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Addition of a Water Module to AccuRate

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EXECUTIVE SUMMARY

For house sustainability assessment and for helping home owners to determine the most appropriate actions to improve the environmental performance of a property, the Residential Buildings Group (RBG) of Department of Environment, Water, Heritage and the Arts (DEWHA) requires the addition of a water module to the AccuRate software. The module calculates water consumption of a residential property (including indoor and outdoor water usages) based on user input.

CSIRO was engaged by RBG to implement the water module in AccuRate. This project accomplished the following deliverables:

- A water page has been implemented in the AccuRate user interface, containing the input data fields required which include: house location, house style and land block information, occupant patterns and behaviours, indoor/outdoor water related facilities, etc.
- The calculations of water consumption in this water page are based on the House Water Expert software, which was developed by CSIRO for people to estimate and reduce household water consumption [1].
- A new water report page has also been added to AccuRate's summary report, showing yearly-averaged daily water consumption estimation of town water, on-site treated water, grey water, rain water, stormwater runoff and the averaged daily total water consumption estimation.

1. BACKGROUND

For house sustainability assessment and for helping home owners to determine the most appropriate actions to improve the environmental performance of a property, the Residential Buildings Group (RBG) of Department of Environment, Water, Heritage and the Arts (DEWHA) requires the addition of a water module to the AccuRate software. The module will calculate water consumption according to the water systems used within the property. CSIRO was engaged by RBG to implement the water module in AccuRate.

The project includes the following deliverables:

- A water page will be implemented in the AccuRate user interface, containing the input data fields required which include: house location, house style and land block information, occupant patterns and behaviours, indoor/outdoor water related facilities, etc.
- The calculations of water consumption in this water page will be based on the House Water Expert software, developed by CSIRO for people to estimate and reduce household water consumption [1].
- A new water report page will be added to AccuRate's summary report, showing annual town water consumed, wastewater generated, stormwater generated.

This report details the implementation of the water module in AccuRate.

2. WATER CONSUMPTION CALCULATION METHODOLOGY

The implementation of the water module was based on the House Water Expert (HWE) software, developed by CSIRO which was designed for household to estimate and reduce water consumption [1]. House Water Expert was primarily a communication and education tool. The development of House Water Expert's algorithms involved trade offs between modelling accuracy and program usability. A one day time-step was adopted. The most sensitive item to time step length in the model is the Rainwater Tank. Whilst time-steps shorter than one day would improve accuracy, the improved accuracy was considered to be relatively insignificant [1]. A longer time-step such as a week or a month was deemed to reduce accuracy and potentially provide misleading results about the effectiveness of a Rainwater Tank.

The modelling platform of House Water Expert was originally based on the National Water Conservation Rating and Labelling Scheme ('A ratings'), which specifies the range of flow rates in litres per minute for each 'A rating'. Since the WELS scheme (Australia's Water Efficiency Labelling Scheme) replaced the 'A rating' from 1st July 2006 (www.waterrating.gov.au), the implementation in AccuRate has been updated the modelling platform to the WELS water labelling scheme. The label scheme has a zero to six star rating. The range of water flow rate in litres per minute is specified in each star level.

To characterise behaviours within the household, AccuRate adopts the methodology of House Water Expert which asks the user to create and input the individual occupant behaviours such as Showers and Toilets require inputs on an individual basis. End Uses with a household focus such as the Garden, Lawn, Car wash and the Dishwasher only require inputs for the household.

The calculation methodologies of water consumption have been detailed in House Water Expert software and its accompany document [1]. In this report, the formula and the parameters used in the water module implementation in AccuRate are listed for references. Table 1 shows the formula used for the calculation of the water consumption for indoor, outdoor, water sources and stormwater runoff. The default input values for various parameters are listed in Appendix A Table A1.

Table 1 Formula used for the calculation of the water consumption (Reference: Grant *et al*, 2004)

Item Name and abbreviation	Formula	Comments
Dishwasher Water used by dishwasher Q_D (L/day); Hot water used by dishwasher Q_{DH} (L/day); Cold water used by dishwasher Q_{DC} (L/day)	Q_D (L/day) = F_D *(S_{DB} + S_D*P_D)/ 7 (1) $Q_{DH} = H_{DF}$* Q_D (2) $Q_{DC} = (1-H_{DF})$* Q_D (3)	Where 7 is a conversion from week to days; S_D corresponding value (L / Place setting) for star rating of dishwasher (see Table 2); F_D frequency of dishwasher used (loads/week); P_D place settings of dishwasher (=13 Place Setting); S_{DB} corresponding baseline (L) for star rating of dishwasher (see Table 2). H_{DF} portion of dishwasher hot water usage (=100%).
Kitchen tap and Sink Water used by kitchen tap and sink Q_K (L/day); Hot water used by kitchen tap and sink Q_{KH} (L/day); Cold water used by kitchen tap and sink Q_{KC} (L/day)	$Q_K = S_K*F_K*D_K/60 + F_{ks}*V_{ks} / 7 + L_K*L_{Kr}$ (4) $Q_{KH} = H_{FF}*S_K*F_K*D_K/60 + H_{SF}*F_{ks}*V_{ks} / 7 + H_{FF}*L_K* L_{Kr}$ (5) $Q_{KC} = (1- H_{FF})*S_K*F_K*D_K/60 + (1- H_{SF})*F_{ks}*V_{ks} / 7 + (1- H_{FF})*L_K*L_{Kr}$ (6)	Where 60 is a conversion from seconds to minutes, 7 is a conversion from weeks to days; S_K corresponding value (L / min) for 'star rating' of kitchen tap (see Table 3); F_K frequency of rinsing (per day); D_K duration of rinsing (seconds); L_K leaking tap (y=1, n=0); L_{Kr} leaking tap rate (10 L/day); F_{ks} frequency of kitchen sink use (times filled per week); V_{ks} volume of kitchen sink (=30 L) (this is not a user input); H_{FF} portion of faucet hot water usage (=0.25); H_{SF} portion of sink hot water usage (=0.57).
Clothes Washer Water used by clothes washer Q_{cw} (L/day); Hot water used by clothes washer Q_{cwH}(L/day); Cold water used by clothes washer Q_{cwC}(L/day)	$Q_{cw} = S_{cw}*C_{cw}*F_{cw}*R_{cw} / 7$ (7) $Q_{cwH} = H_{cwF}*Q_{cw}$ (8) $Q_{cwC} = (1-H_{cwF})*Q_{cw}$ (9)	Where 7 is a unit conversion from week to day; S_{cw} corresponding value (L/kg) for star rating of washing machine (see Table 4); C_{cw} rated capacity of washing machine (kg) (5, 6.5 and 8 kg for small, medium and large); F_{cw} frequency of washing machine use (cycles per week); R_{cw} rinse cycle factor of washing machine = 1.2 (not a user input); H_{cwF} portion of hot water usage (=0.29).
Laundry tap and Sink	$Q_L= S_L* D_L/7 + L_L*L_{Lr} + F_{lt}*V_{lt} / 30.44$ (10)	Where 30.44 is a conversion from months to days, 60

