GENERAL FORMULAE FOR DERIVED PRICES FOR THE TRADEWEB ICE U.S. TREASURY CLOSING PRICES

1. Index Ratio (REGTIPS and WIATIPS)

$$IR = \frac{CPI_{Ref}}{CPI_{Base}}$$

IR = Index Ratio

CPI_{Ref} = US Consumer Price Index*, 3 months from today's date

CPI_{Base} = US Consumer Price Index* at issue date of security

***Note:** For future Index Ratios, the value is calculated based on the projected inflation rate.

Detailed formulae can be found at the following link:

https://www.treasury.gov/about/organizational-structure/offices/Domestic-Finance/Documents/tips-presentation.pdf

2. Accrued Interest (REGNOTE, REGTIPS,WIATIPS and WIANOTE)

Calculation of accrued interest for U.S. Treasury Securities with standard periodic coupons (semi-annual, annual, etc.) or interest at maturity for U.S. Treasury Securities with coupon payment at maturity only.

$$Accrued\ Interest = P * \frac{R}{M} * \frac{A}{D}$$

Where:

A = Number of accrued days counted according to the applicable day count basis. For periodic securities, number of days from beginning of period to settlement date is used; for interest at maturity securities, number of days from the issue date to the settlement date is used to calculate accrued interest, and number of days from the issue date to the maturity date is used to calculate the interest at maturity

D = For periodic items, number of days in interest or the coupon period; for interest at maturity items, annual year basis based on day-count for the security

M = Number of interest or coupon periods per year (M is equal to 1 for interest at maturity items)

P = Par Value (principal amount to be paid at maturity)

R = Annual interest or coupon rate for the security as a decimal

3. Mid-Price

a. (STRIPINT and STRIPPRIN)

$$\boldsymbol{MidPrice} = \sum_{k=1}^{N} \frac{CF_K}{(1 + \frac{Y_{Periodic}}{CPY})^{T_K}}$$

CF_K = Cash Flow (i.e. coupon payment) received by the investor at time T_k after settlement*

CPY = Number of compounding periods per year corresponding to $Y_{Periodic}$ (the Mid-Yield). If the Mid-Yield is Y_{Semi} then $CPY = 2$

N = Number of Cash Flows to maturity

T_K = Time in periods from settlement date to Cash Flow CF_K

$Y_{Periodic}$ = Mid-Yield (as a decimal) on an investment assuming CPY compounding periods per year with security held to redemption.

***Note:** For STRIPS, the Cash Flow would be assumed as 0, except for the final redemption.

b. (REGBILL, WIABILL and WIBBILL)

$$\boldsymbol{MidPrice} = [RV] - [DR * RV * \frac{DSM}{B}]$$

B = Number of days in a year based on day-count for the security

DR = Discount rate (as a decimal) (the Mid-Rate)

DSM = Number of days from settlement date to maturity date

RV = Redemption value per $100 par value

Note: The first term is the redemption value. The second term calculates the discount amount.

4. Mid Dirty Price (REGTIPS and WIATIPS)

$$\boldsymbol{DP} = (MP + Acc) * IR$$

$\boldsymbol{DP}$ = Mid Dirty Price of security

MP = Mid-Price of security

Acc = Accrued Interest of security, as calculated using the formula described within section 2

IR = Index Ratio, as calculated using the formula described within section 1

5. Nominal Price (REGTIPS and WIATIPS)

$$\boldsymbol{NP} = MP * IR$$

$\boldsymbol{NP}$ = Nominal Price of security

MP = Mid-Price of security

IR = Index Ratio, as calculated using the formula described within section 1

6. Mid-Yield

The Mid-Yield is calculated from the Mid-Price.

a. (REGNOTE, REGTIPS, WIANOTE and WIATIPS)

$$MidPrice = \sum_{k=1}^{N} \frac{CF_K}{(1 + \frac{\boldsymbol{Y_{Periodic}}}{CPY})^{T_K}}$$

$\boldsymbol{Y_{Periodic}}$ = Mid-Yield (as a decimal) on an investment assuming CPY compounding periods per year with security held to redemption. The equation above is solved for **this** parameter.

CF_K = Cash Flow (i.e. coupon payment) received by the investor at time T_k after settlement*

CPY = Number of compounding periods per year corresponding to $Y_{Periodic}$ (the Mid-Yield). If the Mid-Yield is Y_{Semi} then $CPY = 2$

N = Number of Cash Flows to maturity

T_K = Time in periods from settlement date to Cash Flow CF_K

***Note:** For STRIPS, the Cash Flow would be assumed as 0, except for the final redemption.

b. (REGBILL, WIABILL and WIBBILL)

$$MidPrice = \left[\frac{100 + \left(\frac{DIM}{B} * R * 100\right)}{1 + \left(\frac{DSM}{B} * \boldsymbol{Y}\right)}\right] - \left[\frac{A}{B} * R * 100\right]$$

Y = Mid-Yield (as a decimal) on an investment with security held to maturity. The equation above is solved for **this** parameter.

A = Number of days from issue date to settlement date (accrued days)

B = Numbers of days in a year based on day-count for the security

DIM = Number of days from issue date to maturity date

DSM = Number of days from settlement date to maturity date

R = Annual interest or coupon rate for the security (as a decimal)

7. Nominal Yield (REGTIPS and WIATIPS)

Nominal Yield is calculated from Nominal Price, as calculated using the formula in section 5.

$$Nominal\ Price = \sum_{k=1}^{N} \frac{CF_K}{(1 + \frac{Y_{Periodic}}{CPY})^{T_K}}$$

$Y_{Periodic}$ = Nominal Yield (as a decimal) on an investment assuming CPY compounding periods per year with security held to redemption. The equation above is solved for **this** parameter.

