Characterizing Bank Erosion on the Upper Neversink River 2012 -2014

A study to support Stream Management Activities



Mark Vian and Emily Smith

Conducted by the NYCDEP Stream Management Program in cooperation with the Rondout Neversink Stream Program, a Project of the Sullivan County Soil and Water Conservation District

March 2015

INTRODUCTION

A stream feature inventory conducted in 2010 on the Upper Neversink River—the mainstems of the East and West Branches and the mainstem Neversink River from Claryville to the Neversink Reservoir identified fifty-eight eroding banks comprising a total area of 289,396 ft² of erosional surface. Descriptions of these erosion sites, with management recommendations for each, were provided in the Upper Neversink River Stream Management Plan (http://catskillstreams.org/stream-managementprogram/sm-implementation-program/). In 2012 NYC DEP Stream Management Program used this information to begin a detailed Bank Erosion Monitoring Study in partnership with the Rondout Neversink Stream Management Program, and with the assistance of SUNY Ulster County Community College Watershed Conservation Corps interns. To prioritize banks of significance for management purposes, this study focused on banks larger than 1000 square feet of exposed surface area. Banks located on New York State land were eliminated from the study. Several erosion sites were also eliminated as a result of channel and bank responses to two historically large flows in 2011 and 2012. From 2012 to 2014, forty-seven banks were evaluated using the BANCS Method (Rosgen 2006) to produce a semi-quantitative characterization of bank erosion hazards. In addition to indexing erosion hazard risk, each site was also characterized in terms of management considerations related to threats to infrastructure, private structures, and water supply and ecosystem impacts from the loading of fine sediment. The results of this study will be used to prioritize restoration efforts undertaken in the coming years by the Rondout Neversink Stream Management Program in partnership with NYCDEP. Results may also be used to validate GIS-based models of erosion risk and sediment loading.

BACKGROUND

The East and West Branches of the Upper Neversink River flow from the higher elevations of the Catskill Mountains in Ulster County, New York. Each branch winds its way to their confluence with the mainstem just beyond the Sullivan County border and from there into the NYC Neversink Reservoir. In total, this accounts for 34 miles of (mainstem) stream, contained within a 71 square mile drainage basin. This watershed is an important part of the NYC DEP water supply, which provides unfiltered drinking water for nearly half the population of New York State. Currently, the primary pollutant of concern for drinking water in this watershed is fine sediment, mobilized by the stream from in situ geologic sources.

1

The Catskill Mountains were formed as an eroded plateau, with deep valleys carved by millions of years of stream erosion and repeated continental glacial advances into lithified river deposits, and then covered by surficial deposits left behind as the glaciers retreated. This geologic history has set the stage for the modern day condition of the Catskill Mountains and its streams. We now see bedrock geology consisting of sedimentary sandstones, shale, siltstones and some conglomerate, and it is not unusual to see extensive reaches of bedrock in Neversink basin streambeds and banks. The surficial geology comprises: glacial till (a generally unsorted mix of boulders, cobble, gravel, silt and clays) in the terraces that bound the stream courses, in some locations layered with more stratified outwash deposits of sand to cobble sized sediment; alluvial deposits of eroded till and outwash in the valley bottoms; and isolated exposures of lacustrine silt and clay deposits, occasionally observed at the margins of alluvial fans where larger tributaries enter a relatively flat valley floor created (historically) by downstream ice impoundments at topographic pinch points. Geology in the Neversink plays a crucial role in stream channel form and function, affecting the distribution of erosion hazards, bed and suspended sediment supply, and stream ecosystem processes. As such, it is a key consideration in the characterization of a bank erosion site.

The land use history in the Neversink basin is largely characterized by its tanneries and mills in the 19th century (Kudish 2000). While the industries that once dominated the area are no longer in operation, the effects are still seen on the landscape and in the streams: floodplains laced with relict raceways that served the mills, and which still channel overbank flows, and stone walls that enclosed valley bottom pastures and cultivated fields. The current land use classifications indicate that nearly 94% of the basin is forested, 5% is non-woody vegetation and recreation, and the remaining 1% land comprising roads, infrastructure and agriculture. While the basin is largely forested, and the valley floors relatively undeveloped, anthropogenic influences such as roads, bridges, berms and land clearing influence adjacent stream bank and channel stability, interrupting continuity of streamflow and sediment transport, in some locations creating unintended flowpaths for overbank flows.

For more detailed information on the Neversink basin, refer to the Upper Neversink Stream Management Plan at the link provided above.

METHODS

This study combined field and office GIS assessments and analyses to characterize bank form, materials and erodibility, channel morphology characteristics significant to hydraulic function, and proximate cultural features (public infrastructure and private structures) potentially at risk due to the bank erosion.

Field Assessments

The erosion sites documented in the 2010 stream feature inventory were first prioritized for further study based on the size of the erosional surface. Additional field surveys were conducted during 2012 and 2013 at forty-seven eroding banks, comprising a total of 199,952 ft², where the erosional exposure was larger than 1,000 ft² based on the 2010 stream feature inventory (Figure 1). Field data collection at these sites began in 2012, and was completed in 2014. Field data collection focused on developing metrics included in the Bank Erosion Hazard Index (BEHI), a semi-quantitative model developed by David Rosgen (1996) to index bank erodibility, and geomorphic characterization using Rosgen's "Level 2" stream classification system (1996). Channel morphology at the eroding bank plays a significant role in the future evolution of the erosion site. At each site the following data were collected:

1. Longitudinal profile, used to obtain the water surface slope for classification and shear stress calculation purposes;

2. Riffle cross-section, used to classify the morphology based on the bankfull width, mean bankfull depth, and entrenchment ratio, a measure of channel confinement;

3. Channel cross-section through the eroding bank, used in developing metrics included in the BEHI and Near Bank Stress (NBS) scoring, and as baseline for long-term monitoring of bank retreat rates;

4. Bankfull channel boundary particle size distribution, using a modified Wolman pebble count (Wolman 1954), to provide various statistics on the size distribution of particles on the surface of the bankfull channel bed, for classification and sediment transport analysis;

5. Pfankuch Channel Stability Rating (1975) assessment, to rank channel stability with a qualitative assessment of fifteen metrics describing reach-wide conditions;

6. Bank Erosion Hazard Index assessment, to provide a semi-quantitative index value for bank erodibility based on five metrics: ratio of bank height to bankfull height, ratio of rooting depth to bank height, rooting density, composition of bank materials, bank angle, bank material stratigraphy, and bank surface protection;



7. Presence/Absence of a significant volume of fine sediment (typically, glacially deposited clays and fine silts) in the visible surface of the eroding bank, which could degrade water quality for drinking water supply or in-stream habitat by increasing embeddedness in the channel substrate (this characterization was completed as part of the 2010 stream feature inventory);

8. Geospatial coordinates of the bank and control pins for the survey, collected with sub-meter resolution GPS, to support future replication and trends analysis;

9. Photodocumentation, to support future replication and trends analysis, and for quality control of BEHI characterization.

GIS-based Assessment and Data Management

As field data collection was completed, the data for each site were compiled using the software package, RiverMorph. This software supports management and analysis of survey data (cross-sections and longitudinal profiles), bed surface particle data and bank and channel characterization data. A feature of the software allows the user to generate morphometric stream variables calculated from the cross-section information provided. A screen shot (Figure 2 below) shows an example of a cross-section summary which includes the metrics used in the Rosgen Level 2 stream classification, including mean bankfull depth, floodprone width, bankfull width, and a calculated entrenchment ratio. In some instances NYC DEP 1M DEM data was used to supplement the cross-section beyond its field-surveyed bounds to obtain a more precise flood prone width and entrenchment ratio. Obtaining more precise flood prone width is particularly important as it affects the metrics generated in the RiverMorph reach summary table (Figure 3). Another of the classification criteria, bankfull water surface slope, is calculated by the software using the water surface elevations collected in the longitudinal profile survey (Figure 4).



Figure 2. A cross-section as displayed in RiverMorph, with summary cross-section statistics at the top. The thin blue line represents bankfull stage, the blue dashed line represents floodprone stage.

Data	Graph	Summar	y Stages	Pł	notographs	D	Data Collection D						
			Channel		Left		Right						
Floodp	orone Ele [,]	vation (ft)	995.	91	995.	91	995.91						
Bankfu	ull Elevati	on (ft)	991.	81	991.	81	991.81						
Floodp	orone Wio	ith (ft)	103.	21									
Bankfi	ull Width	(ft)	48.	63	23.	92	24.71						
Entren	ichment F	Ratio	2.	12									
Mean	Depth (ft))	:	2.6	2.	82	2.38						
Maxim	um Deptł	n (ft)		4.1	3.	81	4.1						
Width	/Depth R	atio	11	B.7	1	3.5	10.38						
Bankfi	ull Area (s	:qft)	126.	22	67.	33	58.89						
Wette	d Perimet	er (ft)	50.	05	- 20	3.7	28.97						
Hydrau	ulic Radiu	us (ft)	2.	52	2.	35	2.03						
Begin	BKF Stat	ion	18.	87	18.	87	42.79						
End B	KF Statio	n	6	7.5	42.	67.5							
Broad Level Stream Classification Entrenchment Ratio: 2.12 (Moderately Entrenched) Width to Depth Ratio: 18.7 (Moderate to High) Classification: B													
Entrainment Formula Calculator													
O S	C Shields Curve												
	Right												
	Slope (I	it/ft)	0.025		0								
Shea	ar Stress	(lb/sq.ft)	3	.93									
Mov	able Parti	cle (mm)	416.1										

Figure 3. The summary table of a classification cross-section in RiverMorph.



