

# **MnPAVE Validation: Comparison of MnROAD HMA Modulus Values**

Witczak (Design Guide) Equation,  
Thompson (ILLI-PAVE) Equation,  
Backcalculation by EVERCALC  
and ELMOD

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# Witczak Equation

$$\log E = a_0 + a_1 p_{200} + a_2 (p_{200})^2 + a_3 p_4 + a_4 V_a + a_5 \frac{V_{beff}}{V_{beff} + V_a} + \frac{a_6 + a_7 p_4 + a_8 p_{3/8} + a_9 (p_{3/8})^2 + a_{10} p_{3/4}}{1 + e^{(a_{11} + a_{12} \log f + a_{13} 2 \log \eta)}}$$

Where:

$E = 10^{-5}$  x Dynamic Modulus (psi)

$f =$  Load frequency (Hz)

$\eta = 10^{-8}$  x Dynamic Viscosity (cP)

$V_{beff} =$  Effective binder content (% by vol.)

$P_b =$  binder content (% by wt. of mix)

$p_{3/4} =$  Cumulative % retained on 3/4" sieve

$V_a =$  Air voids (% by volume)

$p_{3/8} =$  Cumulative % retained on 3/8" sieve

$P_{ba} =$  Absorption (% by wt. of aggregate)  $p_4 =$  Cumulative % retained on No. 4 sieve

$G_b =$  specific gravity of binder

$p_{200} =$  Percent passing No. 200 sieve

$G_{sb} =$  Bulk specific gravity of aggregate



# Thompson (ILLI-PAVE) Equation

$$\log_{10} E_{AC} = 1.48 - 1.76 \log_{10} \left( \frac{AREA}{D_0} \right) + 0.26 \left( \frac{AREA}{T_{AC}} \right)$$

Where:

$$AREA = 6 \left( 1 + \frac{2D_1}{D_0} + \frac{2D_2}{D_0} + \frac{D_3}{D_0} \right)$$

$E_{AC}$  = Modulus of the HMA layer (ksi)

$T_{AC}$  = Temperature of the HMA layer (°F)

$D_0$  = Deflection at center of load (mils)

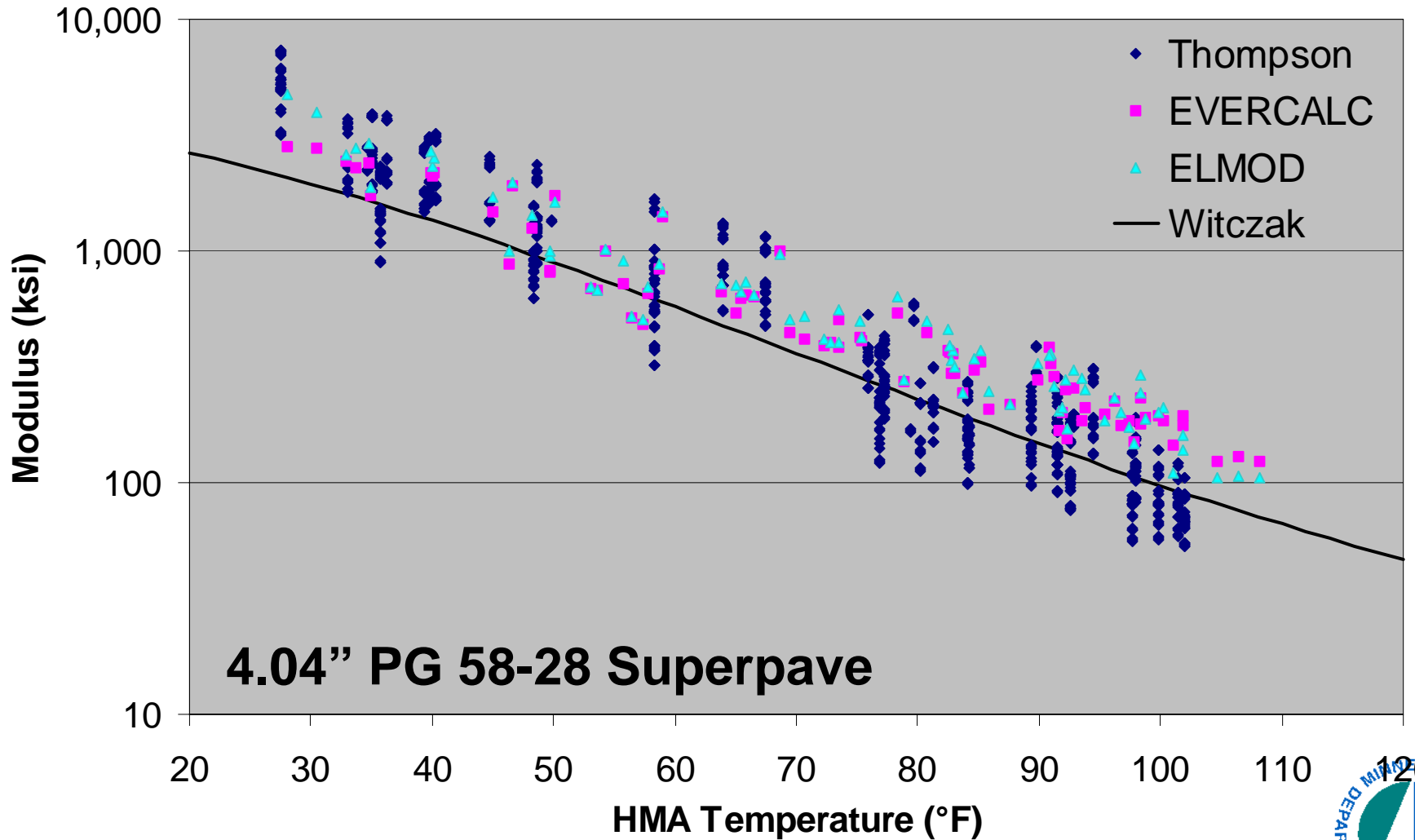
$D_1$  = Deflection at 12 in. (305 mm) from center of load

$D_2$  = Deflection at 24 in. (610 mm) from center of load

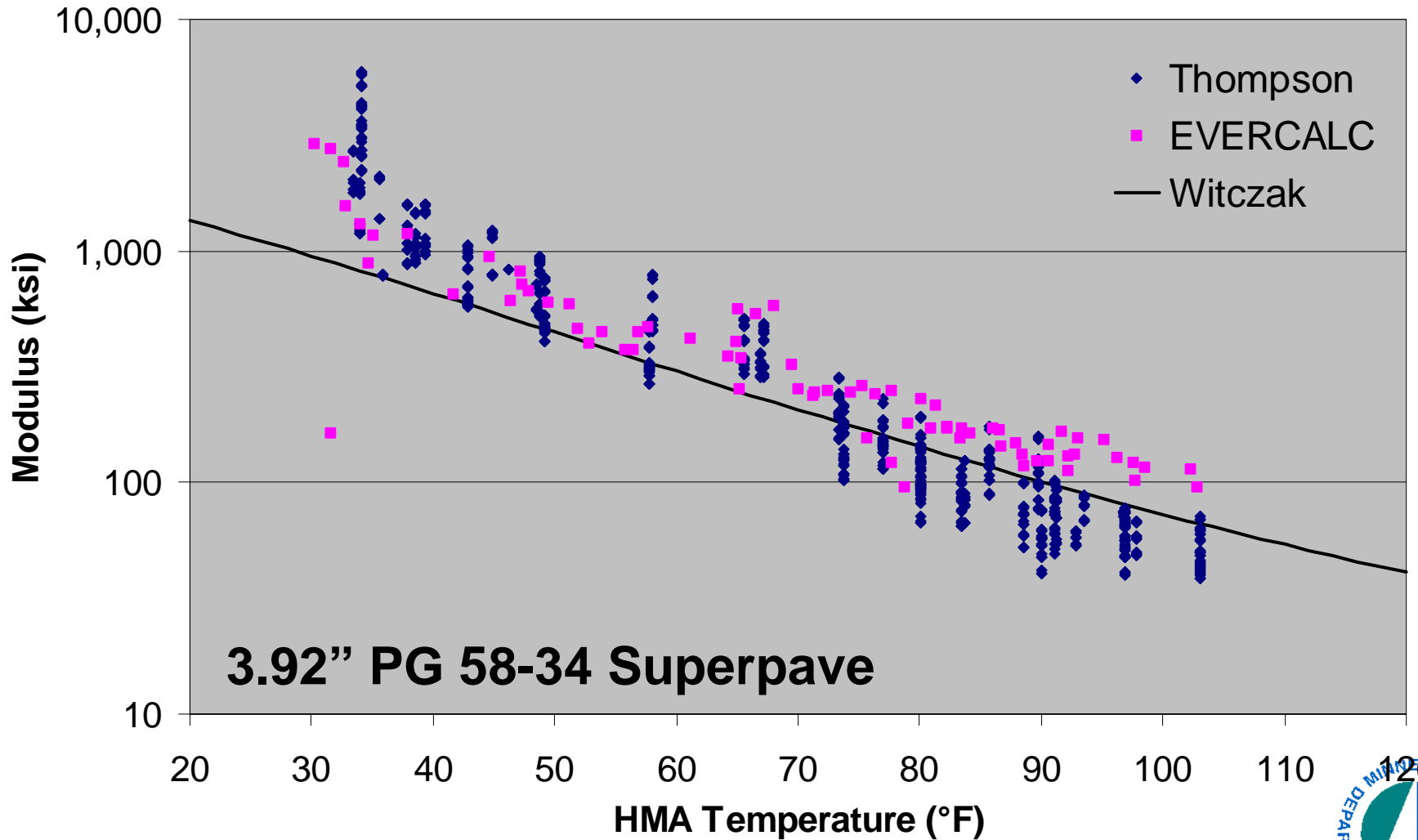
$D_3$  = Deflection at 36 in. (914 mm) from center of load



