894	12.1332	0.76	4.19	1	0.54	6.4		3.9	1.361	8.5	0.85	39	3.66	34.74	3.547892
21																										

AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX	AY	AZ
Name	lnRelief	RelRatio	ChnSlope	EIA	lnEIA	TIA	Cobble	Gravel	Sand	BedRock	SUM	RtAct	LftAct	LandRAct	lnLandRAct	RtVeg	LftVeg	LandRVeg	CSArea	BnchArea	RIArea	DollArea	CSAENIR	RIEnIR
Assembly	3.060115	0.029	0.022	1.1	0.09531	5	15	34.16	50.83	0	99.99	2	1.16	3.16	1.15	1.83	1.83	3.66	0.897	0		1.497	0.59	
BigTree	3.333632	0.02	0.011	16.4	2.797281	30	25.57	40.71	26.85	6.14	99.27	2.42	4.16	6.58	1.88	2	3.57	5.57	3.788	0		3.039	1.24	
Campus	3.565298	0.019	0.013	46.5	3.839452	60	6.25	11.25	82.5	0	100	3.25	2.5	5.75	1.75	3	3	6	7.282	0		4.263	1.7	
Elmsley	3.456001	0.022	0.013	1.1	0.09531	5	26.66	25	32.5	15.83	99.99	2.66	2.66	5.32	1.67	1	1	2	5.411	2.399	2.794	3.213	1.68	0.87
ForestValley	3.266141	0.032	0.024	25.3	3.230804	40	7.83	37.5	41.33	11.66	98.32	3.83	3.16	6.99	1.94	3.66	2.66	6.32	3.437	3.217	4.525	1.526	2.25	2.96
Frazier	3.417071	0.019	0.011	5.8	1.757858	15	2	0	32	66	100	2	2.16	4.16	1.42	1	1.4	2.4	4.814	0		5.549	0.86	
Greenway	3.142427	0.02	0.018	20.7	3.030134	35	16.67	20	45	18.33	100	3.16	2.66	5.82	1.76	3.66	3.33	6.99	2.817	2.058	2.848	2.071	1.36	1.37
Kenview	3.565298	0.027	0.013	20.7	3.030134	35	33.33	20.16	2.5	44	99.99	5	3.66	8.66	2.16	1	1	2	7.055	3.948	5.543	5.478	1.28	1.01
Kettering	3.311637	0.025	0.012	25.3	3.230804	40	12.5	30.5	51.25	5	99.25	3.25	3.5	6.75	1.91	2.25	2.25	4.5	7.309	0		2.92	2.5	
Lakefield	3.376221	0.016	0.015	12.5	2.525729	25	27.5	22	22.5	28	100	2.5	3	5.5	1.7	3	3.16	6.16	4.24	0		2.717	1.56	
Nano	3.599228	0.014	0.01	5.8	1.757858	15	3.16	0	90.5	6.67	100.33	2.33	2	4.33	1.46	2.16	2.5	4.66	13.018	6.199	8.794	7.068	1.84	1.24
Normandy	3.060115	0.039	0.031	5.8	1.757858	15	13	22.5	27.33	36.67	99.5	2.5	2.66	5.16	1.64	3.5	3.33	6.83	2.964	1.148	1.616	0.99	2.99	1.63
Random	3.355153	0.013	0.011	16.4	2.797281	30	36.67	10.83	34.16	18.3	99.96	3	2.33	5.33	1.67	2.66	2.33	4.99	7.734	2.6	3.645	4.425	1.74	0.82
Robinhood	3.512142	0.035	0.029	20.7	3.030134	35	35	44.16	14.16	5	98.32	4	2	6	1.79	2	4	6	10.995	0		2.59	4.24	
Sharing	3.512142	0.015	0.012	8.9	2.186051	20	12.5	3.33	82.5	1.66	99.99	3.16	2.16	5.32	1.67	2.5	1.5	4	6.311	3.264	4.559	5.62	1.12	0.81
Waldron	3.396855	0.026	0.017	16.4	2.797281	30	20	24.16	15.83	40	99.99	3	2.83	5.83	1.76	2.83	2.83	5.66	11.869	2.969	4.171	2.569	4.62	1.62
Wataugu	3.547892	0.023	0.013	12.5	2.525729	25	37.5	24	24.83	13.67	100	3.33	3.16	6.49	1.87	2	2	4	3.12	0		3.758	0.83	
Willowbrook	3.311637	0.028	0.021	20.7	3.030134	35	43.33	15.83	12.33	28	99.49	2.5	3.33	5.83	1.76	4	4	8	4.476	1.3	1.83	2.259	1.98	0.81
Willow	3.547892	0.012	0.01	3.2	1.163151	10	4.16	1.66	75.83	18.33	99.98	3	2.33	5.33	1.67	4	2.16	6.16	7.137	2.9	4.07	7.314	0.97	0.55

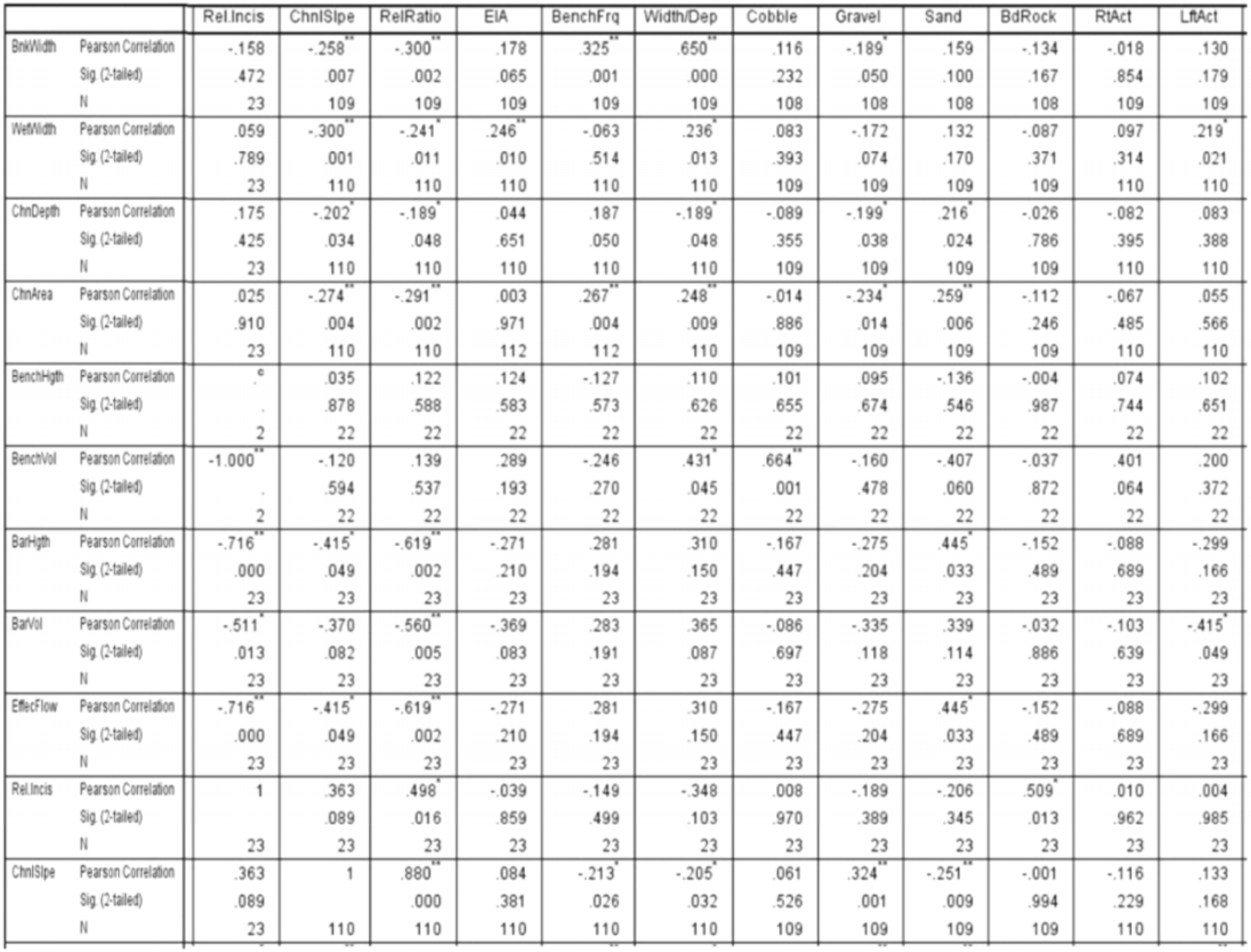
APPENDIX C

INDIVIDUAL SCALE PEARSON CORRELATION MATRIX



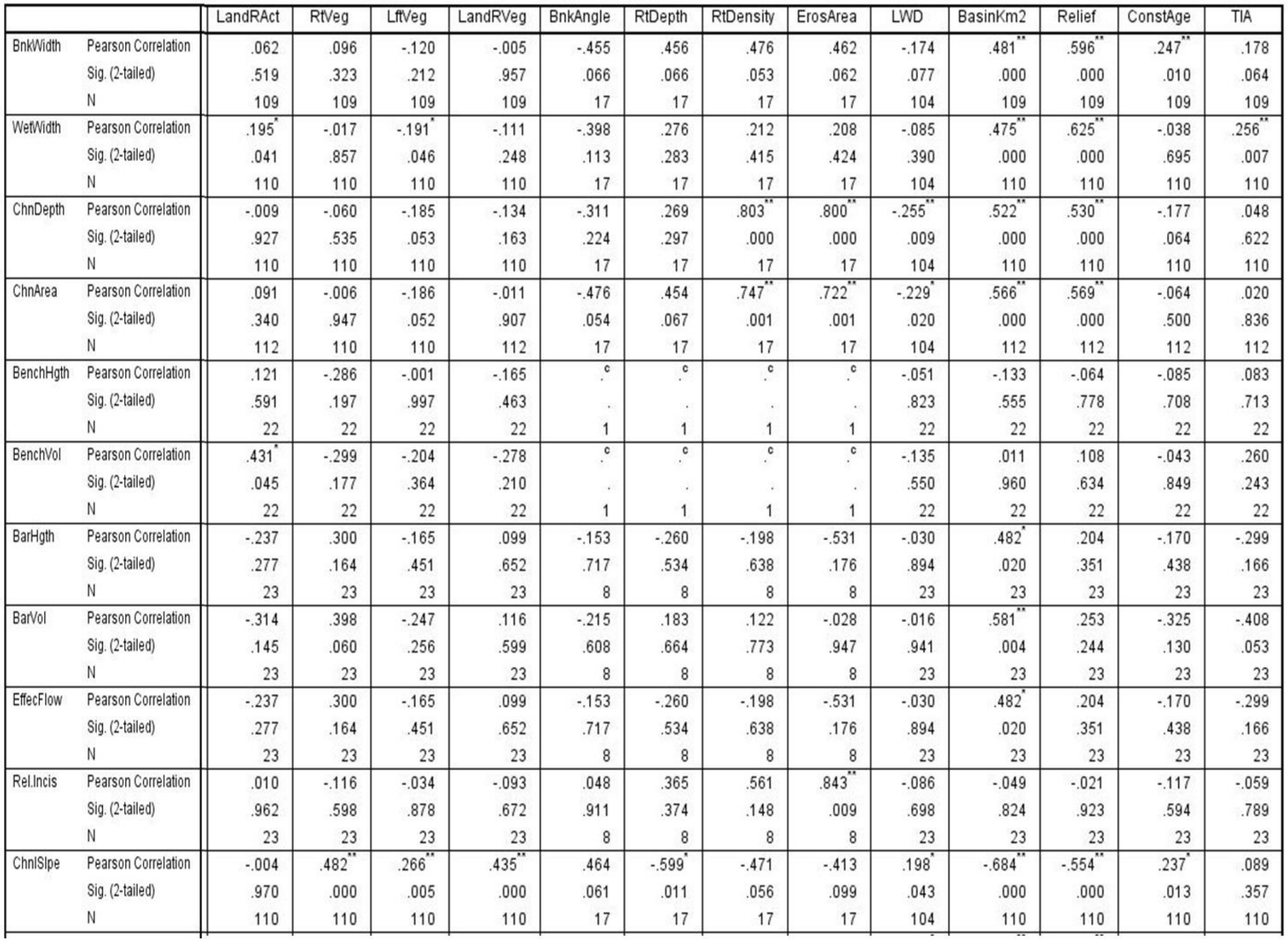
		BnkWidth	WetWidth	ChnDepth	ChnArea	BenchHgth	BenchVol	BarHgth	BarVol	EffecFlow
BnkWidth	Pearson Correlation	1	.535**	.607**	.864**	.049	.435*	.448*	.483*	.448*
	Sig. (2-tailed)		.000	.000	.000	.830	.043	.032	.019	.032
	N	109	109	109	109	22	22	23	23	23
WetWidth	Pearson Correlation	.535**	1	.454**	.654**	.219	.410	.069	.130	.069
	Sig. (2-tailed)	.000		.000	.000	.328	.058	.756	.554	.756
	N	109	110	110	110	22	22	23	23	23
ChnDepth	Pearson Correlation	.607**	.454**	1	.847**	-.092	-.050	.271	.229	.271
	Sig. (2-tailed)	.000	.000		.000	.684	.824	.211	.292	.211
	N	109	110	110	110	22	22	23	23	23
ChnArea	Pearson Correlation	.864**	.654**	.847**	1	.030	.208	.369	.381	.369
	Sig. (2-tailed)	.000	.000	.000		.894	.352	.083	.073	.083
	N	109	110	110	112	22	22	23	23	23
BenchHgth	Pearson Correlation	.049	.219	-.092	.030	1	.315	.[c]	.[c]	.[c]
	Sig. (2-tailed)	.830	.328	.684	.894		.154	.	.	.
	N	22	22	22	22	22	22	2	2	2
BenchVol	Pearson Correlation	.435*	.410	-.050	.208	.315	1	1.000**	-1.000**	1.000**
	Sig. (2-tailed)	.043	.058	.824	.352	.154		.	.	.
	N	22	22	22	22	22	22	2	2	2
BarHgth	Pearson Correlation	.448*	.069	.271	.369	.[c]	1.000**	1	.896**	1.000**
	Sig. (2-tailed)	.032	.756	.211	.083	.	.		.000	.000
	N	23	23	23	23	2	2	23	23	23
BarVol	Pearson Correlation	.483*	.130	.229	.381	.[c]	-1.000**	.896**	1	.896**
	Sig. (2-tailed)	.019	.554	.292	.073	.	.	.000		.000
	N	23	23	23	23	2	2	23	23	23
EffecFlow	Pearson Correlation	.448*	.069	.271	.369	.[c]	1.000**	1.000**	.896**	1
	Sig. (2-tailed)	.032	.756	.211	.083	.	.	.000	.000	
	N	23	23	23	23	2	2	23	23	23
Rel.Incis	Pearson Correlation	-.158	.059	.175	.025	.[c]	-1.000**	-.716**	-.511*	-.716**
	Sig. (2-tailed)	.472	.789	.425	.910	.	.	.000	.013	.000
	N	23	23	23	23	2	2	23	23	23
ChnlSlpe	Pearson Correlation	-.258**	-.300**	-.202*	-.274**	.035	-.120	-.415*	-.370	-.415*
	Sig. (2-tailed)	.007	.001	.034	.004	.878	.594	.049	.082	.049
	N	109	110	110	110	22	22	23	23	23