Figure 4. A longitudinal profile in RiverMorph, noting the location of each cross-section.

Shear Stress Characterization

In addition to conditions affecting bank erodibility, characteristics of channel form that determine the distribution, through the channel cross-section, of erosional forces also play a critical role in the risk of bank erosion. Three metrics proposed by Rosgen (2006) to characterize "Near Bank Stress" (NBS) were calculated for each eroding bank to characterize the effect of channel geometry on the shear stress exerted by flows along the eroding bank. Two methods were used analyzing cross-section data in RiverMorph, and a third involved GIS-based interpretation of aerial imagery.

Rosgen's "Method #2" uses the ratio of stream channel radius of curvature (in planform) to bankfull width to scale near bank shear stress. Radius of curvature, normalized by stream width, is widely recognized as a meaningful metric for the erosive potential of the flow on the bank. A ratio less than 2 is considered to have high NBS. For this study, the "Construct Geodetic" tool in ArcGIS 10.2.2 was used to create circles with a measured radius that were fit to the curvature of each eroding bank line.

"Method #5" uses the ratio of near-bank maximum depth to bankfull mean depth. Near bank maximum depth is defined as the maximum depth in the third of the channel cross-section closest to the bank at bankfull stage.

"Method #6" uses the ratio of shear stress calculated for the third of the channel closest to the bank to bankfull channel-averaged shear stress. Rosgen uses a simplified formula for bed averaged shear stress:

 $\tau = \gamma dS$ where bed averaged shear stress (τ) equals the product of the specific weight of water (γ), channel mean depth (d) and water surface slope (S). Near bank shear stress was calculated substituting, for channel mean depth, maximum depth in the third of the cross-section nearest the eroding bank.

The calculated numeric values generated by each of the three methods were classed into six levels from Very Low to Extreme. The highest level generated from the three methods is used to prioritize the sites. See Rosgen (2006) for a detailed description of the BEHI and NBS methodologies.

Stream Channel Morphology Classification

The reach in which each bank erosion site was located was classed using the Rosgen Level 2 morphological classification system. This system uses water surface slope, entrenchment, width-todepth ratio, sinuosity and the median particle size of the channel substrate as delineative criteria to classify reaches (Rosgen 1994). Each of these variables influence hydraulics and sediment transport dynamics through the full range of flows, and collectively play a significant role in determining the longterm evolution of the channel. For example, all other things being equal, if a channel has a low entrenchment ratio (= very confined), the erosion potential at higher flows will be relatively greater. Rosgen Level 2 classification has been used to make management interpretations of channel morphology; interpretations of potential for bank erosion, channel sensitivity to disturbance and potential for recovery from disturbance, as described by Rosgen (1996), were added to the dataset.

Threats to Infrastructure and Private Structures

Threats from erosion site proximity to public infrastructure and private structures were identified using aerial photography in a GIS-based analysis, using a qualitative assessment of slope and distance from erosional surface and channel width; presence or absence of threat were added to the dataset.

RESULTS

Summary tables of the results of the analyses described above are presented below (Tables 1 -3). The data were sorted to present potential prioritization for three distinct management objectives: 1) presence of fine sediment, with an additional level of sorting by area, to indicate potential loading of fine sediment and concomitant threat to water quality; 2) presence of a threat to infrastructure or private structures; and 3) erosional surface area, as an indication of potential bedload supply, with implication for downstream channel stability. For each sort, other key variables were color coded to provide a graphic illustration of the erosion potential metrics. Fourteen sites were identified as having substantial fine sediment in the bank material, with a total erosional surface area of 88,437ft² (44% of the total at all sites studied). Of these, all had either Extreme or Very High BEHI index ratings, and either Extreme or Very High NBS ratings. One of these sites additionally represented a threat to Infrastructure. Eight sites in all presented threats to adjacent infrastructure or structures, with a total erosional surface of 20,382 ft² (10% of all sites studied). Of these, six had Extreme or Very High BEHI index ratings, and all had Extreme or Very High NBS rating. The locations of these 21 high priority sites, representing over 51% of the erosional area of all sites studied, are presented below in Figure 5. The ten largest erosion sites total 116,575 ft² of erosional surface area (Table 3), and account for more than 61% of the total erosional surface area of all sites.

9

Table 1. Prioritization by Suspended Sediment Source

					NBS N	/lethod 2	NBS Method 5		NBS Method 6		NBS Method 6				Management Impl	lications by Streamt	ype (Rosgen, 1994)
			DELU	BEHI		NBS		NDC		NBS		Structure	Infrastructura	Chroger	Consitivity to	Basayan	Streembonk
Stream	ID	Bank Area	BEHI	Adjective	Ratio	Adjective	Ratio	NBS	Ratio	Adjective	Fine Sed	Structure	Threat	Stream	Sensitivity to	Recovery	Streambank
			Kating	Rating		Rating		Adjective		Rating		inreat	Inreat	туре	Disturbance	Potential	Erosion Potential
WBNS	58275	19,537	48.5	Extreme	0.92	Extreme	2.83	Very High	2.83	Extreme	Y	0	0	B4	Moderate	Excellent	Moderate
EBNS	22800	18,072	51.6	Extreme	2.64	Low	2.57	Very High	2.57	Extreme	Y	0	0	C3	Moderate	Good	Moderate
EBNS	6800	11,170	53.6	Extreme	10.36	Very Low	1.89	High	1.89	Extreme	Y	0	0	C3	Moderate	Good	Moderate
MSNS	15400	9,254	45.8	Very High	10.28	Very Low	3.1	Extreme	3.1	Extreme	Y	0	0	С	Moderate	Good	Moderate
EBNS	41100	6,511	51.1	Extreme	28.41	Very Low	1.86	High	1.86	Extreme	Y	0	Y	B3c	Low	Excellent	Low
WBNS	400	3,672	50.3	Extreme	3.04	Very Low	2.27	High	2.27	Extreme	Y	0	0	B4c	Moderate	Excellent	Moderate
EBNS	7000	3,599	56.8	Extreme	10.58	Very Low	2.09	High	2.09	Extreme	Y	0	0	C3	Moderate	Good	Moderate
EBNS	42300	3,556	49.8	Extreme	1.3	Extreme	2.15	High	2.15	Extreme	Y	0	0	B3c	Low	Excellent	Low
MSNS	26800	3,361	42.9	Very High	2.23	Low	1.86	High	1.86	Extreme	Y	0	0	C3	Moderate	Good	Moderate
EBNS	8200	3,157	57.3	Extreme	3.28	Very Low	1.49	Low	1.49	Very High	Y	0	0	F3	Moderate	Poor	Very High
WBNS	28225	2,224	21.7	Moderate	4.78	Very Low	2.99	Very High	2.99	Extreme	Y	0	0	C3	Moderate	Good	Moderate
WBNS	53150_2	1,525	56.3	Extreme	0.89	Extreme	1.48	Low	1.48	Very High	Y	0	0	C4	Very High	Good	High
WBNS	53150_1	1,525	42.5	Very High	0.83	Extreme	3.1	Extreme	3.1	Extreme	Y	0	0	C4	Very High	Good	High
WBNS	18975	1,274	44.5	Very High	1.72	Very High	2.15	Moderate			Y	0	0	B3c	Low	Excellent	Low
EBNS	20700	18,234	40.6	Very High	2.25	Low	2.43	High	2.43	Extreme	N	0	0	C3	Moderate	Good	Moderate
EBNS	12500	11,851	43.9	Very High	2.46	Low	1.89	high	1.89	Extreme	N	0	0	C4	Very High	Good	High
WBNS	1500 1100	8,085	29.3	Moderate	1.13	Extreme	2.9	Very High	2.9	Extreme	N	0	0	C3	Moderate	Good	Moderate
WBNS	39750	7,229	50.6	Extreme	1.02	Extreme	2	high	2	Extreme	N	0	0	F3	Moderate	Poor	Very High
WBNS	43600	6,576	42.5	Very High	0.82	Extreme	2.09	High	2.09	Extreme	N	0	0	D3	Very High	Poor	Very High
WBNS	13200	6,568	21.3	Moderate	8.7	very low	1.35	Low	1.35	Very High	N	0	0	F3	Moderate	Poor	Very High
EBNS	8800	3,277	46.1	Extreme	2.21	Low	2.28	High	2.28	Extreme	N	Y	0	F3	Moderate	Poor	Very High
EBNS	22400	3,261	48.4	Extreme	2.07	Moderate	1.9	High	1.9	Extreme	N	0	0	C3	Moderate	Good	Moderate
WBNS	19425	2,939	47	Extreme	2.19	Moderate	1.69	Moderate	1.69	Extreme	N	0	0	C3	Moderate	Good	Moderate
MSNS	20600	2,695	48.5	Extreme	3.06	Very Low	1.36	Low	1.36	Very High	N	0	0	B3c	Low	Excellent	Low
EBNS	14900	2,673	52.5	Extreme	11.14	Very Low	1.49	Low	1.49	Very High	N	0	0	B3c	Low	Excellent	Low
WBNS	52525	2,601	56.9	Extreme	2.8	Low	1.39	Low	1.39	Very High	N	0	0	C4	Very High	Good	High
MSNS	5600	2,541	46.9	Extreme	2.57	Low	3.1	Extreme	3.1	Extreme	N	0	0	C3	Moderate	Good	Moderate
EBNS	23600	2,397	40.4	Very High	2.05	Moderate	1.42	LOW	1.42	Very High	N	0	0	B3C	Low	Excellent	Low
EBNS	37900	2,392	32.9	Hign	0.85	High	2.36	High	2.36	Extreme	N	0	0	C3	Moderate	Good	Moderate
EBNS	30500	2,267	56.6	Extreme	1.12	Extreme	1.7	Wioderate	1.7	Extreme	N	0	Ŷ	C3	Noderate	Good	Moderate
EBINS	21600	2,245	47.9	Extreme	5.85	very Low	2.13	High	2.13	Extreme	IN N	0	0	5	Widerate	Good	woderate
	35450	2,117	39.5		1.01	Von High	5.4	Moderate	5.4	Von High	IN N	0	0	C2	Mederate	Good	LUW
EDINS	11500	2,084	49.4	Extreme	1.72		2.09	High	1.0		IN N	0	0	C3	Mederate	Good	Moderate
	20500	2,084	43.0	Extreme	4.0	Very LOW	2.08	⊓igii ⊔iah	2.08	Extreme	IN N	0	U V	C3	Mederate	Good	Moderate
FRNS	17400	2,079	46.0	Extreme	2 20	Extreme	2.07	Moderate	2.07	Von High	N	0	0	R3c	Low	Excellent	
	1/400	1 802	16.5	Low	6.13	Venulow	2.7	Vory High	2.7	Extreme	N	0	v	E3	Moderate	Poor	Very High
WBNS	32200	1,032	10.5	Very High	1.05	Extreme	1 /18		1.48	Von High	N	0	v	F3	Moderate	Poor	Very High
FRNS	32200	1,673	41.4	Extreme	8 /3	Venulow	1.40	Low	1.40	Very High	N	0	0	C3	Moderate	Good	Moderate
EBNS	32100 2	1,072	49.4 /0./	Extreme	32 /10	Very Low	1.40	Moderate	1.40	Very High	N	0	0	C3	Moderate	Good	Moderate
FRNS	36400	1,672	35.6	High	1 / 3	Extreme	1.55	High	1.95	Extreme	N	0	0	C3	Moderate	Good	Moderate
WBNS	55300	1,302	41 5	Very High	3,86	VeryLow	1.50	Moderate	1.50	Extreme	N	0	Y	C3b	Moderate	Good	Moderate
WBNS	33975	1,181	35.6	High	0.6	Extreme	3.45	Extreme	3.45	Extreme	N	0	Y	C3	Moderate	Good	Moderate
EBNS	11100	923	46	Extreme	28.85	VeryLow	1 73	Moderate	1 73	Extreme	N	0	0	B3c	Low	Excellent	Low
WBNS	34700	589	40.5	Very High	0.69	Extreme	2.53	Very High	2.53	Extreme	N	0	0	E3	High	Good	Low
EBNS	44500	555	27.6	Moderate	37.05	Very Low	1.57	Moderate	1.57	Very High	N	0	0	B3c	Low	Excellent	Low
		200								1			-				

