5.2 Calculations

5.2.1 Standard formulae

5.2.1.1 Water and soil calculations

Eqn 1 Crop evapotranspiration (ET_{crop})

The crop water requirement calculated is described as crop-adjusted evapo-transpiration (ET_{crop}), by adjusting PET to account for crop specifics and ground cover.

$$ET_{crop} = PET \times K_c$$

Where

ET_{crop} is crop-adjusted evapo-transpiration (mm/d)

PET is reference potential evapo-transpiration (mm/d)

K_c is the crop water use co-efficient

And $Kc = K_{crop} \times K_{gc}$

Where K_{crop} is crop specific water use factor

K_{gc} is the ground cover fraction

Eqn 2 Crop water use ($ET_{limited}$)

Actual crop water use is a function of PET, limited by soil available water. Potential water use in any period is given by ETcrop. Where soil moisture is limited, the actual water use will be the maximum of ETcrop or available soil moisture (ASM)

$$ET_{limited} = \text{greater of: } ET_{crop} \text{ or } ASM + (P+I)$$

Where

$ET_{limited}$ is actual crop water use

ET_{crop} is crop water use by evapo-transpiration

ASM is available soil moisture

I is beneficial water requirement applied by irrigation system

P is precipitation

Eqn 3 Potential soil moisture deficit (PSMD)

Potential crop growth is reduced in any period where crop water use is restricted due to low soil water availability. PSMD is a measure of moisture stress experienced by a crop, relative to the climatic potential moisture use. PSMD can be estimated from Potential crop water use (ET_{crop}) and actual (water limited) crop water use ($ET_{limited}$).

$$PSMD = ET_{crop} - ET_{limited} : ET_{crop} > ET_{limited}$$

Where:

$PSMD$ is potential soil moisture deficit in any period where SMD>D_c

ET_{crop} is crop water use by evapo-transpiration

$ET_{limited}$ is actual crop water use

5.2.1.2 System capacity calculations

Eqn 4 Design system capacity (SC_{des})

The flow of water per hectare of irrigated area determined by the designer of the system. Presumed to be the basis for the subsequent design. The value would normally be selected based on need to replace water used by the crop plus any additional amounts for other purposes. However water source limitations or regulatory maxima may necessitate a lower value.

Eqn 5 Required system capacity (SC_{req})

The flow of water per hectare of irrigated area required to replace water used by the crop (plus any additional amounts for other purposes) in the time available.

$$\mathrm{SC_{des}} = \frac{\mathrm{PET} \times \mathrm{K_c} \times 24 \times 3600}{10{,}000} \times \frac{T_{irrig}}{T_{rot}}$$

Where

SC_{des} is design system capacity (L/s/ha)

PET is reference potential evapo-transpiration (mm/d)

K_c is the crop water use co-efficient

T_{irrig} is time irrigating per rotation (hrs)

T_{rot} is time per rotation (hrs)

Eqn 6 Potential system capacity (SC_{pot})

The flow of water per hectare of irrigated area that can be supplied if the system as operating was run for 24 hours per day. It is calculated from measured or calculated system flow rate divided by the measured or calculated area irrigated.

$$\mathrm{SC_{pot}} = \frac{Q_{sys}}{A_{irrig}}$$

Where

SC_{pot} is potential system capacity (L/s/ha)

Q_{sys} is the mean system flow rate ((L/s)

A_{irrig} is area irrigated (ha)

Eqn 7 Operating system capacity (SC_{op})

The flow of water per hectare of irrigated area that can be supplied in the time that the system is operating. It is the potential system capacity adjusted by the ratio of time irrigating per rotation to rotation time.

$$\mathrm{SC_{op}} = SC_{pot} \times \frac{T_{irrig}}{T_{rot}}$$

Where

SC_{op} is operating system capacity (L/s/ha)

SC_{pot} is potential system capacity (L/s/ha)