Water used by laundry tap and sink Q_L (L/day); Hot water used by laundry tap and sink Q_{LH}; Cold water used by laundry tap and sink Q_{LC} (L/day)	Q_{LH} (L/day) = $H_{FF}*S_L*D_L/7 + H_{FF}*L_L*L_{Lr} + H_{SF}*F_{lt}*V_{lt}/30.44$ (11) Q_{LC} (L/day) = $(1-H_{FF})*S_L*D_L/7 + (1-H_{FF})*L_L*L_{Lr} + (1-H_{SF})*F_{lt}*V_{lt}/30.44$ (12)	is a conversion from seconds to minutes and 7 is a conversion from weeks to days; S_L corresponding value (L/min) for 'star rating' of laundry tap (see Table 3); D_L typical duration of rinsing (minutes/week); L_L leaking tap (y=1, n=0); L_{Lr} leaking tap rate (= 10 L/day); F_{lt} frequency of laundry tub use (per month); V_{lt} volume laundry tub filled to (= 40 L); H_{FF} portion of faucet hot water usage (= 0.25); H_{SF} portion of sink hot water usage (= 0.57).
Shower Water used by shower Q_s (L/day); Hot water used by shower Q_{SH} (L/day); Cold water used by shower Q_{SC} (L/day)	$Q_s = \sum_{n\ individuals}(S_s*F_s*D_s / 7) + L_s*L_{sr}$ (13) $Q_{SH} = H_{shF}*Q_S$ (14) $Q_{SC} = (1- H_{shF})*Q_S$ (15)	Where 7 is a conversion from week to day; S_s corresponding value (L/min) for star rating of shower (see Table 5) for each shower rose; F_s frequency of shower usage (showers per week) for each individual for each shower rose; D_s typical duration of shower (min) for each individual for each shower rose; L_s leaking shower rose (y=1, n=0) for each shower rose; L_{sr} leaking shower rose rate (= 10 L/day); n number of individuals; H_{shF} portion of shower hot water usage (= 0.57).
Bath Water used by bath Q_B (L/day); Hot water used by bath Q_{BH} (L/day); Cold water used by bath Q_{BC} (L/day)	$Q_B = \sum_{n\ individuals} V_B*F_B / 30.44 + L_B* L_{Br}$ (16) Q_{BH} (L/day) = $H_{BF}*Q_B$ (17) Q_{BC} (L/day) = $(1- H_{BF})* Q_B$ (18)	Where 30.44 is a conversion from month to day; F_B frequency of bath usage (times filled per month); L_B leaking tap (y=1, n=0); L_{Br} leaking bath tap rate (= 10 L/day); V_B volume of water used by bath per use (L) (set to 120 L); n number of individuals. H_{BF} portion of bath / spa bath hot water usage (=0.51).

Spa Bath Water used by spa bath Q_{SB} (L/day); Hot water used by spa bath Q_{SBH} (L/day); Cold water used by spa bath Q_{SBC} (L/day)	$Q_{SB} = F_{SB}*V_{SB} / 30.44 + L_{SB}*L_{SBr}$ (19) $Q_{SBH} = H_{BF}*Q_{SB}$ (20) $Q_{SBC} = (1- H_{BF})*Q_{SB}$ (21)	Where 30.44 is a conversion from months to days; F_{SB} frequency of bath usage (per month); V_{SB} volume of spa bath (user will choose between small, medium & large and see Table 6 for the corresponding size); L_{SB} leaking spa bath tap (y=1, n=0); L_{SBr} leaking spa bath tap rate (= 10 L/day); H_{BF} portion of bath / spa bath hot water usage (= 0.51).
Bathroom Tap and Basin Water used by bathroom tap and basin $Q_{bt\&b}$ (L/day)	$Q_{bt\&b}= \sum_{n\ individuals}(S_{bt}*F_{bt}*D_{bt}/60 + F_{bb}*V_{bb}/7) + L_{bt}*L_{btr}$ (22) $Q_{bt\&bH} = \sum_{n\ individuals}(H_{FF}*S_{bt}*F_{bt}*D_{bt}/60 + H_{SF}*F_{bb}*V_{bb}/7) + H_{FF}*L_{bt}*L_{btr}$ (23) $Q_{bt\&bC} = \sum_{n\ individuals}([1- H_{FF}]*S_{bt}*F_{bt}*D_{bt}/60 + [1- H_{SF}]*F_{bb}*V_{bb}/7) + (1- H_{FF})*L_{bt}*L_{btr}$ (24)	Where 60 is a conversion from seconds to minutes and 7 is a conversion from weeks to days; S_{bt} corresponding value for star rating of bathroom tap (L/min, see Table 3); F_{bt} frequency of rinsing (eg. hand washing, brushing teeth) (per day) for each individual; D_{bt} typical duration of rinsing (sec) for each individual; L_{bt} leaking bathroom basin tap (y=1, n=0); L_{btr} leaking bathroom basin tap rate (= 10 L/day); F_{bb} frequency of basin use (per week) for each individual; V_{bb} volume basin typically filled to (3 L); H_{FF} portion of faucet hot water usage (= 0.25); H_{SF} potion of sink water usage (= 0.57).
Single Flush Toilet Water used by a single flush toilet Q_{Ts} (L/day)	$Q_{Ts} = \sum_{n\ individuals} S_{Tsf}*F_{tsf} + L_{toilet}*L_{toilet\ Rate}$ (25)	Where S_{Tsf} is corresponding value for star rating of single flush toilet (L/flush) (see Table 7); F_{tsf} frequency of use of single flush toilet (per day) for each individual; L_{toilet} toilet cistern leaking (no leak; leak with noise; and leak without noise); $L_{toilet\ Rate}$ toilet cistern leaking rate (24 L/day for slow leak without noise; and 204 L/day for fast audible leak).

Dual Flush Toilet Water used by a dual flush toilet Q_{Td} (L/day)	$Q_{Td} = \sum_{n\ individuals} S_{Tdf} * F_{Tdf} + L_{toilet} * L_{toilet\ Rate}$ (26)	Where S_{Tdf} is corresponding value of average flush volume for star rating (L/flush) (see Table 7) respectively; F_{Tdf} frequency of half flushes (flushes per day) respectively; L_{toilet} toilet cistern leaking (no leak; leak with noise; and leak without noise); $L_{toilet\ Rate}$ toilet cistern leaking rate (24 L/day for slow leak without noise; and 204 L/day for fast audible leak with noise).
Evaporative Air Conditioner Water used by evaporative air conditioner Q_{ac} (L/day); The rate of air conditioner bleed $Q_{ac\ bleed}$ (L/day)	$Q_{ac} = N_{ac} * L_{ac} * F_{ac} * Q_{ac\ rate}/365.25$ (27) $Q_{ac\ bleed} = N_{ac} * L_{ac} * F_{ac} * Q_{ac\ bleed\ rate}/365.25$ (28)	Where F_{ac} is Number of cooling days per season (days) (user input); L_{ac} Length of cooling per cooling day (= 9.7 hours) (this is not a user input); $Q_{ac\ rate}$ rate of consumption by evaporative cooler (L/hr) (User has choice of three types of coolers as per Table 8); N_{ac} number of air conditioner units (user input) (for whole of house system = 1); $Q_{ac\ bleed\ rate}$ rate of water bled from the air conditioner (= 12 L/hr) (this is not a user input).
Swimming Pool Water used by swimming pool Q_p (L/day)	$Q_p = 1000 * P_{av\ depth} * (S * F_{pf} + S * F_{pt} * P_{top\ up}) / 365.25$ (29)	Where 1000 is a conversion from kilolitres to litres; 365.25 a conversion from years to days; S surface area of pool (m^2); F_{pf} frequency of pool filling (times filled per year); F_{pt} frequency of topping up pool (top ups per year); $P_{top\ up}$ (= 20 %) nominal portion of pool that is topped up; $P_{av\ depth}$ average depth of the pool (m).
Spa Water used by spa Q_{spa} (L/day)	$Q_{spa} = 1000 * S_{av\ depth} * (A_S * F_{spaf} + A_S * F_{spat} * S_{top\ up}) / 365.25$ (30)	Where 365.25 is a conversion from years to days; A_S are (m^2); F_{spaf} frequency of spa filling (times filled per year), frequency of topping up spa (times topped up per year); 20%) nominal portion of spa that is topped up (this value HWE); $S_{av\ depth}$ (=1.0 m) (average depth of the spa).