Table 2. Prioritization by Infrastructure / Structure Threat

Image Basis Basis Basis Basis Basis Basis Basis Stream Stream Str						NBS M	lethod 2	NBS N	Aethod 5	NBS Method 6					Management Implie	cations by Streamty	pe (Rosgen, 1994)	
FINE Stolin 2,227 Soling Sectorm 2.8.1 (weight Sectorm 2.9.1 (weight Sectorm N 0 V C Moderate Good Moderate WRMS 5200 2.0.29 6.0.2 (weight Sectorm 2.0.2 (weight Sectorm 2.0.2 (weight Sectorm 2.0.2 (weight Sectorm N 0 V 6.0.3 Moderate Good Moderate WRMS 5200 1.0.29 0.0.2 (weight Sectorm 1.0.4 (weight Sectorm N 0 V 1.0.3 Moderate Good Moderate WRMS 5200 1.0.20 0.0.1 (weight Sectorm 1.0.4 (weight Sectorm N 0 V 1.0.3 Moderate Moder	Stream	ID	Bank Area	BEHI Rating	BEHI Adjective Rating	Ratio	NBS Adjective Rating	Ratio	NBS Adjective	Ratio	NBS Adjective Rating	Fine Sed	Structure Threat	Infrastructure Threat	Stream Type	Sensitivity to Disturbance	Recovery Potential	Streambank Erosion Potential
Bits Allon Gall State Low Low Low Low WBN 2500 1,202 4.20 Very (a) 3.00 Very (a) 3.00 Very (a) 3.00 Moderate Good Moderate WBN 2500 1,207 4.10 Very (a) 3.00 Very (a) 1.00 Moderate N 0 V 1.30 Moderate Good Moderate Good Noderate Good Noderate Good Noderate Good Noderate	EBNS	30500	2,267	56.6	Extreme	1.12	Extreme	1.7	Moderate	1.7	Extreme	N	0	Y	C3	Moderate	Good	Moderate
WINK 5200 2.07 82.2 Store N O Y C3 Moderare Moderare WINK 55.00 1.300 41.5 Very (M) 1.60 Moderare Good Moderare WINK 3307 41.4 Very High 1.60 Earner 5.4.8 Earner 5.4.8 Earner 6.00 Moderare Good Moderare Moderare Good Moderare Good Moderare Good Moderare Good Moderare Moderare Moderare Moderare Moderare Moderare Moderare Moderare Moderare Moderare </td <td>EBNS</td> <td>41100</td> <td>6,511</td> <td>51.1</td> <td>Extreme</td> <td>28.41</td> <td>Very Low</td> <td>1.86</td> <td>High</td> <td>1.86</td> <td>Extreme</td> <td>Y</td> <td>0</td> <td>Y</td> <td>B3c</td> <td>Low</td> <td>Excellent</td> <td>Low</td>	EBNS	41100	6,511	51.1	Extreme	28.41	Very Low	1.86	High	1.86	Extreme	Y	0	Y	B3c	Low	Excellent	Low
WINN Sizo 1.322 44.3 Very High 3.80 Very Ligh N 0 V F3 Moderate Bood Moderate Very High WINN 31975 1.181 3.65 Figs 1.01 Very High Adderate Very High Moderate Poor Very High MINN 2.027 8.25 Status 3.00 Very High Adderate Poor Very High MINN 2.027 8.25 Status 3.00 Very Ligh N 0 0 1.0 Moderate Very High Very High Very High N 0 0 1.0 No Very High Very High Very High N 0 0 1.0 No Very High N 0 0 1.0 No Very High N 0 0 0 1.0 No No No No	WBNS	20500	2,079	50.2	Extreme	1.27	Extreme	2.07	High	2.07	Extreme	N	0	Y	C3	Moderate	Good	Moderate
Warks 3320 1.121 25.6 [High 0.20 5.7 [Wigh] N 0 V 73 Moderate Boor Very High WARS 3327 45.8 [Arren 0.5 [High 0.5 [Starten 2.6 [Starten 2.0 [Starten N 0 V F3 Moderate Boor Very High WARS 3327 45.8 [Arren 2.1 [cw 2.28 [High 2.2 [Starten N 0 0 B3 Moderate Poor Very High WARS 3277 45.8 [Arren 3.0 [Very LW] N 0 0 B3 Moderate Poor Very High WARS 5275 2.001 53.5 [Arren 2.8 [GW 1.3 [GW 1.4 [GW <	WBNS	55300	1,302	41.5	Very High	3.86	Very Low	1.67	Moderate	1.67	Extreme	N	0	Y	C3b	Moderate	Good	Moderate
WHNS 3375 1.18 3.56 Multiple QL VEX 3.45 Sterme N 0 Y G3 Moderate Bood ERN 6800 3.277 6.53 low core 2.21 low vex N 0 Y 0 73 Moderate Poor Very High ERN 6800 3.277 6.53 low vex 4.04 Very High N 0 0 73 Moderate Poor Very High ERN 2.00 3.557 6.73 low vex vex 1.00 0 0 0 0 0 Very High Food Hoderate Food High High High High 1.02 Very High Food 0	WBNS	32200	1,873	41.4	Very High	1.05	Extreme	1.48	Low	1.48	Very High	N	0	Y	F3	Moderate	Poor	Very High
WBMS 0.025 1.8.2 1.6.5 Low 6.3.3 Very High 2.7.2 Key Law 6.3.3 Very High MSMS 20600 2.6.95 1.6.3 Externe 3.6.6 Very Ligh N Y 0 3.6 Low Excellent Low MSMS 2.0600 2.053 1.6.3 Externe 3.6 Very High N 0 0 3.6 Low Excellent Low WBMS 3.157 5.5.3 Externe 0.8.3 Very High N 0 0 C.4 Very High Good High MBMS 5.15.5 2.6.01 5.5.3 Externe 0.5.99 N 0 0 C.4 Very High Good High MBMS 5.15.0 Externe 0.8.9 16.8 High T 0 0 3.6 Low Key Liw <	WBNS	33975	1,181	35.6	High	0.6	Extreme	3.45	Extreme	3.45	Extreme	N	0	Y	C3	Moderate	Good	Moderate
EANS SNM Concentration C2.21 Low 2.28 Low C2.8 Low Concentration Low Figure 10.0 Low Concentration Con	WBNS	4025	1,892	16.5	Low	6.13	Very Low	2.7	Very High	2.7	Extreme	N	0	Y	F3	Moderate	Poor	Very High
MSNS OxfO 2,55 44.5 Statemer 3.00 Pic/N 1.36 Overy High N 0 0 B3c Low Excellent Low WBNS 5235 2,501 553 553 Table (w) 1.39 Cov 1.39 Very High N 0 0.6 CA Very High Good Moderate Good Moderate RNN 5309 25.5 55.3 Stateme 1.38 Low 1.38 Very High 0 0.0 C3 Moderate Good Moderate RNN 5300 1.170 S5.3 Stateme 1.38 High 1.58 Very High N 0 0.0 C3 Moderate Food Moderate Stateme 1.20 Very High Very High N 0.0 0.0 Stateme Very High Very High <td< td=""><td>EBNS</td><td>8800</td><td>3,277</td><td>46.1</td><td>Extreme</td><td>2.21</td><td>Low</td><td>2.28</td><td>High</td><td>2.28</td><td>Extreme</td><td>N</td><td>Y</td><td>0</td><td>F3</td><td>Moderate</td><td>Poor</td><td>Very High</td></td<>	EBNS	8800	3,277	46.1	Extreme	2.21	Low	2.28	High	2.28	Extreme	N	Y	0	F3	Moderate	Poor	Very High
EBNS 52:0 37.3 72.3 Exception 1.39 Low 1.39 Low 1.39 Low 1.39 Low 1.39 Low 1.39 Low Low Low High S000 C4 Very Hgh Good High EBNS 510:0 21.52 Strage 1.03 Low Low Covery Hgh Good High EBNS 5000 2.1.52 Strage 1.03 Low Low Good High EBNS 5000 2.7.5 Strage 1.34 Low Low Strade Good Moderate VPNS 37.5 Strage 2.5.6 Strage 2.5 Strage 2.6.6 Moderate Cov Strade Moderate Cov Strade Moderate Cov Strade Moderate Cov Strade	MSNS	20600	2,695	48.5	Extreme	3.06	Very Low	1.36	Low	1.36	Very High	N	0	0	B3c	Low	Excellent	Low