T_{irrig} is time irrigating per rotation (hrs)

T_{rot} is time per rotation (hrs)

5.2.1.3 Efficiency calculations

Eqn 8 Seasonal application efficiency

Seasonal application efficiency (SAE) is given by the ratio of water retained in the root zone to water applied to the field, over a full irrigation season or year.

$$SAE = \frac{\overline{D}_{wr}}{\overline{D}_{wa}} \times 100$$

Where

SAE	is the seasonal application efficiency
D_{wr}	is the average depth of water retained
D_{wa}	is the average depth of water applied

Eqn 9 Weighted seasonal application efficiency (SAEw)

The overall SAE is a weighted average of these calculated values.

$$SAE_w = \frac{AE_{lq} + 2AE_{mean} + AE_{hq}}{4} \times 100$$

Where

SAE_w	is weighted seasonal application efficiency
$_{lq}$	is low quarter zone
$_{mean}$	is field average zone
$_{hq}$	is high quarter zone

Eqn 10 Potential low quarter application efficiency (PAElq)

The single event potential application efficiency is estimated from field distribution uniformity and surface losses due to runoff and leakages. The value calculated can be used to determine the scheduling co-efficient.

$$PAE_{lq} = DU_{lq} \times (1.0 - (RO + SL))$$

Where

PAE_{lq}	is potential low quarter application efficiency
DU_{lq}	is low quarter distribution uniformity
RO	is field runoff
SL	is system leakages

Eqn 11 Low quarter irrigation adequacy (IA_{lq})

The ratio of the mean low quarter depth applied, to the mean target depth required across the field as a whole.

$$AD_{lq} = \frac{d_{lq}}{d_{t\arg et}}$$

Where

IA_{lq}	is low quarter irrigation adequacy

d_{lq} is low quarter applied depth

d_{target} is targeted application depth

Eqn 12 Seasonal potential soil moisture deficit (PSMD$_{season}$)

Seasonal PSMD is calculated by summing period PSMD's calculated as in Eqn 3.

$$PSMD_{season} = \sum \left(PSMD_1 : PSMD_n \right)$$

Where

$PSMD_{season}$ is seasonal potential soil moisture deficit

$PSMD_1$ is potential soil moisture deficit in the first period

$PSMD_n$ is potential soil moisture deficit in the nth period

And where

$$PSMD_2 > PSMD_1$$

Eqn 13 Seasonal deep percolation (SDP)

Includes all drainage whether from irrigation or precipitation. It is estimated from the balance of water not retained in the root zone, calculated after any surface losses have been accounted for.

$$SDP = \sum \left(DP_1 : DP_n \right)$$

Where:

SDP is seasonal deep percolation

DP deep percolation in periods 1 to n

Eqn 14 Seasonal irrigation deep percolation (SDP$_i$)

Seasonal deep percolation resulting from irrigation is a measure of the amount of irrigation water applied that drains from the soil profile. It is, in effect, seasonal application in-efficiency.

$$SDP_i = (1 - SAE)$$

Where:

SDP_i is seasonal deep percolation from irrigation

SAE is seasonal application efficiency (Eqn 8)

Eqn 15 Drought induced yield loss (YL_{di})

Calculated from potential (farmer expected) yield, PSMD and the drought response factor:

$$YL_{di} = Y_{pot} \times PSMD \times F_{dr}$$

Where:

YL_{di} is drought induced yield loss
Y_{pot} is the Potential Yield (t/ha)
$PSMD$ is potential soil moisture deficit (mm)
F_{dr} is the drought response factor (%yield / mm PSMD)

Eqn 16 Value of lost yield (YL_v)

The value of lost yield is determined from the value of the crop and the amount of lost yield.

$$YL_v = YL_{di} \times Price$$

Where:

YL_v is the value of lost yield ($/ha)
YL_{di} is drought induced yield loss

Price is price paid per unit yield

Eqn 17 Value of wasted water (V_{ww})