Water Features Water used by water features Q_{wf} (L/day)	$Q_{wf} = 1000*W_{av\ depth} * A_{wf} (F_{wf} + F_{wft}* W_{top\ up}) / 365.25$ (31)	Where A_{wf} is area of water feature (m^2) (graphical interaction); F_{wf} frequency of water feature filling (times filled per year); F_{wft} frequency of water feature topping up (times topped up per year); $W_{av\ depth}$ average depth of water feature ; $W_{top\ up}$ average top up percentage of the water feature (= 20%).
Garden and Lawn Water used for watering garden and lawn in the summer season $Q_{Lsummer}$ (L/day); Water used for watering garden and lawn in the winter season $Q_{Lwinter}$ (L/day); Water used for watering garden and lawn in the spring/autumn season $Q_{Lspring/autumn}$ (L/day)	$Q_{Lsummer} = [Q_{IrriMethod} * F_{Irri} *D_{Summer}]$ (32) $Q_{Lwinter} = [Q_{IrriMethod} * F_{Irri} * D_{winter}]$ (33) $Q_{Lspring/autumn} = [Q_{IrriMethod} * F_{Irri} * D_{spring/autumn}]$ (34)	Where $Q_{IrriMethod}$ is application rate of the irrigation method (L/min) (see Table 9); D_{Summer} average duration of each watering in summer (min); D_{winter} average duration of each watering in winter (min); $D_{spring/autumn}$ average duration of each watering in spring and autumn (min); F_{Irri} frequency of irrigation per day.
Car Washing Water used for washing a car with a bucket $Q_{cw\ bucket}$ (L/day); water used for washing a car with a hose, $Q_{cw\ hose}$ (L/day)	$Q_{cw\ bucket} = V_{bucket}*N_{bucket}*F_{cw\ bucket} / 30.44$ (35) $Q_{cw\ hose}$ (L/day) $= Q_{hose}*D_{hose}*F_{cw\ hose} / 30.44$ (36)	Where 30.44 is a conversion from months to days; V_{bucket} volume of water in a bucket (= 10 litres); N_{bucket} number of buckets used per car wash; $F_{cw\ bucket}$ frequency of car washing per month; Q_{hose} volume of water discharged from hose per minute (= 10 litres / min); D_{hose} duration of hose use per car wash (minutes); $F_{cw\ hose}$ frequency of car washing per month.
Stormwater runoff Q_R (L/year)	$Q_R = R*[r_{cb}* A_B + r_{cp}* A_P + r_{cg}* A_{Gr} + r_{cc}* A_C + E_{hsw}/100*A_h*r_{chouse} + E_{ssw}/ 100 * A_s * r_{cshed} + r_{cg} * E_{hg} / 100 * r_{chouse} * A_h + r_{cg} *E_{sg} / 100\ r_{cshed} *A_s] + (R + 365.25*Q_L / A_L)* A_L* r_{cl} + (R + 365.25* Q_G / A_G)* A_G* r_{cg}+ 365.25 *Q_{cw}* r_{ccw} + \sum U_{ff} * r_{cff} + \sum Q_{over}$ (37)	Where R is annual rainfall (mm); r is co-efficient of runoff from impervious and pervious surfaces (see Table 10); A_B brick area (m^2); A_P pervious area (m^2); A_{Gr} gravel area (m^2); A_C concrete area (m^2); Q_L volume of water used on lawn (L/day); Q_G volume of water used on garden (L/day); Q_{cw} volume of water used to wash car (L/day); U_{ff} first flush volume (L/day) of rainwater tank; A_L lawn area (m^2); A_G garden area

		(m^2); r_{ccw} runoff co-efficient from car washing (0.7); Q_{over} overflow from rainwater tank (L/day); A_s area of shed roof (m^2); A_h area of house roof (m^2); E_{hsw} percentage of house roof directed to municipal stormwater drainage (%) (user specified); E_{ssw} percentage of shed roof directed to municipal stormwater drainage (%) (user specified); E_{hg} percentage of house roof directed to garden / lawn (%) (user specified); E_{sg} percentage of shed roof directed to garden / lawn (%) (user specified).
Rainwater Tank Stormwater inflow to the rainwater store tank over timesteps Q_{in} (L/day); First flush F_f (L/day); Overflow from rainwater tank over timesteps Q_{over} (L/day); Consumption of rainwater tank water over timestep Q_{out} (L/day); V_t volume stored in rainwater tank at the end of timestep (L); Demand on rainwater tank water over timestep D_t (L/day)	Q_{in} (L/day) = max(a*R_d*[A_h * E_h / 100 + A_s * E_s / 100] - F_f, 0) (38) F_f (L/day) = min(a*R_d*[A_h * E_h / 100 + A_s * E_s / 100], U_{ff}) (39) $Q_{over} = \max(Q_{in} - Q_{out} + V_{t-1} - V_t, 0)$ (40) V_t (L) = min($V_{t-1} + Q_{in} - Q_{out}$, V_{cap}) (41) Q_{out} (L/day) = min(D_t, $V_{t-1} + Q_{in}$) (42) $D_t = \sum_{\text{User Defined Rainwater Tank Demand}}$ (Dishwasher + Kitchen sink & tap + Clothes Washer + Laundry Tub & Tap + Shower + Bath + Spa Bath + Basin & Tap + Toilet + Air conditioner + Swimming Pool + Spa + Garden + Lawn + Water Feature + Car Washing) (43)	Where a (= $r_{chouse,}$ r_{cshed}) is co-efficient of runoff from shed and house roof (= 0.9); R_d rainfall in the day (mm/day); A_h area of house roof (m^2); E_h percentage of house roof directed to rainwater tank (%); A_s area of shed roof (m^2); E_s percentage of shed roof directed to rainwater tank (%);V_{t-1} volume stored in rainwater tank at the end of previous timestep (L); U_{ff} is first flush volume (L).
On Site Treatment System Inflow to the on site treatment	$Q^T_{in} = \sum_{\text{user defined supply}}$ (Dishwasher + Kitchen Sink &	Where V^T_{t-1} is volume of water in treatment unit at end of previous timestep (L); A diurnal use pattern co-

system over a timestep Q^T_{in} (L/day); Overflow from the on site treatment system over timestep Q^T_{over} (L/day); Volume of water in treatment unit at end of timestep V^T_t (L); Demand of treated water over timestep D^T_t (L/day); Volume of water from the on site treatment system consumed over timestep Q^T_{out} (L/day)	Tap + Clothes Washer + Laundry Tub & Tap + Shower + Bath + Spa Bath + Basin & Tap + Toilet + Air Conditioners) (44) $Q^T_{over} = \max(Q^T_{in} - Q^T_{out} + V^T_{t-1} - V^T_t, 0)$ (45) $V^T_t = \min(V^T_{t-1} + Q^T_{in} - Q^T_{out}, V^T_{cap})$ (46) $D^T_t = \sum_{\text{User Defined On Site Treatment System demand}}$ (Clothes Washer + Toilet + Garden Bed + Lawn + Water Feature) (47) Q^T_{out} ("24 hour flush": FALSE) = $\min(V^T_{t-1} + Q^T_{in}, D^T_t)$ (48) Q^T_{out} ("24 hour flush": TRUE) = $\min(A * Q^T_{in}, D^T_t)$ (49)	efficient (ratio of total water can be used / total water supplied to treatment unit) (= 0.9).
Greywater Diversion Volume of greywater consumed over timestep Q^G_{use} (L/day); Total amount of water diverted to greywater Q^G_{in} (L/day); Demand of water over timestep D^G_t (L/day)	$Q^G_{use} = \min(D^G_t, B * Q^G_{in})$ (50) $Q^G_{in} = \sum_{\text{user defined supply}}$ (Dishwasher + Kitchen Sink & Tap + Clothes Washer + Laundry Tub & Tap + Shower + Bath + Spa Bath + Bathroom Basin & Tap + Air Conditioners) (51) $D^G_t = \sum$On Site Treatment System demand from (Toilet + Garden + Lawn) (52)	Where B is diurnal use pattern co-efficient (1-greywater overflow/total greywater) (= 0.7).

Table 2 Dishwasher water consumption by star rating (Reference: AS/NZS 6400:2005)

Star	**0**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**
Baseline (L)	3.0	2.5	2.27	2.06	1.87	1.7	1.55	1.4	1.28	1.16	1.05	0.96
Values (L/Place setting)	1.95	1.60	1.45	1.32	1.20	1.09	0.99	0.90	0.82	0.74	0.67	0.61

Table 3 Star rating specifications for taps (Reference: AS/NZS 6400:2005)

	0 Star	**1 Star**	**2 Star**	**3 Star**	**4 Star**	**5 Star**	**6 Star**
Ranges as per standard (L/min)	>16.0	12.0-16.0	9.0-12.0	7.5-9.0	6.0-7.5	4.5-6.0	0-4.5
Values used in AccuRate	≥16, user input	14.0	10.5	8.25	6.75	5.25	4.5

Table 4 Cloth washing machines water consumption by star rating (Reference: AS/NZS 6400:2005)

Star	**0**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**
Values (L/Place setting)	35.0	30	25.1	21	17.6	14.7	12.3	10.3	8.6	7.2	6	5

Table 5 Star rating specifications for showers (Reference: AS/NZS 6400:2005)