Individual variable correlations 1



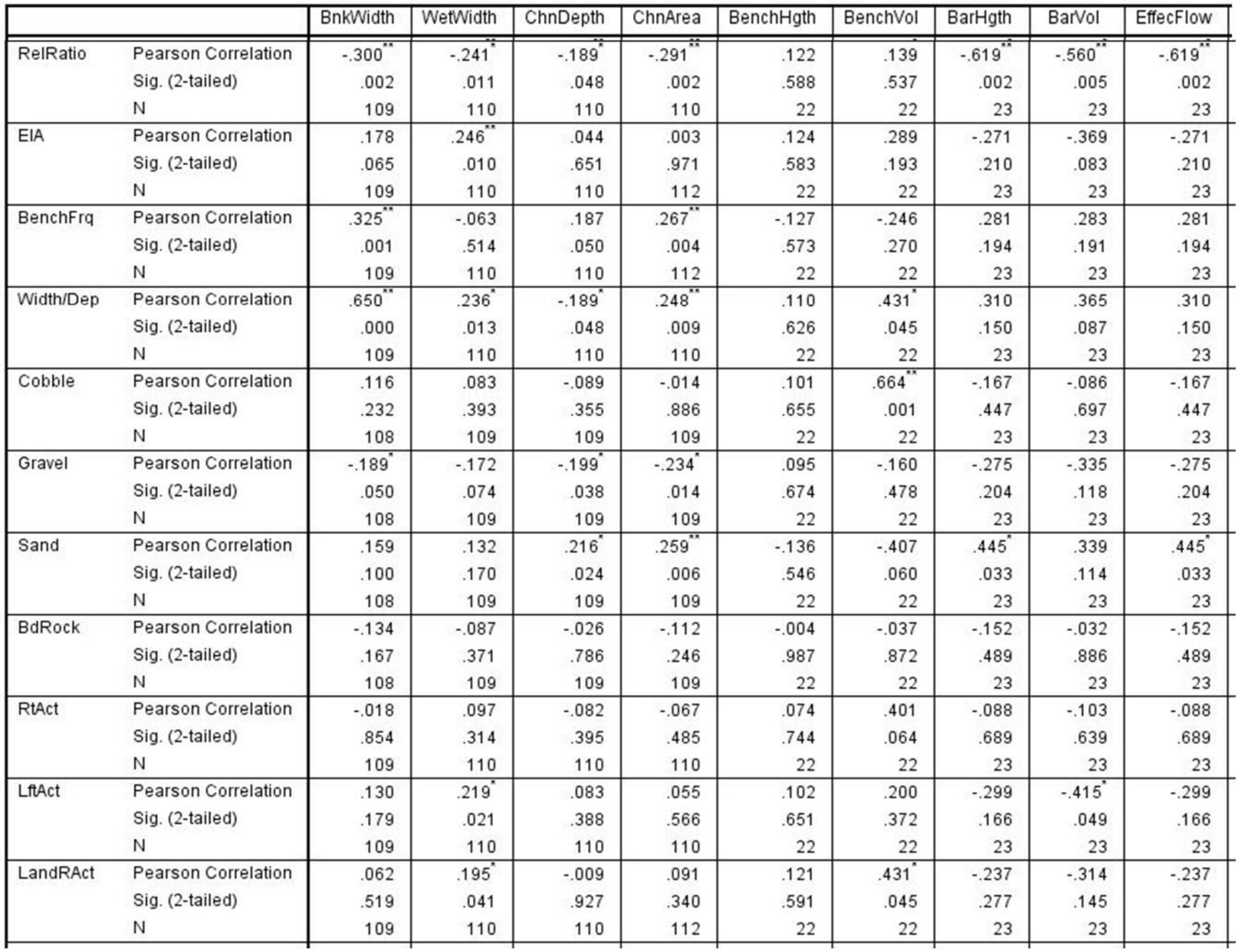
		Rel.Incis	ChnlSlpe	RelRatio	EIA	BenchFrq	Width/Dep	Cobble	Gravel	Sand	BdRock	RtAct	LftAct
BnkWidth	Pearson Correlation	-.158	-.258**	-.300**	.178	.325**	.650**	.116	-.189*	.159	-.134	-.018	.130
	Sig. (2-tailed)	.472	.007	.002	.065	.001	.000	.232	.050	.100	.167	.854	.179
	N	23	109	109	109	109	109	108	108	108	108	109	109
WetWidth	Pearson Correlation	.059	-.300**	-.241*	.246**	-.063	.236*	.083	-.172	.132	-.087	.097	.219*
	Sig. (2-tailed)	.789	.001	.011	.010	.514	.013	.393	.074	.170	.371	.314	.021
	N	23	110	110	110	110	110	109	109	109	109	110	110
ChnDepth	Pearson Correlation	.175	-.202*	-.189*	.044	.187	-.189*	-.089	-.199*	.216*	-.026	-.082	.083
	Sig. (2-tailed)	.425	.034	.048	.651	.050	.048	.355	.038	.024	.786	.395	.388
	N	23	110	110	110	110	110	109	109	109	109	110	110
ChnArea	Pearson Correlation	.025	-.274**	-.291**	.003	.267**	.248**	-.014	-.234*	.259**	-.112	-.067	.055
	Sig. (2-tailed)	.910	.004	.002	.971	.004	.009	.886	.014	.006	.246	.485	.566
	N	23	110	110	112	112	110	109	109	109	109	110	110
BenchHgth	Pearson Correlation	.^{c}	.035	.122	.124	-.127	.110	.101	.095	-.136	-.004	.074	.102
	Sig. (2-tailed)	.	.878	.588	.583	.573	.626	.655	.674	.546	.987	.744	.651
	N	2	22	22	22	22	22	22	22	22	22	22	22
BenchVol	Pearson Correlation	-1.000**	-.120	.139	.289	-.246	.431*	.664**	-.160	-.407	-.037	.401	.200
	Sig. (2-tailed)	.	.594	.537	.193	.270	.045	.001	.478	.060	.872	.064	.372
	N	2	22	22	22	22	22	22	22	22	22	22	22
BarHgth	Pearson Correlation	-.716**	-.415*	-.619**	-.271	.281	.310	-.167	-.275	.445*	-.152	-.088	-.299
	Sig. (2-tailed)	.000	.049	.002	.210	.194	.150	.447	.204	.033	.489	.689	.166
	N	23	23	23	23	23	23	23	23	23	23	23	23
BarVol	Pearson Correlation	-.511*	-.370	-.560**	-.369	.283	.365	-.086	-.335	.339	-.032	-.103	-.415*
	Sig. (2-tailed)	.013	.082	.005	.083	.191	.087	.697	.118	.114	.886	.639	.049
	N	23	23	23	23	23	23	23	23	23	23	23	23
EffecFlow	Pearson Correlation	-.716**	-.415*	-.619**	-.271	.281	.310	-.167	-.275	.445*	-.152	-.088	-.299
	Sig. (2-tailed)	.000	.049	.002	.210	.194	.150	.447	.204	.033	.489	.689	.166
	N	23	23	23	23	23	23	23	23	23	23	23	23
Rel.Incis	Pearson Correlation	1	.363	.498*	-.039	-.149	-.348	.008	-.189	-.206	.509*	.010	.004
	Sig. (2-tailed)		.089	.016	.859	.499	.103	.970	.389	.345	.013	.962	.985
	N	23	23	23	23	23	23	23	23	23	23	23	23
ChnlSlpe	Pearson Correlation	.363	1	.880**	.084	-.213*	-.205*	.061	.324**	-.251**	-.001	-.116	.133
	Sig. (2-tailed)	.089		.000	.381	.026	.032	.526	.001	.009	.994	.229	.168
	N	23	110	110	110	110	110	109	109	109	109	110	110

Individual variable correlations 2



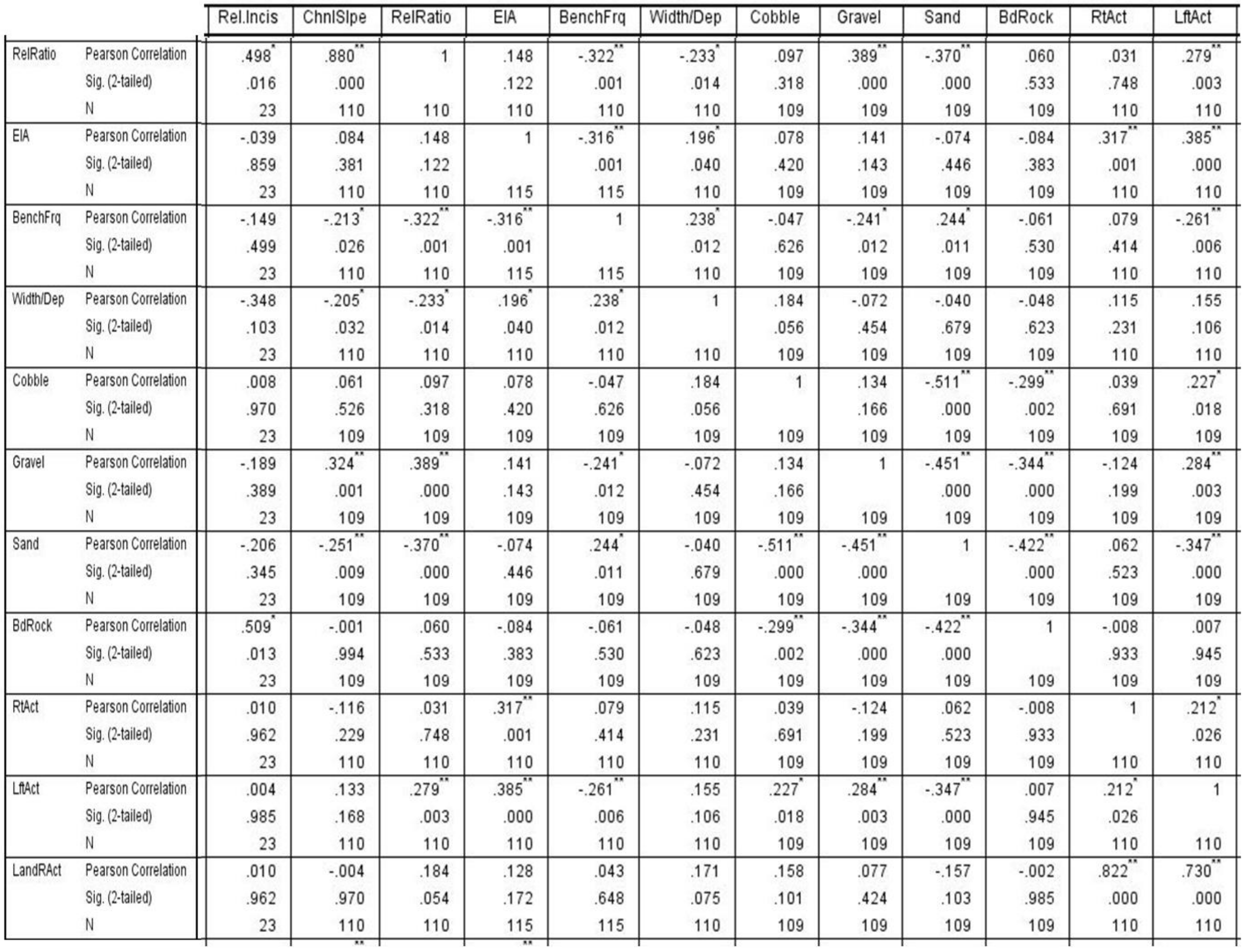
		LandRAct	RtVeg	LftVeg	LandRVeg	BnkAngle	RtDepth	RtDensity	ErosArea	LWD	BasinKm2	Relief	ConstAge	TIA
BnkWidth	Pearson Correlation	.062	.096	-.120	-.005	-.455	.456	.476	.462	-.174	.481**	.596**	.247**	.178
	Sig. (2-tailed)	.519	.323	.212	.957	.066	.066	.053	.062	.077	.000	.000	.010	.064
	N	109	109	109	109	17	17	17	17	104	109	109	109	109
WetWidth	Pearson Correlation	.195*	-.017	-.191*	-.111	-.398	.276	.212	.208	-.085	.475**	.625**	-.038	.256**
	Sig. (2-tailed)	.041	.857	.046	.248	.113	.283	.415	.424	.390	.000	.000	.695	.007
	N	110	110	110	110	17	17	17	17	104	110	110	110	110
ChnDepth	Pearson Correlation	-.009	-.060	-.185	-.134	-.311	.269	.803**	.800**	-.255**	.522**	.530**	-.177	.048
	Sig. (2-tailed)	.927	.535	.053	.163	.224	.297	.000	.000	.009	.000	.000	.064	.622
	N	110	110	110	110	17	17	17	17	104	110	110	110	110
ChnArea	Pearson Correlation	.091	-.006	-.186	-.011	-.476	.454	.747**	.722**	-.229*	.566**	.569**	-.064	.020
	Sig. (2-tailed)	.340	.947	.052	.907	.054	.067	.001	.001	.020	.000	.000	.500	.836
	N	112	110	110	112	17	17	17	17	104	112	112	112	112
BenchHgth	Pearson Correlation	.121	-.286	-.001	-.165	.c	.c	.c	.c	-.051	-.133	-.064	-.085	.083
	Sig. (2-tailed)	.591	.197	.997	.463	.	.	.	.	.823	.555	.778	.708	.713
	N	22	22	22	22	1	1	1	1	22	22	22	22	22
BenchVol	Pearson Correlation	.431*	-.299	-.204	-.278	.c	.c	.c	.c	-.135	.011	.108	-.043	.260
	Sig. (2-tailed)	.045	.177	.364	.210	.	.	.	.	.550	.960	.634	.849	.243
	N	22	22	22	22	1	1	1	1	22	22	22	22	22
BarHgth	Pearson Correlation	-.237	.300	-.165	.099	-.153	-.260	-.198	-.531	-.030	.482*	.204	-.170	-.299
	Sig. (2-tailed)	.277	.164	.451	.652	.717	.534	.638	.176	.894	.020	.351	.438	.166
	N	23	23	23	23	8	8	8	8	23	23	23	23	23
BarVol	Pearson Correlation	-.314	.398	-.247	.116	-.215	.183	.122	-.028	-.016	.581**	.253	-.325	-.408
	Sig. (2-tailed)	.145	.060	.256	.599	.608	.664	.773	.947	.941	.004	.244	.130	.053
	N	23	23	23	23	8	8	8	8	23	23	23	23	23
EffecFlow	Pearson Correlation	-.237	.300	-.165	.099	-.153	-.260	-.198	-.531	-.030	.482*	.204	-.170	-.299
	Sig. (2-tailed)	.277	.164	.451	.652	.717	.534	.638	.176	.894	.020	.351	.438	.166
	N	23	23	23	23	8	8	8	8	23	23	23	23	23
Rel.Incis	Pearson Correlation	.010	-.116	-.034	-.093	.048	.365	.561	.843**	-.086	-.049	-.021	-.117	-.059
	Sig. (2-tailed)	.962	.598	.878	.672	.911	.374	.148	.009	.698	.824	.923	.594	.789
	N	23	23	23	23	8	8	8	8	23	23	23	23	23
ChnlSlpe	Pearson Correlation	-.004	.482**	.266**	.435**	.464	-.599*	-.471	-.413	.198*	-.684**	-.554**	.237*	.089
	Sig. (2-tailed)	.970	.000	.005	.000	.061	.011	.056	.099	.043	.000	.000	.013	.357
	N	110	110	110	110	17	17	17	17	104	110	110	110	110

Individual variable correlations 3



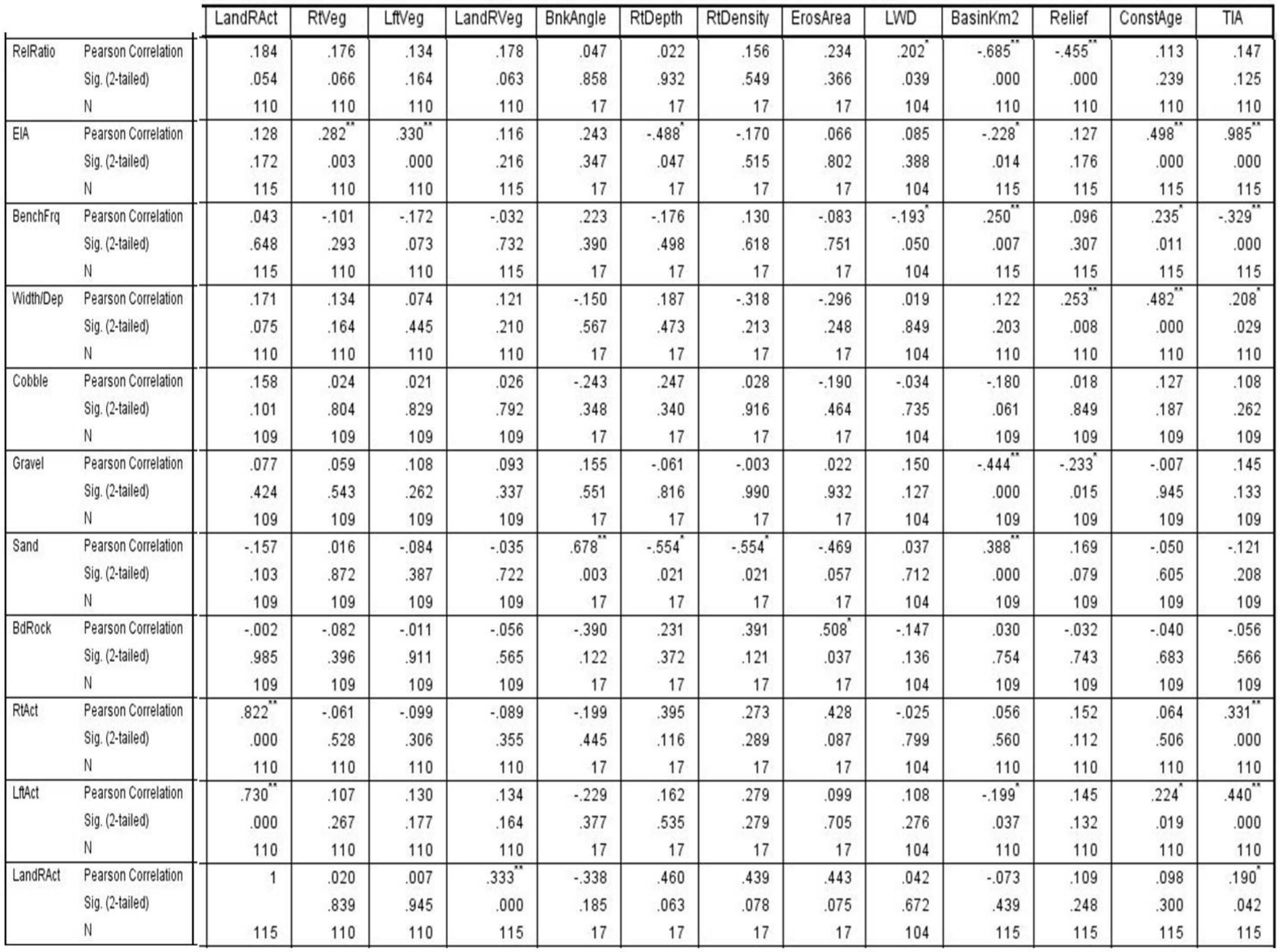
		BnkWidth	WetWidth	ChnDepth	ChnArea	BenchHgth	BenchVol	BarHgth	BarVol	EffecFlow
RelRatio	Pearson Correlation	-.300**	-.241*	-.189*	-.291**	.122	.139	-.619**	-.560**	-.619**
	Sig. (2-tailed)	.002	.011	.048	.002	.588	.537	.002	.005	.002
	N	109	110	110	110	22	22	23	23	23
EIA	Pearson Correlation	.178	.246**	.044	.003	.124	.289	-.271	-.369	-.271
	Sig. (2-tailed)	.065	.010	.651	.971	.583	.193	.210	.083	.210
	N	109	110	110	112	22	22	23	23	23
BenchFrq	Pearson Correlation	.325**	-.063	.187	.267**	-.127	-.246	.281	.283	.281
	Sig. (2-tailed)	.001	.514	.050	.004	.573	.270	.194	.191	.194
	N	109	110	110	112	22	22	23	23	23
Width/Dep	Pearson Correlation	.650**	.236*	-.189*	.248**	.110	.431*	.310	.365	.310
	Sig. (2-tailed)	.000	.013	.048	.009	.626	.045	.150	.087	.150
	N	109	110	110	110	22	22	23	23	23
Cobble	Pearson Correlation	.116	.083	-.089	-.014	.101	.664**	-.167	-.086	-.167
	Sig. (2-tailed)	.232	.393	.355	.886	.655	.001	.447	.697	.447
	N	108	109	109	109	22	22	23	23	23
Gravel	Pearson Correlation	-.189*	-.172	-.199*	-.234*	.095	-.160	-.275	-.335	-.275
	Sig. (2-tailed)	.050	.074	.038	.014	.674	.478	.204	.118	.204
	N	108	109	109	109	22	22	23	23	23
Sand	Pearson Correlation	.159	.132	.216*	.259**	-.136	-.407	.445*	.339	.445*
	Sig. (2-tailed)	.100	.170	.024	.006	.546	.060	.033	.114	.033
	N	108	109	109	109	22	22	23	23	23
BdRock	Pearson Correlation	-.134	-.087	-.026	-.112	-.004	-.037	-.152	-.032	-.152
	Sig. (2-tailed)	.167	.371	.786	.246	.987	.872	.489	.886	.489
	N	108	109	109	109	22	22	23	23	23
RtAct	Pearson Correlation	-.018	.097	-.082	-.067	.074	.401	-.088	-.103	-.088
	Sig. (2-tailed)	.854	.314	.395	.485	.744	.064	.689	.639	.689
	N	109	110	110	110	22	22	23	23	23
LftAct	Pearson Correlation	.130	.219*	.083	.055	.102	.200	-.299	-.415*	-.299
	Sig. (2-tailed)	.179	.021	.388	.566	.651	.372	.166	.049	.166
	N	109	110	110	110	22	22	23	23	23
LandRAct	Pearson Correlation	.062	.195*	-.009	.091	.121	.431*	-.237	-.314	-.237
	Sig. (2-tailed)	.519	.041	.927	.340	.591	.045	.277	.145	.277
	N	109	110	110	112	22	22	23	23	23