CF_K = Cash Flow (i.e. coupon payment) received by the investor at time T_k after settlement where each Cash Flow is multiplied by the Cash Flow period's Index Ratio.

CPY = Number of compounding periods per year corresponding to $Y_{Periodic}$ (the Nominal Yield). If the Nominal Yield is Y_{Semi} then $CPY = 2$

N = Number of Cash Flows to maturity

T_K = Time in periods from settlement date to Cash Flow CF_K

Note: The final redemption value is deflation protected. If the projected Index Ratio is less than one, the redemption value is par value.

8. Bond Yield

a. (REGBILL, WIABILL and WIBBILL)

If next 12 months include leap day, then T_{basis}= 366, else T_{basis}= 365.

If sm <= H_{basis} where $\mathrm{H}_{basis} = T_{basis}/2$, then formula:

$$\boldsymbol{BEY} = \left[\frac{T_{basis} * dr}{360 - 0.01 * dr * sm}\right]$$

sm = Number of days between maturity and settlement

Else formula:

$$\boldsymbol{BEY} = \left[\frac{100\left(-2x + 2\left(x^2 - (2x-1)\left(1 - \frac{100}{p}\right)\right)^{0.5}\right)}{2x - 1}\right]$$

$\boldsymbol{BEY}$ = Bond Yield (as a percentage)

x = (sm/T_{basis})

dr = Discount Rate (as a percentage) (the Mid-Rate)

p = Mid-Price

b. (WIANOTE, REGNOTES, STRIPPRIN and STRIPINT)

The same as Mid-Yield.

c. (REGTIPS and WIATIPS)

Always 0.

9. Modified Duration/Effective Duration

a. Modified Duration (REGBILL, WIABILL, WIBBILL)

Modified Duration is calculated from Bond Yield, as calculated using the formula in section 8.

If next 12 months include leap day, then T_{basis}= 366, else T_{basis}= 365.

If sm <= H_{basis} where $\mathrm{H}_{basis} = T_{basis}/2$, then formula:

$$DPDY = -\left[\frac{sm * T_{basis}}{(T_{basis} + sm * \frac{BEY}{100})^2}\right]$$

sm = Number of days between maturity and settlement

Else formula:

Where $B = (sm * T_{basis}) - 0.5$

$$DPDY = -\left[\frac{p + 2p * B + 0.02B * p * BEY}{200 + (1 + 2B + 0.01B * BEY) * BEY}\right]$$

Then, for modified duration:

$$\boldsymbol{MODDUR} = (-100 * \frac{DPDY}{p})$$

$\boldsymbol{MODDUR}$ = Modified Duration

BEY = Bond Yield (as a percentage)

p = Mid-Price

b. Modified Duration (STRIPINT, STRIPPRIN, REGNOTE,WIANOTE, REGTIPS and WIATIPS) and Effective Duration (REGTIPS, WIATIPS)

Modified Duration is calculated from the Mid-Yield as calculated using the Methodology or the formula in section 6. Effective Duration is calculated from the Nominal Yield, as calculated using the formula in section 7.

Macaulay Duration in Periods

$$DUR_{Periods} = \frac{\sum_{k=1}^{N}(T_k * \frac{CF_K}{\left(1 + \frac{Y_{Periodic}}{CPY}\right)^{T_K}})}{\sum_{k=1}^{N}\frac{CF_K}{(1 + \frac{Y_{Periodic}}{CPY})^{T_K}}}$$

CF_K = Cash Flow (i.e. coupon payment) received by the investor at time T_k after settlement (where each Cash Flow is multiplied by the Cash Flow period's Index Ratio in the case of the Effective Duration calculation only)

CPY = Number of compounding periods per year corresponding to $Y_{Periodic}$ (Yield). If the yield is Y_{Semi} then $CPY = 2$*

$DUR_{Periods}$ = Macaulay duration in periods

N = Number of Cash Flows to maturity

T_K = Time in periods from settlement date to Cash Flow CF_K

$Y_{Periodic}$ = Mid-Yield (Nominal Yield for Effective Duration calculation only) (as a decimal) on an investment assuming CPY compounding periods per year with security held to redemption*

Conversion of Macaulay Duration in Periods to Macaulay Duration in Years

$$DUR_{Years} = \frac{DUR_{Periods}}{CPY}$$

CPY = Number of compounding periods per year corresponding to $DUR_{Periods}$

$DUR_{Periods}$ = Macaulay duration in periods

DUR_{Years} = Macaulay duration in years

Modified Duration

$$\boldsymbol{MODDUR} = \frac{DUR_{Years}}{1 + \frac{Y_{Periodic}}{CPY}}$$

$\boldsymbol{MODDUR}$ = Modified Duration (or Effective Duration)

CPY = Number of compounding periods per year corresponding to $Y_{Periodic}$ (Yield). If the Yield is Y_{Semi} then CPY = 2*

DUR_{Years} = Macaulay duration in years

$Y_{Periodic}$ = Mid-Yield (Nominal Yield for Effective Duration calculation only) (as a decimal) on an investment assuming CPY compounding periods per year with security held to redemption*

***Note**: Effective Duration Calculation

Effective Duration Calculation is Modified Duration Calculation except that, where each Cash Flow is calculated, each Cash Flow is multiplied by the Cash Flow period's Index Ratio. Also, for Effective Duration, the Nominal Yield is used instead of Mid-Yield.