WINK 52525 2,61 55.6 type 2,81 0.0 0.0 C.4 Verythy Good High BINK 7000 3.599 55.8 Exceme 0.299 High 209 High 100 0.0 C3 Moderate Good Moderate Good Moderate Good Moderate Moderate Cood High 200 Low C3 Moderate Moderate Moderate Moderate Moderate Moderate Moderate Cood High High 210 Lipt Cood Add Moderate Cood High High Low Low Excellent Low Excellent Low Excellent Low High High Hi	EBNS	8200	3,157	57.3	Extreme	3.28	Very Low	1.49	Low	1.49	Very High	Y	0	0	F3	Moderate	Poor	Very High
IBMS 7000 3.58 Material 10.58 Very Hot 7 0 0 C3 Moderate Good High VBMS 513.20 1.525 55.20 terms 1.38 Very High Y 0 0 C3 Moderate Good High EBMS 14900 2.673 2.620 terms 1.34 Very High X 0 0 0.82 Low Excellent Low EBMS 2.9300 18.07 3.52 tetrem 2.97 Very High X Terreme Y 0 0 0 7.28 Moderate Good Moderate VBMS 3750 7.22 30.26 tetrem 3.04 Very High 2.15 Very High N 0 0 0 Bacerial Moderate Very High N 0 0 0 0 S.0 Moderate Moderate VBMS 3150 tetrerer 3.43 Very High <td>WBNS</td> <td>52525</td> <td>2,601</td> <td>56.9</td> <td>Extreme</td> <td>2.8</td> <td>Low</td> <td>1.39</td> <td>Low</td> <td>1.39</td> <td>Very High</td> <td>N</td> <td>0</td> <td>0</td> <td>C4</td> <td>Very High</td> <td>Good</td> <td>High</td>	WBNS	52525	2,601	56.9	Extreme	2.8	Low	1.39	Low	1.39	Very High	N	0	0	C4	Very High	Good	High
WBMS 53150.2 1.5.2 56.3 Exterme 1.4.8 Very High 0 0 C4 Very High Good High EBMS 53100 2.2.7 52.6 Exterme 11.10 0.38 Very Low 1.4.0 Very High 2.7 Very High 1.0 Very High 0 0 0 0 0 0 0 0 0 0 0 0	EBNS	7000	3,599	56.8	Extreme	10.58	Very Low	2.09	High	2.09	Extreme	Y	0	0	C3	Moderate	Good	Moderate
EBNS 1400 State Streeme 10.30 Very High N 0 0 C3 Moderate Good Moderate EBNS 14.20 22.52 Stateme 2.11.24 Very High N 0 0 8.3 Moderate Good Moderate EBNS 14.20 Very High 2.21 Stateme Y 0 0 6.3 Moderate Good Moderate VBNS 3700 7.22 50.5 Stateme 2.04 High 2.23 Stateme Y 0 0 8.4 Moderate Excellent Low EBNS 3200 1.672 4.84 Stateme 2.24 High 2.23 Very High N 0 0 C3 Moderate Good Moderate EBNS 12.00 1.672 4.84 Streeme 1.23 Very High N 0 0 C3 Moderate Good Moderate Excellent Low	WBNS	53150_2	1,525	56.3	Extreme	0.89	Extreme	1.48	Low	1.48	Very High	Y	0	0	C4	Very High	Good	High
EBMS 14900 2,573 525 Stateme 1,49 Low 1,49 Very 1,43 Very N 0 0 837 Low Excellent Low BMS 2300 18,072 505 Stateme 2,04 12,05 Stateme 0 0 63 Moderate Poor Very High MWS 400 3,572 505 Stateme 2,04 Very Low 2,27 High 2,25 Stateme 0 0 83.6 Low Excellent Moderate BMS 4200 3,556 6,88 Stateme 2,49 Very Low 1,48 Very High N 0 0 G3 Moderate Good Moderate EBMS 2100 1,672 428 Stateme 1,16 Moderate 1,16 Very High N 0 0 G3 Moderate Scalent Moderate Scalent Moderate Scalent Moderate Scalent Mod	EBNS	6800	11,170	53.6	Extreme	10.36	Very Low	1.89	High	1.89	Extreme	Y	0	0	C3	Moderate	Good	Moderate
EBNS 22800 18.072 93.16 Externe 2.67 Very High 2.72 Externe N 0 0 G3 Moderate Good Moderate VMNS 39.07 52.05 Externe 3.04 Very Low 2.27 Infight 2.23 Infight 2.23 Infight N 0 0 B4 Moderate Excellent Moderate EBNS 32100 1.672 45.8 Externe 8.43 Very Low 1.48 Low 1.48 Very High N 0 0 C3 Moderate Good Moderate EBNS 32100 1.672 45.8 Externe 1.33 Moderate 1.6 Very High N 0 0 C3 Moderate Good Moderate EBNS 21600 2.245 45.8 Externe 2.83 Very High 2.13 Externe N 0 0 G3 Moderate Excellent Moderate Excellent<	EBNS	14900	2,673	52.5	Extreme	11.14	Very Low	1.49	Low	1.49	Very High	N	0	0	B3c	Low	Excellent	Low
WBNS 39750 7,229 30.6 Laterner 2 Description N 0 0 67 Moderate Poor Very High VBNS 40.00 3,672 30.3 tatterner 3.1.5 Statterner 2.1.5 High 2.2.5 High 2.2.5 High 2.2.5 High 2.2.5 High N 0 0 Bdc Moderate Excellent Moderate EBNS 32100 1.672 3.4.4 Laterner 3.2.4 Laterner 3.3.4 Very Low 1.4.5 Very High N 0 0 C3 Moderate Good Moderate EBNS 21000 2.4.64 4.4.4 Laterner 2.3.2 Very High N 0 0 C3 Moderate Good Moderate Excellent Moderate 1.5.3 Very High N 0 0 C3 Moderate Good Moderate Excellent Moderate 1.5.3 Very High 1.5.3 <td>EBNS</td> <td>22800</td> <td>18,072</td> <td>51.6</td> <td>Extreme</td> <td>2.64</td> <td>Low</td> <td>2.57</td> <td>Very High</td> <td>2.57</td> <td>Extreme</td> <td>Y</td> <td>0</td> <td>0</td> <td>C3</td> <td>Moderate</td> <td>Good</td> <td>Moderate</td>	EBNS	22800	18,072	51.6	Extreme	2.64	Low	2.57	Very High	2.57	Extreme	Y	0	0	C3	Moderate	Good	Moderate
WBNS 400 5.472 6.92 Barrent 2.27 High 2.22 Description V 0 0 Bac Moderate Excellent Moderate EBNS 42300 3.555 64.9 barrent 2.15 barrent 2.15 barrent 0.15 barrent 0.15 barrent 0.15 barrent 0.0 0.0 B3c Low Excellent Moderate 0.0 0.0 C3 Moderate Good Moderate EBNS 15.00 2.044 42.4 barrent 1.25 legrent N 0 0 C3 Moderate Good Moderate 0.0 Moderate 0.0 Moderate Good Moderate 0.0 Moderate 0.0 Moderate Moderate 0.0 Moderate Good Moderate 0.0 Moderate 0.0 Moderate Good Moderate Moderate Low Moderate Low Moderate Low Moderate Low <	WBNS	39750	7,229	50.6	Extreme	1.02	Extreme	2	high	2	Extreme	Ν	0	0	F3	Moderate	Poor	Very High
EBMS 42300 3,556 49.8 Excenter 1.3 Externe 2.15 High 2.13 Number of the state State Constraint EBMS 32100 2 1,672 49.4 Streme 32.49 Very Low 1.58 Moderate 1.50 Moderate	WBNS	400	3,672	50.3	Extreme	3.04	Very Low	2.27	High	2.27	Extreme	Y	0	0	B4c	Moderate	Excellent	Moderate