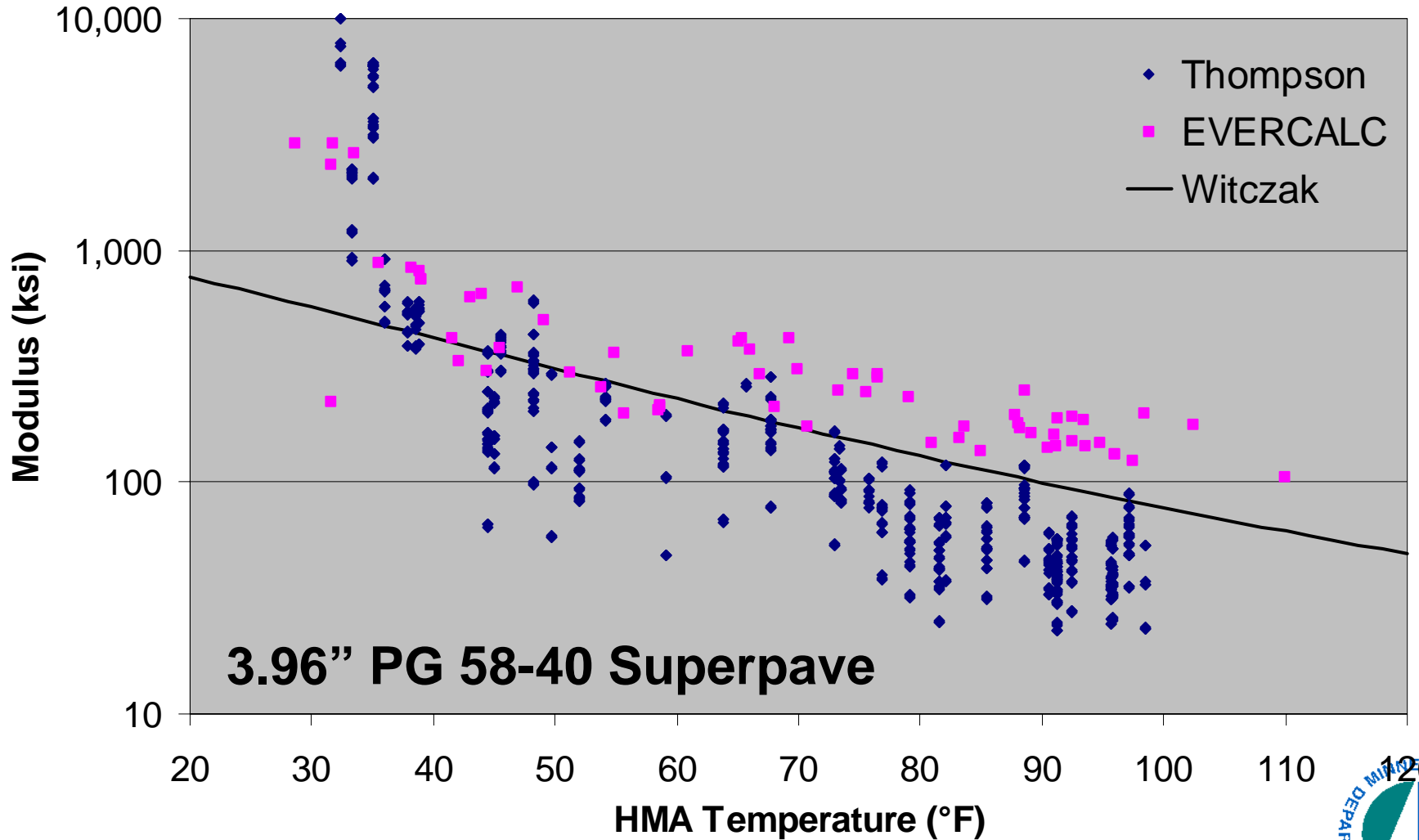
# 2000 Cell 33 Modulus Comparison



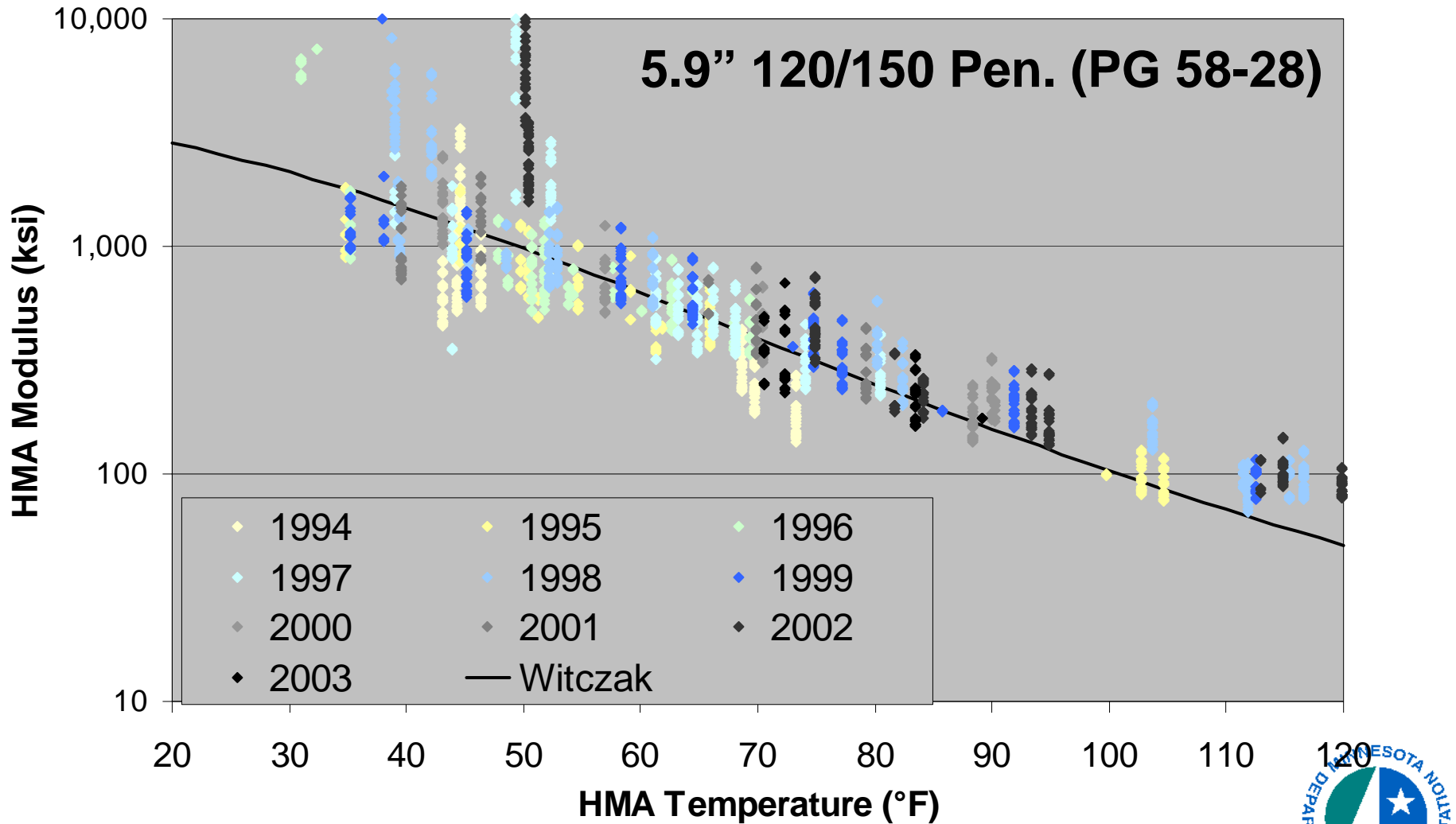
# 2000 Cell 34 Modulus Comparison



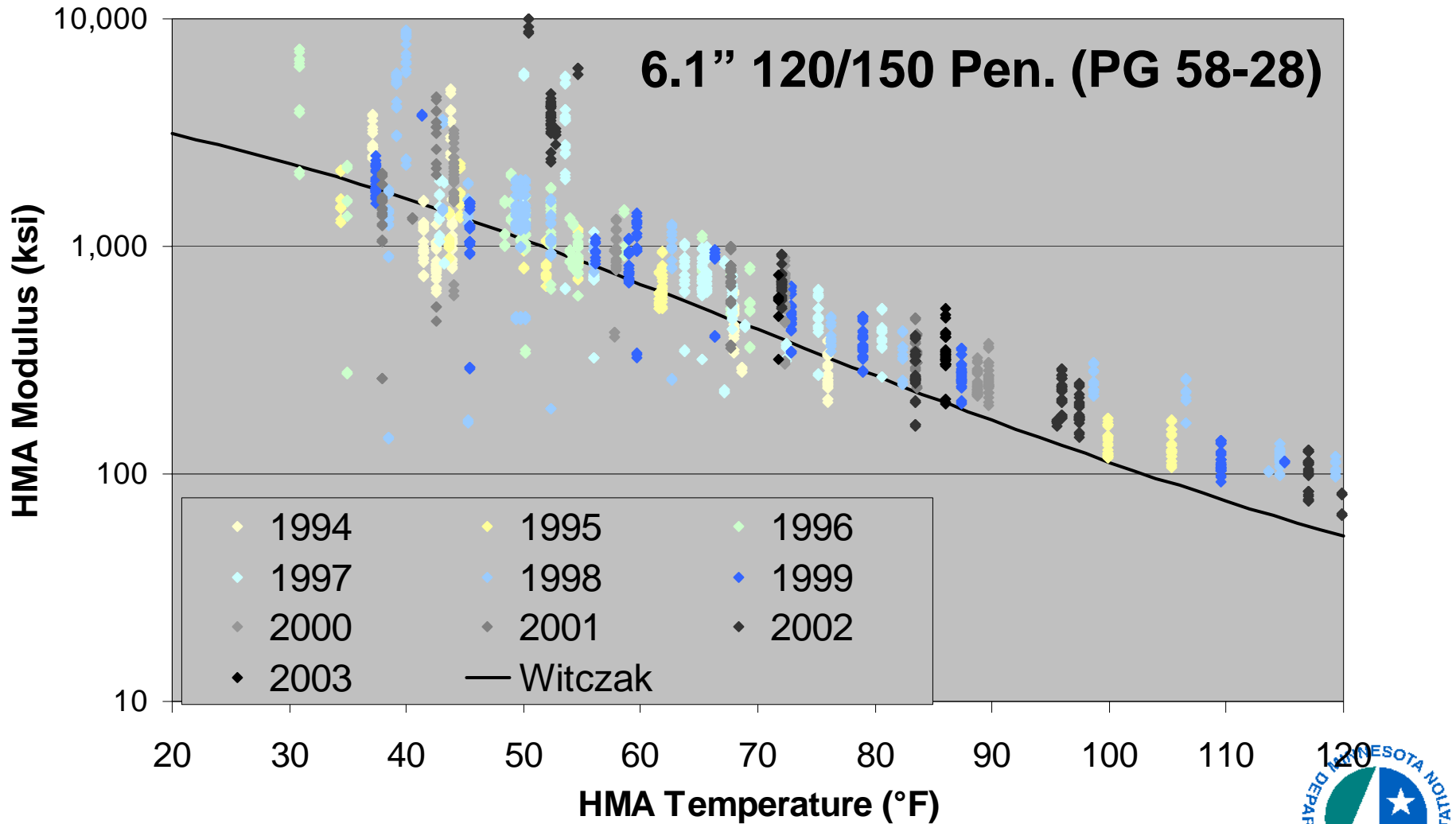
# 2000 Cell 35 Modulus Comparison



# Cell 1 Modulus Comparison 1994-2003 Witczak and Thompson Equations

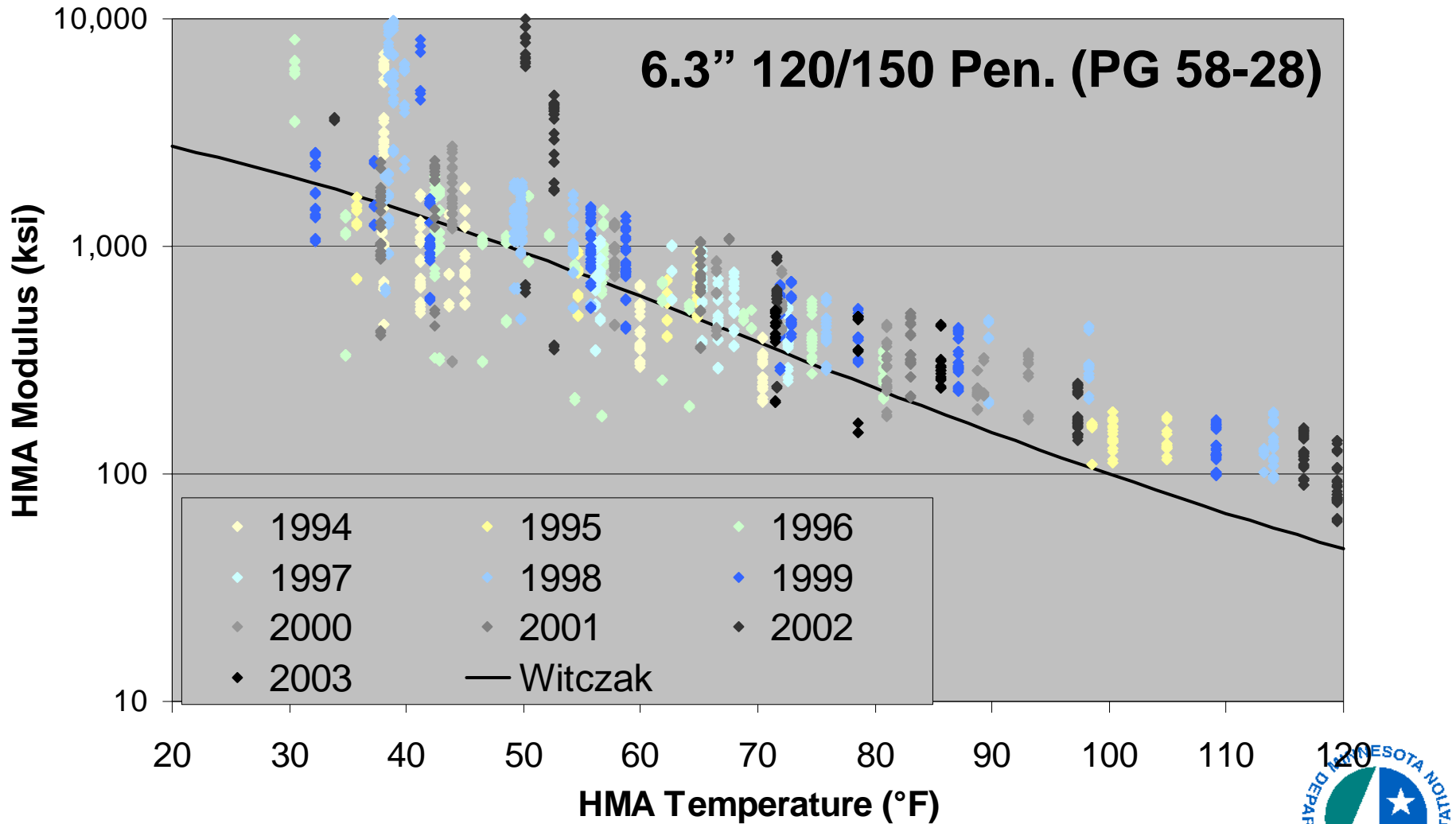