One estimate of the cost of water non-beneficially used is to multiply the amount of irrigation water lost through deep percolation, runoff and off-target application by the price paid for the water.

$$V_{ww} = 10 \times (SDP_i + RO + OTA) \times P_w$$

where:

V_{ww} is the value of wasted water ($/mm/ha)

SDP_i is seasonal deep percolation from irrigation (mm)

RO is depth equivalent lost through run-off (mm)

OTA is depth equivalent of off-target application (mm)

P_w is the price paid for water ($/m^3)

10 constant converting m^3/ha to mm/ha

Eqn 18 Value of wasted energy (V_{we})

$$V_{we} = \frac{10 \times (SDP_i + RO + OTA) \times (EC_{vol} \times P_{energy})}{\left(E_{pump} \times E_{hydraulic}\right)}$$

where:

V_{we} is the value of wasted water ($/mm/ha)

SDP_i is seasonal deep percolation from irrigation (mm)

RO is depth equivalent lost through run-off (mm)

OTA is depth equivalent of off-target application (mm)

EC_{vol} is volumetric energy consumption

P_{energy} is the price paid for energy ($/kWhr)

E_{pump} is pump efficiency

$E_{hydraulic}$ is hydraulic efficiency

10 constant converting m^3/ha to mm/ha

Eqn 19 Irrigation requirement (*IR*)

Irrigation requirement is given by crop water requirement plus any additional beneficial water requirement less received precipitation and stored soil moisture.

$$IR = \frac{(ET_{crop} + WR_b)}{\left(DU_{lq}\right)} (P + ASM)$$

Where:

IR is irrigation requirement
ET_{crop} is crop water use by evapo-transpiration
WR_b is beneficial water requirement applied by irrigation system
P is precipitation
ASM is available soil moisture
DU_{lq} is low quarter Distribution uniformity

5.2.1.4 Base calculations

Eqn 20 Coefficient of variation (Cv)

The coefficient of variation is a statistical measure of variation within a sample, calculated using the formula:

$$C_v = \frac{s}{\bar{x}}$$

where

C_v	is the coefficient of variation
s	is the standard deviation in the sample
$\bar{x}$	is the mean value from the sample

and

Eqn 21 Standard deviation from the mean (s)

$$s = \left[\frac{\sum_{i=1}^{n} \left(x_i - \bar{x}\right)^2}{n-1} \right]^{1/2}$$

where

x_i	is the performance of an individual within the sample
i	is a number assigned to identify a particular individual
n	is the number of individuals in the sample

A Cv of 0.05 implies 68% of flows are within 5% of the mean, and 95% of flows within 10% of the mean (DAM).

Eqn 22 Emitter pressure flow relationship

The relationship between emitter operating pressure and flow rate is given by the equation:

$$q = K_d p^x$$

where

q	is the emitter flow rate
K_d	is the emitter discharge coefficient
p	is operating pressure
x	is the emitter discharge exponent

Eqn 23 Emitter discharge exponent

The emitter discharge exponent can be determined using the formula (DAM):

$$x = \frac{\log\left(\frac{q_1}{q_2}\right)}{\log\left(\frac{p_1}{p_2}\right)}$$

where

x is the emitter discharge exponent

p_1 & p_2 are pressures

q_1 & q_2 are flows at p_1 & p_2 respectively.

The coefficient is typically between 0 and 1, often in the range 0.5 – 0.7.

A coefficient value = 0 describes an emitter where flow is totally independent of pressure, and a value = 1 describes an emitter where flow increases directly in proportion to pressure.

Eqn 24 Emitter discharge coefficient (K_d)

The emitter discharge coefficient is determined from the rearranged pressure flow equation:

$$K_d = \frac{q}{p^x}$$

where terms are as above.

Eqn 25 Manufacturer's emission uniformity (EU_{man})

Manufacturer's emission uniformity is determined from physical laboratory measurements at a standard temperature.