EBNS 32100 1.672 49.6 Externe 8.43 Very Low 1.48 Low 1.80 N 0 C C3 Moderate Good Moderate EBNS 32100 2 1.672 49.8 Very Low 1.53 Moderate 1.50 Very High N 0 C3 Moderate Good Moderate EBNS 2100 2.264 49.6 Extreme 0.0 Kitmen Y 0 0 C3 Moderate Excellent Moderate EBNS 22400 3.261 48.6 Extreme 2.00 Moderate 5.85 Very Low 2.13 High 2.13 Kitmen N 0 0 C3 Moderate Good Moderate 1.60 Moderate 1.60 Moderate 1.60 Moderate 1.60 Moderate 1.60 Moderate 1.60 Moderate 6.00 Moderate Good Moderate Excellent Low Excellent <	EBNS	42300	3,556	49.8	Extreme	1.3	Extreme	2.15	High	2.15	Extreme	Y	0	0	B3c	Low	Excellent	Low
EBNS 32100_2 1.672 40.4 Extreme 32.49 Very low 1.53 Moderate 1.6 Noderate 1.6 Moderate 1.6 Moderate 1.6 Moderate 1.6 Moderate 1.6 Moderate 1.6 Moderate N 0 0 C3 Moderate Excellent Moderate EBNS 21600 2.251 48.4 Extreme 2.03 Moderate 1.9 High 1.9 Extreme N 0 0 C3 Moderate Excellent Moderate EBNS 21600 2.245 47.8 Extreme 2.19 Moderate 1.9 High 2.13 Extreme N 0 0 C3 Moderate Good Moderate VBNS 19425 2.939 47 Extreme 2.13 Moderate 1.38 Moderate 1.39 Very High N 0 0 83.0 Low Excellent Low EBNS 1100 <td>EBNS</td> <td>32100</td> <td>1,672</td> <td>49.4</td> <td>Extreme</td> <td>8.43</td> <td>Very Low</td> <td>1.48</td> <td>Low</td> <td>1.48</td> <td>Very High</td> <td>N</td> <td>0</td> <td>0</td> <td>C3</td> <td>Moderate</td> <td>Good</td> <td>Moderate</td>	EBNS	32100	1,672	49.4	Extreme	8.43	Very Low	1.48	Low	1.48	Very High	N	0	0	C3	Moderate	Good	Moderate
EBNS 11500 2.084 94.94 Streme 1.12 Very High 2.83 Very High 1.9 Extence N 0 0 C3 Moderate Good Moderate EBNS 22400 3.261 4.84 Extreme 5.85 Very Low 2.13 High 2.15 Extreme N 0 0 C3 Moderate Good Moderate BNS 19402 2.031 4.65 Extreme 1.58 Very High N 0 0 C3 Moderate Good Moderate Low Excellent Low Excellent<	EBNS	32100_2	1,672	49.4	Extreme	32.49	Very Low	1.53	Moderate	1.53	Very High	N	0	0	C3	Moderate	Good	Moderate
WENS 5827s 19,537 48.5 Exterme 2.83 Exterme Y 0 0 B4 Moderate Excellent Moderate EBNS 22400 3,261 48.4 Éxtreme 2.07 Moderate 1.9 High 2.19 Extreme N 0 0 C3 Moderate Good Moderate VBNS 12400 2,245 47.9 Extreme 2.19 Moderate 1.69 Moderate N 0 0 C3 Moderate Good Moderate VBNS 19425 2.939 47 Extreme 1.58 Moderate 1.58 Very High N 0 0 B3c Low Excellent Low EBNS 11100 923 46 Extreme 1.3 Moderate Y 0 0 B3c Low Excellent Low MSNS 15400 9,254 48.8 Very High 2.15 Moderate Y <	EBNS	11500	2,084	49.4	Extreme	1.72	Very High	1.6	Moderate	1.6	Very High	N	0	0	C3	Moderate	Good	Moderate
EBNS 22400 3,261 48.8 Extreme 2.07 Moderate 1.9 Extreme N 0 0 C3 Moderate Good Moderate EBNS 21600 2,245 47.9 Distment 5.85 Very Low 2.13 High 1.16 Extreme N 0 0 C3 Moderate Good Moderate EBNS 17400 2,031 46.9 Extreme 1.58 Moderate 1.58 Very High N 0 0 83.6 Low Excellent Low EBNS 11400 923 46 bitteme 2.88 Very High 1.28 Kerteme Y 0 0 B3.6 Low Excellent Low WBNS 15400 9,254 4.8.8 Very High 2.12 Moderate Y 0 0 C4 Very High Moderate Low Extreme Y 0 0 C4 Very High Good <t< td=""><td>WBNS</td><td>58275</td><td>19,537</td><td>48.5</td><td>Extreme</td><td>0.92</td><td>Extreme</td><td>2.83</td><td>Very High</td><td>2.83</td><td>Extreme</td><td>Y</td><td>0</td><td>0</td><td>B4</td><td>Moderate</td><td>Excellent</td><td>Moderate</td></t<>	WBNS	58275	19,537	48.5	Extreme	0.92	Extreme	2.83	Very High	2.83	Extreme	Y	0	0	B4	Moderate	Excellent	Moderate
EBNS 21600 2,245 47.9 Extreme 5.85 Very Low 2.13 High 2.13 Extreme N 0 0 C3 Moderate Good Moderate VMBNS 19425 2.939 4.7 Extreme 2.19 Moderate 1.69 Moderate 1.73 Moderate	EBNS	22400	3,261	48.4	Extreme	2.07	Moderate	1.9	High	1.9	Extreme	N	0	0	C3	Moderate	Good	Moderate
WBNS 19425 2.93 47 Externe 2.19 Moderate 1.69 Moderate 1.58 Moderate 1.58 Very High N 0 0 C3 Moderate Good Moderate EBNS 11/10 923 46 Externe 2.85 Very Lips 1.58 Very High N 0 0 83c Low Excellent Low MSNS 15400 9.254 45.8 Very High 1.27 Very High 1.27 Very High 1.27 Very High 2.15 Moderate Y 0 0 C4 Very High Good High EBNS 1250 11.51 4.3.9 Very High 2.16 Moderate 1.85 Kerne N 0 0 C4 Very High Good High EBNS 15501 1.52 Very High 2.23 Low 1.86 High N 0 0 C4 Very High Good High	EBNS	21600	2,245	47.9	Extreme	5.85	Very Low	2.13	High	2.13	Extreme	N	0	0	C3	Moderate	Good	Moderate
EBNS 17400 2,031 46.9 Extreme 2.39 Extreme 1.58 Moderate 1.73 Karrene N 0 0 B3c Low Excellent Low EBNS 11100 923 46 Extreme 2.88 Very Low 1.73 Moderate 1.73 Karrene N 0 0 B3c Low Excellent Low WBNS 18975 1.274 44.5 Very High 1.72 Very High 2.15 Moderate Y 0 0 C Moderate Low Excellent Low EBNS 11501 2.084 43.6 Very High 2.08 High 2.08 Extreme N 0 0 C3 Moderate Good Moderate WBNS 53150.1 1.525 42.9 Very High 0.83 Extreme 3.1 Extreme N 0 0 C3 Moderate Good Moderate WBNS	WBNS	19425	2,939	47	Extreme	2.19	Moderate	1.69	Moderate	1.69	Extreme	N	0	0	C3	Moderate	Good	Moderate
EBNS 11100 923 46 Extreme 28.85 Very Low 1.73 Moderate N 0 0 B3c Low Excellent Low MSNS 15400 9.254 45.8 Very High 10.28 Very Low 3.1 Extreme Y 0 0 C Moderate Good Moderate WBNS 18975 1.274 44.5 Very High 2.15 Moderate Y 0 0 B3c Low Excellent Low EBNS 12500 11.851 43.9 Very High 2.23 Low 1.86 Extreme N 0 0 C3 Moderate Good Moderate MSNS 26800 3.361 42.9 Very High 0.82 Extreme 3.1 Extreme N 0 0 C3 Moderate Good Moderate WBNS 53150_1 1.525 42.5 Very High 0.82 Extreme 3.1	EBNS	17400	2,031	46.9	Extreme	2.39	Extreme	1.58	Moderate	1.58	Very High	N	0	0	B3c	Low	Excellent	Low