# Cell 2 Modulus Comparison 1994-2003 Witczak and Thompson Equations

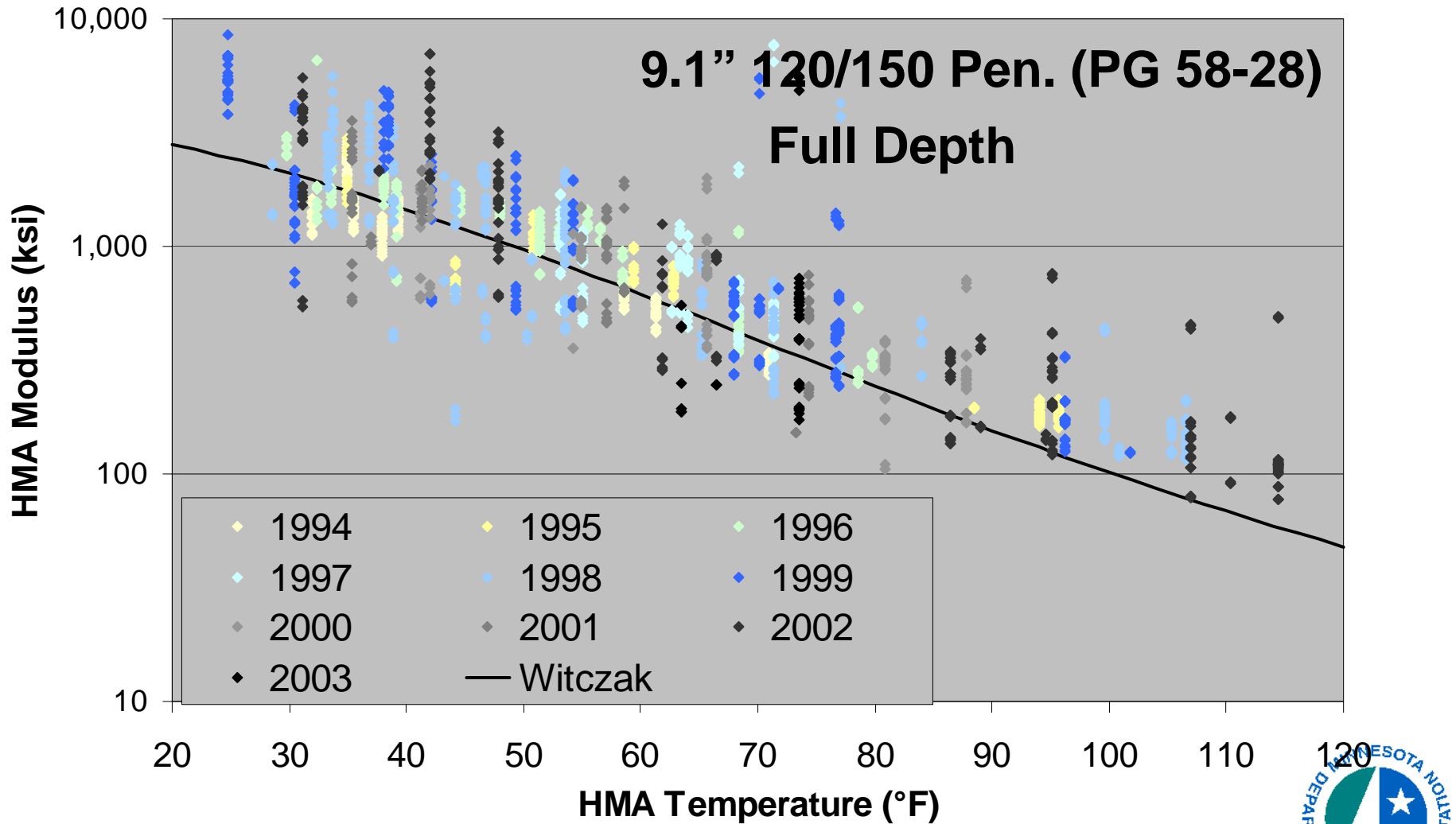




# Cell 3 Modulus Comparison 1994-2003 Witczak and Thompson Equations

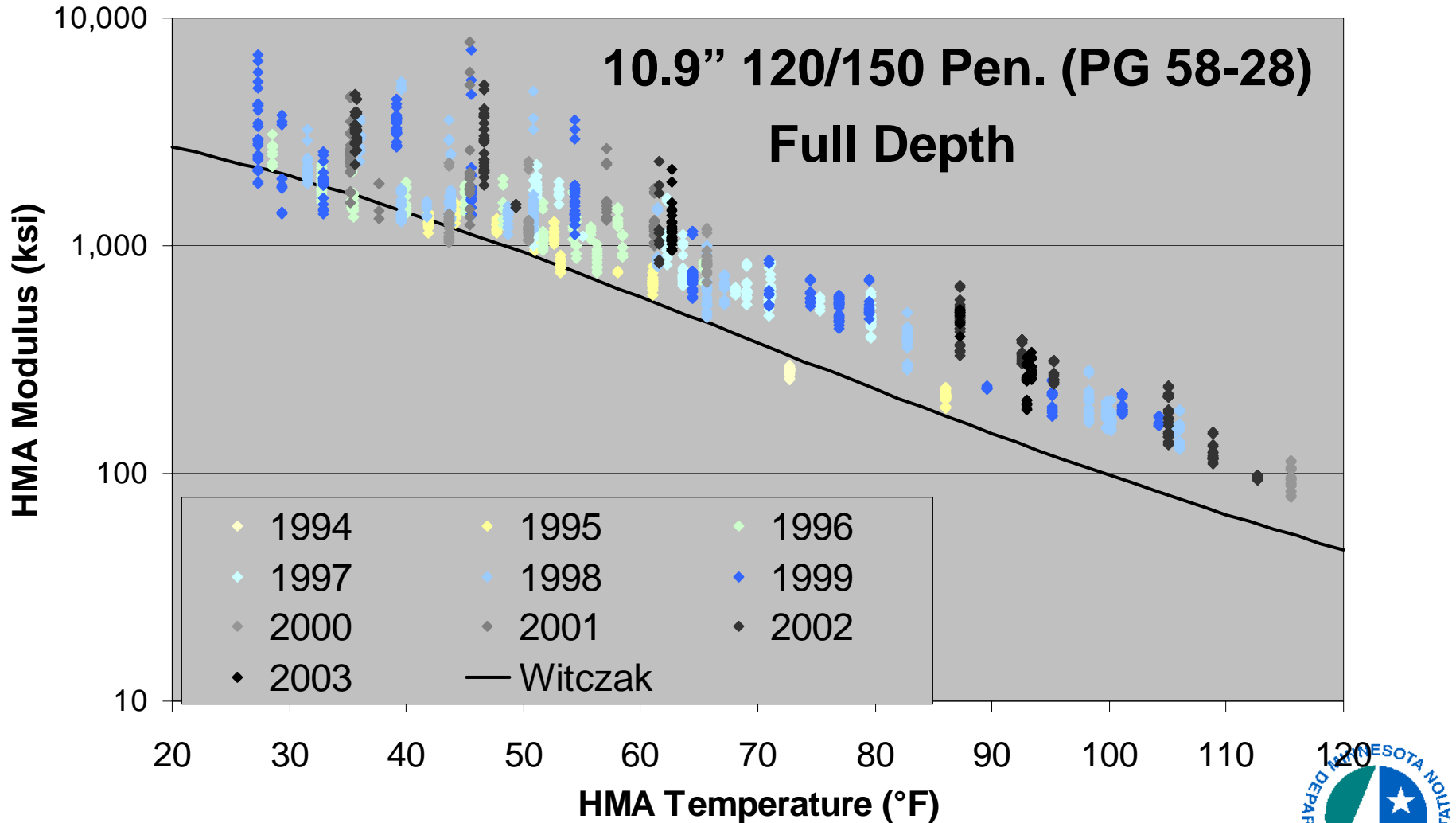


# Cell 4 Modulus Comparison 1994-2003 Witczak and Thompson Equations



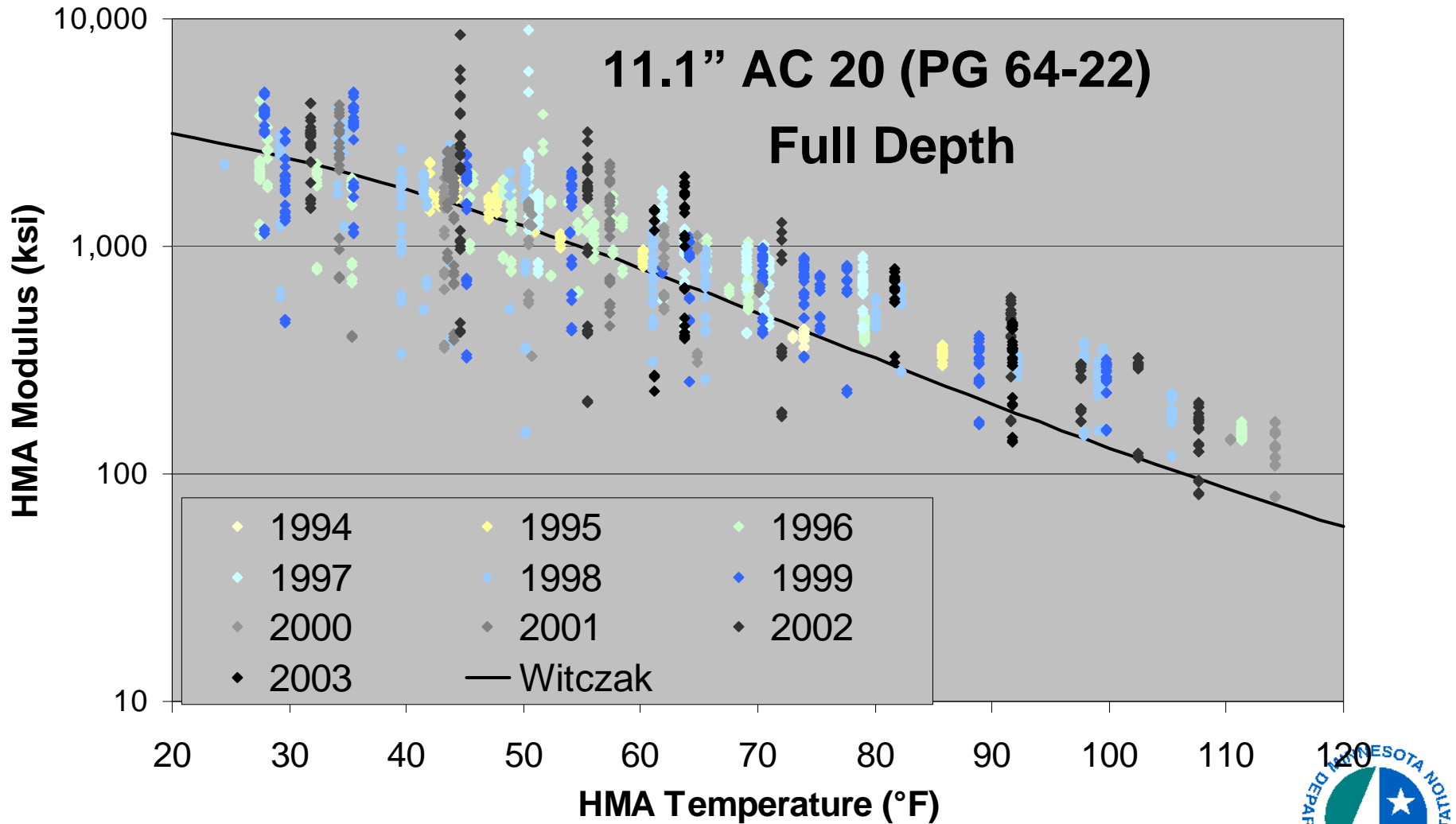
# Cell 14 Modulus Comparison 1994-2003

## Witczak and Thompson Equations



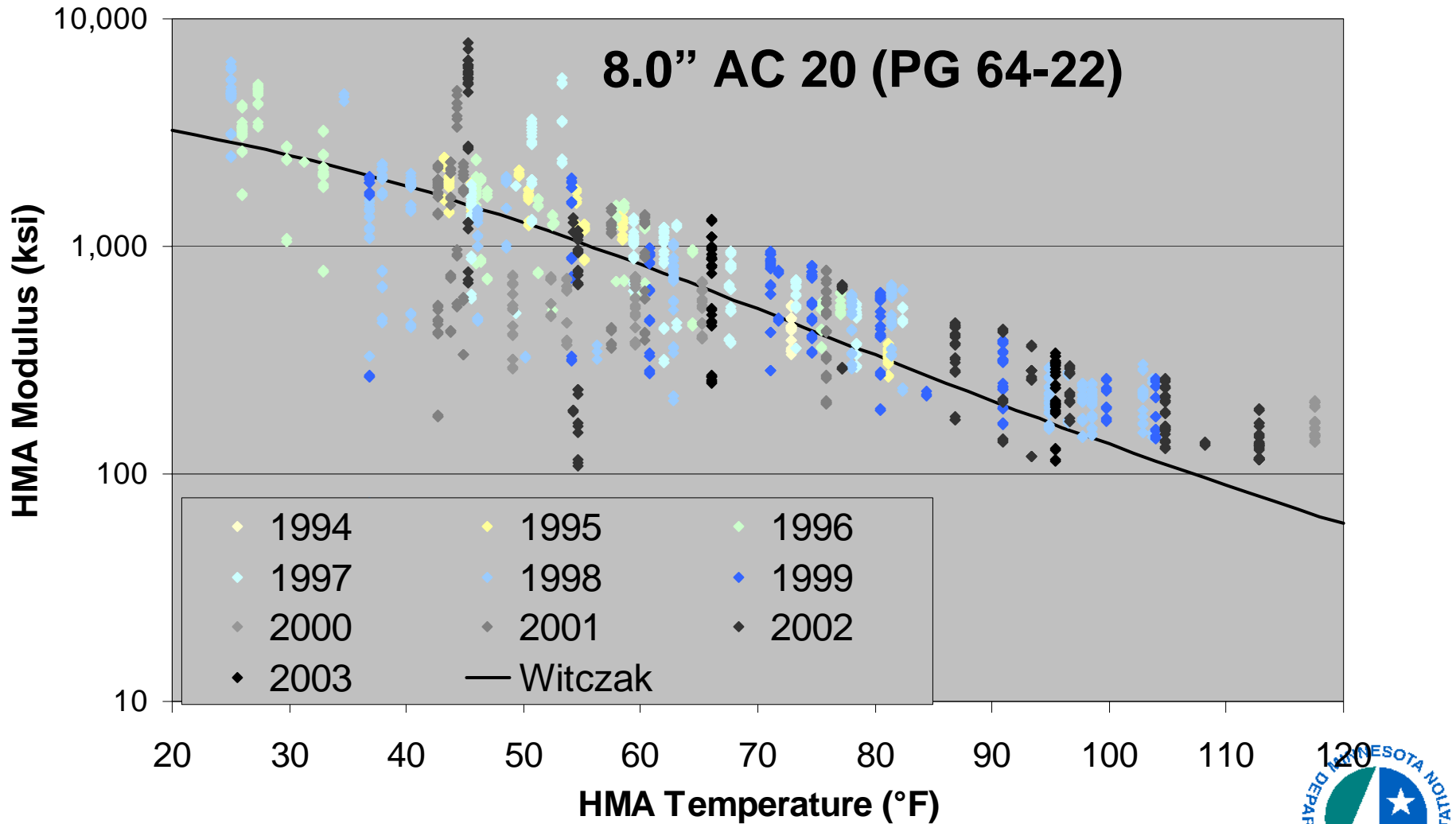