	0 Star	**1 Star**	**2 Star**	**3 Star**
Ranges as per standard (L/min)	>16.0	12.0-16.0	9.0-12.0	7.5-9.0
Values used in AccuRate	≥16, user input	14.0	10.5	8.25

Table 6 Spa bath size classifications (Reference: Grant *et al* 2004)

	Small	**Medium**	**Large**
Size of Spa (L)	200	275	350
Volume to fill (L)	120	180	250

Table 7 Star rating specifications for toilets (Reference: AS/NZS 6400:2005)

Ranges per standard	**0 Star**	**1 Star**	**2 Star**	**3 Star**	**4 Star**	**5 Star**	**6 Star**
Full flush (L)	N/A	6.5-9.5	6.5-9.5	4.7-6.5	0-4.7	0-4.7	0-4.7
Half flush (L)	N/A	3.5-4.5	3.5-4.5	3.2-3.5	0-3.2		
Average flush volume(L)	N/A	4.5-5.5	4.0-5.5	3.5-4.0	3.0-3.5	2.5-3.0	0-2.5
Values used in AccuRate							
Average Full flush (L)	11.0	8.0	8.0	5.6	4.7	3.0	2.5
Average Half flush (L)	6.0	4.0	4.0	3.35	3.2	3.0	2.5
Average flush volume(L)	7.0	5.5	4.5	4.0	3.5	3.0	2.5
Single flush (L)	11.0						

Table 8 Rate of consumption by evaporative coolers (Reference: Grant *et al* 2004))

Cooler type	**Rate (L/hr)**	**Source**
Whole of House Evaporative Cooler with bleeding	33	Extrapolated from Karpiscak et al. (1998)
Whole of House Evaporative Cooler without bleeding	14	Extrapolated from Karpiscak et al. (1998)
Portable or zoned cooler	4	Sustainable Energy Authority of Victoria (2004) & Country Energy (2002)

Table 9 Application rate for different irrigation method (Reference: Grant *et al* 2004)

Irrigation Method	**Application rate – $AppRate_{IrriMethod}$**
By Hand – Bucket / Watering Can	10 litres per bucket[a]
By Hand – Hose	20 L/min[b]
By Sprinkler – Hose Connections	15 L/min[b]
By Sprinkler – Fixed Connections	30 L/min[b]
By Drip Irrigation	5 L/min[b]
By Micro-spray Irrigation	10 L/min[c]

a: This is an estimate – assumes a full bucket / watering can of a fixed size
b: Green Plumbers (2003)
c: assumed to be twice the flow rate of drip irrigation

Table 10 Runoff coefficients (Reference: Grant *et al* 2004)

Bricks / Tiles (r_{cb})	0.6
Pervious Paving (r_{cp})	0.2
Gravel (r_{cgr})	0.2
Concrete (r_{cc})	0.7
Lawn (r_{cl})	0.05
Garden (r_{cg})	0.05
First Flush (r_{cff})	0.05
Shed Roof, House Roof (r_{cshed}, r_{chouse})	0.9
runoff co-efficient from car washing (r_{ccw})	value is dependant on surface car is being washed on

3. IMPLEMENTATION OF WATER MODULE IN ACCURATE

Using the same style as the other AccuRate input pages, a water page has been added to the AccuRate user interface as shown in Figure 1, which contains the input data fields required. As shown in Figures 1-8, the user input data fields for house water usage include:

- occupant numbers (Fig. 1);
- indoor water related facilities (Fig. 2): dishwasher, kitchen tap and sink, clothes washer, laundry tap and sink, shower, bath, spa bath, bathroom tap and basin, toilet (single flush or dual flush) and air conditioner;
- outdoor water related facilities (Fig. 4): swimming pool, spa, water features, garden and lawn, car washing;
- water source information (Fig. 6): rainwater tank, on-site water treatment system, grey water diversion and bore water;
- Storm water information (Fig. 8): impervious areas such as brick, paving, concrete, gravel areas, ratio of stormwater from roofs to municipal drainage and to garden/lawn;

Based on the user inputs, AccuRate calculates for indoor water usage, outdoor water usage, seasonal average daily water usage for different water sources and stormwater runoff as shown in Figures 3, 5, 7 and 8. The yearly-averaged daily water usages from different water sources are displayed on the top of the water page as shown in Fig. 1. Figure 9 shows the AccuRate summary report for the house water usage.