Individual variable correlations 4



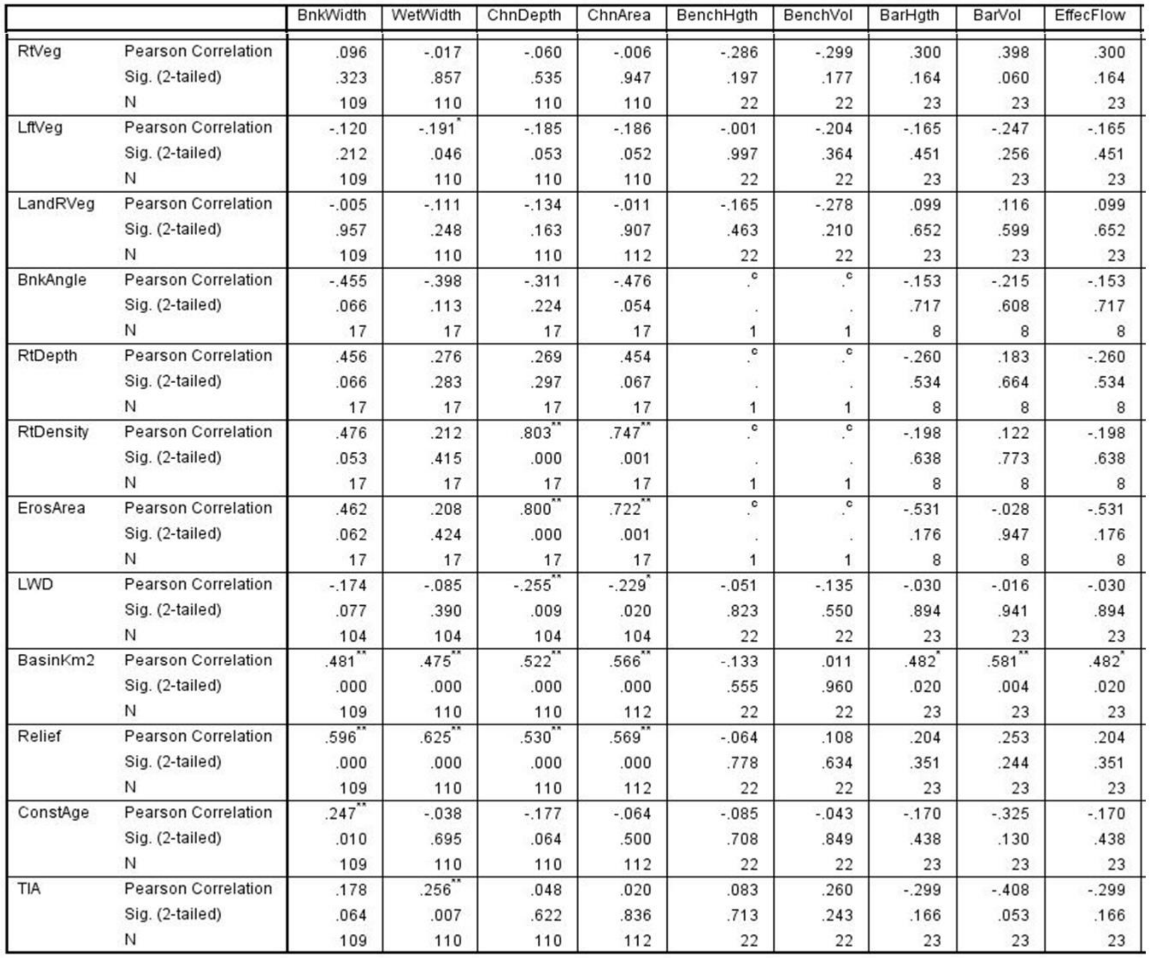
		Rel.Incis	ChnlSlpe	RelRatio	EIA	BenchFrq	Width/Dep	Cobble	Gravel	Sand	BdRock	RtAct	LftAct
RelRatio	Pearson Correlation	.498*	.880**	1	.148	-.322**	-.233*	.097	.389**	-.370**	.060	.031	.279**
	Sig. (2-tailed)	.016	.000		.122	.001	.014	.318	.000	.000	.533	.748	.003
	N	23	110	110	110	110	110	109	109	109	109	110	110
EIA	Pearson Correlation	-.039	.084	.148	1	-.316**	.196*	.078	.141	-.074	-.084	.317**	.385**
	Sig. (2-tailed)	.859	.381	.122		.001	.040	.420	.143	.446	.383	.001	.000
	N	23	110	110	115	115	110	109	109	109	109	110	110
BenchFrq	Pearson Correlation	-.149	-.213*	-.322**	-.316**	1	.238*	-.047	-.241*	.244*	-.061	.079	-.261**
	Sig. (2-tailed)	.499	.026	.001	.001		.012	.626	.012	.011	.530	.414	.006
	N	23	110	110	115	115	110	109	109	109	109	110	110
Width/Dep	Pearson Correlation	-.348	-.205*	-.233*	.196*	.238*	1	.184	-.072	-.040	-.048	.115	.155
	Sig. (2-tailed)	.103	.032	.014	.040	.012		.056	.454	.679	.623	.231	.106
	N	23	110	110	110	110	110	109	109	109	109	110	110
Cobble	Pearson Correlation	.008	.061	.097	.078	-.047	.184	1	.134	-.511**	-.299**	.039	.227*
	Sig. (2-tailed)	.970	.526	.318	.420	.626	.056		.166	.000	.002	.691	.018
	N	23	109	109	109	109	109	109	109	109	109	109	109
Gravel	Pearson Correlation	-.189	.324**	.389**	.141	-.241*	-.072	.134	1	-.451**	-.344**	-.124	.284**
	Sig. (2-tailed)	.389	.001	.000	.143	.012	.454	.166		.000	.000	.199	.003
	N	23	109	109	109	109	109	109	109	109	109	109	109
Sand	Pearson Correlation	-.206	-.251**	-.370**	-.074	.244*	-.040	-.511**	-.451**	1	-.422**	.062	-.347**
	Sig. (2-tailed)	.345	.009	.000	.446	.011	.679	.000	.000		.000	.523	.000
	N	23	109	109	109	109	109	109	109	109	109	109	109
BdRock	Pearson Correlation	.509*	-.001	.060	-.084	-.061	-.048	-.299**	-.344**	-.422**	1	-.008	.007
	Sig. (2-tailed)	.013	.994	.533	.383	.530	.623	.002	.000	.000		.933	.945
	N	23	109	109	109	109	109	109	109	109	109	109	109
RtAct	Pearson Correlation	.010	-.116	.031	.317**	.079	.115	.039	-.124	.062	-.008	1	.212*
	Sig. (2-tailed)	.962	.229	.748	.001	.414	.231	.691	.199	.523	.933		.026
	N	23	110	110	110	110	110	109	109	109	109	110	110
LftAct	Pearson Correlation	.004	.133	.279**	.385**	-.261**	.155	.227*	.284**	-.347**	.007	.212*	1
	Sig. (2-tailed)	.985	.168	.003	.000	.006	.106	.018	.003	.000	.945	.026	
	N	23	110	110	110	110	110	109	109	109	109	110	110
LandRAct	Pearson Correlation	.010	-.004	.184	.128	.043	.171	.158	.077	-.157	-.002	.822**	.730**
	Sig. (2-tailed)	.962	.970	.054	.172	.648	.075	.101	.424	.103	.985	.000	.000
	N	23	110	110	115	115	110	109	109	109	109	110	110

Individual variable correlations 5



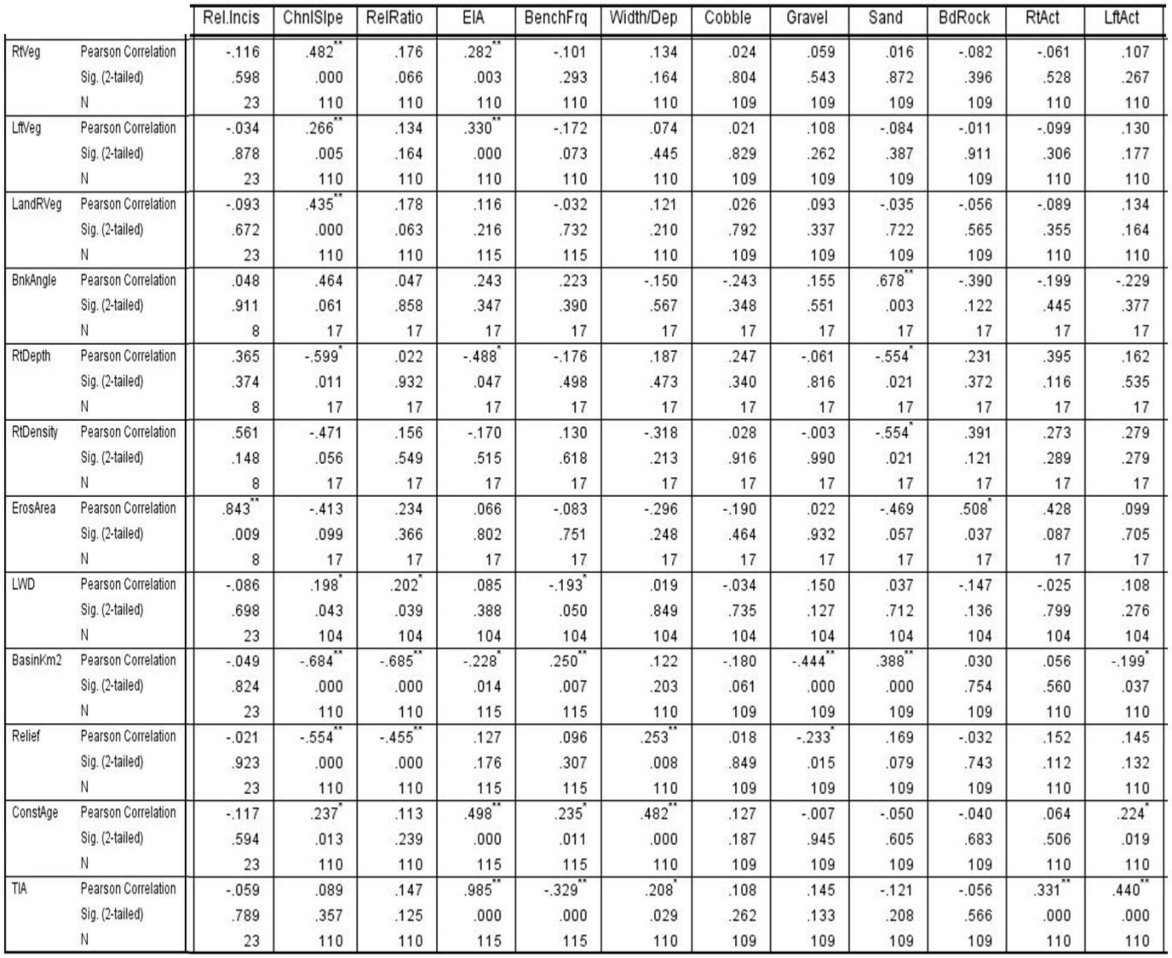
		LandRAct	RtVeg	LftVeg	LandRVeg	BnkAngle	RtDepth	RtDensity	ErosArea	LWD	BasinKm2	Relief	ConstAge	TIA
RelRatio	Pearson Correlation	.184	.176	.134	.178	.047	.022	.156	.234	.202*	-.685**	-.455**	.113	.147
	Sig. (2-tailed)	.054	.066	.164	.063	.858	.932	.549	.366	.039	.000	.000	.239	.125
	N	110	110	110	110	17	17	17	17	104	110	110	110	110
EIA	Pearson Correlation	.128	.282**	.330**	.116	.243	-.488*	-.170	.066	.085	-.228*	.127	.498**	.985**
	Sig. (2-tailed)	.172	.003	.000	.216	.347	.047	.515	.802	.388	.014	.176	.000	.000
	N	115	110	110	115	17	17	17	17	104	115	115	115	115
BenchFrq	Pearson Correlation	.043	-.101	-.172	-.032	.223	-.176	.130	-.083	-.193*	.250**	.096	.235*	-.329**
	Sig. (2-tailed)	.648	.293	.073	.732	.390	.498	.618	.751	.050	.007	.307	.011	.000
	N	115	110	110	115	17	17	17	17	104	115	115	115	115
Width/Dep	Pearson Correlation	.171	.134	.074	.121	-.150	.187	-.318	-.296	.019	.122	.253**	.482**	.208*
	Sig. (2-tailed)	.075	.164	.445	.210	.567	.473	.213	.248	.849	.203	.008	.000	.029
	N	110	110	110	110	17	17	17	17	104	110	110	110	110
Cobble	Pearson Correlation	.158	.024	.021	.026	-.243	.247	.028	-.190	-.034	-.180	.018	.127	.108
	Sig. (2-tailed)	.101	.804	.829	.792	.348	.340	.916	.464	.735	.061	.849	.187	.262
	N	109	109	109	109	17	17	17	17	104	109	109	109	109
Gravel	Pearson Correlation	.077	.059	.108	.093	.155	-.061	-.003	.022	.150	-.444**	-.233*	-.007	.145
	Sig. (2-tailed)	.424	.543	.262	.337	.551	.816	.990	.932	.127	.000	.015	.945	.133
	N	109	109	109	109	17	17	17	17	104	109	109	109	109
Sand	Pearson Correlation	-.157	.016	-.084	-.035	.678**	-.554*	-.554*	-.469	.037	.388**	.169	-.050	-.121
	Sig. (2-tailed)	.103	.872	.387	.722	.003	.021	.021	.057	.712	.000	.079	.605	.208
	N	109	109	109	109	17	17	17	17	104	109	109	109	109
BdRock	Pearson Correlation	-.002	-.082	-.011	-.056	-.390	.231	.391	.508*	-.147	.030	-.032	-.040	-.056
	Sig. (2-tailed)	.985	.396	.911	.565	.122	.372	.121	.037	.136	.754	.743	.683	.566
	N	109	109	109	109	17	17	17	17	104	109	109	109	109
RtAct	Pearson Correlation	.822**	-.061	-.099	-.089	-.199	.395	.273	.428	-.025	.056	.152	.064	.331**
	Sig. (2-tailed)	.000	.528	.306	.355	.445	.116	.289	.087	.799	.560	.112	.506	.000
	N	110	110	110	110	17	17	17	17	104	110	110	110	110
LftAct	Pearson Correlation	.730**	.107	.130	.134	-.229	.162	.279	.099	.108	-.199*	.145	.224*	.440**
	Sig. (2-tailed)	.000	.267	.177	.164	.377	.535	.279	.705	.276	.037	.132	.019	.000
	N	110	110	110	110	17	17	17	17	104	110	110	110	110
LandRAct	Pearson Correlation	1	.020	.007	.333**	-.338	.460	.439	.443	.042	-.073	.109	.098	.190*
	Sig. (2-tailed)		.839	.945	.000	.185	.063	.078	.075	.672	.439	.248	.300	.042
	N	115	110	110	115	17	17	17	17	104	115	115	115	115