# Cell 15 Modulus Comparison 1994-2003

## Witczak and Thompson Equations

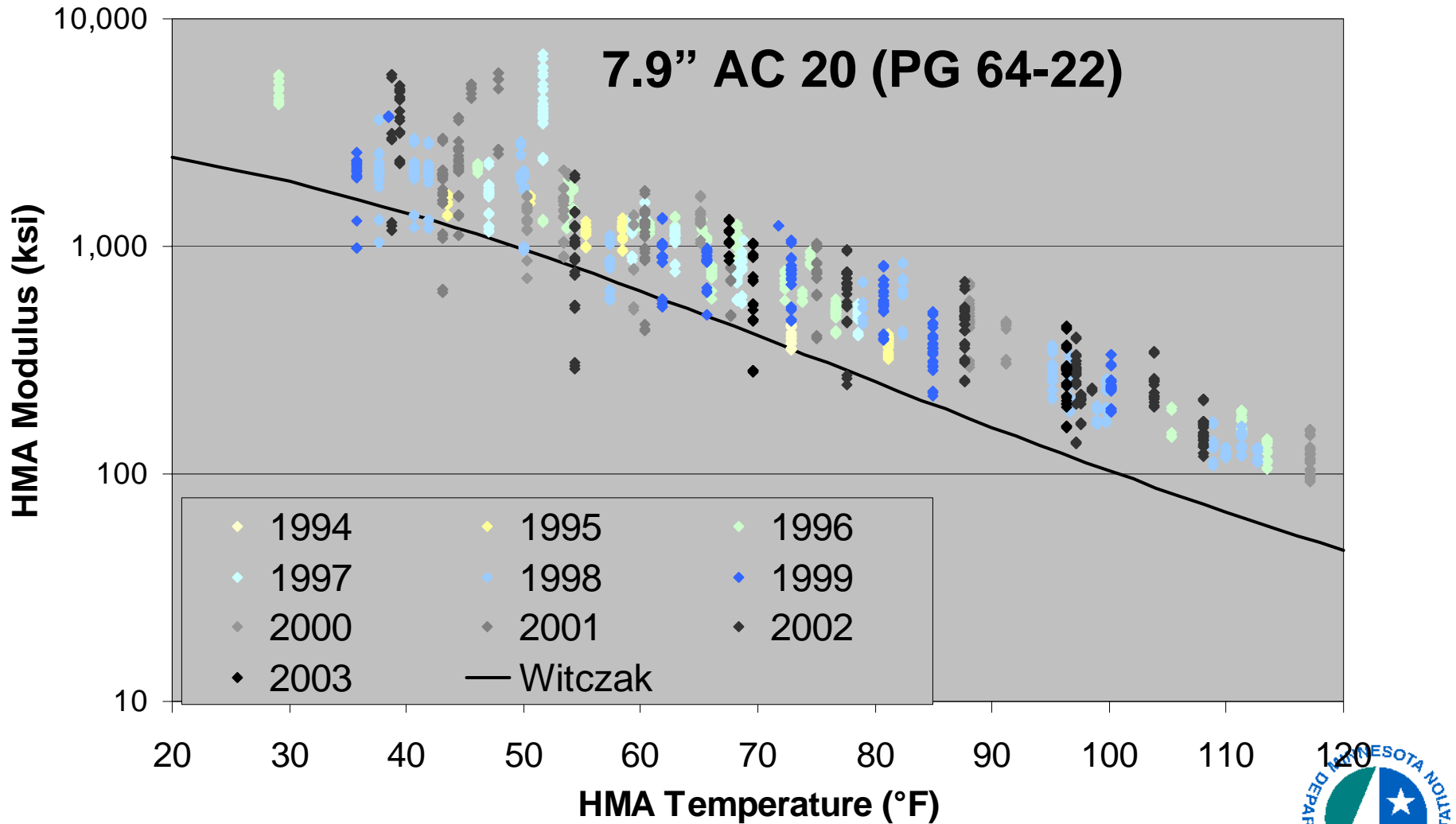


# Cell 16 Modulus Comparison 1994-2003

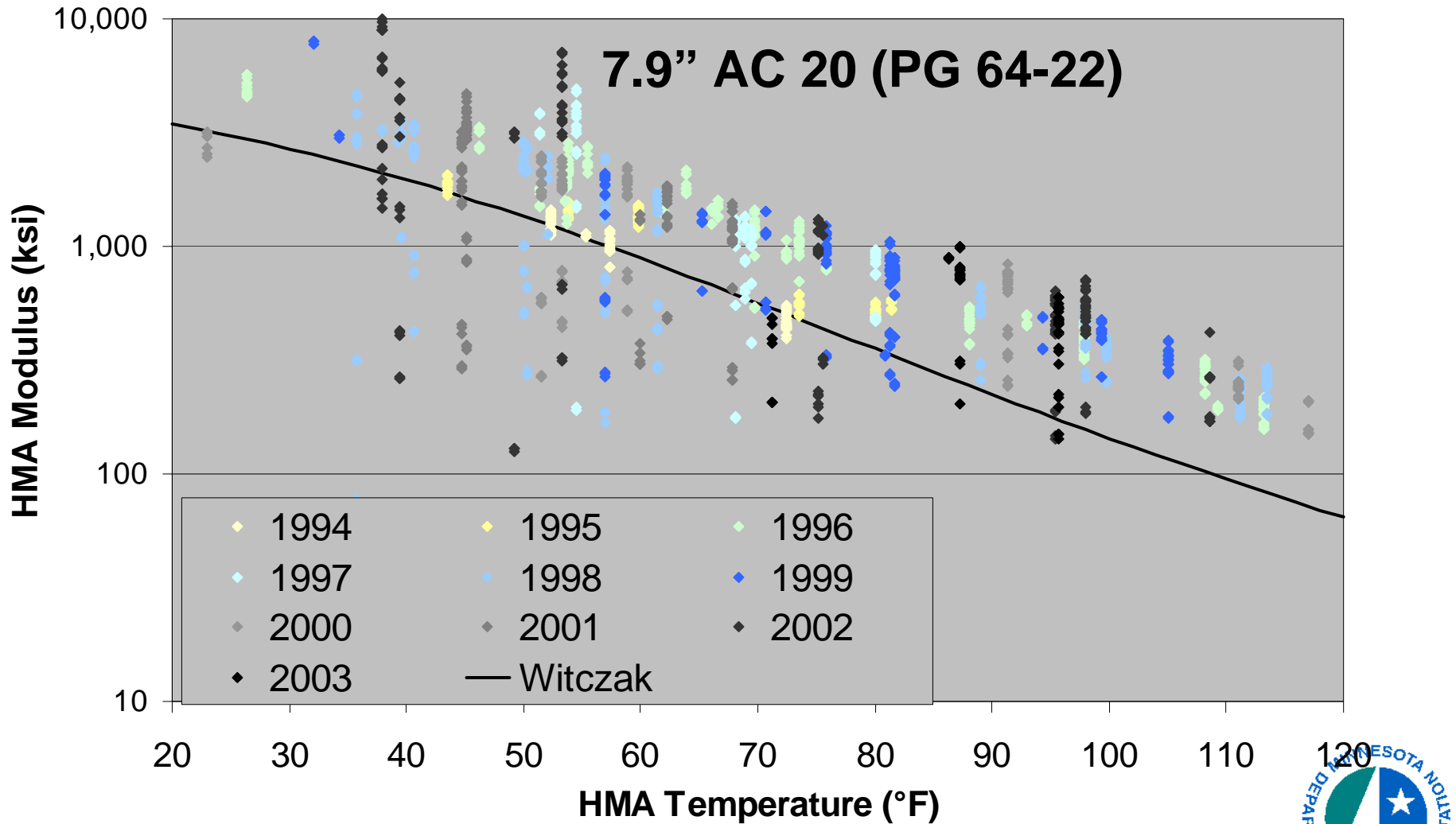
## Witczak and Thompson Equations



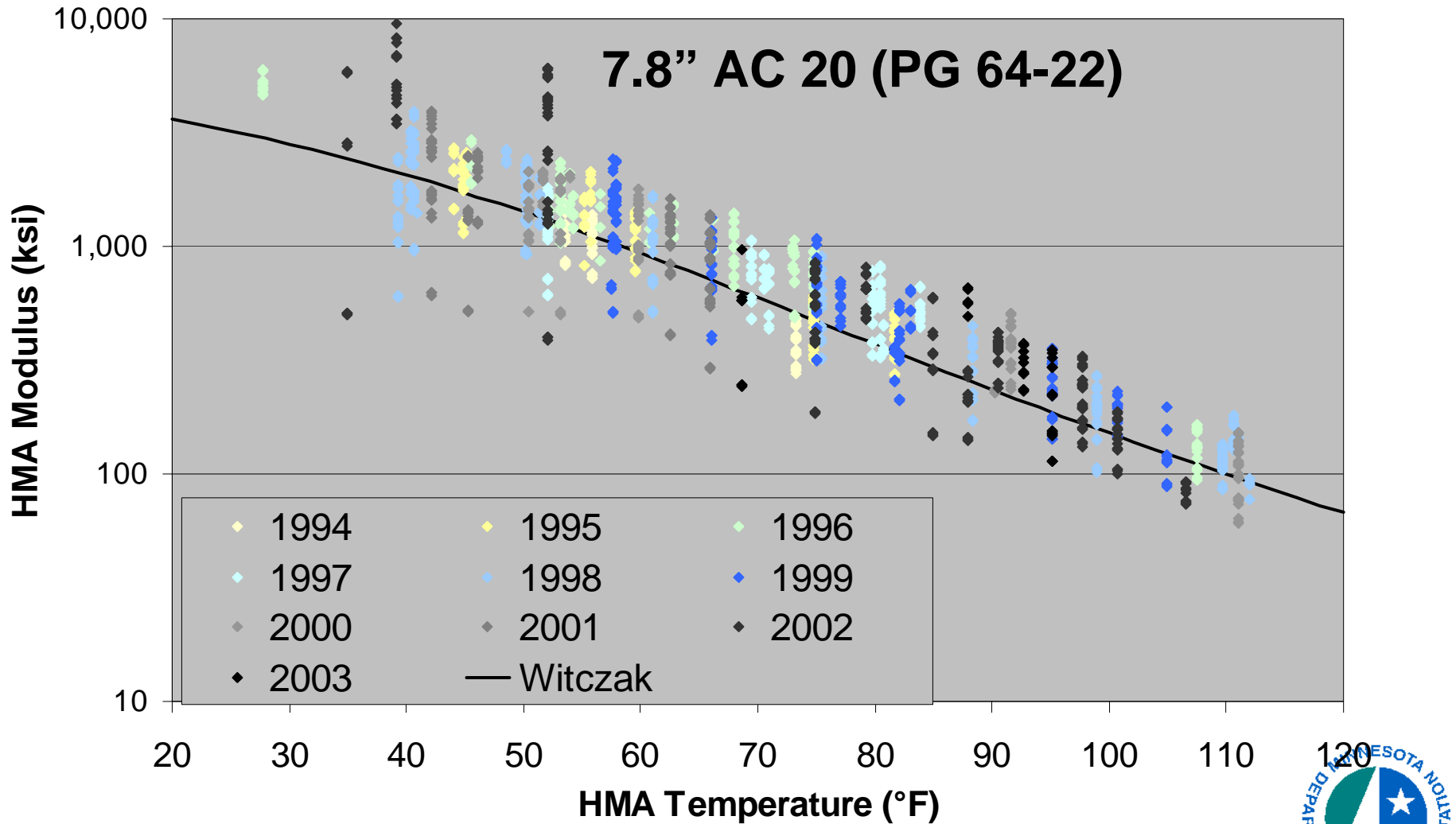
# Cell 17 Modulus Comparison 1994-2003 Witczak and Thompson Equations