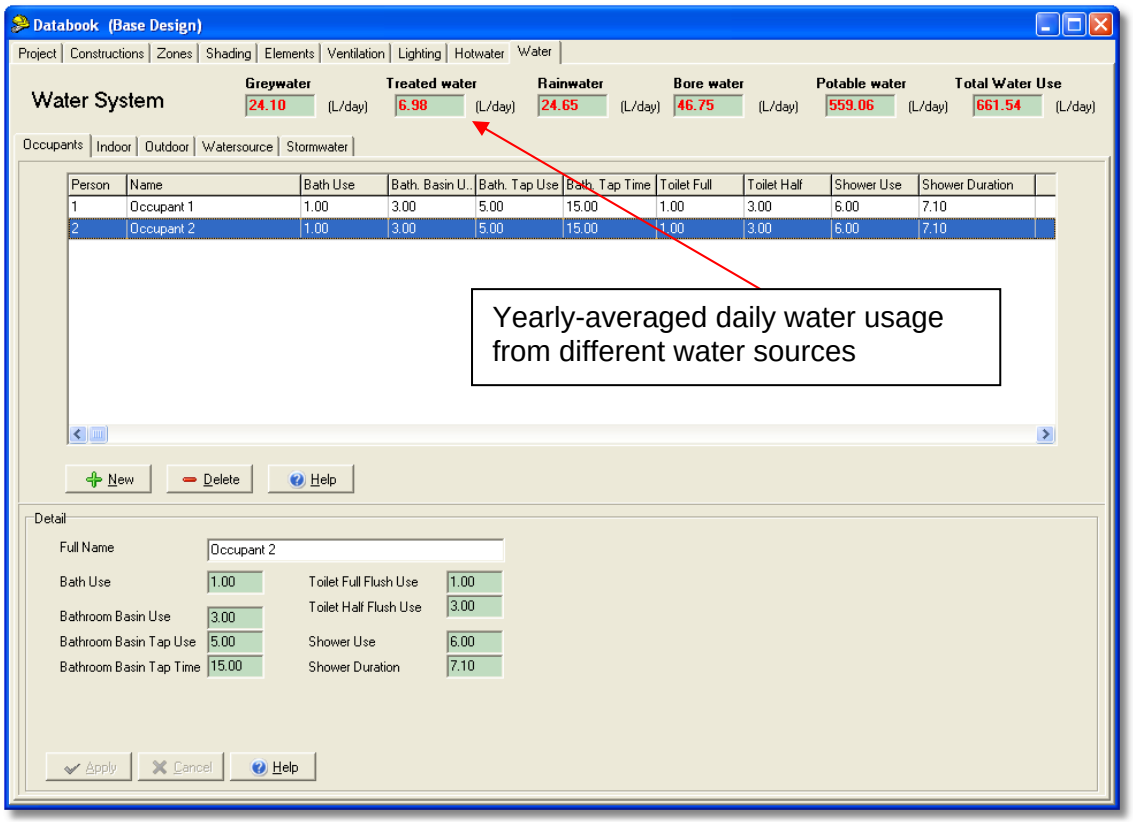


Figure 1. Occupants information

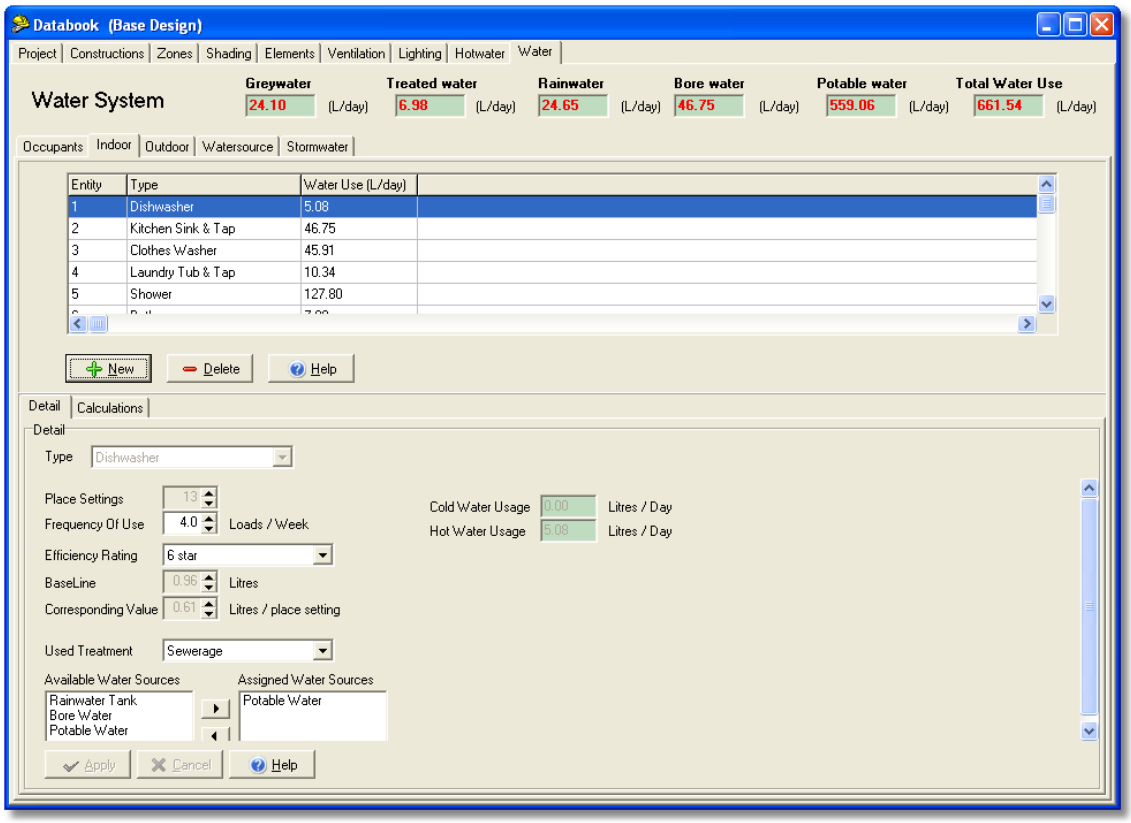


Figure 2. Indoor water related facilities inputs

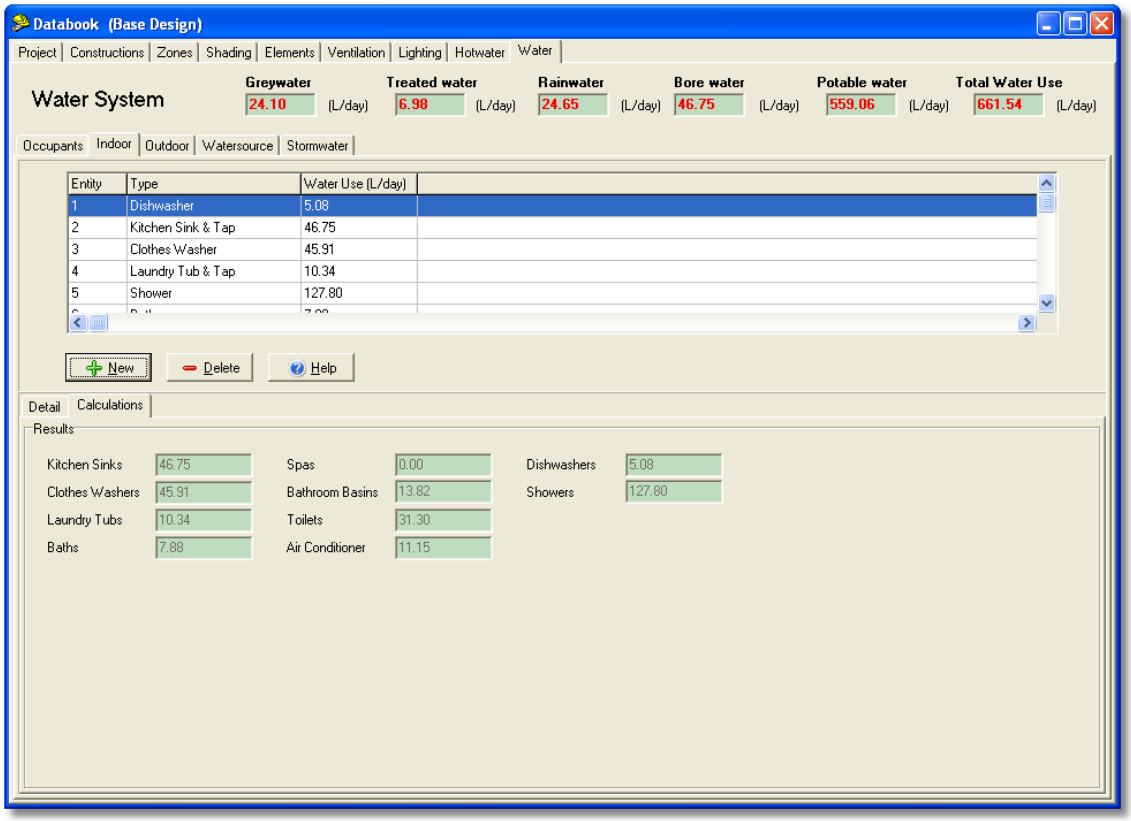


Figure 3. Indoor water usage calculation

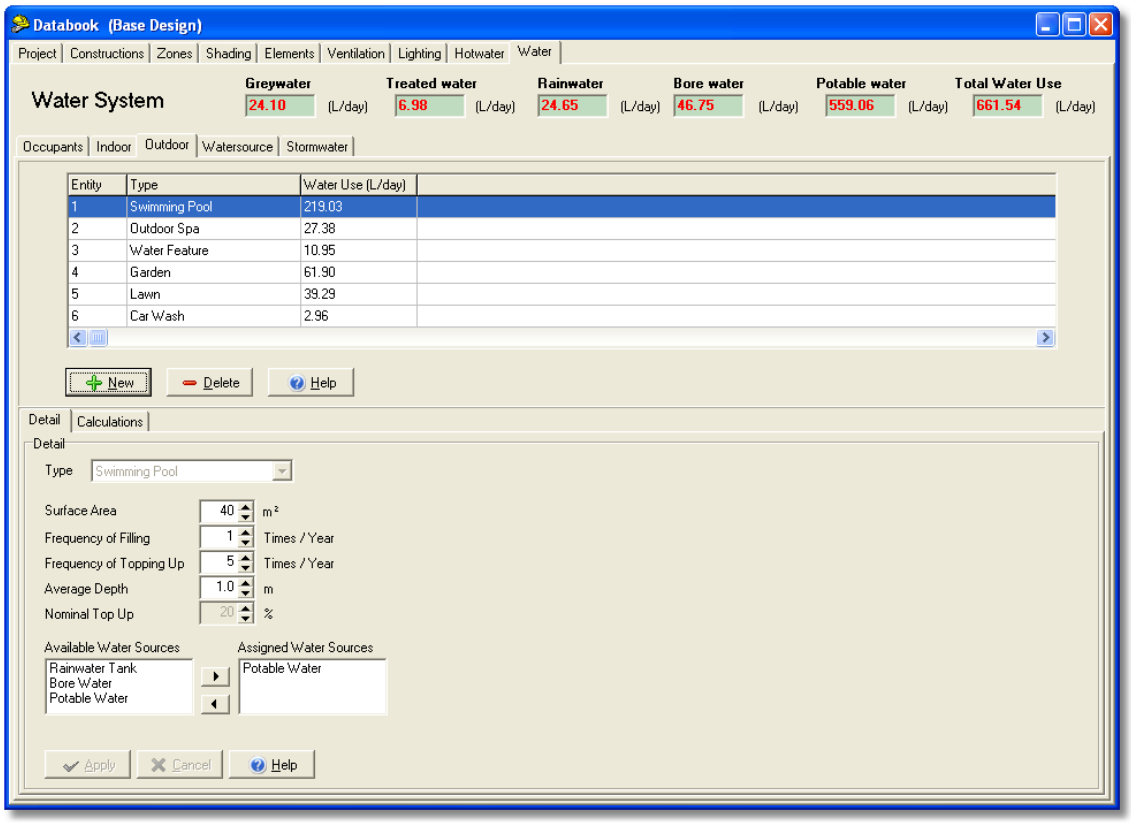


Figure 4. Outdoor water related facilities inputs

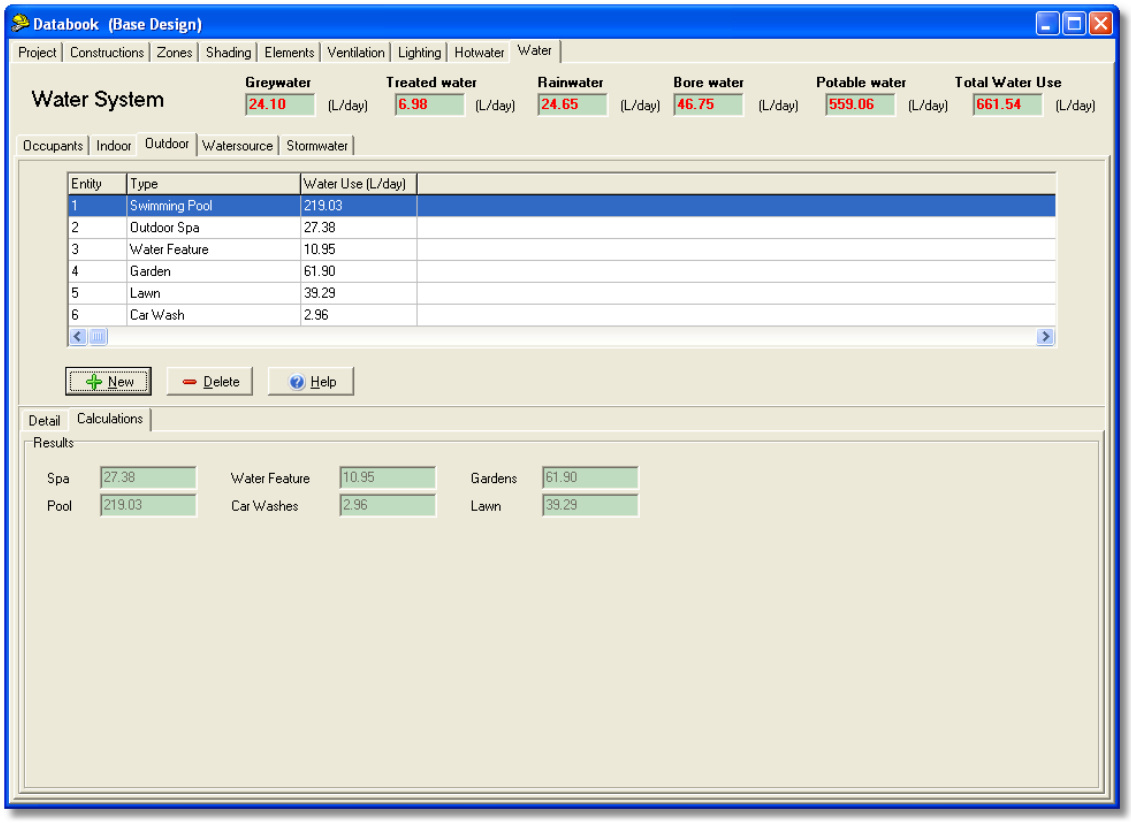


Figure 5. Outdoor water usage calculation

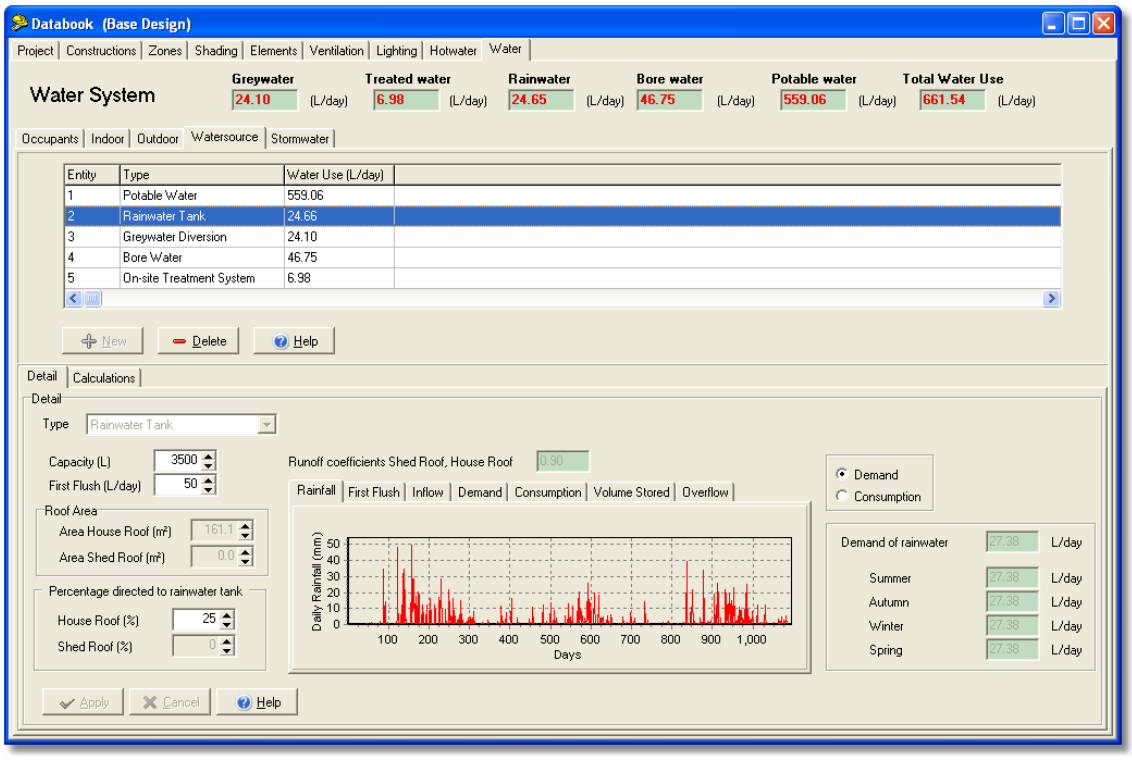


Figure 6. Water source inputs

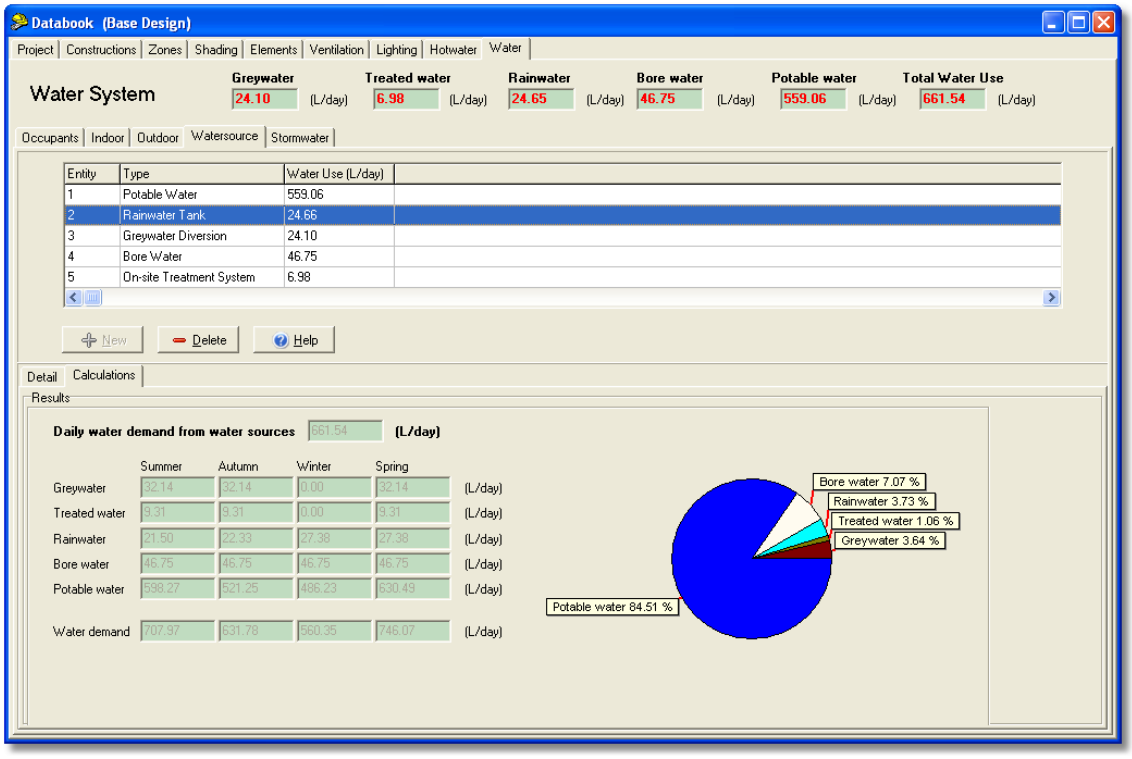


Figure 7. Seasonal average daily water usage for different water sources

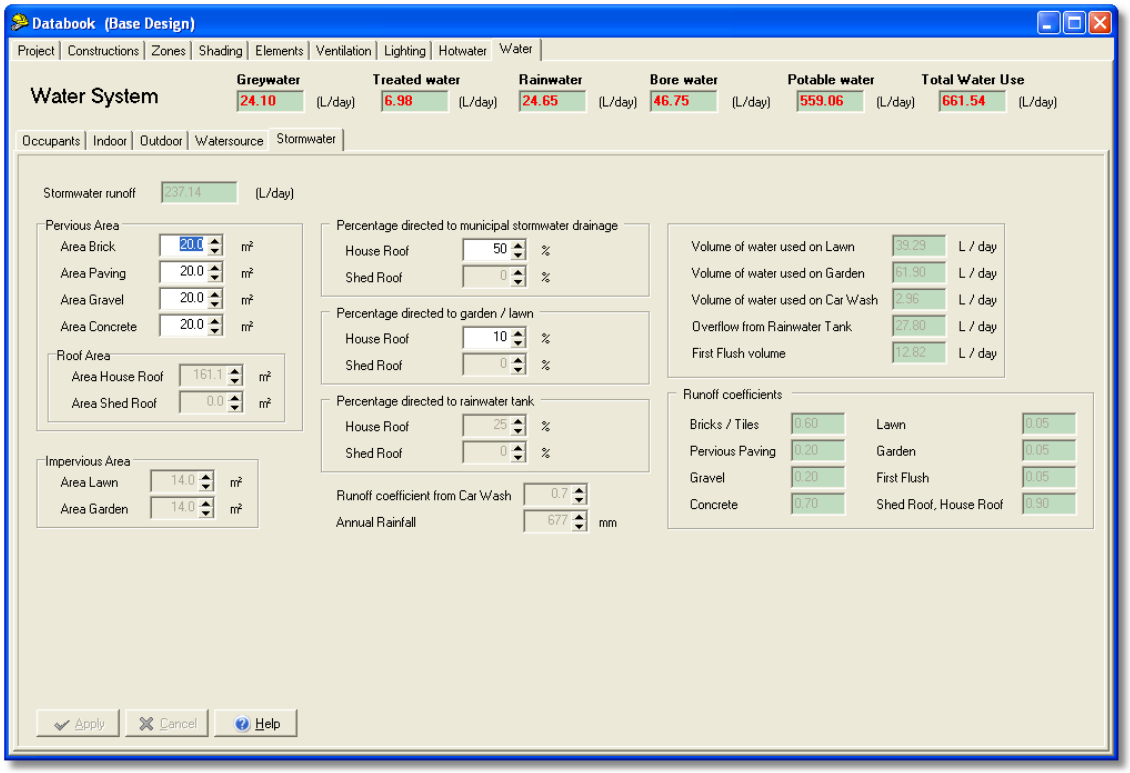
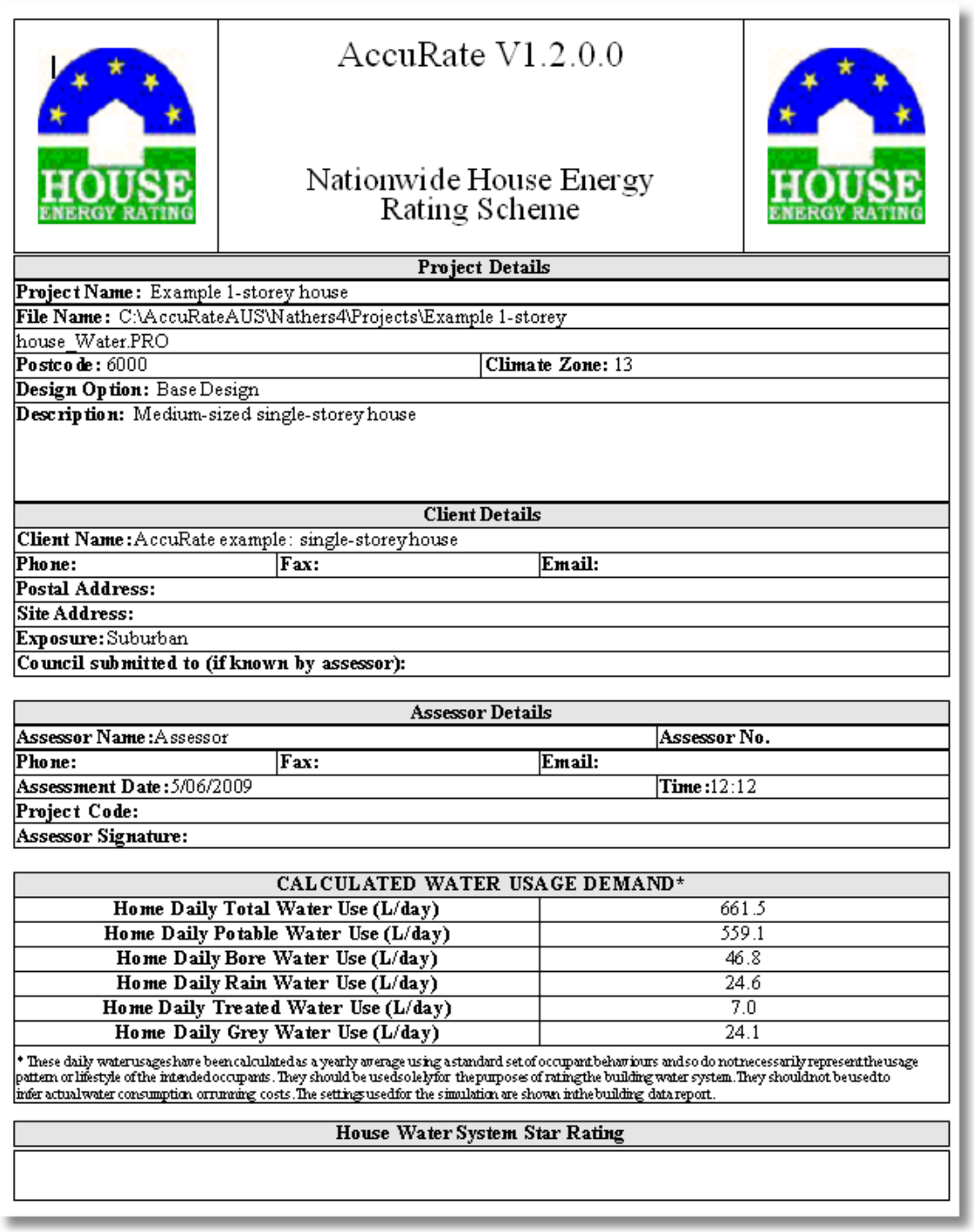