MSNS 15400 9,254 45.8 Very High 10.28 Very Low 3.1 Extreme Y 0 0 C Moderate Good Moderate WBNS 18975 1,274 44.5 Very High 1.72 Very Low 1.89 high 1.89 Fixme Y 0 0 B3c Low Excellent Low EBNS 12500 11,851 43.9 Very High 2.46 Low 1.89 Extreme N 0 0 C3 Moderate Good High EBNS 11501 2.084 43.6 Very Low 2.08 High 2.08 Extreme N 0 0 C3 Moderate Good Moderate MSNS 26800 3.361 42.9 Very High 0.88 Extreme 3.1 Extreme Y 0 0 0 0 0 D3 Very High D60 D4 Kery High D6 Extreme	EBNS	11100	923	46	Extreme	28.85	Very Low	1.73	Moderate	1.73	Extreme	N	0	0	B3c	Low	Excellent	Low
WBNS 18975 1,274 44.5 Very High 1.72 Very High 2.15 Moderate Y 0 0 B3c Low Excellent Low EBNS 12500 11,851 43.9 Very High 2.46 Low 1.88 high 1.88 Extreme N 0 0 C4 Very High Good High EBNS 11501 2.084 43.6 Extreme 4.6 Very Ligh 2.08 Extreme N 0 0 C3 Moderate Good Moderate WSNS 26800 3.361 42.9 Very High 0.83 Extreme 3.1 Extreme Y 0 0 C3 Moderate Good Moderate WBNS 53150_1 1,525 42.5 Very High 0.83 Extreme 2.09 Extreme N 0 0 D3 Very High Poor Very High WBNS 34500 5,576 42.5 Very High 2.25 Low 2.43 Krerme N 0 0	MSNS	15400	9,254	45.8	Very High	10.28	Very Low	3.1	Extreme	3.1	Extreme	Y	0	0	С	Moderate	Good	Moderate
EBNS 12500 11,851 43.9 Very High 2.46 Low 1.89 high 1.89 Extreme N 0 0 C4 Very High Good High EBNS 11501 2,084 43.6 Extreme 4.6 Very Low 2.08 High 2.08 Extreme N 0 0 C3 Moderate Good Moderate MSNS 26800 3,361 42.9 Very High 2.3 Low 1.86 Extreme Y 0 0 C3 Moderate Good High WBNS 33600 6,576 42.5 Very High 0.82 Extreme 2.09 High 2.43 Extreme N 0 </td <td>WBNS</td> <td>18975</td> <td>1,274</td> <td>44.5</td> <td>Very High</td> <td>1.72</td> <td>Very High</td> <td>2.15</td> <td>Moderate</td> <td></td> <td></td> <td>Y</td> <td>0</td> <td>0</td> <td>B3c</td> <td>Low</td> <td>Excellent</td> <td>Low</td>	WBNS	18975	1,274	44.5	Very High	1.72	Very High	2.15	Moderate			Y	0	0	B3c	Low	Excellent	Low
EBNS 11501 2,084 43.6 Extreme 4.6 Very Low 2.08 High 2.08 Extreme N 0 0 C3 Moderate Good Moderate MSNS 26800 3,361 42.9 Very High 2.23 Low 1.86 Extreme Y 0 0 C3 Moderate Good Moderate WBNS 53150_1 1,525 42.5 Very High 0.83 Extreme 3.1 Extreme Y 0 0 C4 Very High Good High WBNS 43600 6,576 42.5 Very High 0.25 Low 2.43 High 2.43 Extreme N 0 0 C3 Moderate Good Moderate WBNS 34700 589 40.5 Very High 2.05 Moderate 3.4 Extreme N 0 0 E3 High Good Low WBNS 34500 2.397 <td>EBNS</td> <td>12500</td> <td>11,851</td> <td>43.9</td> <td>Very High</td> <td>2.46</td> <td>Low</td> <td>1.89</td> <td>high</td> <td>1.89</td> <td>Extreme</td> <td>N</td> <td>0</td> <td>0</td> <td>C4</td> <td>Very High</td> <td>Good</td> <td>High</td>	EBNS	12500	11,851	43.9	Very High	2.46	Low	1.89	high	1.89	Extreme	N	0	0	C4	Very High	Good	High
MSNS 26800 3,361 42.9 Very High 2.23 Low 1.86 High 1.86 Extreme Y 0 0 C3 Moderate Good Moderate WBNS 53150_1 1,525 42.5 Very High 0.83 Extreme 3.1 Extreme Y 0 0 C4 Very High Good High WBNS 43600 6,576 42.5 Very High 0.82 Extreme 2.09 High 2.09 Extreme N 0 0 C3 Moderate Good Moderate WBNS 34700 589 40.5 Very High 2.05 Very High 2.53 Very High N 0 0 E3 High Good Low EBNS 34700 589 40.5 Very High 2.05 Moderate 1.42 Very High N 0 0 B32 Low Excellent Low WBNS 35450 2	EBNS	11501	2,084	43.6	Extreme	4.6	Very Low	2.08	High	2.08	Extreme	N	0	0	C3	Moderate	Good	Moderate
WBNS 53150_1 1,525 42.5 Very High 0.83 Extreme 3.1 Extreme Y 0 0 C4 Very High Good High WBNS 43600 6,576 42.5 Very High 0.82 Extreme 2.09 High 2.09 Extreme N 0 0 D3 Very High Poor Very High EBNS 20700 18,234 40.6 Very High 2.25 Low 2.43 High 2.43 Extreme N 0 0 C3 Moderate Good Moderate WBNS 34700 589 40.5 Very High 2.05 Moderate 1.42 Low 1.42 Very High N 0 0 B3 High Good Low EBNS 36400 1.633 35.6 High 1.01 Extreme 1.96 Extreme N 0 0 C3 Moderate Good Moderate EBN	MSNS	26800	3,361	42.9	Very High	2.23	Low	1.86	High	1.86	Extreme	Y	0	0	C3	Moderate	Good	Moderate
WBNS 43600 6,576 42.5 Very High 0.82 Extreme 2.09 High 2.09 Extreme N 0 0 D3 Very High Poor Very High EBNS 20700 18,234 40.6 Very High 2.25 Low 2.43 High 2.43 Extreme N 0 0 C3 Moderate Good Moderate WBNS 34700 589 40.5 Very High 0.69 Extreme 2.53 Very High 2.53 Extreme N 0 0 E3 High Good Low EBNS 23600 2,397 40.4 Very High 1.01 Extreme 3.4 Extreme N 0 0 B3c Low Excellent Low WBNS 35450 2,117 39.5 Very High 1.01 Extreme 3.4 Extreme N 0 0 C3 Moderate Good Moderate Excellent	WBNS	53150 1	1,525	42.5	Very High	0.83	Extreme	3.1	Extreme	3.1	Extreme	Y	0	0	C4	Very High	Good	High
EBNS 20700 18,234 40.6 Very High 2.25 Low 2.43 High 2.43 Extreme N 0 0 C3 Moderate Good Moderate WBNS 34700 589 40.5 Very High 0.69 Extreme 2.53 Very High 2.53 Very High 2.53 Very High N 0 0 E3 High Good Low EBNS 23600 2,397 40.4 Very High 1.01 Extreme 1.42 Low 1.42 Very High N 0 0 B3c Low Excellent Low WBNS 35450 2,117 39.5 Very High 1.01 Extreme 3.4 Extreme N 0 0 C3 Moderate Good Low EBNS 36400 1,633 35.6 High 1.43 Extreme 1.96 High 2.96 Extreme N 0 0 C3 Moderat	WBNS	43600	6,576	42.5	Very High	0.82	Extreme	2.09	High	2.09	Extreme	N	0	0	D3	Very High	Poor	Very High
WBNS 34700 589 40.5 Very High 0.69 Extreme 2.53 Very High 2.53 Very High 0 0 E3 High Good Low EBNS 23600 2,397 40.4 Very High 2.05 Moderate 1.42 Low 1.42 Very High N 0 0 B3c Low Excellent Low WBNS 35450 2,117 39.5 Very High 1.01 Extreme 3.4 Extreme N 0 0 E3 High Good Low WBNS 35450 2,117 39.5 Very High 1.01 Extreme 3.4 Extreme N 0 0 C3 Moderate Good Low EBNS 36400 1.633 35.6 High 0.85 High 2.36 High 2.36 Extreme N 0 0 C3 Moderate Good Moderate BNS 1500 1100	EBNS	20700	18,234	40.6	Very High	2.25	Low	2.43	High	2.43	Extreme	N	0	0	C3	Moderate	Good	Moderate