# Cell 18 Modulus Comparison 1994-2003 Witczak and Thompson Equations

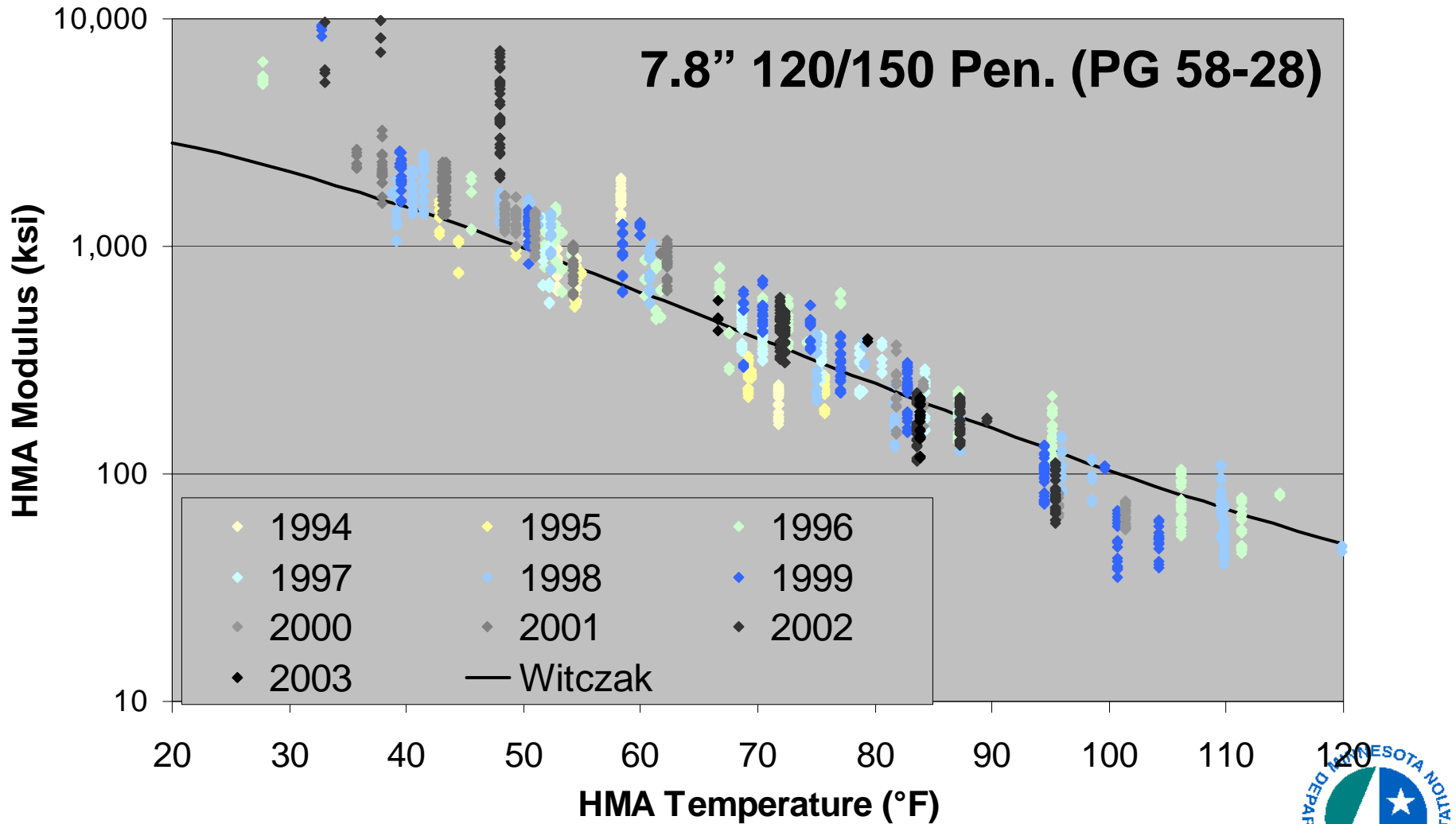


# Cell 19 Modulus Comparison 1994-2003 Witczak and Thompson Equations



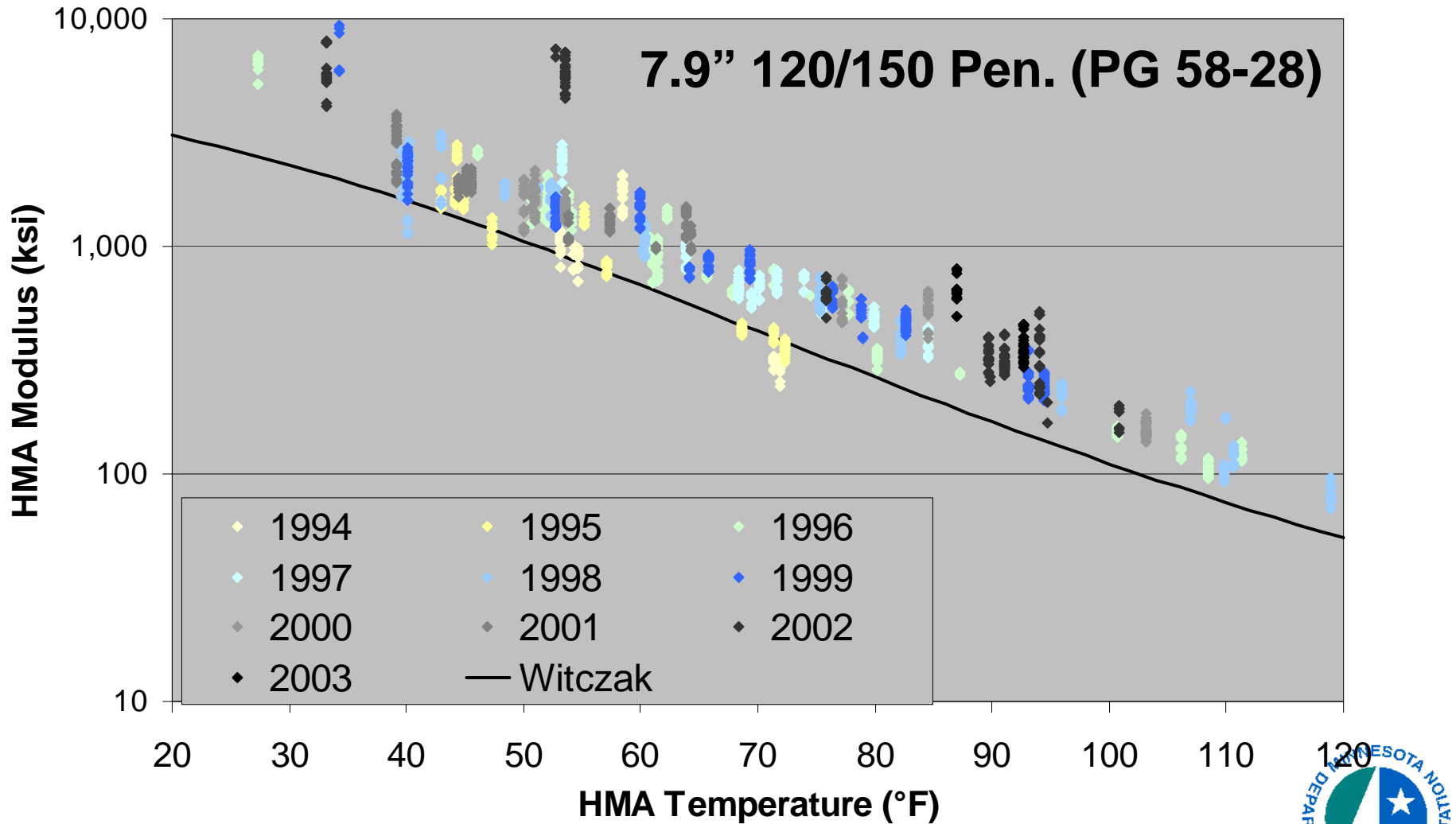


# Cell 20 Modulus Comparison 1994-2003 Witczak and Thompson Equations

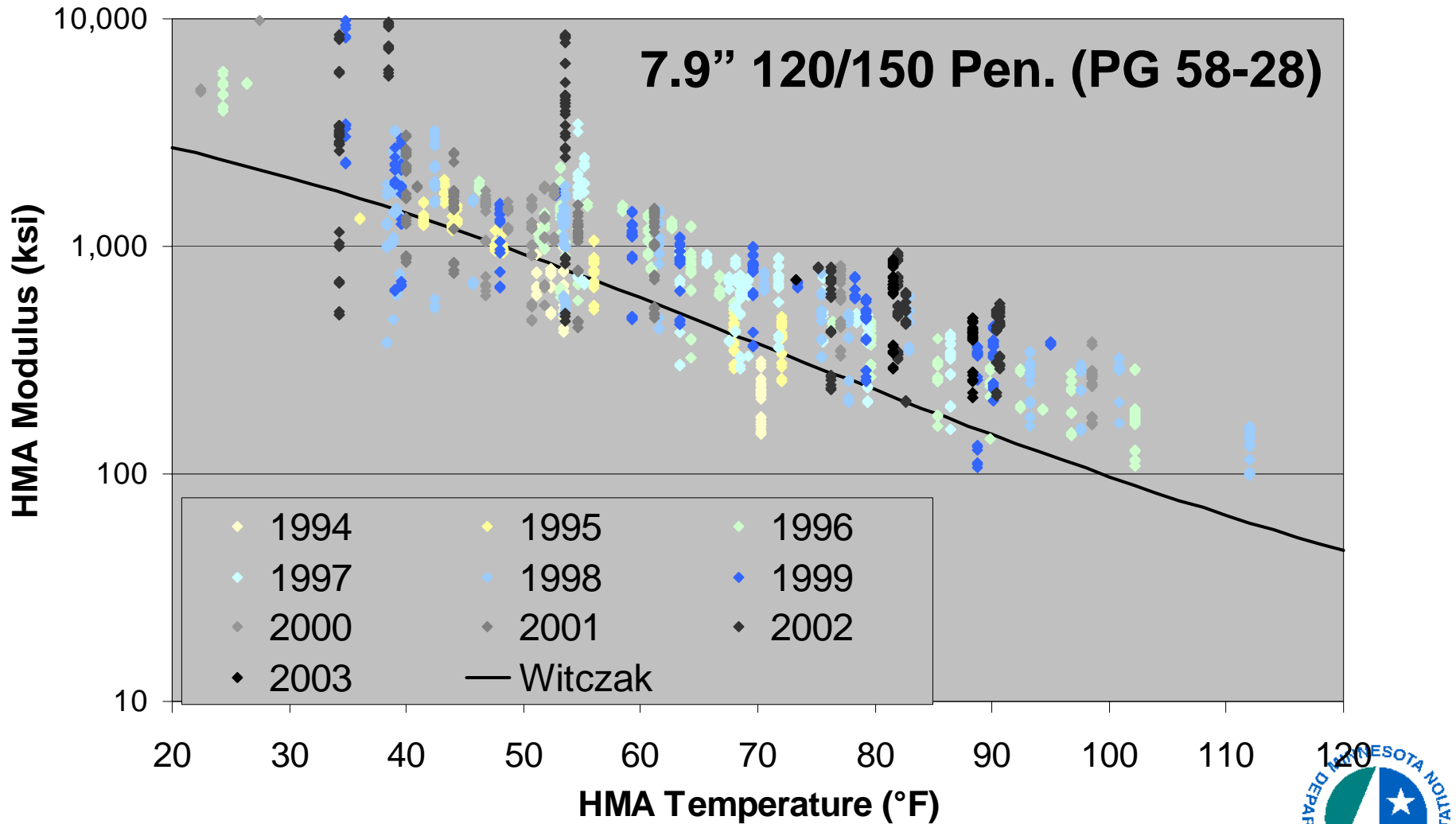


# Cell 21 Modulus Comparison 1994-2003

## Witczak and Thompson Equations

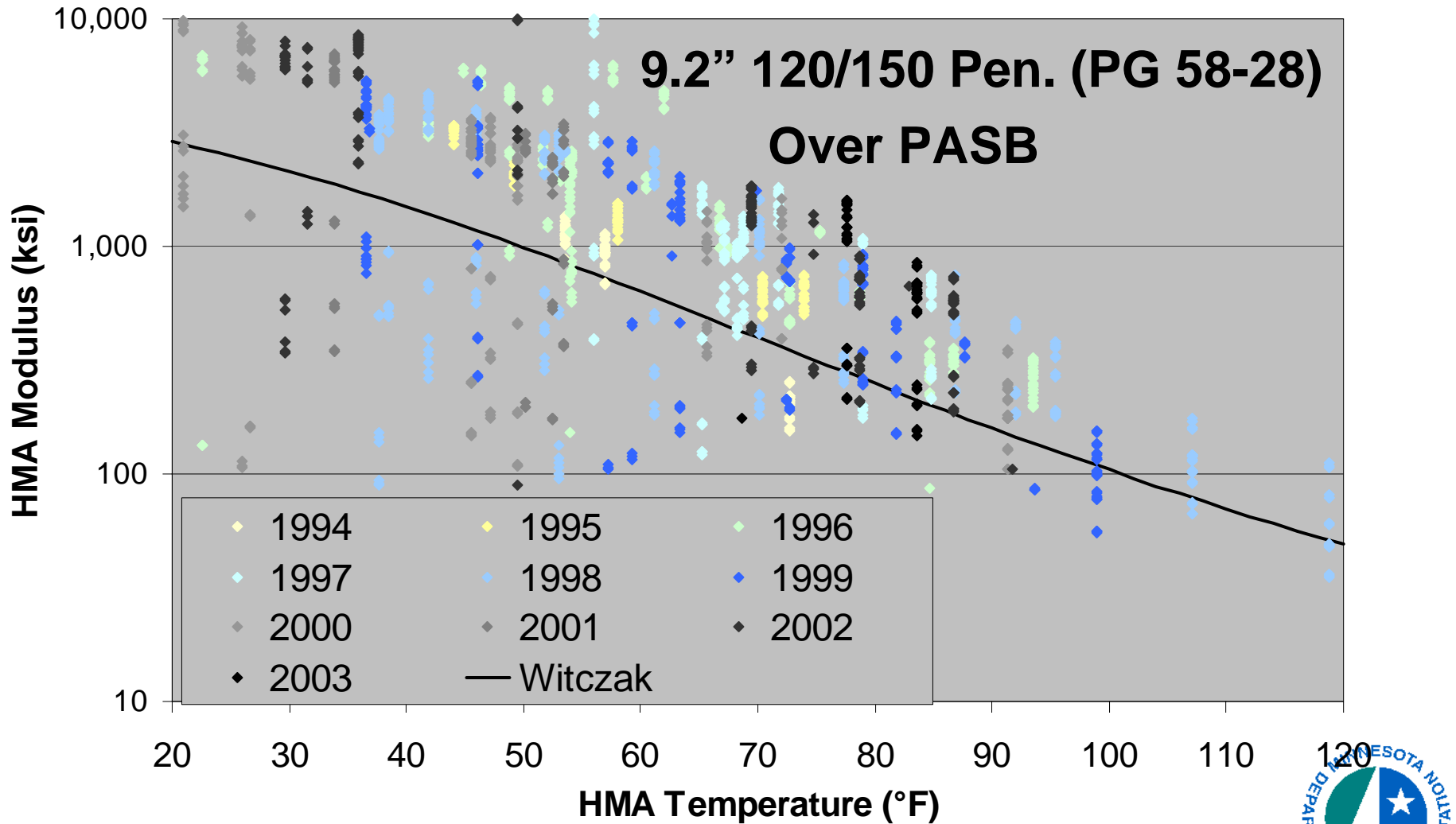


