DECLARATION

I declare that this review is my own unaided work. It is being submitted for the Degree of Master of Science in engineering to the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination to any other University.

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…………………………………………day of …………………………year……………………………………

ABSTRACT

The resistance to flow in rivers over the years has been largely an issue of great concern. There have been many suggestions as to how to compute the resistance to flow especially in a composite channel.

This work looks into the factors that contribute to the total flow resistance as a result of the elements that may be present in the body of water.

A critical review of previous work done to determine the total resistance to flow in a composite channel was made in this work and existing formulas were tested to see their reliability.

Ways of predicting resistance coefficients for individual elements were tested using those of James (2012), Meile et al. (2011) and Hirschowitz and James (2009).

This work has been limited to sparse arrangements of obstructions, vegetation and bank irregularities.

After careful observation, recording of data and analysis, formulas were developed for calculating the total resistance to flow for composite channel with permutations of three different elements these formulas were tested and seen to be useful in computing the total resistance to flow in a channel with low flow in a composite channel.

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Notation

A_{bf} = bed area subjected to surface shear [m^2]

A_p= projected area of elements [m^2]

a = Constant in friction factor relationship [-]

b = Constant in in friction factor relationship [-]

C_D = drag coefficient [-]

C = constant in friction factor relationship [-]

D = flow depth [m]

d = cylinder diameter [m]

F = downslope weight component of water [N]

F'surface shear resisting force [N]

F''= form drag [N]

f = friction factor [-]

f'= friction factor associated with bed shear [-]

f'' = friction factor associated with form drag [-]

f_b = friction factor for bed [-]

g = gravitational acceleration [m/s^2]

k_s = Nikuradse grain roughness [m]

n = Manning resistance coefficient [s/m$^{1/3}$]

n'= Manning resistance coefficient associated with bed shear [s/m$^{1/3}$]

n''= Manning resistance coefficient associated with form drag [s/m$^{1/3}$]

N = number of elements per unit area of bed [-]

R = hydraulic radius [m]

R_e = flow Reynolds number [-]

R_d = element Reynolds number [-]

S = channel slope [-]

$u*$ = shear velocity [m/s]

V = average velocity [m/s]

v = volume of water above bed [m^3]

W = channel width [m]

α = factor to account for area of separation zone [-]

δ = kinematic viscosity of water [m^2/s]

ρ = water density [kg/m^3]

τ_o= boundary shear stress [N/m^2]

irr = irregularities

$obst$ = obstructions

veg =Vegetation

f_{to} = a constant to be equal to zero by Hirschowitz and James (2009) for W/D greater than about 5 and between 0.06 and 0.1 for narrow channels.

f_m= total friction factor for bed with irregularities.

f_{Mr} = resistance due to micro-roughness of the sidewalls of the elements causing the irregularities

f_{prism} = the resistance due to the bed.

l.= the ratio of water volume to projected plant area,

a_x= longitudinal stem spacing

a_y= lateral stem spacing,

d_p= the stem diameter

V_{inf} = the depth-averaged velocity in the channel as unaffected by vegetation

V_{veg} = the depth-averaged velocity within the vegetated zone,

h_t= the flow depth