Figure 8. Stormwater inputs and calculation



AccuRate V1.2.0.0

Nationwide House Energy Rating Scheme

Project Details	
Project Name: Example 1-storey house	
File Name: C:\AccuRateAUS\Nathers4\Projects\Example 1-storey house_Water.PRO	
Postcode: 6000	**Climate Zone:** 13
Design Option: Base Design	
Description: Medium-sized single-storey house	

Client Details		
Client Name: AccuRate example: single-storey house		
Phone:	**Fax:**	**Email:**
Postal Address:		
Site Address:		
Exposure: Suburban		
Council submitted to (if known by assessor):		

Assessor Details			
Assessor Name: Assessor			**Assessor No.**
Phone:	**Fax:**	**Email:**	
Assessment Date: 5/06/2009			**Time:** 12:12
Project Code:			
Assessor Signature:			

CALCULATED WATER USAGE DEMAND*	
Home Daily Total Water Use (L/day)	661.5
Home Daily Potable Water Use (L/day)	559.1
Home Daily Bore Water Use (L/day)	46.8
Home Daily Rain Water Use (L/day)	24.6
Home Daily Treated Water Use (L/day)	7.0
Home Daily Grey Water Use (L/day)	24.1

* These daily water usages have been calculated as a yearly average using a standard set of occupant behaviours and so do not necessarily represent the usage pattern or lifestyle of the intended occupants. They should be used solely for the purposes of rating the building water system. They should not be used to infer actual water consumption or running costs. The settings used for the simulation are shown in the building data report.