Individual variable correlations 6



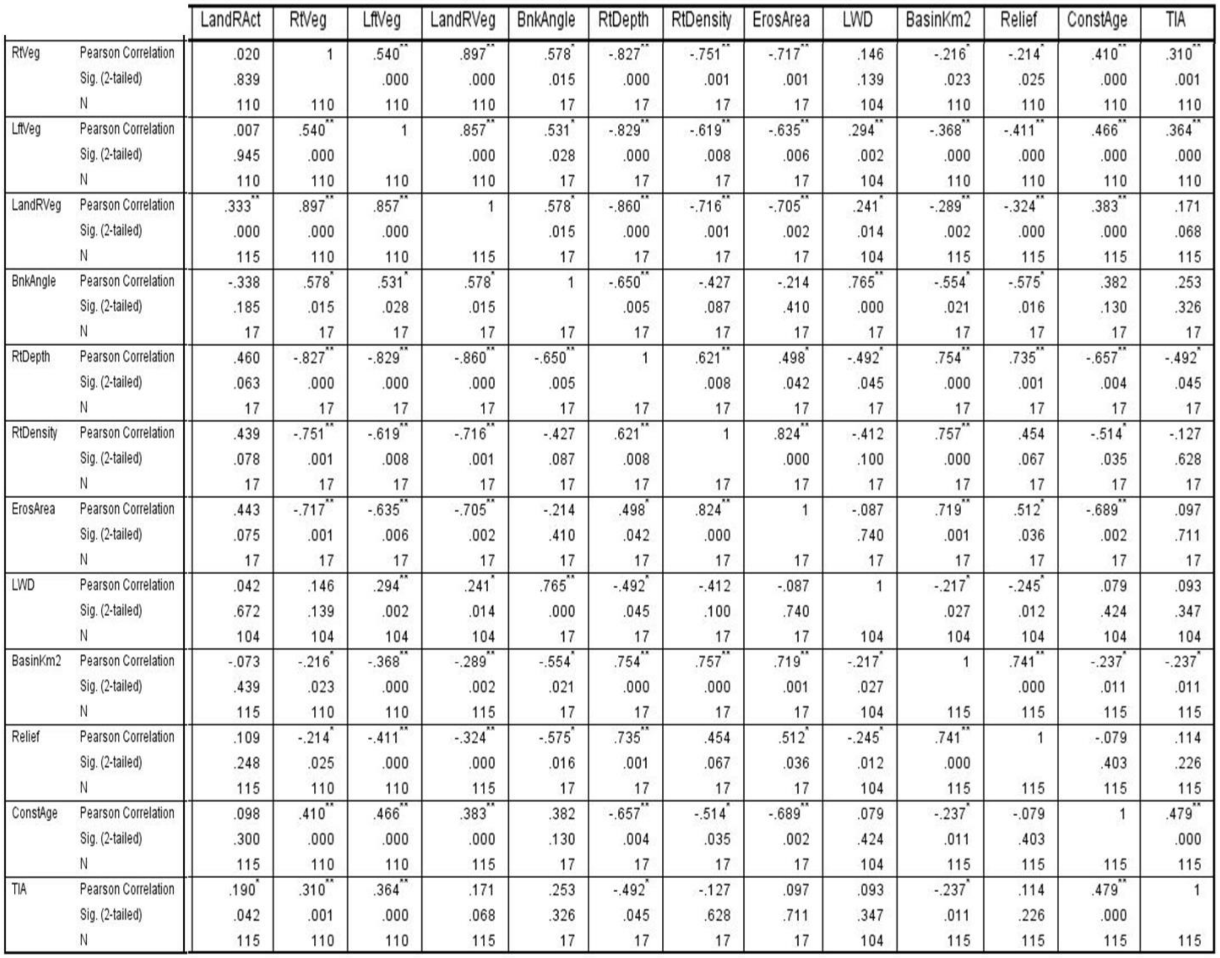
		BnkWidth	WetWidth	ChnDepth	ChnArea	BenchHgth	BenchVol	BarHgth	BarVol	EffecFlow
RtVeg	Pearson Correlation	.096	-.017	-.060	-.006	-.286	-.299	.300	.398	.300
	Sig. (2-tailed)	.323	.857	.535	.947	.197	.177	.164	.060	.164
	N	109	110	110	110	22	22	23	23	23
LftVeg	Pearson Correlation	-.120	-.191*	-.185	-.186	-.001	-.204	-.165	-.247	-.165
	Sig. (2-tailed)	.212	.046	.053	.052	.997	.364	.451	.256	.451
	N	109	110	110	110	22	22	23	23	23
LandRVeg	Pearson Correlation	-.005	-.111	-.134	-.011	-.165	-.278	.099	.116	.099
	Sig. (2-tailed)	.957	.248	.163	.907	.463	.210	.652	.599	.652
	N	109	110	110	112	22	22	23	23	23
BnkAngle	Pearson Correlation	-.455	-.398	-.311	-.476	.[c]	.[c]	-.153	-.215	-.153
	Sig. (2-tailed)	.066	.113	.224	.054	.	.	.717	.608	.717
	N	17	17	17	17	1	1	8	8	8
RtDepth	Pearson Correlation	.456	.276	.269	.454	.[c]	.[c]	-.260	.183	-.260
	Sig. (2-tailed)	.066	.283	.297	.067	.	.	.534	.664	.534
	N	17	17	17	17	1	1	8	8	8
RtDensity	Pearson Correlation	.476	.212	.803**	.747**	.[c]	.[c]	-.198	.122	-.198
	Sig. (2-tailed)	.053	.415	.000	.001	.	.	.638	.773	.638
	N	17	17	17	17	1	1	8	8	8
ErosArea	Pearson Correlation	.462	.208	.800**	.722**	.[c]	.[c]	-.531	-.028	-.531
	Sig. (2-tailed)	.062	.424	.000	.001	.	.	.176	.947	.176
	N	17	17	17	17	1	1	8	8	8
LWD	Pearson Correlation	-.174	-.085	-.255**	-.229*	-.051	-.135	-.030	-.016	-.030
	Sig. (2-tailed)	.077	.390	.009	.020	.823	.550	.894	.941	.894
	N	104	104	104	104	22	22	23	23	23
BasinKm2	Pearson Correlation	.481**	.475**	.522**	.566**	-.133	.011	.482*	.581**	.482*
	Sig. (2-tailed)	.000	.000	.000	.000	.555	.960	.020	.004	.020
	N	109	110	110	112	22	22	23	23	23
Relief	Pearson Correlation	.596**	.625**	.530**	.569**	-.064	.108	.204	.253	.204
	Sig. (2-tailed)	.000	.000	.000	.000	.778	.634	.351	.244	.351
	N	109	110	110	112	22	22	23	23	23
ConstAge	Pearson Correlation	.247**	-.038	-.177	-.064	-.085	-.043	-.170	-.325	-.170
	Sig. (2-tailed)	.010	.695	.064	.500	.708	.849	.438	.130	.438
	N	109	110	110	112	22	22	23	23	23
TIA	Pearson Correlation	.178	.256**	.048	.020	.083	.260	-.299	-.408	-.299
	Sig. (2-tailed)	.064	.007	.622	.836	.713	.243	.166	.053	.166
	N	109	110	110	112	22	22	23	23	23

Individual variable correlations 7



		Rel.Incis	ChnlSlpe	RelRatio	EIA	BenchFrq	Width/Dep	Cobble	Gravel	Sand	BdRock	RtAct	LftAct
RtVeg	Pearson Correlation	-.116	.482**	.176	.282**	-.101	.134	.024	.059	.016	-.082	-.061	.107
	Sig. (2-tailed)	.598	.000	.066	.003	.293	.164	.804	.543	.872	.396	.528	.267
	N	23	110	110	110	110	110	109	109	109	109	110	110
LftVeg	Pearson Correlation	-.034	.266**	.134	.330**	-.172	.074	.021	.108	-.084	-.011	-.099	.130
	Sig. (2-tailed)	.878	.005	.164	.000	.073	.445	.829	.262	.387	.911	.306	.177
	N	23	110	110	110	110	110	109	109	109	109	110	110
LandRVeg	Pearson Correlation	-.093	.435**	.178	.116	-.032	.121	.026	.093	-.035	-.056	-.089	.134
	Sig. (2-tailed)	.672	.000	.063	.216	.732	.210	.792	.337	.722	.565	.355	.164
	N	23	110	110	115	115	110	109	109	109	109	110	110
BnkAngle	Pearson Correlation	.048	.464	.047	.243	.223	-.150	-.243	.155	.678**	-.390	-.199	-.229
	Sig. (2-tailed)	.911	.061	.858	.347	.390	.567	.348	.551	.003	.122	.445	.377
	N	8	17	17	17	17	17	17	17	17	17	17	17
RtDepth	Pearson Correlation	.365	-.599*	.022	-.488*	-.176	.187	.247	-.061	-.554*	.231	.395	.162
	Sig. (2-tailed)	.374	.011	.932	.047	.498	.473	.340	.816	.021	.372	.116	.535
	N	8	17	17	17	17	17	17	17	17	17	17	17
RtDensity	Pearson Correlation	.561	-.471	.156	-.170	.130	-.318	.028	-.003	-.554*	.391	.273	.279
	Sig. (2-tailed)	.148	.056	.549	.515	.618	.213	.916	.990	.021	.121	.289	.279
	N	8	17	17	17	17	17	17	17	17	17	17	17
ErosArea	Pearson Correlation	.843**	-.413	.234	.066	-.083	-.296	-.190	.022	-.469	.508*	.428	.099
	Sig. (2-tailed)	.009	.099	.366	.802	.751	.248	.464	.932	.057	.037	.087	.705
	N	8	17	17	17	17	17	17	17	17	17	17	17
LWD	Pearson Correlation	-.086	.198*	.202*	.085	-.193*	.019	-.034	.150	.037	-.147	-.025	.108
	Sig. (2-tailed)	.698	.043	.039	.388	.050	.849	.735	.127	.712	.136	.799	.276
	N	23	104	104	104	104	104	104	104	104	104	104	104
BasinKm2	Pearson Correlation	-.049	-.684**	-.685**	-.228*	.250**	.122	-.180	-.444**	.388**	.030	.056	-.199*
	Sig. (2-tailed)	.824	.000	.000	.014	.007	.203	.061	.000	.000	.754	.560	.037
	N	23	110	110	115	115	110	109	109	109	109	110	110
Relief	Pearson Correlation	-.021	-.554**	-.455**	.127	.096	.253**	.018	-.233*	.169	-.032	.152	.145
	Sig. (2-tailed)	.923	.000	.000	.176	.307	.008	.849	.015	.079	.743	.112	.132
	N	23	110	110	115	115	110	109	109	109	109	110	110
ConstAge	Pearson Correlation	-.117	.237*	.113	.498**	.235*	.482**	.127	-.007	-.050	-.040	.064	.224*
	Sig. (2-tailed)	.594	.013	.239	.000	.011	.000	.187	.945	.605	.683	.506	.019
	N	23	110	110	115	115	110	109	109	109	109	110	110
TIA	Pearson Correlation	-.059	.089	.147	.985**	-.329**	.208*	.108	.145	-.121	-.056	.331**	.440**
	Sig. (2-tailed)	.789	.357	.125	.000	.000	.029	.262	.133	.208	.566	.000	.000
	N	23	110	110	115	115	110	109	109	109	109	110	110

Individual variable correlations 8

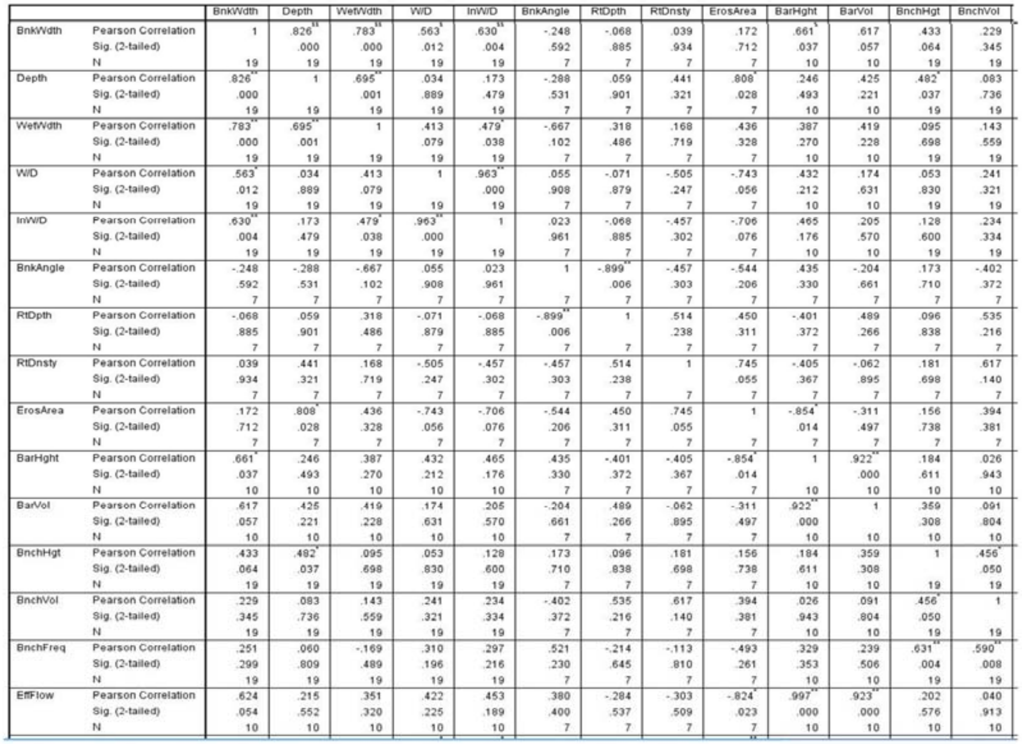


		LandRAct	RtVeg	LftVeg	LandRVeg	BnkAngle	RtDepth	RtDensity	ErosArea	LWD	BasinKm2	Relief	ConstAge	TIA
RtVeg	Pearson Correlation	.020	1	.540**	.897**	.578*	-.827**	-.751**	-.717**	.146	-.216*	-.214*	.410**	.310**
	Sig. (2-tailed)	.839		.000	.000	.015	.000	.001	.001	.139	.023	.025	.000	.001
	N	110	110	110	110	17	17	17	17	104	110	110	110	110
LftVeg	Pearson Correlation	.007	.540**	1	.857**	.531*	-.829**	-.619**	-.635**	.294**	-.368**	-.411**	.466**	.364**
	Sig. (2-tailed)	.945	.000		.000	.028	.000	.008	.006	.002	.000	.000	.000	.000
	N	110	110	110	110	17	17	17	17	104	110	110	110	110
LandRVeg	Pearson Correlation	.333**	.897**	.857**	1	.578*	-.860**	-.716**	-.705**	.241*	-.289**	-.324**	.383**	.171
	Sig. (2-tailed)	.000	.000	.000		.015	.000	.001	.002	.014	.002	.000	.000	.068
	N	115	110	110	115	17	17	17	17	104	115	115	115	115
BnkAngle	Pearson Correlation	-.338	.578*	.531*	.578*	1	-.650**	-.427	-.214	.765**	-.554*	-.575*	.382	.253
	Sig. (2-tailed)	.185	.015	.028	.015		.005	.087	.410	.000	.021	.016	.130	.326
	N	17	17	17	17	17	17	17	17	17	17	17	17	17
RtDepth	Pearson Correlation	.460	-.827**	-.829**	-.860**	-.650**	1	.621**	.498*	-.492*	.754**	.735**	-.657**	-.492*
	Sig. (2-tailed)	.063	.000	.000	.000	.005		.008	.042	.045	.000	.001	.004	.045
	N	17	17	17	17	17	17	17	17	17	17	17	17	17
RtDensity	Pearson Correlation	.439	-.751**	-.619**	-.716**	-.427	.621**	1	.824**	-.412	.757**	.454	-.514*	-.127
	Sig. (2-tailed)	.078	.001	.008	.001	.087	.008		.000	.100	.000	.067	.035	.628
	N	17	17	17	17	17	17	17	17	17	17	17	17	17
ErosArea	Pearson Correlation	.443	-.717**	-.635**	-.705**	-.214	.498*	.824**	1	-.087	.719**	.512*	-.689**	.097
	Sig. (2-tailed)	.075	.001	.006	.002	.410	.042	.000		.740	.001	.036	.002	.711
	N	17	17	17	17	17	17	17	17	17	17	17	17	17
LWD	Pearson Correlation	.042	.146	.294**	.241*	.765**	-.492*	-.412	-.087	1	-.217*	-.245*	.079	.093
	Sig. (2-tailed)	.672	.139	.002	.014	.000	.045	.100	.740		.027	.012	.424	.347
	N	104	104	104	104	17	17	17	17	104	104	104	104	104
BasinKm2	Pearson Correlation	-.073	-.216*	-.368**	-.289**	-.554*	.754**	.757**	.719**	-.217*	1	.741**	-.237*	-.237*
	Sig. (2-tailed)	.439	.023	.000	.002	.021	.000	.000	.001	.027		.000	.011	.011
	N	115	110	110	115	17	17	17	17	104	115	115	115	115
Relief	Pearson Correlation	.109	-.214*	-.411**	-.324**	-.575*	.735**	.454	.512*	-.245*	.741**	1	-.079	.114
	Sig. (2-tailed)	.248	.025	.000	.000	.016	.001	.067	.036	.012	.000		.403	.226
	N	115	110	110	115	17	17	17	17	104	115	115	115	115
ConstAge	Pearson Correlation	.098	.410**	.466**	.383**	.382	-.657**	-.514*	-.689**	.079	-.237*	-.079	1	.479**
	Sig. (2-tailed)	.300	.000	.000	.000	.130	.004	.035	.002	.424	.011	.403		.000
	N	115	110	110	115	17	17	17	17	104	115	115	115	115
TIA	Pearson Correlation	.190*	.310**	.364**	.171	.253	-.492*	-.127	.097	.093	-.237*	.114	.479**	1
	Sig. (2-tailed)	.042	.001	.000	.068	.326	.045	.628	.711	.347	.011	.226	.000	
	N	115	110	110	115	17	17	17	17	104	115	115	115	115