# Cell 22 Modulus Comparison 1994-2003 Witczak and Thompson Equations

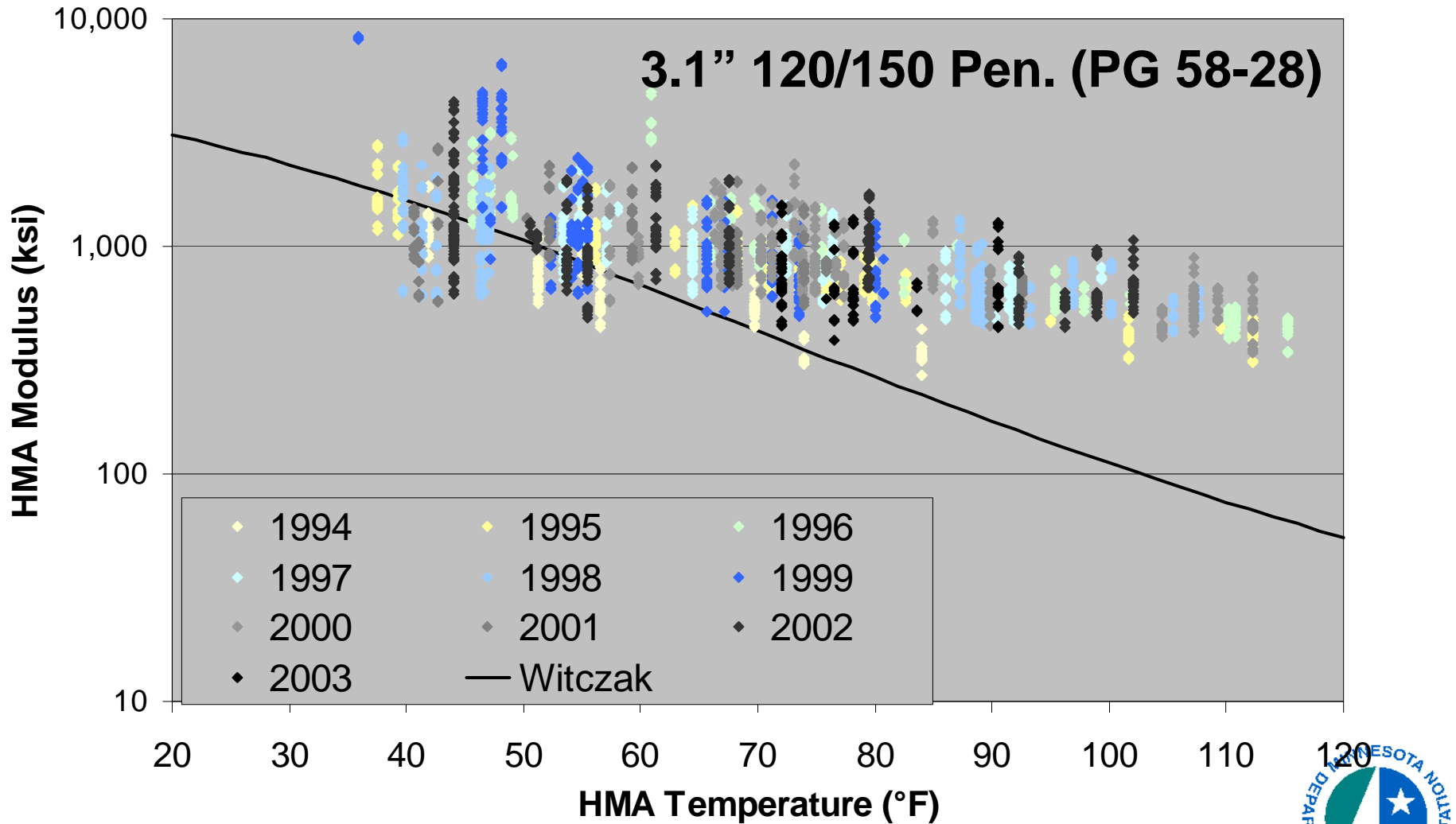


# Cell 23 Modulus Comparison 1994-2003

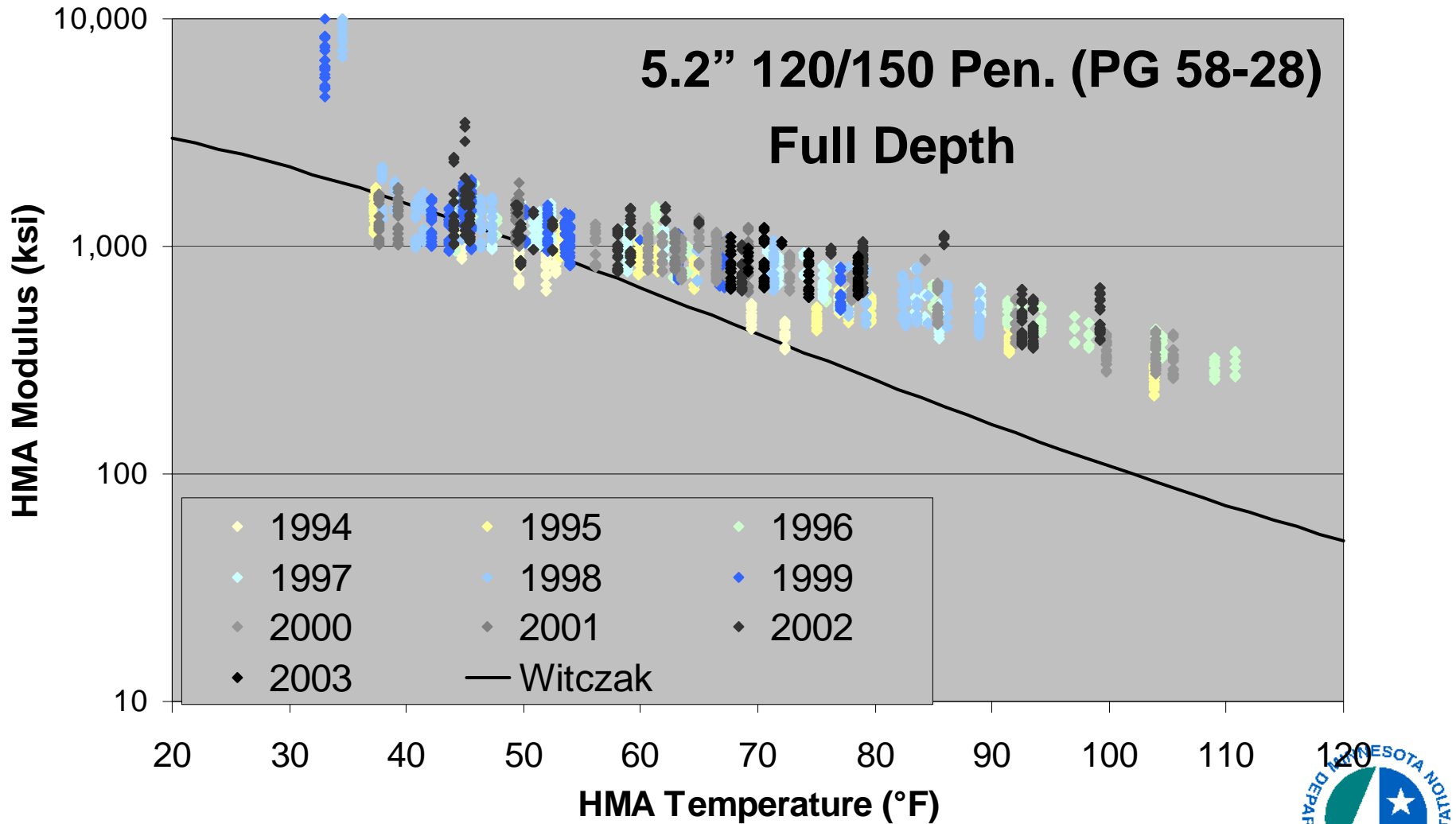
## Witczak and Thompson Equations



# Cell 24 Modulus Comparison 1994-2003 Witczak and Thompson Equations

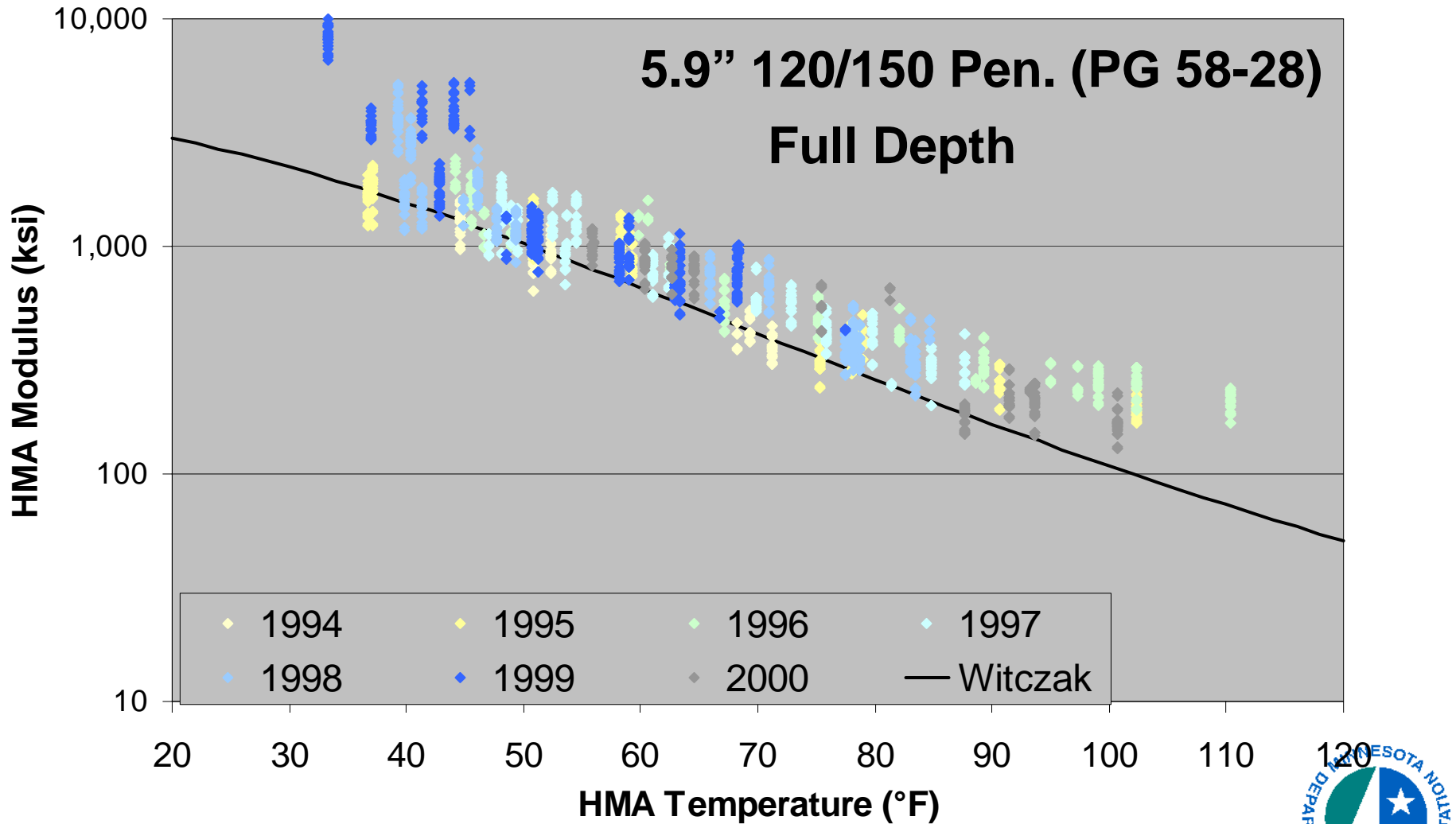