House Water System Star Rating

Figure 9. Water usage summary report

4. CONCLUSIONS

A water usage module has been implemented in AccuRate based on the House Water Expert (HWE) software, developed by CSIRO for estimating household water consumption [1].

The project achieved the following deliverables:

- A water page has been implemented in the AccuRate user interface, containing the input data fields required which include: house location, house style and land block information, occupant patterns and behaviours, indoor/outdoor water related facilities, etc.
- The calculations of water consumption in this water page are based on the House Water Expert software, which was developed by CSIRO for people to estimate and reduce household water consumption [1].
- A new water report page has also been added to AccuRate's summary report, showing yearly-averaged daily water consumption estimation of town water, on-site treated water, grey water, rain water, stormwater runoff and the averaged daily total water consumption estimation.

REFERENCES

1. Grant A.L., Mitchell V.G. and Dell'Oro E.R. (2004) House Water Expert: Explanation of Algorithms, MIT Doc. Number 2004/210, ©CSIRO July 2004.
2. Karpiscak M.M, Babcock T.M., France G.W., Zauderer J., Hopf S.B. and Foster K.E. (1998) Evaporative Cooler Water Use in Phoenix, Journal AWWA, **90 (4)**, 121-130.
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4. Country Energy (2002) Choosing a Cooling System, Retrieved: July 4, 2004, from http://www.countryenergy.com.au/internet/cewebpub.nsf/AttachmentsByTitle/flib-energyeff/$file/es cooling.pdf.
5. Green Plumbers 2003, *50 point environmental household inspection report,* Green Plumbers – Master Plumbers & Mechanical Services Association of Australia, West Melbourne.

APPENDIX A – DEFAULT USER INTERFACE INPUT VALUES

Table A 1: Default User Interface Input Values (Source: Grant *el at*, 2004)

End Use	User Interface Input	Unit	Default Value
Dish Washer	Frequency of dishwasher used, F_D	loads/week	4
	Star rating, S_D		0
Kitchen sink & tap	Frequency of rinsing, F_K	per day	1
	Duration of rinsing, D_K	seconds	30
	Leaking tap, L_K	y/n	N
	Frequency of kitchen sink use, F_{ks}	per week	7
	Star rating, S_K		0
Clothes Washer	Star rating, S_{cw}		0
	Rated capacity of washing machine, C_{cw}	kg	Medium (6.5)
	Frequency of washing machine use, F_{cw}	per week	4
Laundry Tub & Tap	Star rating, S_L		0
	Frequency of rinsing from laundry tap, F_L	per week	1
	Typical duration of rinsing, D_L	minutes	5
	Leaking tap, L_L	y/n	N
	Frequency of laundry tub use, F_{lt}	per week	1
Shower (per individual)	Star rating, S_s		0
	Frequency of shower usage, F_s	per week	6
	Typical duration of shower, D_s	min	7.1
	Leaking shower head, L_s	y/n	N
Bath (per individual)	Frequency of bath usage, F_B	per month	1
	Leaking bath tap, L_B	y/n	N
Spa Bath	Frequency of spa bath usage, F_{SB}	per month	4
	Volume of spa bath,V_{SB}	small, medium & large	medium
	Leaking spa bath tap, L_{SB}	y/n	N
Bathroom Tap (per individual)	Star rating, S_{bt}		0
	Frequency of rinsing, F_{bt}	per day	5
	Typical duration of rinsing, D_{bt}	sec	15
	Leaking bathroom basin tap, L_{bt}	y/n	N
	Frequency of basin use, F_{bb}	per week	3
Toilet (per individual)	Toilet type (Full, half, composting)		Half
	Single flush Star rating, S_{Tsf}		0
	Dual flush Star rating, S_{Thf}		3
	Frequency of half flushes, F_{Thf}	per day	3
	Frequency of full flushes, F_{Tff}	per day	1
	Frequency of use of single flush toilet, F_{tsf}	per day	4
Air conditioner (refrigerative)	Number of cooling days per season, F_{ac}	days	30
	Cooler type (Whole of House Evaporative Cooler with bleeding, Whole of House Evaporative Cooler without bleeding,		Whole of House Evaporative

End Use	User Interface Input	Unit	Default Value
	Portable or zoned cooler)		Cooler without bleeding
	Number of air conditioner units, N_{ac}		whole of house system = 1
Swimming pool	Frequency of pool filling, F_{pf}	per year	1
	Frequency of topping up pool, F_{pt}	per year	5
	Average depth of the pool, $P_{av\ depth}$	metres	1.0 m
Spa	Frequency of spa filling, F_{spaf}	per year	1
	Frequency of topping up spa, F_{spat}	per year	5
	Average depth of the pool, $S_{av\ depth}$	metres	1.0 m
Water feature	Frequency of water feature filling, F_{wf}	per year	1
	Frequency of water feature topping up, F_{wt}	per year	5
	Average depth of the water feature, $W_{av\ depth}$	metres	1.0 m
Car washing by bucket (per car)	Number of buckets used, N_{bucket}	per car wash	3
	Frequency of car washing, $F_{cw\ bucket}$	per month	3
Car washing by hose (per car)	Duration of hose use per car wash, D_{hose}	minutes	10
	Frequency of car washing, $F_{cw\ hose}$	per month	3
House Roof	Percentage of House Roof directed to municipal stormwater drainage, E_{hsw}	%	100
	Percentage of House Roof directed to garden / lawn, E_{hg}	%	0
	Percentage of House Roof directed to Rainwater tank, E_h	%	0
Shed roof	Percentage of Shed Roof directed to municipal stormwater drainage, E_{ssw}	%	100
	Percentage of Shed Roof directed to garden / lawn, E_{sg}	%	0
	Percentage of Shed Roof directed to Rainwater tank, E_s	%	0
Rainwater tank	First Flush device capacity, U_{ff}	L/day	50
	Capacity of Rainwater Tank, V_{cap}	L	3500
On Site treatment	Capacity of Treatment Unit, V^T_{cap}	L	1000
	24 hour flush	True/False	True
Bore Water	Pump rate	L/d	200

Garden Watering (per garden bed)

Watering Method	Summer		Autumn/Spring		Winter	
	Frequency	Number of buckets	Frequency	Number of buckets	Frequency	Number of buckets
By Hand – Bucket or watering can	Every 3 days	10	Once a week	10	never	0

Watering Method	Summer		Autumn/Spring		Winter	
	Frequency	Duration, min	Frequency	Duration, min	Frequency	Duration, min
By Hand – Hose	Every 3 days	20	Once a week	20	never	0
By Sprinkler – Hose Connections	Every 3 days	20	Once a week	20	never	0
By Sprinkler – Fixed Connections	Every 3 days	20	Once a week	20	never	0
By Drip Irrigation	Every 3 days	90	Once a week	90	never	0
By Micro-spray Irrigation	Every 3 days	40	Once a week	40	never	0

Lawn Watering

Watering Method	Summer		Autumn/Spring		Winter	
	Frequency	Number of buckets	Frequency	Number of buckets	Frequency	Number of buckets
By Hand – Bucket	Every 3 days	10	Once a week	10	never	0

Watering Method	Summer		Autumn/Spring		Winter	
	Frequency	Duration, min	Frequency	Duration, min	Frequency	Duration, min
By Hand – Hose	Every 3 days	45	Once a week	45	never	0
By Sprinkler – Hose Connections	Every 3 days	45	Once a week	45	never	0
By Sprinkler – Fixed Connections	Every 3 days	45	Once a week	45	never	0
By Drip Irrigation	Every 3 days	180	Once a week	180	never	0
By Micro-spray Irrigation	Every 3 days	90	Once a week	90	never	0

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