Individual variable correlations 9

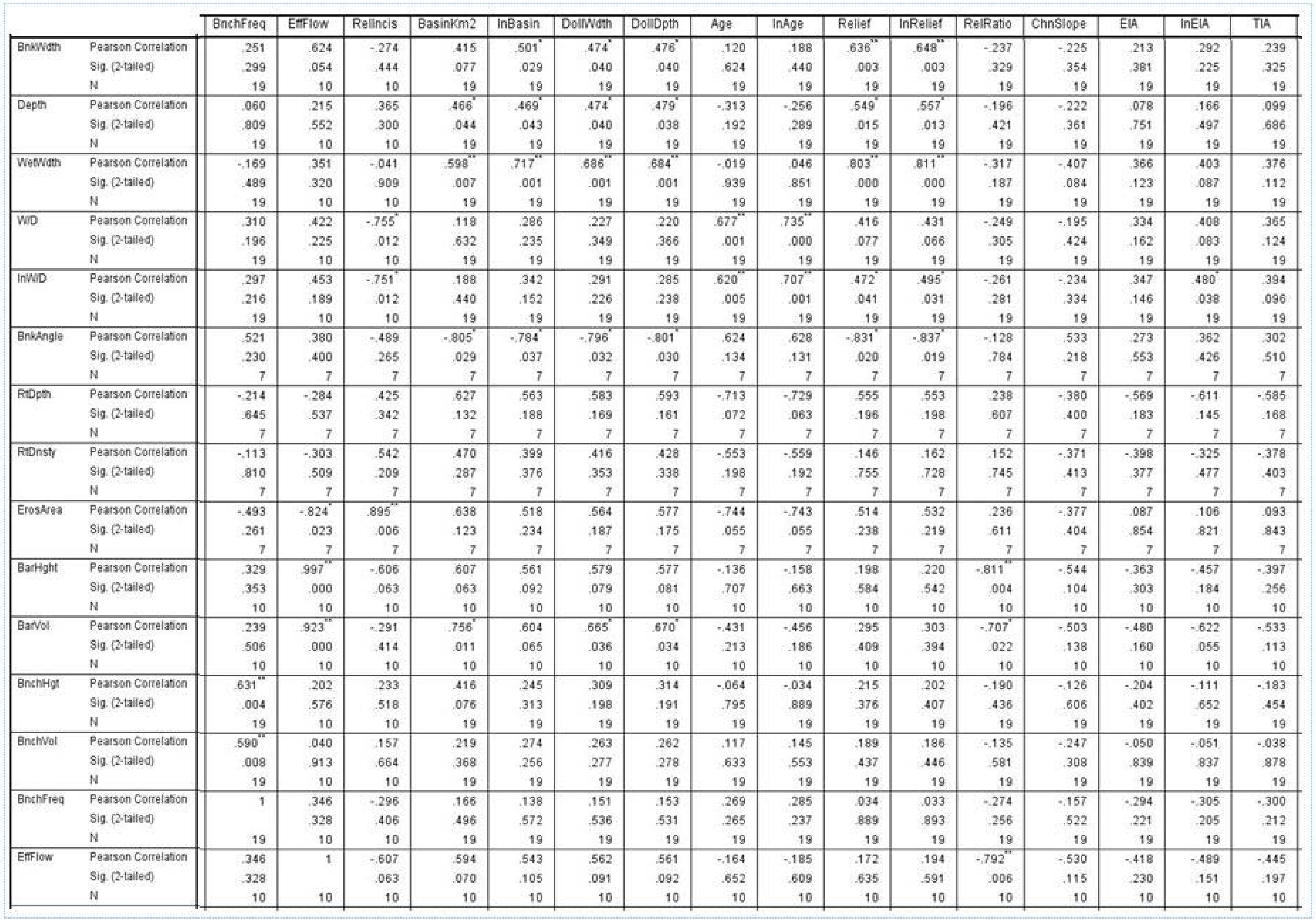
APPENDIX D

WATERSHED SCALE PEARSON CORRELATION MATRIX



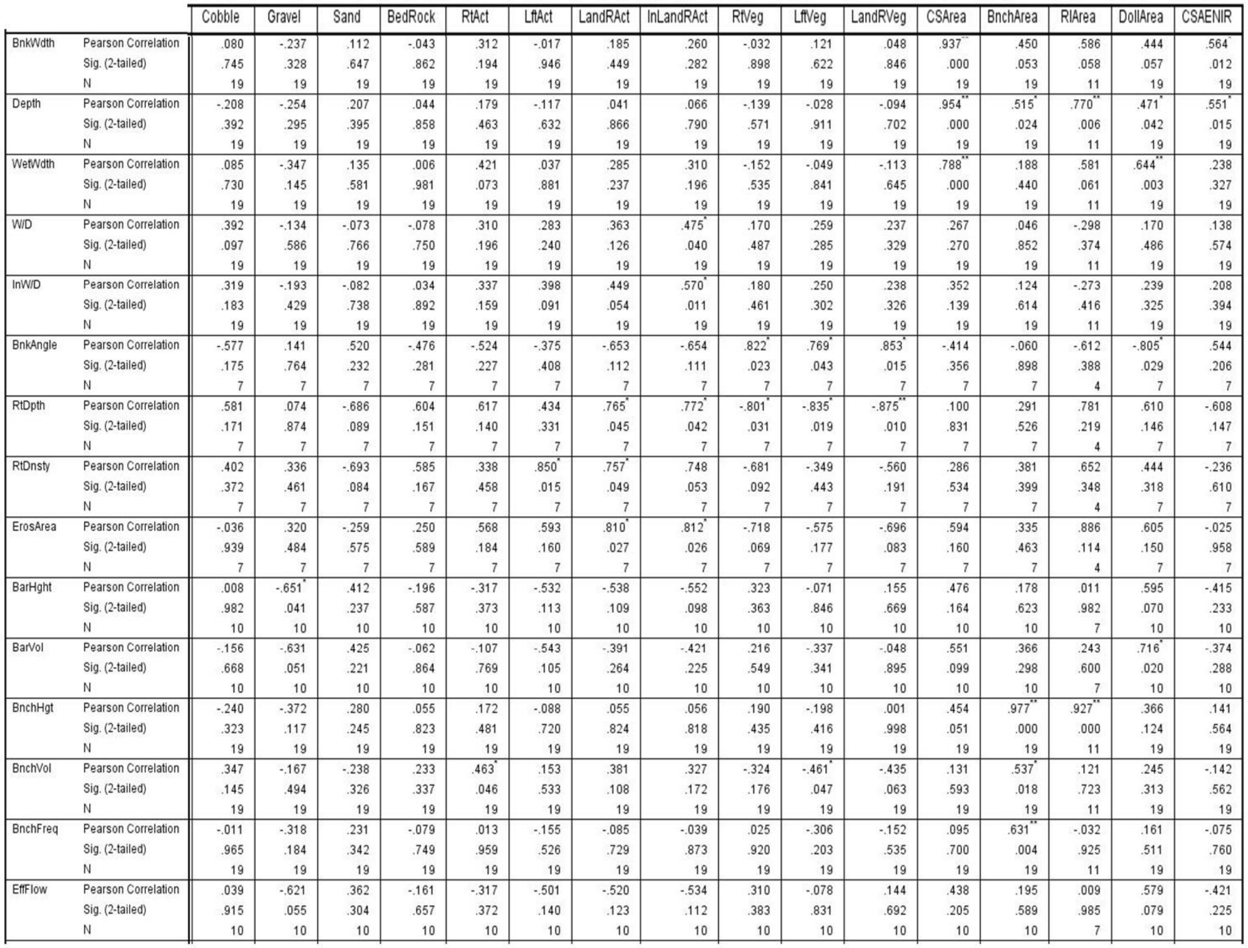
		BnkWdth	Depth	WetWdth	W/D	lnW/D	BnkAngle	RtDpth	RtDnsty	ErosArea	BarHght	BarVol	BnchHgt	BnchVol
BnkWdth	Pearson Correlation	1	.826**	.783**	.563*	.630**	-.248	-.068	.039	.172	.661*	.617	.433	.229
	Sig. (2-tailed)		.000	.000	.012	.004	.592	.885	.934	.712	.037	.057	.064	.345
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
Depth	Pearson Correlation	.826**	1	.695**	.034	.173	-.288	.059	.441	.808*	.246	.425	.482*	.083
	Sig. (2-tailed)	.000		.001	.889	.479	.531	.901	.321	.028	.493	.221	.037	.736
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
WetWdth	Pearson Correlation	.783**	.695**	1	.413	.479*	-.667	.318	.168	.436	.387	.419	.095	.143
	Sig. (2-tailed)	.000	.001		.079	.038	.102	.486	.719	.328	.270	.228	.698	.559
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
W/D	Pearson Correlation	.563*	.034	.413	1	.963**	.055	-.071	-.505	-.743	.432	.174	.053	.241
	Sig. (2-tailed)	.012	.889	.079		.000	.908	.879	.247	.056	.212	.631	.830	.321
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
lnW/D	Pearson Correlation	.630**	.173	.479*	.963**	1	.023	-.068	-.457	-.706	.465	.205	.128	.234
	Sig. (2-tailed)	.004	.479	.038	.000		.961	.885	.302	.076	.176	.570	.600	.334
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
BnkAngle	Pearson Correlation	-.248	-.288	-.667	.055	.023	1	-.899**	-.457	-.544	.435	-.204	.173	-.402
	Sig. (2-tailed)	.592	.531	.102	.908	.961		.006	.303	.206	.330	.661	.710	.372
	N	7	7	7	7	7	7	7	7	7	7	7	7	7
RtDpth	Pearson Correlation	-.068	.059	.318	-.071	-.068	-.899**	1	.514	.450	-.401	.489	.096	.535
	Sig. (2-tailed)	.885	.901	.486	.879	.885	.006		.238	.311	.372	.266	.838	.216
	N	7	7	7	7	7	7	7	7	7	7	7	7	7
RtDnsty	Pearson Correlation	.039	.441	.168	-.505	-.457	-.457	.514	1	.745	-.405	-.062	.181	.617
	Sig. (2-tailed)	.934	.321	.719	.247	.302	.303	.238		.055	.367	.895	.698	.140
	N	7	7	7	7	7	7	7	7	7	7	7	7	7
ErosArea	Pearson Correlation	.172	.808*	.436	-.743	-.706	-.544	.450	.745	1	-.854*	-.311	.156	.394
	Sig. (2-tailed)	.712	.028	.328	.056	.076	.206	.311	.055		.014	.497	.738	.381
	N	7	7	7	7	7	7	7	7	7	7	7	7	7
BarHght	Pearson Correlation	.661*	.246	.387	.432	.465	.435	-.401	-.405	-.854*	1	.922**	.184	.026
	Sig. (2-tailed)	.037	.493	.270	.212	.176	.330	.372	.367	.014		.000	.611	.943
	N	10	10	10	10	10	7	7	7	7	10	10	10	10
BarVol	Pearson Correlation	.617	.425	.419	.174	.205	-.204	.489	-.062	-.311	.922**	1	.359	.091
	Sig. (2-tailed)	.057	.221	.228	.631	.570	.661	.266	.895	.497	.000		.308	.804
	N	10	10	10	10	10	7	7	7	7	10	10	10	10
BnchHgt	Pearson Correlation	.433	.482*	.095	.053	.128	.173	.096	.181	.156	.184	.359	1	.456*
	Sig. (2-tailed)	.064	.037	.698	.830	.600	.710	.838	.698	.738	.611	.308		.050
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
BnchVol	Pearson Correlation	.229	.083	.143	.241	.234	-.402	.535	.617	.394	.026	.091	.456*	1
	Sig. (2-tailed)	.345	.736	.559	.321	.334	.372	.216	.140	.381	.943	.804	.050	
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
BnchFreq	Pearson Correlation	.251	.060	-.169	.310	.297	.521	-.214	-.113	-.493	.329	.239	.631**	.590**
	Sig. (2-tailed)	.299	.809	.489	.196	.216	.230	.645	.810	.261	.353	.506	.004	.008
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
EffFlow	Pearson Correlation	.624	.215	.351	.422	.453	.380	-.284	-.303	-.824*	.997**	.923**	.202	.040
	Sig. (2-tailed)	.054	.552	.320	.225	.189	.400	.537	.509	.023	.000	.000	.576	.913
	N	10	10	10	10	10	7	7	7	7	10	10	10	10