# Cell 25 Modulus Comparison 1994-2003 Witczak and Thompson Equations



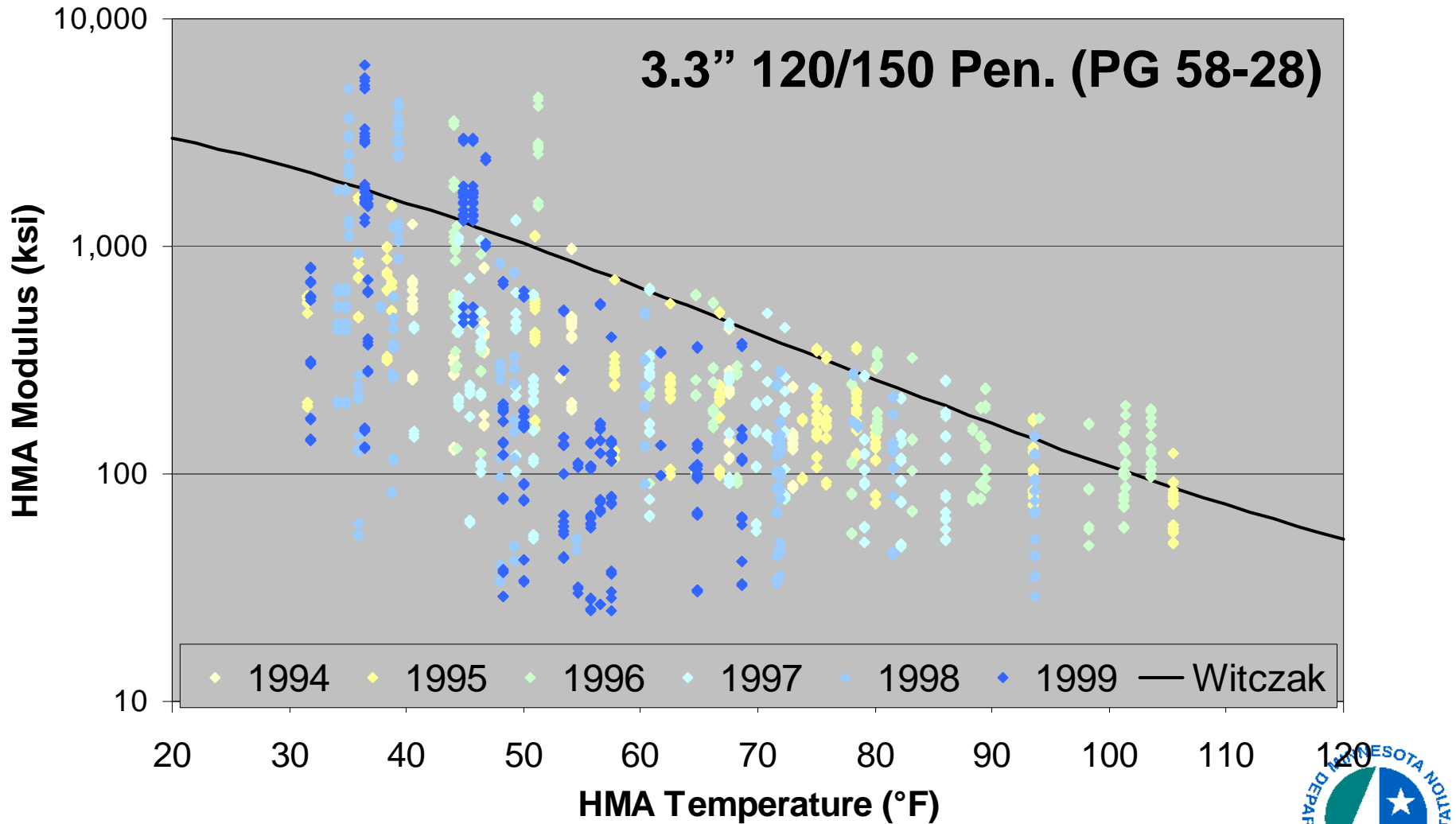
# Cell 26 Modulus Comparison 1994-2000

## Witczak and Thompson Equations



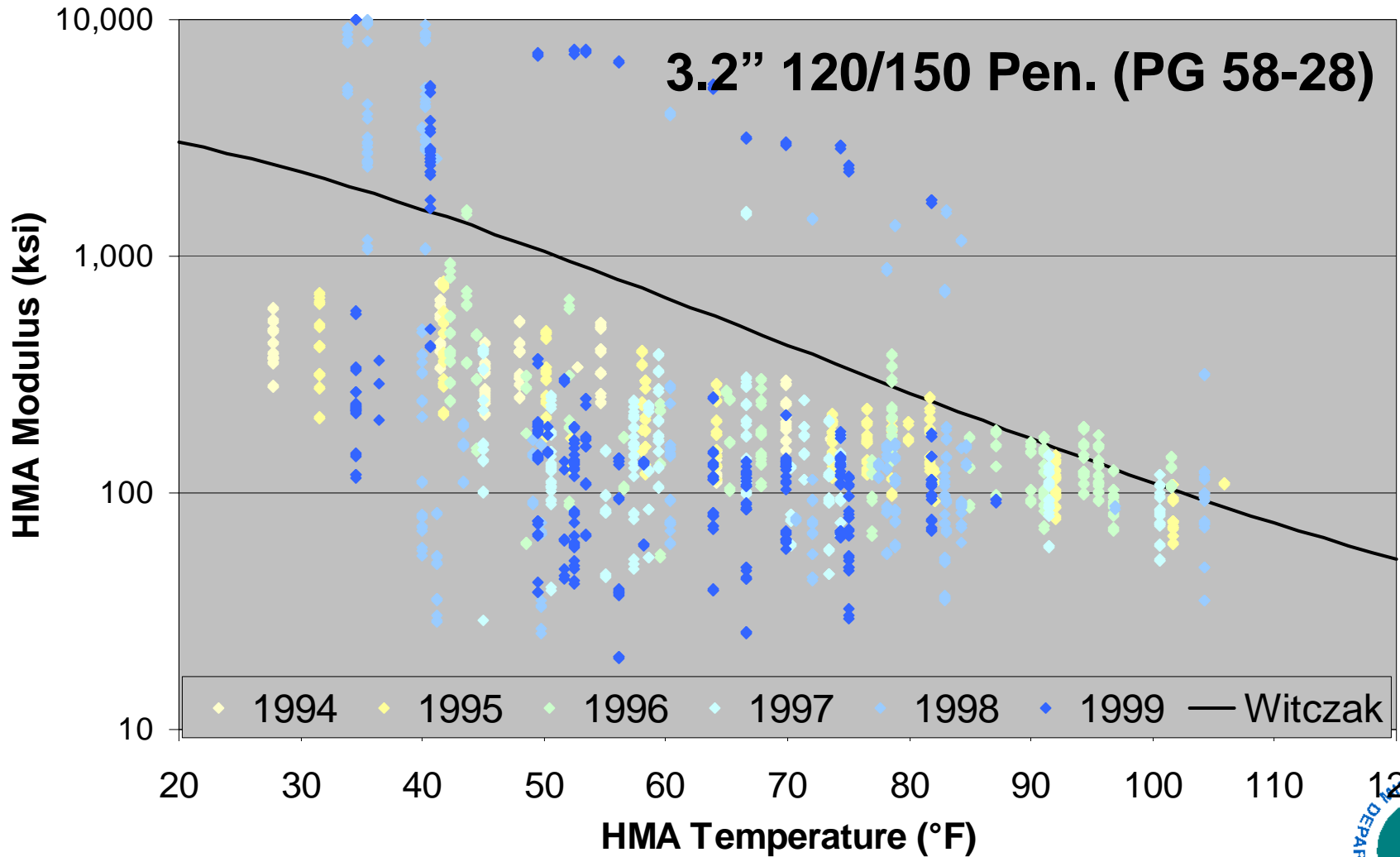
# Cell 27 Modulus Comparison 1994-1999

## Witczak and Thompson Equations

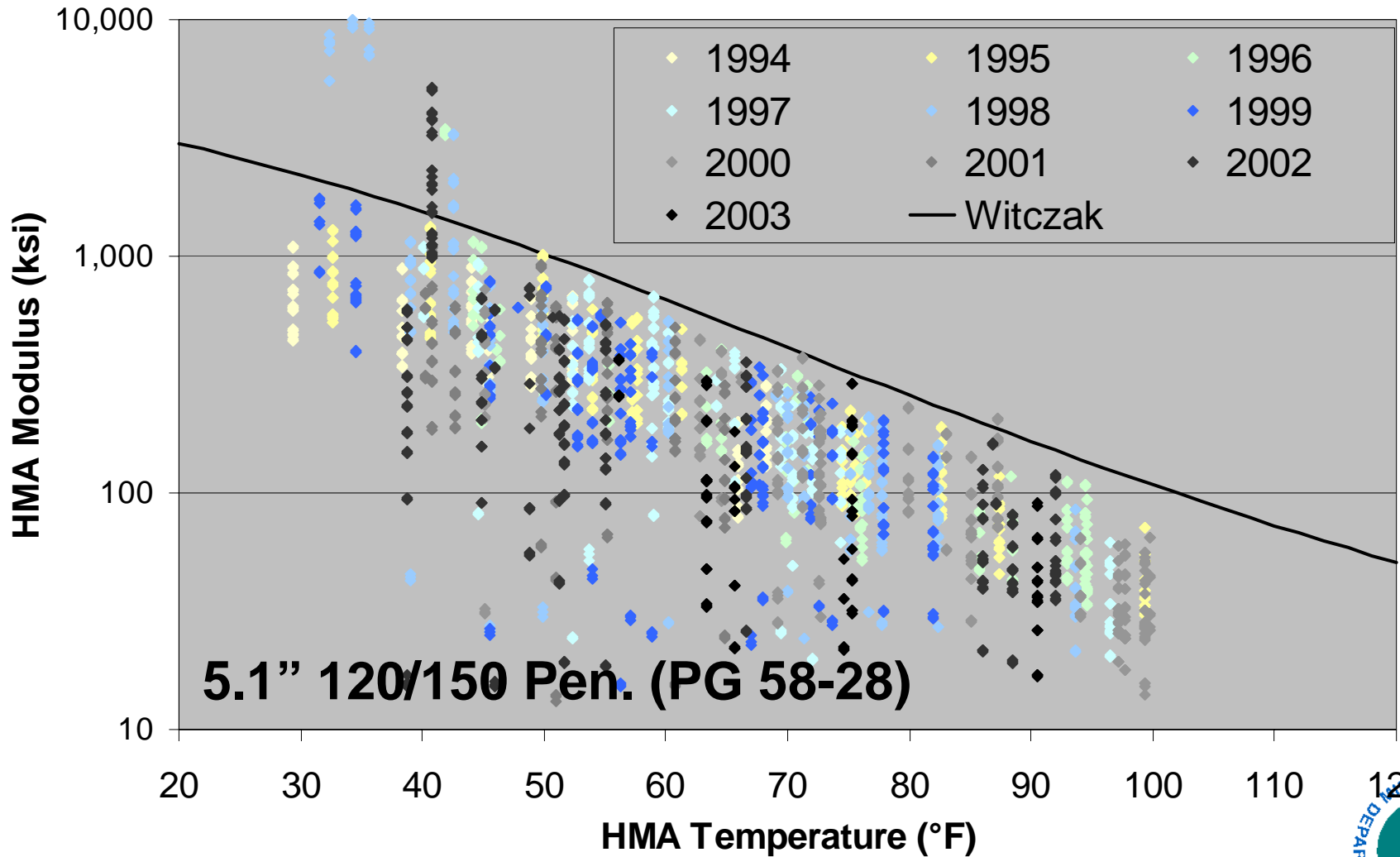




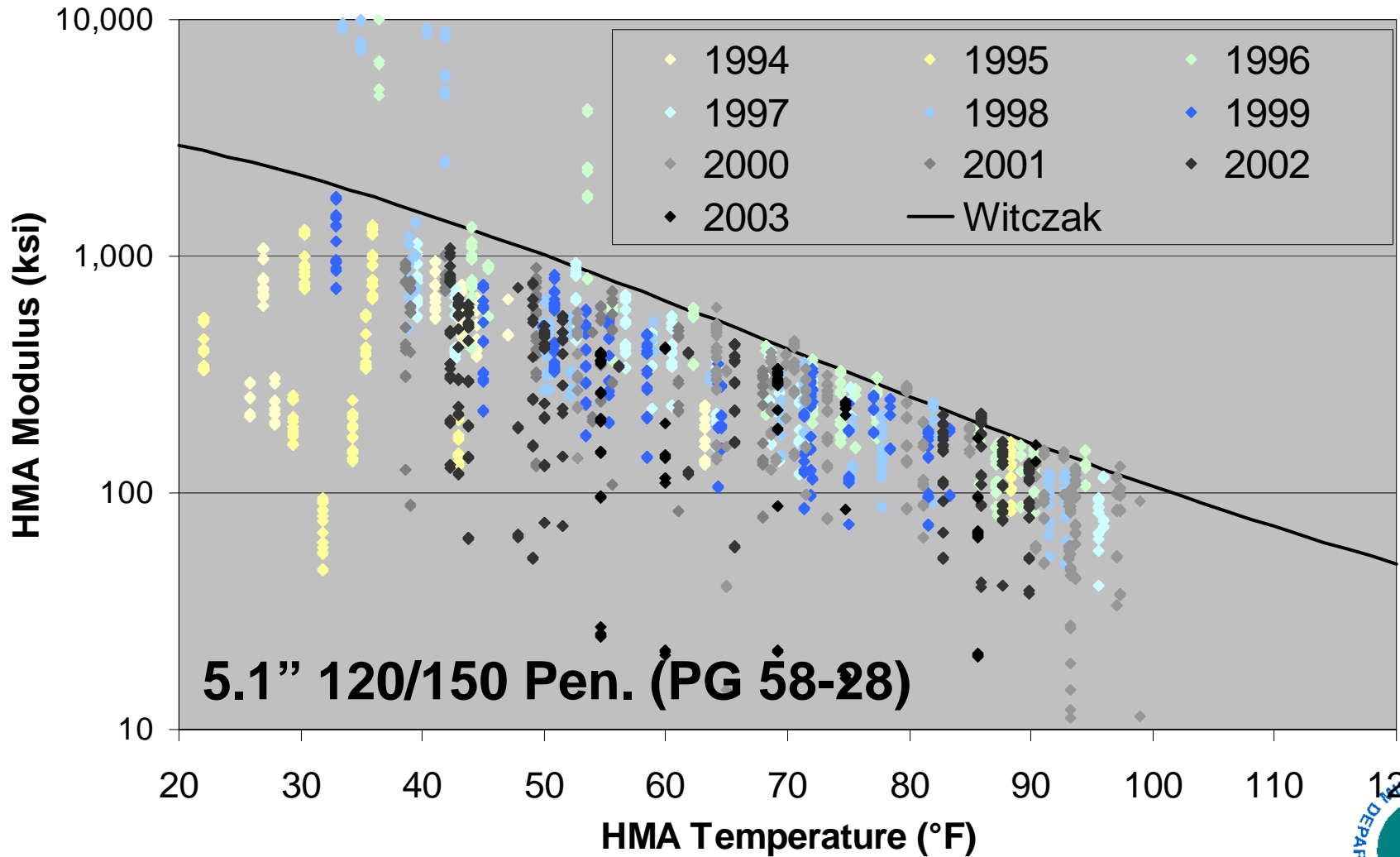
# Cell 28 Modulus Comparison 1994-1999 Witczak and Thompson Equations