EBNS 23600 2,397 40.4 Very High 2.05 Moderate 1.42 Low 1.42 Very High N 0 0 B3c Low Excellent Low WBNS 35450 2,117 39.5 Very High 1.01 Extreme 3.4 Extreme N 0 0 E3 High Good Low EBNS 36400 1,633 35.6 High 1.43 Extreme 1.96 High 1.96 Extreme N 0 0 C3 Moderate Good Moderate EBNS 37900 2,392 32.9 High 0.85 High 2.36 High 2.36 Extreme N 0 0 C3 Moderate Good Moderate WBNS 1500 1100 8.085 2.9.3 Moderate 2.9 Very High 2.9 Extreme N 0 0 C3 Moderate Good Moderate WBNS <td>WBNS</td> <td>34700</td> <td>589</td> <td>40.5</td> <td>Very High</td> <td>0.69</td> <td>Extreme</td> <td>2.53</td> <td>Very High</td> <td>2.53</td> <td>Extreme</td> <td>N</td> <td>0</td> <td>0</td> <td>E3</td> <td>High</td> <td>Good</td> <td>Low</td>	WBNS	34700	589	40.5	Very High	0.69	Extreme	2.53	Very High	2.53	Extreme	N	0	0	E3	High	Good	Low
WBNS 35450 2,117 39.5 Very High 1.01 Extreme 3.4 Extreme N 0 0 E3 High Good Low EBNS 36400 1,633 35.6 High 1.43 Extreme 1.96 High 1.96 Extreme N 0 0 C3 Moderate Good Moderate EBNS 37900 2,392 32.9 High 0.85 High 2.36 High 2.36 Extreme N 0 0 C3 Moderate Good Moderate WBNS 1500 1100 8,085 2.9.3 Moderate 2.9 Very High 2.9 Extreme N 0 0 C3 Moderate Good Moderate WBNS 1500 1100 8,085 2.9.3 Moderate 3.7.05 Very Low 1.57 Moderate 1.57 Very High N 0 0 0 B3c Low Excellent Low <td>EBNS</td> <td>23600</td> <td>2,397</td> <td>40.4</td> <td>Very High</td> <td>2.05</td> <td>Moderate</td> <td>1.42</td> <td>Low</td> <td>1.42</td> <td>Very High</td> <td>N</td> <td>0</td> <td>0</td> <td>B3c</td> <td>Low</td> <td>Excellent</td> <td>Low</td>	EBNS	23600	2,397	40.4	Very High	2.05	Moderate	1.42	Low	1.42	Very High	N	0	0	B3c	Low	Excellent	Low
EBNS 36400 1,633 35.6 High 1.43 Extreme 1.96 High 1.96 Extreme N 0 0 C3 Moderate Good Moderate EBNS 37900 2,392 32.9 High 0.85 High 2.36 High 2.36 Extreme N 0 0 C3 Moderate Good Moderate WBNS 1500 1100 8,085 2.9.3 Moderate 2.9 Very High 2.9 Extreme N 0 0 C3 Moderate Good Moderate WBNS 1500 1100 8,085 2.9.3 Moderate 2.9 Very High 2.9 Extreme N 0 0 C3 Moderate Good Moderate EBNS 44500 555 27.6 Moderate 37.05 Very Low 1.57 Moderate 1.57 Very High N 0 0 C3 Moderate Good Moderate <tr< td=""><td>WBNS</td><td>35450</td><td>2,117</td><td>39.5</td><td>Very High</td><td>1.01</td><td>Extreme</td><td>3.4</td><td>Extreme</td><td>3.4</td><td>Extreme</td><td>N</td><td>0</td><td>0</td><td>E3</td><td>High</td><td>Good</td><td>Low</td></tr<>	WBNS	35450	2,117	39.5	Very High	1.01	Extreme	3.4	Extreme	3.4	Extreme	N	0	0	E3	High	Good	Low
EBNS 37900 2,392 32.9 High 0.85 High 2.36 High 2.36 Extreme N 0 0 C3 Moderate Good Moderate WBNS 1500 1100 8,085 29.3 Moderate 1.13 Extreme 2.9 Very High 2.9 Extreme N 0 0 C3 Moderate Good Moderate EBNS 1500 1100 8,085 29.3 Moderate 1.13 Extreme 2.9 Very High 2.9 Extreme N 0 0 C3 Moderate Good Moderate EBNS 44500 555 27.6 Moderate 37.05 Very Low 1.57 Moderate 1.57 Very High N 0 0 83c Low Excellent Low WBNS 28225 2,224 21.7 Moderate 8.7 very Low 2.99 Very High N 0 0 C3 Moderate Goo	EBNS	36400	1,633	35.6	High	1.43	Extreme	1.96	High	1.96	Extreme	N	0	0	C3	Moderate	Good	Moderate
WBNS 1500 1100 8,085 29.3 Moderate 1.13 Extreme 2.9 Very High 2.9 Extreme N 0 0 C3 Moderate Good Moderate EBNS 44500 555 27.6 Moderate 37.05 Very Low 1.57 Moderate 1.57 Very High N 0 0 B3c Low Excellent Low WBNS 28225 2,224 21.7 Moderate 4.78 Very Low 2.99 Very High 2.99 Extreme Y 0 0 C3 Moderate Good Moderate WBNS 13200 6,568 21.3 Moderate 8.7 very low 1.35 Low 1.35 Very High N 0 0 C3 Moderate Poor Very High MSNS 5600 2,541 46.9 Extreme 3.1 Extreme N 0 0 C3 Moderate Good Moderate <	EBNS	37900	2,392	32.9	High	0.85	High	2.36	High	2.36	Extreme	N	0	0	C3	Moderate	Good	Moderate
EBNS 44500 555 27.6 Moderate 37.05 Very Low 1.57 Moderate 1.57 Very High N 0 0 B3c Low Excellent Low WBNS 28225 2,224 21.7 Moderate 4.78 Very Low 2.99 Very High 2.99 Xery High N 0 0 C3 Moderate Good Moderate WBNS 13200 6,568 21.3 Moderate 8.7 very low 1.35 Low 1.35 Very High N 0 0 F3 Moderate Poor Very High MSNS 5600 2,541 46.9 Extreme 3.1 Extreme N 0 0 C3 Moderate Good Moderate	WBNS	1500 1100	8,085	29.3	Moderate	1.13	Extreme	2.9	Very High	2.9	Extreme	N	0	0	C3	Moderate	Good	Moderate
WBNS 28225 2,224 21.7 Moderate 4.78 Very Low 2.99 Very High 2.99 Extreme Y 0 0 C3 Moderate Good Moderate WBNS 13200 6,568 21.3 Moderate 8.7 very low 1.35 Low 1.35 Very High N 0 0 F3 Moderate Poor Very High MSNS 5600 2,541 46.9 Extreme 2.57 Low 3.1 Extreme N 0 0 C3 Moderate Good Moderate	EBNS	44500	555	27.6	Moderate	37.05	Very Low	1.57	Moderate	1.57	Very High	N	0	0	B3c	Low	Excellent	Low
WBNS 13200 6,568 21.3 Moderate 8.7 very low 1.35 Low 1.35 Very High N 0 0 F3 Moderate Poor Very High MSNS 5600 2,541 46.9 Extreme 3.1 Extreme N 0 0 C3 Moderate Good Moderate	WBNS	28225	2.224	21.7	Moderate	4.78	Very Low	2.99	Very High	2.99	Extreme	Y	0	0	C3	Moderate	Good	Moderate
MSNS 5600 2,541 46.9 Extreme 2.57 Low 3.1 Extreme 3.1 Extreme N 0 0 C3 Moderate Good Moderate	WBNS	13200	6,568	21.3	Moderate	8.7	very low	1.35	Low	1.35	Very High	N	0	0	F3	Moderate	Poor	Very High
	MSNS	5600	2,541	46.9	Extreme	2.57	Low	3.1	Extreme	3.1	Extreme	N	0	0	C3	Moderate	Good	Moderate