Values of EU_{man} are typically reported as a percentage value, but should be converted to a decimal. EU_{man} is derived from the coefficient of variation using the formula:

$$EU_{man} = 1.0 - Cv_{man}$$

where

EU_{man} is manufacturer's emission uniformity

Cv_{man} is the coefficient of variation in manufacturing

5.2.1.5 Combination formulae

Eqn 26 Weighted averages

When combining data from seasonal irrigation estimates that split into low quarter, mean and high quarter calculations it is necessary to apply a weighted average method.

$$X_{field} = \frac{X_{lq} + 2X_{mean} + X_{hq}}{4}$$

Where:

X_{field} is the overall result for the field for any particular parameter, X

X_{lq} is the result for the area receiving the low quarter irrigation

X_{mean} is the result for the area receiving the mean irrigation

X_{hq} is the result for the the area receiving the high quarter irrigation

See also Eqn 9

Eqn 27 Clemmens-Solomon

Combination of uniformity components where their influence is multiplicative should use the Clemmens-Solomon statistical procedure:

$$SDU_{lq} = \left[1 - \sqrt{(1-DU_1)^2 + (1-DU_2)^2 + (1-DU_n)^2}\right]$$

Where:

SDU_{lq} is low quarter system distribution uniformity

DU_n is low quarter distribution uniformity of factor n

Examples include combining Pressure DU and emitter manufacturing DU.

Eqn 28 DU of combined populations

Where several populations are to be combined to determine an overall uniformity, the all data should be aggregated and a new DU determined from the whole data set.

It is not correct to take a simple mean of several DU's to find an overall value.

If, for example, three areas (three drip blocks or three traveller transects) each had perfect DU (DU=1.00) but the measured application depths were different in each, the overall DU is not DU=1.00, but some lower value.

5.2.1.6 Uniformity calculations

Eqn 29 Distribution uniformity *(DU_{lq})*

This Code adopts the low quarter distribution uniformity ratio.

The low quarter distribution uniformity coefficient formula is:

$$DU_{lq} = \frac{\overline{V_{lq}}}{\overline{V}}$$

where

DU_{lq} is the lowest quarter distribution uniformity coefficient

V_{lq} is the average volume (or alternatively the mass or depth) of water collected in the lowest quarter of the field

$\overline{V}$ is the average volume (or alternatively mass or depth) of water collected by all collectors used in the data analysis

Eqn 30 Distance adjusted lowest quarter determination (D_{adj})

The distance adjusted lowest quarter of collectors is determined by ranking collected volumes and adjusting for distance from the pivot centre.

1. Rank all evaporation adjusted collector volumes, *V*.
2. Multiply each adjusted volume by its distance from the centre (*S*) to give the Distance adjusted volume *Va*.
3. Sum distances from pivot centre (*Si*) cumulatively from the lowest value. Divide by four to determine the low quartile point.
4. The low quarter is all the results at or below the low quartile point.

Eqn 31 Centre pivot radial uniformity

The low quarter distribution uniformity coefficient formula is adjusted to account for increasing field areas represented by collectors placed further from the pivot centre.

$$DU_{lq} = \frac{\overline{Va_{lq}}}{\overline{Va}}$$

where

DU_{lq} is the lowest quarter distribution uniformity coefficient

Va_{lq} is the distance adjusted average volume (or alternatively the mass or depth) of water collected in the lowest quarter of the field, calculated as:

Eqn 32 Distance adjusted average volume

$$\overline{Va_{lq}} = \frac{\sum_{i=1}^{n/4} Va_i S_i}{\sum_{i=1}^{n/4} S_i}$$

Where:

i is a number assigned to identify a particular collector, normally beginning with the collector with the lowest catch volume (*i* = 1) and ending with *i* = n for the collector with the highest catch volume

n is the number of collectors used in the data analysis

S_i is the distance of the ith collector from the pivot point

$\overline{Va}$ is the distance adjusted average volume (or alternatively mass or depth) of water collected by all collectors used in the data analysis, calculated as:

$$\overline{Va} = \frac{\sum_{i=1}^{n} Va_i S_i}{\sum_{i=1}^{n} S_i}$$

Eqn 33 Christiansen coefficient (*CU_c*)