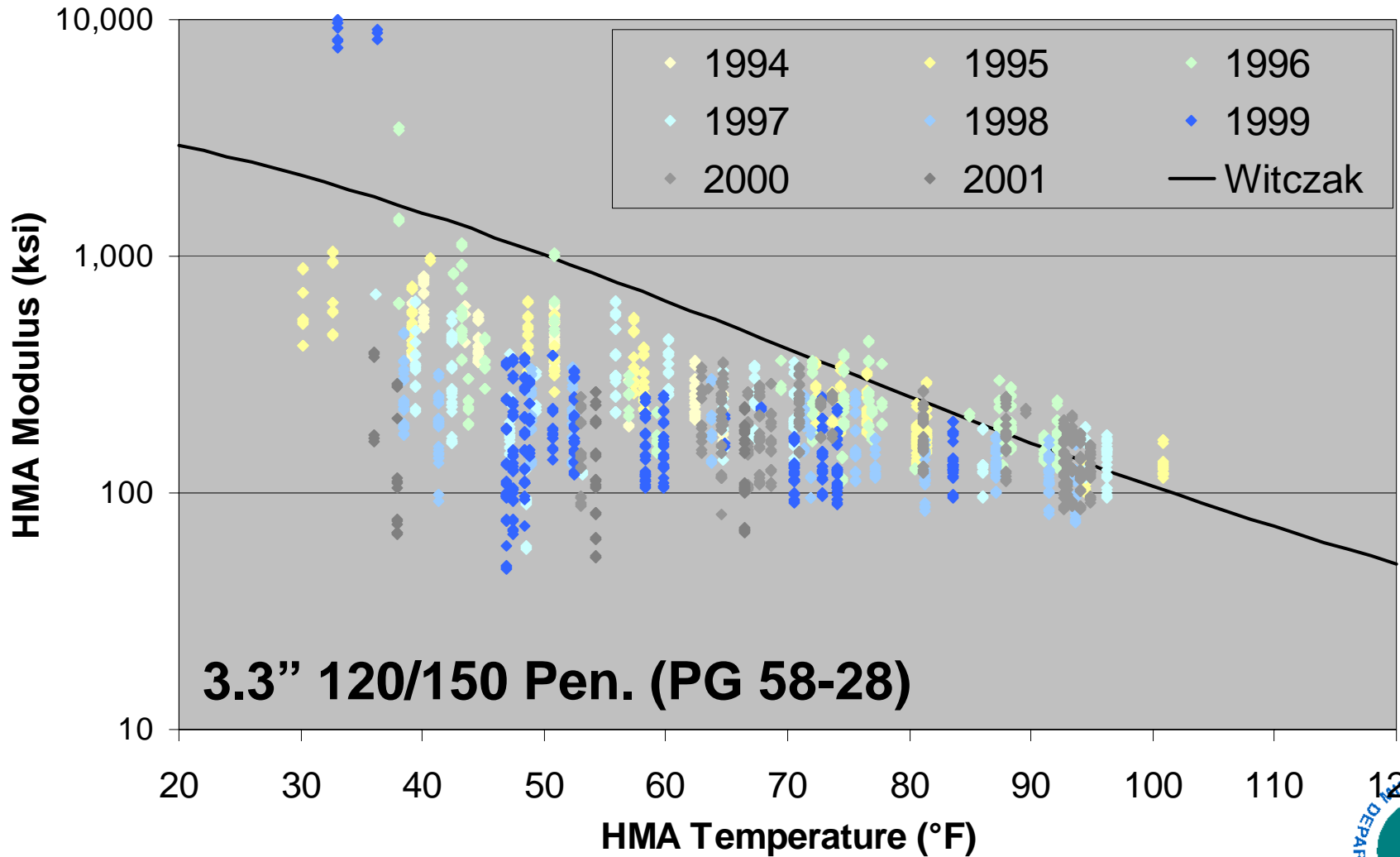
# Cell 29 Modulus Comparison 1994-2003 Witczak and Thompson Equations



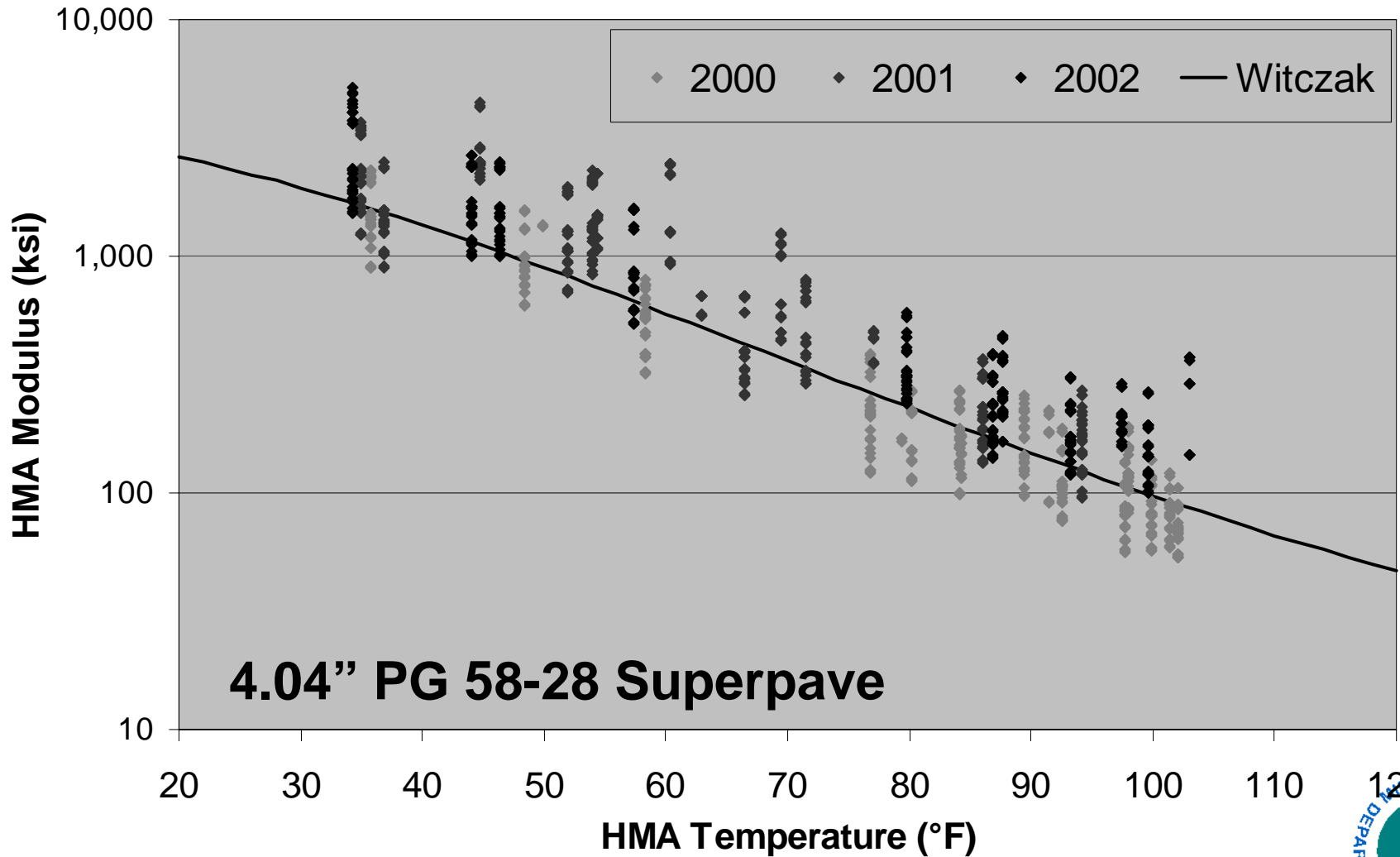
# Cell 30 Modulus Comparison 1994-2003 Witczak and Thompson Equations



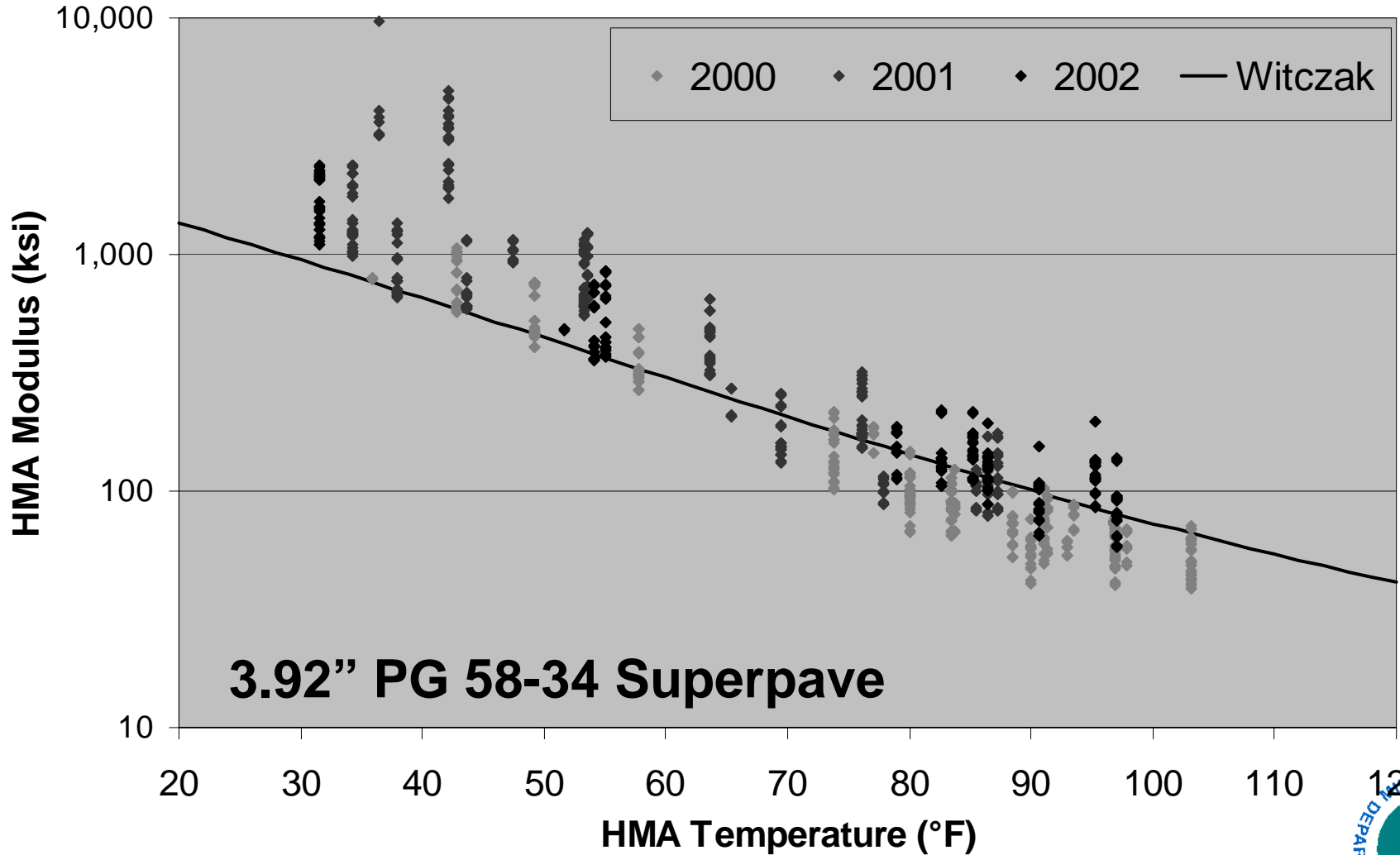
# Cell 31 Modulus Comparison 1994-2001 Witczak and Thompson Equations



# Cell 33 Modulus Comparison 2000-2002 Witczak and Thompson Equations



# Cell 34 Modulus Comparison 2000-2002 Witczak and Thompson Equations



# Cell 35 Modulus Comparison 2000-2002 Witczak and Thompson Equations