Mean Variable Correlations 1



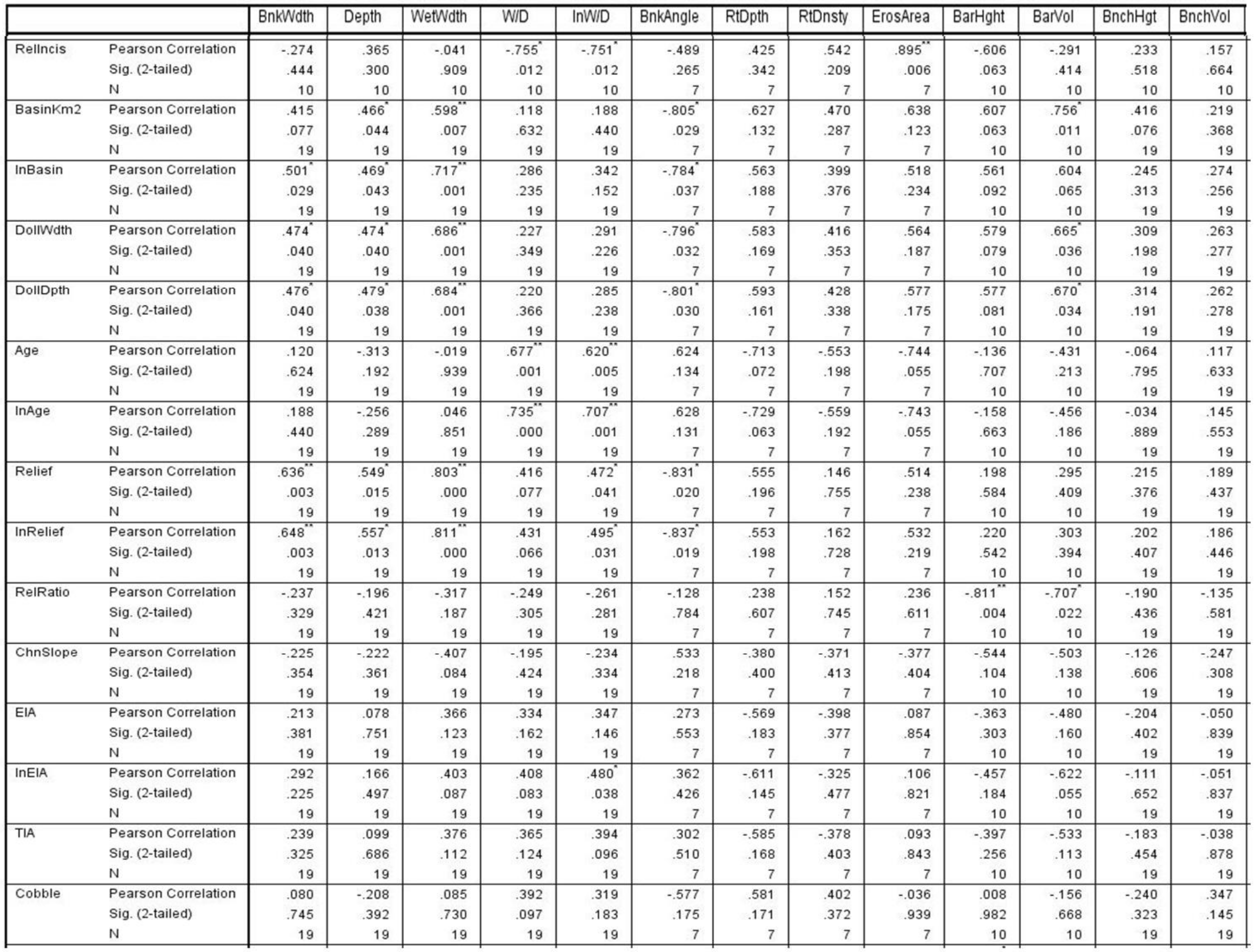
		BnchFreq	EffFlow	RelIncis	BasinKm2	lnBasin	DollWdth	DollDpth	Age	lnAge	Relief	lnRelief	RelRatio	ChnSlope	EIA	lnEIA	TIA
BnkWdth	Pearson Correlation	.251	.624	-.274	.415	.501*	.474*	.476*	.120	.188	.636**	.648**	-.237	-.225	.213	.292	.239
	Sig. (2-tailed)	.299	.054	.444	.077	.029	.040	.040	.624	.440	.003	.003	.329	.354	.381	.225	.325
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
Depth	Pearson Correlation	.060	.215	.365	.466*	.469*	.474*	.479*	-.313	-.256	.549*	.557*	-.196	-.222	.078	.166	.099
	Sig. (2-tailed)	.809	.552	.300	.044	.043	.040	.038	.192	.289	.015	.013	.421	.361	.751	.497	.686
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
WetWdth	Pearson Correlation	-.169	.351	-.041	.598**	.717**	.686**	.684**	-.019	.046	.803**	.811**	-.317	-.407	.366	.403	.376
	Sig. (2-tailed)	.489	.320	.909	.007	.001	.001	.001	.939	.851	.000	.000	.187	.084	.123	.087	.112
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
W/D	Pearson Correlation	.310	.422	-.755*	.118	.286	.227	.220	.677**	.735**	.416	.431	-.249	-.195	.334	.408	.365
	Sig. (2-tailed)	.196	.225	.012	.632	.235	.349	.366	.001	.000	.077	.066	.305	.424	.162	.083	.124
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
lnW/D	Pearson Correlation	.297	.453	-.751*	.188	.342	.291	.285	.620**	.707**	.472*	.495*	-.261	-.234	.347	.480*	.394
	Sig. (2-tailed)	.216	.189	.012	.440	.152	.226	.238	.005	.001	.041	.031	.281	.334	.146	.038	.096
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
BnkAngle	Pearson Correlation	.521	.380	-.489	-.805*	-.784*	-.796*	-.801*	.624	.628	-.831*	-.837*	-.128	.533	.273	.362	.302
	Sig. (2-tailed)	.230	.400	.265	.029	.037	.032	.030	.134	.131	.020	.019	.784	.218	.553	.426	.510
	N	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
RtDpth	Pearson Correlation	-.214	-.284	.425	.627	.563	.583	.593	-.713	-.729	.555	.553	.238	-.380	-.569	-.611	-.585
	Sig. (2-tailed)	.645	.537	.342	.132	.188	.169	.161	.072	.063	.196	.198	.607	.400	.183	.145	.168
	N	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
RtDnsty	Pearson Correlation	-.113	-.303	.542	.470	.399	.416	.428	-.553	-.559	.146	.162	.152	-.371	-.398	-.325	-.378
	Sig. (2-tailed)	.810	.509	.209	.287	.376	.353	.338	.198	.192	.755	.728	.745	.413	.377	.477	.403
	N	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
ErosArea	Pearson Correlation	-.493	-.824*	.895**	.638	.518	.564	.577	-.744	-.743	.514	.532	.236	-.377	.087	.106	.093
	Sig. (2-tailed)	.261	.023	.006	.123	.234	.187	.175	.055	.055	.238	.219	.611	.404	.854	.821	.843
	N	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
BarHght	Pearson Correlation	.329	.997**	-.606	.607	.561	.579	.577	-.136	-.158	.198	.220	-.811**	-.544	-.363	-.457	-.397
	Sig. (2-tailed)	.353	.000	.063	.063	.092	.079	.081	.707	.663	.584	.542	.004	.104	.303	.184	.256
	N	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
BarVol	Pearson Correlation	.239	.923**	-.291	.756*	.604	.665*	.670*	-.431	-.456	.295	.303	-.707*	-.503	-.480	-.622	-.533
	Sig. (2-tailed)	.506	.000	.414	.011	.065	.036	.034	.213	.186	.409	.394	.022	.138	.160	.055	.113
	N	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
BnchHgt	Pearson Correlation	.631**	.202	.233	.416	.245	.309	.314	-.064	-.034	.215	.202	-.190	-.126	-.204	-.111	-.183
	Sig. (2-tailed)	.004	.576	.518	.076	.313	.198	.191	.795	.889	.376	.407	.436	.606	.402	.652	.454
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
BnchVol	Pearson Correlation	.590**	.040	.157	.219	.274	.263	.262	.117	.145	.189	.186	-.135	-.247	-.050	-.051	-.038
	Sig. (2-tailed)	.008	.913	.664	.368	.256	.277	.278	.633	.553	.437	.446	.581	.308	.839	.837	.878
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
BnchFreq	Pearson Correlation	1	.346	-.296	.166	.138	.151	.153	.269	.285	.034	.033	-.274	-.157	-.294	-.305	-.300
	Sig. (2-tailed)		.328	.406	.496	.572	.536	.531	.265	.237	.889	.893	.256	.522	.221	.205	.212
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
EffFlow	Pearson Correlation	.346	1	-.607	.594	.543	.562	.561	-.164	-.185	.172	.194	-.792**	-.530	-.418	-.489	-.445
	Sig. (2-tailed)	.328		.063	.070	.105	.091	.092	.652	.609	.635	.591	.006	.115	.230	.151	.197
	N	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

Mean Variable Correlations 2



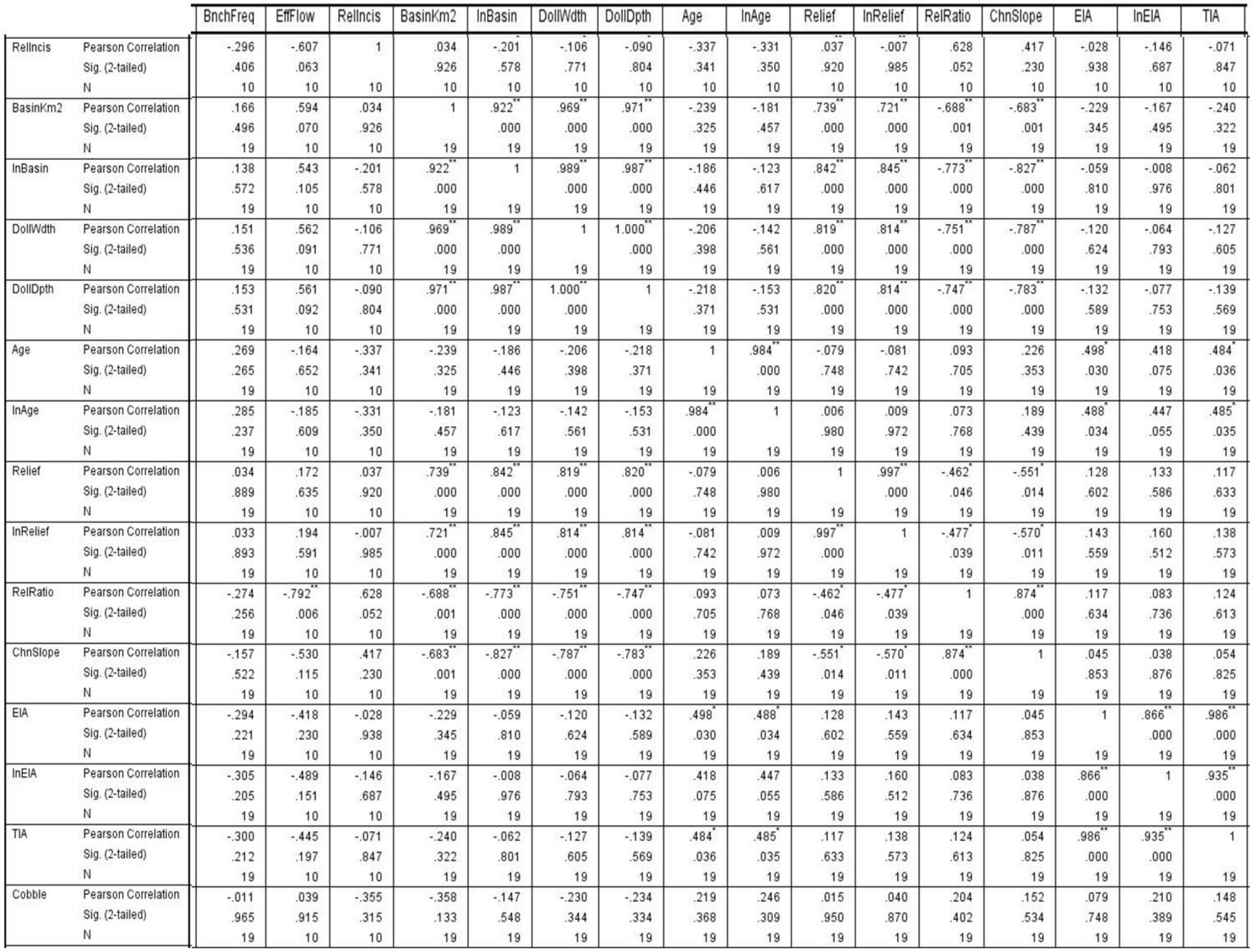
		Cobble	Gravel	Sand	BedRock	RtAct	LftAct	LandRAct	InLandRAct	RtVeg	LftVeg	LandRVeg	CSArea	BnchArea	RIArea	DollArea	CSAENIR
BnkWdth	Pearson Correlation	.080	-.237	.112	-.043	.312	-.017	.185	.260	-.032	.121	.048	.937**	.450	.586	.444	.564*
	Sig. (2-tailed)	.745	.328	.647	.862	.194	.946	.449	.282	.898	.622	.846	.000	.053	.058	.057	.012
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
Depth	Pearson Correlation	-.208	-.254	.207	.044	.179	-.117	.041	.066	-.139	-.028	-.094	.954**	.515*	.770**	.471*	.551*
	Sig. (2-tailed)	.392	.295	.395	.858	.463	.632	.866	.790	.571	.911	.702	.000	.024	.006	.042	.015
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
WetWdth	Pearson Correlation	.085	-.347	.135	.006	.421	.037	.285	.310	-.152	-.049	-.113	.788**	.188	.581	.644**	.238
	Sig. (2-tailed)	.730	.145	.581	.981	.073	.881	.237	.196	.535	.841	.645	.000	.440	.061	.003	.327
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
W/D	Pearson Correlation	.392	-.134	-.073	-.078	.310	.283	.363	.475*	.170	.259	.237	.267	.046	-.298	.170	.138
	Sig. (2-tailed)	.097	.586	.766	.750	.196	.240	.126	.040	.487	.285	.329	.270	.852	.374	.486	.574
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
lnW/D	Pearson Correlation	.319	-.193	-.082	.034	.337	.398	.449	.570*	.180	.250	.238	.352	.124	-.273	.239	.208
	Sig. (2-tailed)	.183	.429	.738	.892	.159	.091	.054	.011	.461	.302	.326	.139	.614	.416	.325	.394
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
BnkAngle	Pearson Correlation	-.577	.141	.520	-.476	-.524	-.375	-.653	-.654	.822*	.769*	.853*	-.414	-.060	-.612	-.805*	.544
	Sig. (2-tailed)	.175	.764	.232	.281	.227	.408	.112	.111	.023	.043	.015	.356	.898	.388	.029	.206
	N	7	7	7	7	7	7	7	7	7	7	7	7	7	4	7	7
RtDpth	Pearson Correlation	.581	.074	-.686	.604	.617	.434	.765*	.772*	-.801*	-.835*	-.875**	.100	.291	.781	.610	-.608
	Sig. (2-tailed)	.171	.874	.089	.151	.140	.331	.045	.042	.031	.019	.010	.831	.526	.219	.146	.147
	N	7	7	7	7	7	7	7	7	7	7	7	7	7	4	7	7
RtDnsty	Pearson Correlation	.402	.336	-.693	.585	.338	.850*	.757*	.748	-.681	-.349	-.560	.286	.381	.652	.444	-.236
	Sig. (2-tailed)	.372	.461	.084	.167	.458	.015	.049	.053	.092	.443	.191	.534	.399	.348	.318	.610
	N	7	7	7	7	7	7	7	7	7	7	7	7	7	4	7	7
ErosArea	Pearson Correlation	-.036	.320	-.259	.250	.568	.593	.810*	.812*	-.718	-.575	-.696	.594	.335	.886	.605	-.025
	Sig. (2-tailed)	.939	.484	.575	.589	.184	.160	.027	.026	.069	.177	.083	.160	.463	.114	.150	.958
	N	7	7	7	7	7	7	7	7	7	7	7	7	7	4	7	7
BarHght	Pearson Correlation	.008	-.651*	.412	-.196	-.317	-.532	-.538	-.552	.323	-.071	.155	.476	.178	.011	.595	-.415
	Sig. (2-tailed)	.982	.041	.237	.587	.373	.113	.109	.098	.363	.846	.669	.164	.623	.982	.070	.233
	N	10	10	10	10	10	10	10	10	10	10	10	10	10	7	10	10
BarVol	Pearson Correlation	-.156	-.631	.425	-.062	-.107	-.543	-.391	-.421	.216	-.337	-.048	.551	.366	.243	.716*	-.374
	Sig. (2-tailed)	.668	.051	.221	.864	.769	.105	.264	.225	.549	.341	.895	.099	.298	.600	.020	.288
	N	10	10	10	10	10	10	10	10	10	10	10	10	10	7	10	10
BnchHgt	Pearson Correlation	-.240	-.372	.280	.055	.172	-.088	.055	.056	.190	-.198	.001	.454	.977**	.927**	.366	.141
	Sig. (2-tailed)	.323	.117	.245	.823	.481	.720	.824	.818	.435	.416	.998	.051	.000	.000	.124	.564
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
BnchVol	Pearson Correlation	.347	-.167	-.238	.233	.463*	.153	.381	.327	-.324	-.461*	-.435	.131	.537*	.121	.245	-.142
	Sig. (2-tailed)	.145	.494	.326	.337	.046	.533	.108	.172	.176	.047	.063	.593	.018	.723	.313	.562
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
BnchFreq	Pearson Correlation	-.011	-.318	.231	-.079	.013	-.155	-.085	-.039	.025	-.306	-.152	.095	.631**	-.032	.161	-.075
	Sig. (2-tailed)	.965	.184	.342	.749	.959	.526	.729	.873	.920	.203	.535	.700	.004	.925	.511	.760
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
EffFlow	Pearson Correlation	.039	-.621	.362	-.161	-.317	-.501	-.520	-.534	.310	-.078	.144	.438	.195	.009	.579	-.421
	Sig. (2-tailed)	.915	.055	.304	.657	.372	.140	.123	.112	.383	.831	.692	.205	.589	.985	.079	.225
	N	10	10	10	10	10	10	10	10	10	10	10	10	10	7	10	10

Mean Variable Correlations 3



		BnkWdth	Depth	WetWdth	W/D	lnW/D	BnkAngle	RtDpth	RtDnsty	ErosArea	BarHght	BarVol	BnchHgt	BnchVol
RelIncis	Pearson Correlation	-.274	.365	-.041	-.755*	-.751*	-.489	.425	.542	.895**	-.606	-.291	.233	.157
	Sig. (2-tailed)	.444	.300	.909	.012	.012	.265	.342	.209	.006	.063	.414	.518	.664
	N	10	10	10	10	10	7	7	7	7	10	10	10	10
BasinKm2	Pearson Correlation	.415	.466*	.598**	.118	.188	-.805*	.627	.470	.638	.607	.756*	.416	.219
	Sig. (2-tailed)	.077	.044	.007	.632	.440	.029	.132	.287	.123	.063	.011	.076	.368
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
lnBasin	Pearson Correlation	.501*	.469*	.717**	.286	.342	-.784*	.563	.399	.518	.561	.604	.245	.274
	Sig. (2-tailed)	.029	.043	.001	.235	.152	.037	.188	.376	.234	.092	.065	.313	.256
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
DollWdth	Pearson Correlation	.474*	.474*	.686**	.227	.291	-.796*	.583	.416	.564	.579	.665*	.309	.263
	Sig. (2-tailed)	.040	.040	.001	.349	.226	.032	.169	.353	.187	.079	.036	.198	.277
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
DollDpth	Pearson Correlation	.476*	.479*	.684**	.220	.285	-.801*	.593	.428	.577	.577	.670*	.314	.262
	Sig. (2-tailed)	.040	.038	.001	.366	.238	.030	.161	.338	.175	.081	.034	.191	.278
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
Age	Pearson Correlation	.120	-.313	-.019	.677**	.620**	.624	-.713	-.553	-.744	-.136	-.431	-.064	.117
	Sig. (2-tailed)	.624	.192	.939	.001	.005	.134	.072	.198	.055	.707	.213	.795	.633
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
lnAge	Pearson Correlation	.188	-.256	.046	.735**	.707**	.628	-.729	-.559	-.743	-.158	-.456	-.034	.145
	Sig. (2-tailed)	.440	.289	.851	.000	.001	.131	.063	.192	.055	.663	.186	.889	.553
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
Relief	Pearson Correlation	.636**	.549*	.803**	.416	.472*	-.831*	.555	.146	.514	.198	.295	.215	.189
	Sig. (2-tailed)	.003	.015	.000	.077	.041	.020	.196	.755	.238	.584	.409	.376	.437
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
lnRelief	Pearson Correlation	.648**	.557*	.811**	.431	.495*	-.837*	.553	.162	.532	.220	.303	.202	.186
	Sig. (2-tailed)	.003	.013	.000	.066	.031	.019	.198	.728	.219	.542	.394	.407	.446
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
RelRatio	Pearson Correlation	-.237	-.196	-.317	-.249	-.261	-.128	.238	.152	.236	-.811**	-.707*	-.190	-.135
	Sig. (2-tailed)	.329	.421	.187	.305	.281	.784	.607	.745	.611	.004	.022	.436	.581
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
ChnSlope	Pearson Correlation	-.225	-.222	-.407	-.195	-.234	.533	-.380	-.371	-.377	-.544	-.503	-.126	-.247
	Sig. (2-tailed)	.354	.361	.084	.424	.334	.218	.400	.413	.404	.104	.138	.606	.308
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
EIA	Pearson Correlation	.213	.078	.366	.334	.347	.273	-.569	-.398	.087	-.363	-.480	-.204	-.050
	Sig. (2-tailed)	.381	.751	.123	.162	.146	.553	.183	.377	.854	.303	.160	.402	.839
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
lnEIA	Pearson Correlation	.292	.166	.403	.408	.480*	.362	-.611	-.325	.106	-.457	-.622	-.111	-.051
	Sig. (2-tailed)	.225	.497	.087	.083	.038	.426	.145	.477	.821	.184	.055	.652	.837
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
TIA	Pearson Correlation	.239	.099	.376	.365	.394	.302	-.585	-.378	.093	-.397	-.533	-.183	-.038
	Sig. (2-tailed)	.325	.686	.112	.124	.096	.510	.168	.403	.843	.256	.113	.454	.878
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
Cobble	Pearson Correlation	.080	-.208	.085	.392	.319	-.577	.581	.402	-.036	.008	-.156	-.240	.347
	Sig. (2-tailed)	.745	.392	.730	.097	.183	.175	.171	.372	.939	.982	.668	.323	.145
	N	19	19	19	19	19	7	7	7	7	10	10	19	19