The Christiansen formula is:

$$CU_c = \left[1 - \frac{\sum_{i=1}^{n} \left| V_i - \overline{V} \right|}{\sum_{i=1}^{n} V_i} \right]$$

Where

CU_c is the Christiansen coefficient of uniformity

n is the number of collectors used in the data analysis

i is a number assigned to identify a particular collector

Vi is the volume (or alternatively the mass or depth) of water collected in the ith container

$\overline{V}$ is the arithmetic average volume (or alternatively mass or depth) of water collected by all collectors used in the data analysis, calculated as:

$$\overline{V} = \frac{\sum_{i=1}^{n} V_i}{n}$$

Eqn 34 Heermann-Hein uniformity coefficient

The Christiansen uniformity coefficient formula is adjusted as proposed by Heermann and Hein to account for increasing field areas represented by collectors placed further from the pivot centre.

The Heermann and Hein formula is:

$$CU_r = \left[1 - \frac{\sum_{i=1}^{n} \left| V_i - \overline{V_w} \right| S_i}{\sum_{i=1}^{n} \left| V_i S_i \right|} \right]$$

where

CU_r is the Heermann and Hein coefficient of uniformity *n* is the number of collectors used in the data analysis

i is a number assigned to identify a particular collector, normally beginning with the collector located nearest the pivot point (i = 1) and ending with i = n for the collector furthest from the pivot point

V_i is the volume (or alternatively the mass or depth) of water collected in the *i*th container

S_i is the distance of the *i*th collector from the pivot point

$\overline{V_w}$ is the weighted average volume (or alternatively mass or depth) of water collected, calculated as:

$$\overline{V_w} = \frac{\sum_{i=1}^{n} V_i S_i}{\sum_{i=1}^{n} S_i}$$

Eqn 35 Emission uniformity (*EU*)

Corresponds mathematically to the Christiansen coefficient and is based on the coefficient of variation using the formula:

$$EU = (1.0 - Cv)$$

where

EU is the statistical emission uniformity

Cv is the coefficient of variation

Eqn 36 Emission v's Distribution Uniformity

Emission uniformity (EU) is related to low quarter distribution uniformity (DU_{lq}) by the equation:

$$DU_{lq} = 1 - (1.27C_v) \text{ or } DU_{lq} = 1 - 1.27(1 - EU_{stat})$$

The factor k_{lq} = 1.27 equates the statistical uniformity coefficient to a low quarter uniformity equivalent assuming a normal distribution.

Eqn 37 Emitter emission uniformity (EEU_{lq})

$$EEU_{lq} = 1 - 1.27\left(\frac{\sqrt{(Cv_{man})^2 + (\overline{Cv_{defect}})^2}}{(\sqrt{n})}\right)$$

where

EEU_{lq} is the emitter emission uniformity

Cv_{man} is the coefficient of emitter manufacturing variation

Cv_{defect} is the mean coefficient of variation due to blockages, wear and tear determined from emitter tests 1, 3 & 4.

n is the number of emitters per plant

The factor k_{lq} = 1.27 equates the statistical uniformity coefficient to a low quarter uniformity equivalent assuming a normal distribution.