Table 3. Prioritization by Erosional Surface Area

					NBS M	lethod 2	NBS Method 5		NBS Method 6						Management Implications by Strear		eamtype (Rosgen, 1994)
Stream	ID	Bank Area	BEHI Rating	BEHI Adjective Rating	Ratio	NBS Adjective Rating	Ratio	NBS Adjective	Ratio	NBS Adjective Rating	Fine Sed	Structure Threat	Infrastructure Threat	Stream Type	Sensitivity to Disturbance	Recovery Potential	Streambank Erosion Potential
WBNS	58275	19,537	48.5	Extreme	0.92	Extreme	2.83	Very High	2.83	Extreme	Y	0	0	B4	Moderate	Excellent	Moderate
EBNS	20700	18,234	40.6	Very High	2.25	Low	2.43	High	2.43	Extreme	N	0	0	C3	Moderate	Good	Moderate
EBNS	22800	18,072	51.6	Extreme	2.64	Low	2.57	Very High	2.57	Extreme	Y	0	0	C3	Moderate	Good	Moderate
EBNS	12500	11,851	43.9	Very High	2.46	Low	1.89	high	1.89	Extreme	N	0	0	C4	Very High	Good	High
EBNS	6800	11,170	53.6	Extreme	10.36	Very Low	1.89	High	1.89	Extreme	Y	0	0	C3	Moderate	Good	Moderate
MSNS	15400	9,254	45.8	Very High	10.28	Very Low	3.1	Extreme	3.1	Extreme	Y	0	0	С	Moderate	Good	Moderate
WBNS	1500 1100	8,085	29.3	Moderate	1.13	Extreme	2.9	Very High	2.9	Extreme	N	0	0	C3	Moderate	Good	Moderate
WBNS	39750	7,229	50.6	Extreme	1.02	Extreme	2	high	2	Extreme	N	0	0	F3	Moderate	Poor	Very High
WBNS	43600	6,576	42.5	Very High	0.82	Extreme	2.09	High	2.09	Extreme	N	0	0	D3	Very High	Poor	Very High
WBNS	13200	6,568	21.3	Moderate	8.7	very low	1.35	Low	1.35	Very High	N	0	0	F3	Moderate	Poor	Very High
EBNS	41100	6,511	51.1	Extreme	28.41	Very Low	1.86	High	1.86	Extreme	Y	0	Y	B3c	Low	Excellent	Low
WBNS	400	3,672	50.3	Extreme	3.04	Very Low	2.27	High	2.27	Extreme	Y	0	0	B4c	Moderate	Excellent	Moderate
EBNS	7000	3,599	56.8	Extreme	10.58	Very Low	2.09	High	2.09	Extreme	Y	0	0	C3	Moderate	Good	Moderate
EBNS	42300	3,556	49.8	Extreme	1.3	Extreme	2.15	High	2.15	Extreme	Y	0	0	B3c	Low	Excellent	Low
MSNS	26800	3,361	42.9	Very High	2.23	Low	1.86	High	1.86	Extreme	Y	0	0	C3	Moderate	Good	Moderate
EBNS	8800	3,277	46.1	Extreme	2.21	Low	2.28	High	2.28	Extreme	N	Y	0	F3	Moderate	Poor	Very High
EBNS	22400	3,261	48.4	Extreme	2.07	Moderate	1.9	High	1.9	Extreme	N	0	0	C3	Moderate	Good	Moderate
EBNS	8200	3,157	57.3	Extreme	3.28	Very Low	1.49	Low	1.49	Very High	Y	0	0	F3	Moderate	Poor	Very High
WBNS	19425	2,939	47	Extreme	2.19	Moderate	1.69	Moderate	1.69	Extreme	N	0	0	C3	Moderate	Good	Moderate
MSNS	20600	2,695	48.5	Extreme	3.06	Very Low	1.36	Low	1.36	Very High	N	0	0	B3c	Low	Excellent	Low
EBNS	14900	2,673	52.5	Extreme	11.14	Very Low	1.49	Low	1.49	Very High	N	0	0	B3c	Low	Excellent	Low
WBNS	52525	2,601	56.9	Extreme	2.8	Low	1.39	Low	1.39	Very High	N	0	0	C4	Very High	Good	High
MSNS	5600	2,541	46.9	Extreme	2.57	Low	3.1	Extreme	3.1	Extreme	N	0	0	C3	Moderate	Good	Moderate
EBNS	23600	2,397	40.4	Very High	2.05	Moderate	1.42	Low	1.42	Very High	N	0	0	B3c	Low	Excellent	Low
EBNS	37900	2,392	32.9	High	0.85	High	2.36	High	2.36	Extreme	N	0	0	C3	Moderate	Good	Moderate
EBNS	30500	2,267	56.6	Extreme	1.12	Extreme	1.7	Moderate	1.7	Extreme	N	0	Y	C3	Moderate	Good	Moderate
EBNS	21600	2,245	47.9	Extreme	5.85	Very Low	2.13	High	2.13	Extreme	N	0	0	C3	Moderate	Good	Moderate
WBNS	28225	2,224	21.7	Moderate	4.78	Very Low	2.99	Very High	2.99	Extreme	Y	0	0	C3	Moderate	Good	Moderate
WBNS	35450	2,117	39.5	Very High	1.01	Extreme	3.4	Extreme	3.4	Extreme	N	0	0	E3	High	Good	Low
EBNS	11500	2,084	49.4	Extreme	1.72	Very High	1.6	Moderate	1.6	Very High	N	0	0	C3	Moderate	Good	Moderate
EBNS	11501	2,084	43.6	Extreme	4.6	Very Low	2.08	High	2.08	Extreme	N	0	0	C3	Moderate	Good	Moderate
WBNS	20500	2,079	50.2	Extreme	1.27	Extreme	2.07	High	2.07	Extreme	N	0	Y	C3	Moderate	Good	Moderate
EBNS	17400	2,031	46.9	Extreme	2.39	Extreme	1.58	Moderate	1.58	Very High	N	0	0	B3c	Low	Excellent	Low
WBNS	4025	1,892	16.5	Low	6.13	Very Low	2.7	Very High	2.7	Extreme	N	0	Ŷ	F3	Moderate	Poor	Very High
WBINS	32200	1,873	41.4	Very High	1.05	Extreme	1.48	LOW	1.48	Very High	N	0	Ŷ	F3	Moderate	Poor	Very High
EBINS	32100 2	1,672	49.4	Extreme	8.43	Very Low	1.48	LOW	1.48	Very High	IN N	0	0	C3	Moderate	Good	Moderate
EBINS	32100_2	1,072	49.4 25.6	Extreme	32.49	Very Low	1.53	Nioderate	1.53	Very High	IN N	0	0	C3	Moderate	Good	Moderate
	50400	1,035	55.0	Extromo	0.80	Extreme	1.90		1.90	Von High	IN V	0	0	C3	Von High	Good	High
WBNS	53150_2	1,525	/2 5	Very High	0.89	Extreme	2.1	Evtreme	1.40	Extreme	V	0	0	C4	Very High	Good	High
WRNS	553001	1 302	42.5	Very High	3.86	VeryLow	1.67	Moderate	1.67	Extreme	N	0	v v	C3h	Moderate	Good	Moderate
WBNS	18975	1.274	44.5	Very High	1.72	Very High	2.15	Moderate	1.07	CALICINE	Y	0	0	B3c	Low	Excellent	Low
WBNS	33975	1.181	35.6	High	0,6	Extreme	3.45	Extreme	3.45	Extreme	N	0	Y	C3	Moderate	Good	Moderate
EBNS	11100	923	46	Extreme	28.85	Very Low	1.73	Moderate	1.73	Extreme	N	0	0	B3c	Low	Excellent	Low
WBNS	34700	589	40.5	Very High	0.69	Extreme	2.53	Very High	2.53	Extreme	N	0	0	E3	High	Good	Low
EBNS	44500	555	27.6	Moderate	37.05	Very Low	1.57	Moderate	1.57	Very High	N	0	0	B3c	Low	Excellent	Low



Discussion

This semi-quantitative analysis is intended to support management decisions regarding future efforts to monitor the bank erosion sites, as well as allocation of funds for stream channel improvements undertaken by the Rondout Neversink Stream Program. The study serves to complement the recommendations made in the Upper Neversink Stream Management Plan, as well as the Local Flood Analysis currently being conducted to identify flood hazards from inundation, and their potential mitigation, in the hamlet of Claryville. It is not intended to provide a single algorithm to determine the order in which projects will be undertaken or sites identified for further study, but rather to present data from all of the sites in a format that supports comparative consideration of key variables for management decisions. Decisions regarding funding for restoration work will be made in cooperation with the town and county highway departments, the RNSP Watershed Advisory Group, as well as individual landowners on whose property the erosion sites are located. These decisions will necessarily need to reflect, in addition to the results of the preceding analysis, the potential benefits and costs of projects, their technical complexity and prognosis for project sustainability, staging and permit considerations, and program resources.

Acknowledgements

The authors would like to thank Chris Tran for his substantial field and office contributions to this study, supervising the Watershed Conservation Corps interns from Ulster County Community College and managing the field data collection and storage. Stacie Howell in particular from Rondout Neversink Stream Program provided leadership and quality control throughout the field season. Karen Rauter and Brenden Wagner from the Rondout Neversink Stream Program also contributed to field data collection. Interns from UCCC included Amanda Cabanillas, Kesslie Carlson-Ham, Gabrielle Coutant, Bruce Donohue, Ian Dunn, Stacey Duval, Erich Horn, KC Keegan-Twombly, Jesse McCarthy, Steve Monteverde, Matt Polchlopek, and Tiffany Runge.

References

Kudish, Michael. 2000. The Catskill Forest: A History. Fleischmanns, NY: Purple Mountain Press.

Rondout Neversink Stream Program. 2013. The Upper Neversink River Stream Management Plan. <u>http://catskillstreams.org/stream-management-program/sm-implementation-program/</u>

Rosgen, Dave. 1994. A Classification of Natural Rivers. Catena, Catena 22: 169-199.

Rosgen, Dave and Lee Silvey. 1996. Applied River Morphology. Pagosa Springs: Wildland Hydrology.

Rosgen, Dave. 2006. Watershed Assessment of River Stability and Sediment Supply. Pagosa Springs: Wildland Hydrology.

Wolman, M.G., 1954. A Method of Sampling Coarse River-Bed Material. Transactions of the American Geophysical Union 35(6):951-956.