Mean Variable Correlations 4

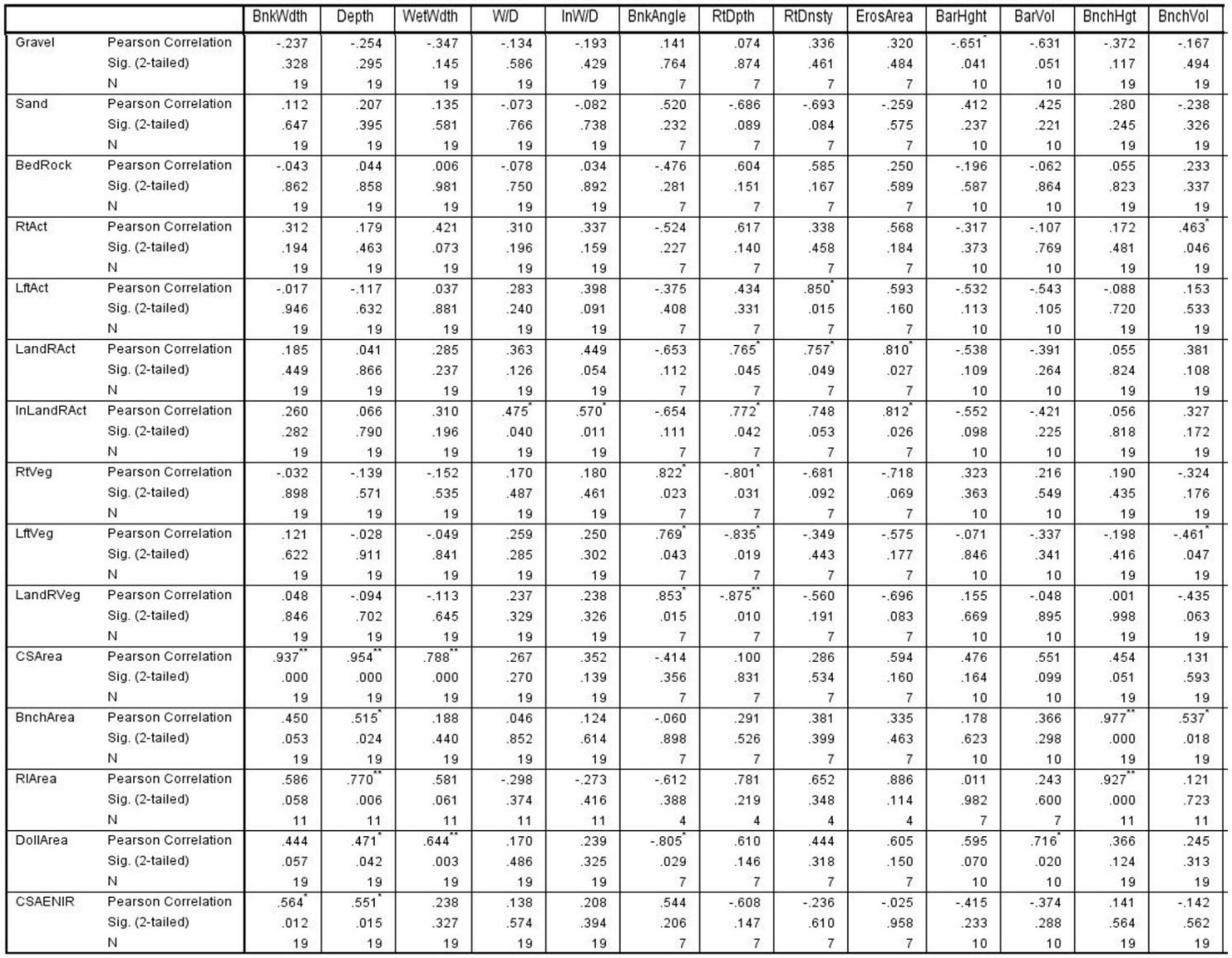


		BnchFreq	EffFlow	RelIncis	BasinKm2	lnBasin	DollWdth	DollDpth	Age	lnAge	Relief	lnRelief	RelRatio	ChnSlope	EIA	lnEIA	TIA
RelIncis	Pearson Correlation	-.296	-.607	1	.034	-.201	-.106	-.090	-.337	-.331	.037	-.007	.628	.417	-.028	-.146	-.071
	Sig. (2-tailed)	.406	.063		.926	.578	.771	.804	.341	.350	.920	.985	.052	.230	.938	.687	.847
	N	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
BasinKm2	Pearson Correlation	.166	.594	.034	1	.922**	.969**	.971**	-.239	-.181	.739**	.721**	-.688**	-.683**	-.229	-.167	-.240
	Sig. (2-tailed)	.496	.070	.926		.000	.000	.000	.325	.457	.000	.000	.001	.001	.345	.495	.322
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
lnBasin	Pearson Correlation	.138	.543	-.201	.922**	1	.989**	.987**	-.186	-.123	.842**	.845**	-.773**	-.827**	-.059	-.008	-.062
	Sig. (2-tailed)	.572	.105	.578	.000		.000	.000	.446	.617	.000	.000	.000	.000	.810	.976	.801
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
DollWdth	Pearson Correlation	.151	.562	-.106	.969**	.989**	1	1.000**	-.206	-.142	.819**	.814**	-.751**	-.787**	-.120	-.064	-.127
	Sig. (2-tailed)	.536	.091	.771	.000	.000		.000	.398	.561	.000	.000	.000	.000	.624	.793	.605
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
DollDpth	Pearson Correlation	.153	.561	-.090	.971**	.987**	1.000**	1	-.218	-.153	.820**	.814**	-.747**	-.783**	-.132	-.077	-.139
	Sig. (2-tailed)	.531	.092	.804	.000	.000	.000		.371	.531	.000	.000	.000	.000	.589	.753	.569
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
Age	Pearson Correlation	.269	-.164	-.337	-.239	-.186	-.206	-.218	1	.984**	-.079	-.081	.093	.226	.498*	.418	.484*
	Sig. (2-tailed)	.265	.652	.341	.325	.446	.398	.371		.000	.748	.742	.705	.353	.030	.075	.036
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
lnAge	Pearson Correlation	.285	-.185	-.331	-.181	-.123	-.142	-.153	.984**	1	.006	.009	.073	.189	.488*	.447	.485*
	Sig. (2-tailed)	.237	.609	.350	.457	.617	.561	.531	.000		.980	.972	.768	.439	.034	.055	.035
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
Relief	Pearson Correlation	.034	.172	.037	.739**	.842**	.819**	.820**	-.079	.006	1	.997**	-.462*	-.551*	.128	.133	.117
	Sig. (2-tailed)	.889	.635	.920	.000	.000	.000	.000	.748	.980		.000	.046	.014	.602	.586	.633
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
lnRelief	Pearson Correlation	.033	.194	-.007	.721**	.845**	.814**	.814**	-.081	.009	.997**	1	-.477*	-.570*	.143	.160	.138
	Sig. (2-tailed)	.893	.591	.985	.000	.000	.000	.000	.742	.972	.000		.039	.011	.559	.512	.573
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
RelRatio	Pearson Correlation	-.274	-.792**	.628	-.688**	-.773**	-.751**	-.747**	.093	.073	-.462*	-.477*	1	.874**	.117	.083	.124
	Sig. (2-tailed)	.256	.006	.052	.001	.000	.000	.000	.705	.768	.046	.039		.000	.634	.736	.613
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
ChnSlope	Pearson Correlation	-.157	-.530	.417	-.683**	-.827**	-.787**	-.783**	.226	.189	-.551*	-.570*	.874**	1	.045	.038	.054
	Sig. (2-tailed)	.522	.115	.230	.001	.000	.000	.000	.353	.439	.014	.011	.000		.853	.876	.825
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
EIA	Pearson Correlation	-.294	-.418	-.028	-.229	-.059	-.120	-.132	.498*	.488*	.128	.143	.117	.045	1	.866**	.986**
	Sig. (2-tailed)	.221	.230	.938	.345	.810	.624	.589	.030	.034	.602	.559	.634	.853		.000	.000
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
lnEIA	Pearson Correlation	-.305	-.489	-.146	-.167	-.008	-.064	-.077	.418	.447	.133	.160	.083	.038	.866**	1	.935**
	Sig. (2-tailed)	.205	.151	.687	.495	.976	.793	.753	.075	.055	.586	.512	.736	.876	.000		.000
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
TIA	Pearson Correlation	-.300	-.445	-.071	-.240	-.062	-.127	-.139	.484*	.485*	.117	.138	.124	.054	.986**	.935**	1
	Sig. (2-tailed)	.212	.197	.847	.322	.801	.605	.569	.036	.035	.633	.573	.613	.825	.000	.000	
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
Cobble	Pearson Correlation	-.011	.039	-.355	-.358	-.147	-.230	-.234	.219	.246	.015	.040	.204	.152	.079	.210	.148
	Sig. (2-tailed)	.965	.915	.315	.133	.548	.344	.334	.368	.309	.950	.870	.402	.534	.748	.389	.545
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19

Mean Variable Correlations 5

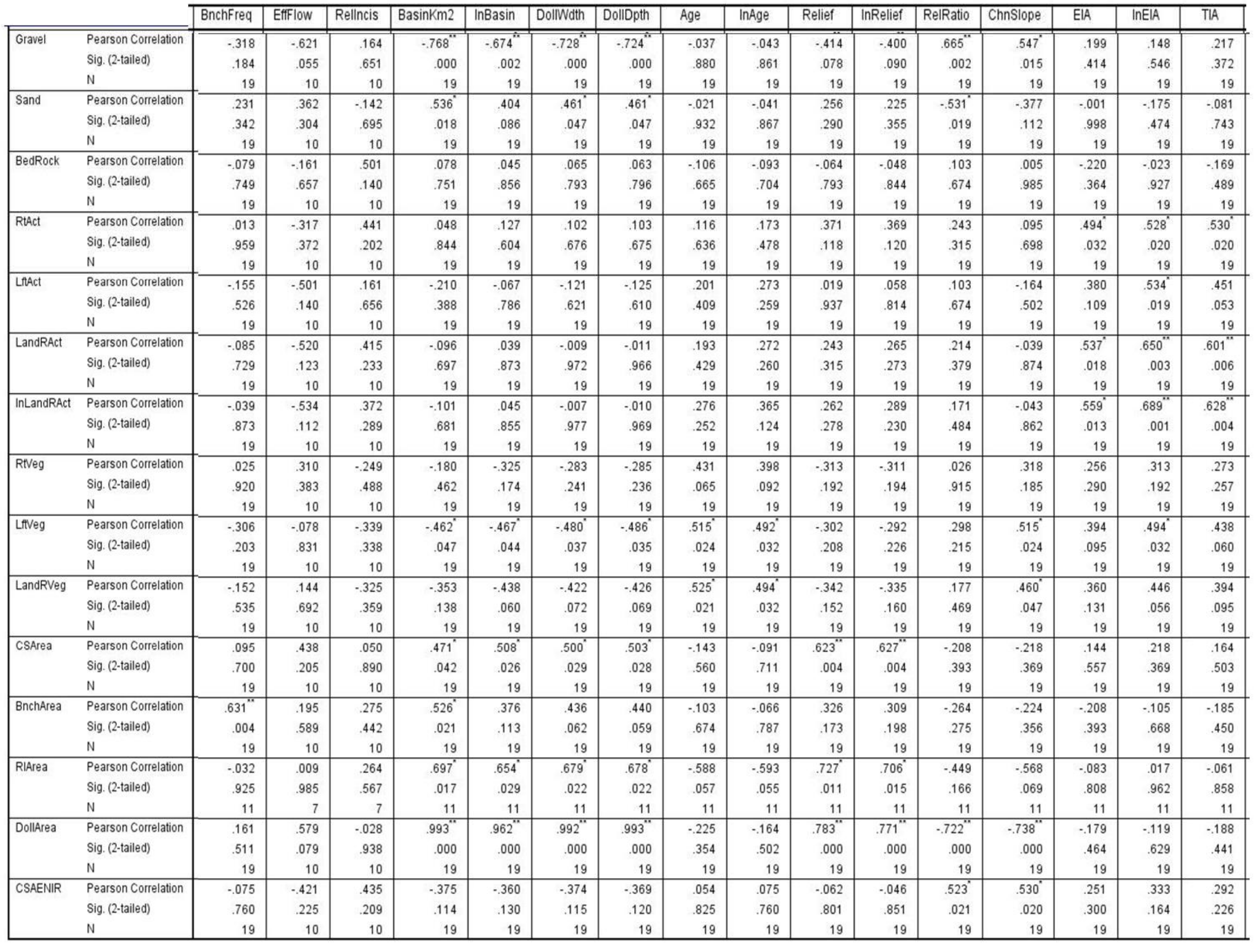
		Cobble	Gravel	Sand	BedRock	RtAct	LftAct	LandRAct	InLandRAct	RtVeg	LftVeg	LandRVeg	CSArea	BnchArea	RIArea	DollArea	CSAENIR
RelIncis	Pearson Correlation	-.355	.164	-.142	.501	.441	.161	.415	.372	-.249	-.339	-.325	.050	.275	.264	-.028	.435
	Sig. (2-tailed)	.315	.651	.695	.140	.202	.656	.233	.289	.488	.338	.359	.890	.442	.567	.938	.209
	N	10	10	10	10	10	10	10	10	10	10	10	10	10	7	10	10
BasinKm2	Pearson Correlation	-.358	-.768**	.536*	.078	.048	-.210	-.096	-.101	-.180	-.462*	-.353	.471*	.526*	.697*	.993**	-.375
	Sig. (2-tailed)	.133	.000	.018	.751	.844	.388	.697	.681	.462	.047	.138	.042	.021	.017	.000	.114
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
InBasin	Pearson Correlation	-.147	-.674**	.404	.045	.127	-.067	.039	.045	-.325	-.467*	-.438	.508*	.376	.654*	.962**	-.360
	Sig. (2-tailed)	.548	.002	.086	.856	.604	.786	.873	.855	.174	.044	.060	.026	.113	.029	.000	.130
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
DollWdth	Pearson Correlation	-.230	-.728**	.461*	.065	.102	-.121	-.009	-.007	-.283	-.480*	-.422	.500*	.436	.679*	.992**	-.374
	Sig. (2-tailed)	.344	.000	.047	.793	.676	.621	.972	.977	.241	.037	.072	.029	.062	.022	.000	.115
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
DollDpth	Pearson Correlation	-.234	-.724**	.461*	.063	.103	-.125	-.011	-.010	-.285	-.486*	-.426	.503*	.440	.678*	.993**	-.369
	Sig. (2-tailed)	.334	.000	.047	.796	.675	.610	.966	.969	.236	.035	.069	.028	.059	.022	.000	.120
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
Age	Pearson Correlation	.219	-.037	-.021	-.106	.116	.201	.193	.276	.431	.515*	.525*	-.143	-.103	-.588	-.225	.054
	Sig. (2-tailed)	.368	.880	.932	.665	.636	.409	.429	.252	.065	.024	.021	.560	.674	.057	.354	.825
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
InAge	Pearson Correlation	.246	-.043	-.041	-.093	.173	.273	.272	.365	.398	.492*	.494*	-.091	-.066	-.593	-.164	.075
	Sig. (2-tailed)	.309	.861	.867	.704	.478	.259	.260	.124	.092	.032	.032	.711	.787	.055	.502	.760
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
Relief	Pearson Correlation	.015	-.414	.256	-.064	.371	.019	.243	.262	-.313	-.302	-.342	.623**	.326	.727*	.783**	-.062
	Sig. (2-tailed)	.950	.078	.290	.793	.118	.937	.315	.278	.192	.208	.152	.004	.173	.011	.000	.801
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
InRelief	Pearson Correlation	.040	-.400	.225	-.048	.369	.058	.265	.289	-.311	-.292	-.335	.627**	.309	.706*	.771**	-.046
	Sig. (2-tailed)	.870	.090	.355	.844	.120	.814	.273	.230	.194	.226	.160	.004	.198	.015	.000	.851
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
RelRatio	Pearson Correlation	.204	.665**	-.531*	.103	.243	.103	.214	.171	.026	.298	.177	-.208	-.264	-.449	-.722**	.523*
	Sig. (2-tailed)	.402	.002	.019	.674	.315	.674	.379	.484	.915	.215	.469	.393	.275	.166	.000	.021
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
ChnSlope	Pearson Correlation	.152	.547*	-.377	.005	.095	-.164	-.039	-.043	.318	.515*	.460*	-.218	-.224	-.568	-.738**	.530*
	Sig. (2-tailed)	.534	.015	.112	.985	.698	.502	.874	.862	.185	.024	.047	.369	.356	.069	.000	.020
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
EIA	Pearson Correlation	.079	.199	-.001	-.220	.494*	.380	.537*	.559*	.256	.394	.360	.144	-.208	-.083	-.179	.251
	Sig. (2-tailed)	.748	.414	.998	.364	.032	.109	.018	.013	.290	.095	.131	.557	.393	.808	.464	.300
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
InEIA	Pearson Correlation	.210	.148	-.175	-.023	.528*	.534*	.650**	.689**	.313	.494*	.446	.218	-.105	.017	-.119	.333
	Sig. (2-tailed)	.389	.546	.474	.927	.020	.019	.003	.001	.192	.032	.056	.369	.668	.962	.629	.164
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
TIA	Pearson Correlation	.148	.217	-.081	-.169	.530*	.451	.601**	.628**	.273	.438	.394	.164	-.185	-.061	-.188	.292
	Sig. (2-tailed)	.545	.372	.743	.489	.020	.053	.006	.004	.257	.060	.095	.503	.450	.858	.441	.226
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
Cobble	Pearson Correlation	1	.379	-.723**	.033	.275	.362	.389	.391	-.111	.218	.055	-.070	-.200	-.431	-.298	.136
	Sig. (2-tailed)		.110	.000	.895	.255	.127	.100	.098	.651	.370	.822	.775	.412	.186	.215	.580
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19