Eqn 38 **Uneven drainage coefficient (*$F_{drainage}$*)**

$$F_{drainage} = 1 - \left(\frac{n_{ER}}{100} \left(\frac{(T_{ER})}{(T_{irrig})} \right) \right)$$

where

$F_{drainage}$	is the effect of unequal system drainage
n_{ER}	is the percentage of emitters that run after system shut down
T_{ER}	is the average time for which those emitters run after system shut down
T_{irrig}	is normal duration of a scheduled irrigation event

Eqn 39 **Uneven spacing coefficient (*$F_{spacing}$*)**

$$F_{spacing} = \frac{(D_{Z\min})}{(D_{Zmean})}$$

where

$F_{spacing}$	is the effect of spacing
D_{Zmin}	is the minimum depth applied to a zone
D_{Zmean}	is the mean depth applied to the whole field

Eqn 40 **Pressure adjusted emitter flow (*Q_{Padj}*)**

$$Q_{Padj} = Q_{Em} \left(\frac{(\overline{P_{field}})^x}{(P_{test})^x} \right)$$

Where:

Q_{Padj}	is Pressure adjusted emitter flow
Q_{Em}	is measured emitter flow
P_{field}	is mean pressure determined from whole field pressure tests
P_{test}	is pressure at which block was flow tested
x	emitter discharge exponent

Eqn 41 **Emitter defect coefficient of variation (*Cv_{defect}*)**

$$Cv_{defect} = \sqrt{(Cv_{QPadj})^2 - (Cv_{man})^2}$$

where

Cv_{defect}	is the effect of emitter blockages, wear and tear
Cv_{QPadj}	is the coefficient of variation of pressure adjusted flows
Cv_{man}	is the manufacturer's coefficient of variation of emitters

NOTE: The Clemmens – Solomon equation (Eqn 27) causes problems here if the measured field uniformity is better than CV_{man} as it would require a square root of a negative number.

Eqn 42 Design Uniformity (*EU_{des}*)

$$EU_{design} = \left[1.0 - \frac{1.27Cv_{man}}{\sqrt{n}}\right]\frac{q_m}{q_a}$$

where

EU_{des}	is design emission uniformity
Cv_{man}	is the manufacturer's coefficient of variation of emitters
n	is the number of emitters per plant
q_m	is the mean low quarter emitter discharge due to the mean low quarter pressure
q_a	is the overall mean emitter discharge

(Keller and Karmeli, 1974: ASAE 405.1)

5.2.1.7 Application calculations

Eqn 43 Mean system application depth (*D_{mf}*)

$$D_{mf} = \frac{Q_m \times T_{irrig}}{A}$$

where

D_{mf}	mean application depth based on system flow rate (mm)
Q_m	system flow rate (L/h)
T_{irrig}	is the duration of an irrigation event (hours)
A	area of the irrigated strip (m2)

Eqn 44 Infiltration depth (drip-micro and long-lateral)

$$D_{\inf} = \frac{Q_{\bar{x}} \times T_{irrig}}{A_{wetted}}$$

where

Dinf	is the depth water infiltrates (mm)
Q_x	is the average flow per emitter (L/h)
T_{irrig}	is the duration of an irrigation event (h)
A_{wetted}	is the wetted area per emitter (m^2)

Eqn 45 Equivalent applied depth (drip-micro)

$$Dz_{app} = \frac{Q_{\bar{x}} \times n_e \times T_{irrig}}{A_{plant}}$$

where

Dz_{app}	is the Applied Depth in an given zone, z
Q_x	is the average flow per emitter
N_e	is the number of emitters per plant
T_{irrig}	is the duration of an irrigation event
A_{plant}	is the ground area per plant

Eqn 46 **Reference application rate (R_{ir})**

$$R_{ir} = \frac{\overline{D}}{T_{irrig}}$$

Where:

- R_{ir} is the reference application rate (Assumed constant)
- $\overline{D}$ is mean depth of water from all collectors used in analysis
- T_{irrig} is the duration of an irrigation event

Eqn 47 **Instantaneous application rate (R_{it})**

(changed from FDIS)

$$R_{it} = \overline{D}_i \left(\frac{V_i}{A_w} \right)$$

Where:

- R_{it} is instantaneous application rate for transect *i* (mm/hr)
- $\overline{D}_i$ is mean application depth applied to strip width at transect *i* (mm)
- A_w is wetting area of distribution system (m)
- V_i is mean travel speed of the distribution system at transect *i* (m/h)

Eqn 48 **Instantaneous application rates – linear move (R_{il})**

$$R_{il} = 3{,}600 \left(\frac{Qm}{L_e \times W} \right)$$

Where:

- R_{il} is the instantaneous application rate (mm/hr)
- W is the wetted width (diameter) of nozzle pattern (m)
- Q_m is the Machine discharge (L/s)
- L_e is the effective length of lateral (m)

The constant 3,600 assumes that the peak application rate is about 4π that of the average application rate if the application rate pattern is elliptically shaped (CPD).

Eqn 49 **Instantaneous application rates – centre pivot (R_{ip})**

$$R_{ip} = 9{,}170 \left(\frac{Q_f}{r_e^{\,2}} \right) \frac{r}{W}$$

Where:

- R_{ip} is the instantaneous application rate at radius, *r* (mm/hr)
- r is radial distance from pivot centre to point under study (m)
- W is the wetted width (diameter) of nozzle pattern at *r* (m)
- Q_f is the discharge for the full irrigated circle (L/s)
- r_e is the effective radius of the full irrigated circle (m)

The constant 9,170 assumes peak application rate is about 4π the average application rate if the application rate pattern is elliptically shaped (CPD).

5.2.1.8 Additional calculations

Eqn 50 Machine speed, (*S*)

$$S_i = 60 \times \left[\frac{D_i}{T_i} \right]$$

where

S_i	is machine travel speed at position, *i* (m/minute)
D_i	is a selected travel distance at position *i* (m)
T_i	is the time taken for machine to move distance D_i (seconds)
60	is constant changing seconds to minutes

Eqn 51 Speed difference for travelling irrigator (*DV_{max}*)

$$Dv_{\max} = \left[\frac{S_{\max} - S_{\min}}{\bar{S}} \right]$$

where

$DV_{\max}$	max deviation in travel speed relative to the mean
S_{max}	maximum machine speed
S_{min}	minimum machine speed
$\bar{S}$	mean machine speed (m/h)

Eqn 52 Hydraulic efficiency (E_{hyd})

$$E_{hydx} = 100 - \left[\frac{(P_{HW} + (EL_{HW} \times 9.81)) - (P_{EI} + (EL_{EI} \times 9.81))}{P_{HW}} \right] \times 100$$

where

E_{hydx}	is hydraulic efficiency (%)
P_{HW}	is pressure after the headworks (kPa)
EL_{HW}	is elevation at headworks (m)
P_{EI}	is pressure at entry to irrigator/distribution system (kPa)
EL_{EI}	is elevation at entry to irrigator/distribution system (m)

Eqn 53 Headworks efficiency (E_{hw})

$$E_{HW} = 100 - \left[\frac{P_{PD} - P_{HW}}{P_{PD}} \right] \times 100$$

where

E_{HW} is hydraulic efficiency (%)

P_{PD} is pressure after the pump (kPa)

P_{HW} is pressure after the headworks (kPa)

Eqn 54 Pumping efficiency (E_{pump})

$$E_{pump} = \left[\frac{(Q_{sys} \times 60) - (P_{NP} / 9.81}{P_{PD}} \right] \times 100$$

where

E_{pump} is pumping efficiency (%)

Q_{sys} is pumped volume (system flow (from water meter))

P_{np} is nett pump pressure (kPa)

P_{PD} is pressure after the pump (kPa)

Eqn 55 Theoretical return interval (RI_{the})

The theoretical return interval is calculated from the readily available water and the crop water use. Crop water use is determined from Peak PET and crop factor.

$$RI_{ther} = \left[\frac{RAW}{(PeakPETxCropFactor} \right]$$