Mean Variable Correlations 6



		BnkWdth	Depth	WetWdth	W/D	lnW/D	BnkAngle	RtDpth	RtDnsty	ErosArea	BarHght	BarVol	BnchHgt	BnchVol
Gravel	Pearson Correlation	-.237	-.254	-.347	-.134	-.193	.141	.074	.336	.320	-.651*	-.631	-.372	-.167
	Sig. (2-tailed)	.328	.295	.145	.586	.429	.764	.874	.461	.484	.041	.051	.117	.494
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
Sand	Pearson Correlation	.112	.207	.135	-.073	-.082	.520	-.686	-.693	-.259	.412	.425	.280	-.238
	Sig. (2-tailed)	.647	.395	.581	.766	.738	.232	.089	.084	.575	.237	.221	.245	.326
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
BedRock	Pearson Correlation	-.043	.044	.006	-.078	.034	-.476	.604	.585	.250	-.196	-.062	.055	.233
	Sig. (2-tailed)	.862	.858	.981	.750	.892	.281	.151	.167	.589	.587	.864	.823	.337
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
RtAct	Pearson Correlation	.312	.179	.421	.310	.337	-.524	.617	.338	.568	-.317	-.107	.172	.463*
	Sig. (2-tailed)	.194	.463	.073	.196	.159	.227	.140	.458	.184	.373	.769	.481	.046
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
LftAct	Pearson Correlation	-.017	-.117	.037	.283	.398	-.375	.434	.850*	.593	-.532	-.543	-.088	.153
	Sig. (2-tailed)	.946	.632	.881	.240	.091	.408	.331	.015	.160	.113	.105	.720	.533
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
LandRAct	Pearson Correlation	.185	.041	.285	.363	.449	-.653	.765*	.757*	.810*	-.538	-.391	.055	.381
	Sig. (2-tailed)	.449	.866	.237	.126	.054	.112	.045	.049	.027	.109	.264	.824	.108
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
InLandRAct	Pearson Correlation	.260	.066	.310	.475*	.570*	-.654	.772*	.748	.812*	-.552	-.421	.056	.327
	Sig. (2-tailed)	.282	.790	.196	.040	.011	.111	.042	.053	.026	.098	.225	.818	.172
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
RtVeg	Pearson Correlation	-.032	-.139	-.152	.170	.180	.822*	-.801*	-.681	-.718	.323	.216	.190	-.324
	Sig. (2-tailed)	.898	.571	.535	.487	.461	.023	.031	.092	.069	.363	.549	.435	.176
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
LftVeg	Pearson Correlation	.121	-.028	-.049	.259	.250	.769*	-.835*	-.349	-.575	-.071	-.337	-.198	-.461*
	Sig. (2-tailed)	.622	.911	.841	.285	.302	.043	.019	.443	.177	.846	.341	.416	.047
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
LandRVeg	Pearson Correlation	.048	-.094	-.113	.237	.238	.853*	-.875**	-.560	-.696	.155	-.048	.001	-.435
	Sig. (2-tailed)	.846	.702	.645	.329	.326	.015	.010	.191	.083	.669	.895	.998	.063
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
CSArea	Pearson Correlation	.937**	.954**	.788**	.267	.352	-.414	.100	.286	.594	.476	.551	.454	.131
	Sig. (2-tailed)	.000	.000	.000	.270	.139	.356	.831	.534	.160	.164	.099	.051	.593
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
BnchArea	Pearson Correlation	.450	.515*	.188	.046	.124	-.060	.291	.381	.335	.178	.366	.977**	.537*
	Sig. (2-tailed)	.053	.024	.440	.852	.614	.898	.526	.399	.463	.623	.298	.000	.018
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
RlArea	Pearson Correlation	.586	.770**	.581	-.298	-.273	-.612	.781	.652	.886	.011	.243	.927**	.121
	Sig. (2-tailed)	.058	.006	.061	.374	.416	.388	.219	.348	.114	.982	.600	.000	.723
	N	11	11	11	11	11	4	4	4	4	7	7	11	11
DollArea	Pearson Correlation	.444	.471*	.644**	.170	.239	-.805*	.610	.444	.605	.595	.716*	.366	.245
	Sig. (2-tailed)	.057	.042	.003	.486	.325	.029	.146	.318	.150	.070	.020	.124	.313
	N	19	19	19	19	19	7	7	7	7	10	10	19	19
CSAENIR	Pearson Correlation	.564*	.551*	.238	.138	.208	.544	-.608	-.236	-.025	-.415	-.374	.141	-.142
	Sig. (2-tailed)	.012	.015	.327	.574	.394	.206	.147	.610	.958	.233	.288	.564	.562
	N	19	19	19	19	19	7	7	7	7	10	10	19	19

Mean Variable Correlations 7



		BnchFreq	EffFlow	RelIncis	BasinKm2	lnBasin	DollWdth	DollDpth	Age	lnAge	Relief	lnRelief	RelRatio	ChnSlope	EIA	lnEIA	TIA
Gravel	Pearson Correlation	-.318	-.621	.164	-.768**	-.674**	-.728**	-.724**	-.037	-.043	-.414	-.400	.665**	.547*	.199	.148	.217
	Sig. (2-tailed)	.184	.055	.651	.000	.002	.000	.000	.880	.861	.078	.090	.002	.015	.414	.546	.372
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
Sand	Pearson Correlation	.231	.362	-.142	.536*	.404	.461*	.461*	-.021	-.041	.256	.225	-.531*	-.377	-.001	-.175	-.081
	Sig. (2-tailed)	.342	.304	.695	.018	.086	.047	.047	.932	.867	.290	.355	.019	.112	.998	.474	.743
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
BedRock	Pearson Correlation	-.079	-.161	.501	.078	.045	.065	.063	-.106	-.093	-.064	-.048	.103	.005	-.220	-.023	-.169
	Sig. (2-tailed)	.749	.657	.140	.751	.856	.793	.796	.665	.704	.793	.844	.674	.985	.364	.927	.489
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
RtAct	Pearson Correlation	.013	-.317	.441	.048	.127	.102	.103	.116	.173	.371	.369	.243	.095	.494*	.528*	.530*
	Sig. (2-tailed)	.959	.372	.202	.844	.604	.676	.675	.636	.478	.118	.120	.315	.698	.032	.020	.020
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
LftAct	Pearson Correlation	-.155	-.501	.161	-.210	-.067	-.121	-.125	.201	.273	.019	.058	.103	-.164	.380	.534*	.451
	Sig. (2-tailed)	.526	.140	.656	.388	.786	.621	.610	.409	.259	.937	.814	.674	.502	.109	.019	.053
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
LandRAct	Pearson Correlation	-.085	-.520	.415	-.096	.039	-.009	-.011	.193	.272	.243	.265	.214	-.039	.537*	.650**	.601**
	Sig. (2-tailed)	.729	.123	.233	.697	.873	.972	.966	.429	.260	.315	.273	.379	.874	.018	.003	.006
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
lnLandRAct	Pearson Correlation	-.039	-.534	.372	-.101	.045	-.007	-.010	.276	.365	.262	.289	.171	-.043	.559*	.689**	.628**
	Sig. (2-tailed)	.873	.112	.289	.681	.855	.977	.969	.252	.124	.278	.230	.484	.862	.013	.001	.004
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
RfVeg	Pearson Correlation	.025	.310	-.249	-.180	-.325	-.283	-.285	.431	.398	-.313	-.311	.026	.318	.256	.313	.273
	Sig. (2-tailed)	.920	.383	.488	.462	.174	.241	.236	.065	.092	.192	.194	.915	.185	.290	.192	.257
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
LftVeg	Pearson Correlation	-.306	-.078	-.339	-.462*	-.467*	-.480*	-.486*	.515*	.492*	-.302	-.292	.298	.515*	.394	.494*	.438
	Sig. (2-tailed)	.203	.831	.338	.047	.044	.037	.035	.024	.032	.208	.226	.215	.024	.095	.032	.060
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
LandRVeg	Pearson Correlation	-.152	.144	-.325	-.353	-.438	-.422	-.426	.525*	.494*	-.342	-.335	.177	.460*	.360	.446	.394
	Sig. (2-tailed)	.535	.692	.359	.138	.060	.072	.069	.021	.032	.152	.160	.469	.047	.131	.056	.095
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
CSArea	Pearson Correlation	.095	.438	.050	.471*	.508*	.500*	.503*	-.143	-.091	.623**	.627**	-.208	-.218	.144	.218	.164
	Sig. (2-tailed)	.700	.205	.890	.042	.026	.029	.028	.560	.711	.004	.004	.393	.369	.557	.369	.503
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
BnchArea	Pearson Correlation	.631**	.195	.275	.526*	.376	.436	.440	-.103	-.066	.326	.309	-.264	-.224	-.208	-.105	-.185
	Sig. (2-tailed)	.004	.589	.442	.021	.113	.062	.059	.674	.787	.173	.198	.275	.356	.393	.668	.450
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
RIArea	Pearson Correlation	-.032	.009	.264	.697*	.654*	.679*	.678*	-.588	-.593	.727*	.706*	-.449	-.568	-.083	.017	-.061
	Sig. (2-tailed)	.925	.985	.567	.017	.029	.022	.022	.057	.055	.011	.015	.166	.069	.808	.962	.858
	N	11	7	7	11	11	11	11	11	11	11	11	11	11	11	11	11
DollArea	Pearson Correlation	.161	.579	-.028	.993**	.962**	.992**	.993**	-.225	-.164	.783**	.771**	-.722**	-.738**	-.179	-.119	-.188
	Sig. (2-tailed)	.511	.079	.938	.000	.000	.000	.000	.354	.502	.000	.000	.000	.000	.464	.629	.441
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19
CSAENIR	Pearson Correlation	-.075	-.421	.435	-.375	-.360	-.374	-.369	.054	.075	-.062	-.046	.523*	.530*	.251	.333	.292
	Sig. (2-tailed)	.760	.225	.209	.114	.130	.115	.120	.825	.760	.801	.851	.021	.020	.300	.164	.226
	N	19	10	10	19	19	19	19	19	19	19	19	19	19	19	19	19

Mean Variable Correlations 8

		Cobble	Gravel	Sand	BedRock	RtAct	LftAct	LandRAct	InLandRAct	RtVeg	LftVeg	LandRVeg	CSArea	BnchArea	RIArea	DollArea	CSAENIR
Gravel	Pearson Correlation	.379	1	-.521	-.301	.245	.315	.342	.308	-.094	.354	.139	-.245	-.434	-.414	-.756	.378
	Sig. (2-tailed)	.110		.022	.210	.313	.188	.152	.200	.702	.137	.570	.313	.063	.206	.000	.111
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
Sand	Pearson Correlation	-.723**	-.521*	1	-.532*	-.237	-.457*	-.422	-.393	.198	-.182	.014	.184	.308	.518	.502*	-.324
	Sig. (2-tailed)	.000	.022		.019	.328	.049	.072	.096	.417	.457	.955	.450	.200	.102	.029	.176
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
BedRock	Pearson Correlation	.033	-.301	-.532*	1	-.052	.156	.061	.043	-.144	-.180	-.179	-.031	.035	-.324	.076	.072
	Sig. (2-tailed)	.895	.210	.019		.833	.523	.803	.861	.558	.461	.462	.898	.887	.330	.757	.768
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
RtAct	Pearson Correlation	.275	.245	-.237	-.052	1	.334	.825**	.787**	-.059	-.109	-.093	.244	.229	.191	.076	.234
	Sig. (2-tailed)	.255	.313	.328	.833		.163	.000	.000	.810	.657	.706	.313	.346	.573	.757	.334
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
LftAct	Pearson Correlation	.362	.315	-.457*	.156	.334	1	.808**	.821**	.062	.183	.135	-.135	-.092	-.295	-.168	.053
	Sig. (2-tailed)	.127	.188	.049	.523	.163		.000	.000	.802	.452	.582	.583	.708	.378	.491	.829
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
LandRAct	Pearson Correlation	.389	.342	-.422	.061	.825**	.808**	1	.985**	.000	.042	.023	.072	.088	-.006	-.053	.178
	Sig. (2-tailed)	.100	.152	.072	.803	.000	.000		.000	.999	.865	.926	.770	.721	.987	.828	.465
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
InLandRAct	Pearson Correlation	.391	.308	-.393	.043	.787**	.821**	.985**	1	.084	.121	.113	.110	.075	-.098	-.056	.236
	Sig. (2-tailed)	.098	.200	.096	.861	.000	.000	.000		.732	.622	.644	.653	.761	.775	.821	.330
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
RtVeg	Pearson Correlation	-.111	-.094	.198	-.144	-.059	.062	.000	.084	1	.618**	.904**	-.115	.077	-.395	-.235	.183
	Sig. (2-tailed)	.651	.702	.417	.558	.810	.802	.999	.732		.005	.000	.641	.755	.229	.332	.452
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
LftVeg	Pearson Correlation	.218	.354	-.182	-.180	-.109	.183	.042	.121	.618**	1	.894**	.052	-.290	-.368	-.479*	.486*
	Sig. (2-tailed)	.370	.137	.457	.461	.657	.452	.865	.622	.005		.000	.833	.228	.266	.038	.035
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
LandRVeg	Pearson Correlation	.055	.139	.014	-.179	-.093	.135	.023	.113	.904**	.894**	1	-.037	-.114	-.401	-.394	.368
	Sig. (2-tailed)	.822	.570	.955	.462	.706	.582	.926	.644	.000	.000		.881	.642	.221	.095	.121
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
CSArea	Pearson Correlation	-.070	-.245	.184	-.031	.244	-.135	.072	.110	-.115	.052	-.037	1	.487*	.735**	.485*	.569*
	Sig. (2-tailed)	.775	.313	.450	.898	.313	.583	.770	.653	.641	.833	.881		.035	.010	.035	.011
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
BnchArea	Pearson Correlation	-.200	-.434	.308	.035	.229	-.092	.088	.075	.077	-.290	-.114	.487*	1	.996**	.485*	.048
	Sig. (2-tailed)	.412	.063	.200	.887	.346	.708	.721	.761	.755	.228	.642	.035		.000	.035	.844
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
RIArea	Pearson Correlation	-.431	-.414	.518	-.324	.191	-.295	-.006	-.098	-.395	-.368	-.401	.735**	.996**	1	.692*	-.143
	Sig. (2-tailed)	.186	.206	.102	.330	.573	.378	.987	.775	.229	.266	.221	.010	.000		.018	.674
	N	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
DollArea	Pearson Correlation	-.298	-.756**	.502*	.076	.076	-.168	-.053	-.056	-.235	-.479*	-.394	.485*	.485*	.692*	1	-.379
	Sig. (2-tailed)	.215	.000	.029	.757	.757	.491	.828	.821	.332	.038	.095	.035	.035	.018		.109
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19
CSAENIR	Pearson Correlation	.136	.378	-.324	.072	.234	.053	.178	.236	.183	.486*	.368	.569*	.048	-.143	-.379	1
	Sig. (2-tailed)	.580	.111	.176	.768	.334	.829	.465	.330	.452	.035	.121	.011	.844	.674	.109	
	N	19	19	19	19	19	19	19	19	19	19	19	19	19	11	19	19

Mean Variable Correlations 9