

WATER HARVESTING SYSTEM

FIELD OF THE INVENTION

The present invention relates to a water harvesting system, in particular a
5 rainwater harvesting system directed to harvesting rainwater surface runoff.

BACKGROUND TO THE INVENTION

The following discussion of the background to the invention is intended to
facilitate an understanding of the present invention. However, it should be
10 appreciated that the discussion is not an acknowledgment or admission that any of
the material referred to was published, known or part of the common general
knowledge in any jurisdiction as at the priority date of the application.

Many tropical countries experience a hot and wet climate where precipitation
volume can vary substantially, ranging from light rainfall to storms during monsoon
15 surges. A tropical country such as Singapore may experience about 2400
millimetres of precipitation annually. Accordingly, flood risks vary with the amount of
precipitation in a given amount of time. Terrain can exacerbate flood risks where
flatter terrain will generally retain and collect rainwater. Low-lying areas with flatter
terrain face higher flood risks, especially when heavy rain coincides with high tides.

20 Urbanisation increases flood risks because green spaces are reduced and
impervious areas are increased. Therefore during a storm event, more surface
runoff is generated and flows faster into a drainage system over a shorter period of
time. If the drainage system is unable to cope with the increased fluid flow over a
shorter period of time, flooding occurs.

25 Detention tanks form part of a flood management system. Such tanks collect
and store stormwater runoff during a storm event, and release the stormwater at
controlled rates to downstream drainage systems, thereby attenuating peak
discharge rates from a site. Such detention tanks can be part of an online detention
system where runoff is routed through the detention tank or they can be part of an
30 offline detention system where excess flow above weir level is diverted into the
detention tank and the diverted stormwater is rerouted and discharged back into

the drainage system via a pump when the water in the drainage system has subsided. The problem with detention tanks is that the stormwater is not optimally utilised and is allowed to simply drain into the drainage systems. While drainage water can collect in a reservoir and be ultimately treated to become potable water or for other uses, this journey is relatively long, and time and energy may be unnecessarily expanded for such water treatment.

Retention tanks can also be used in flood management systems. While such tanks can be used with detention tanks, they are generally independent tanks where collected stormwater is divided and channelled to each individual tank for their specific purposes. Retention tanks are designed to collect stormwater typically for irrigation, washing of common areas and carparks while allowing excess stormwater to flow into the drainage system. However the uses of such water depend on the quality of the water collected. Surface runoffs are generally more turbid, have a higher amount of total suspended solids and dirtier than roof runoffs because they pick up more debris and dirt as they flow. Therefore, water collected from roof runoffs are generally more widely used as the water is cleaner and less comprehensive treatment systems are required. Water collected from surface runoffs typically have to be treated more extensively before they can be used.

There is accordingly a need to improve existing detention and retention tanks, and also the need to better utilise the water collected at a site rather than allowing it flow away into the drainage system.

SUMMARY OF THE INVENTION

Throughout this document, unless otherwise indicated to the contrary, the terms “comprising”, “consisting of”, and the like, are to be construed as non-exhaustive, or in other words, as meaning “including, but not limited to”.

The abovementioned need is met at least in part and an improvement in the art is made by a water harvesting system in accordance with this invention.

In accordance to an aspect of the present invention, there is a water harvesting system comprising a first tank in fluid communication with a second tank, wherein the first tank is adapted to collect water and release the water at a

controlled rate to a drainage system, and wherein the first tank is further adapted to allow the water to accumulate and overflow into the second tank for storage. The fact that the first tank is adapted to release the water at a controlled rate in a drainage system allows the system to be part of a storm management system.

- 5 Further, water which is allowed to accumulate in the first tank, can overflow into the second tank for storage, where such portion of water which overflows is substantially less turbid, has less total suspended solids and is cleaner than the initial portion of water that entered the first tank. The quality of the initial portion of the collected water (especially from surface runoffs) is generally poor, but improves
10 over time as more water is collected.

Preferably, the water harvesting system further comprises a sedimentator for receiving the water and releasing the water via an aperture into the first tank.

- Preferably, the sedimentator is adapted to control the rate of water release via the aperture into the first tank, and wherein the sedimentator is adapted to allow the
15 water to accumulate and overflow into the second tank. Preferably, the sedimentator has a side for water to overflow into the second tank and the height of the side ranges from 0.3 m to 0.8 m. More preferably, the aperture has a cross-sectional diameter of 0.1 m to 0.25 m and even more preferably, the sedimentator has a base area of 1 m² to 36 m².

- 20 Preferably, the first tank, the sedimentator and the second tank are adapted to share a side. Preferably, the sedimentator is located in the first tank and more preferably, the sedimentator is located at a top portion of the shared side.

Preferably, the system comprises at least one collection channel and more preferably, the at least one collection channel comprises a filter screen.

- 25 Preferably, the first tank comprises an overflow outlet adapted to allow water to overflow into the drainage system.

Preferably, the water comprises surface runoff.

Preferably, the second tank is adapted to release the stored water to a water treatment facility.

- 30 Preferably, the system is located underground.

In accordance to another aspect of the present invention, there is a water harvesting system comprising a sedimentator adapted to receive water from a collection channel, a first tank adapted to receive water from the collection channel, and adapted to release the water at a controlled rate to a drainage system, and a second tank, wherein the sedimentator is adapted to accumulate water and cause the water to overflow into the second tank.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 illustrates an embodiment of a water harvesting system of the present invention as part of an online system.

Figure 2 illustrates another embodiment of a water harvesting system of the present invention as part of in an online system.

Figure 3 illustrates another embodiment of a water harvesting system of the present invention as part of an online system.

Figure 4 provides a perspective view of the embodiment of Figure 3.

Figure 5 illustrates a sedimentator of the water harvesting system of Figure 4.

Figures 6A and 6B illustrate another embodiment of a water harvesting system of the present invention as part of an offline system. Figure 6A provides a perspective view of this embodiment while Figure 6B provides a cross-sectional view of this embodiment view in the direction of X in Figure 6A.

Figures 7A-D provide data of a study done on the typical water quality of surface runoff in an area. Figure 7A provides data during a 1st rain event of a rainfall of 38.6 mm/hr, where there were more than 3 dry days prior to this 1st rain event. Figure 7B provides data during a 2nd rain event of a rainfall of 15.4 mm/hr, where there was 1 dry day prior to this 2nd rain event. Figure 7C provides data during a 3rd rain event of a rainfall of 9 mm/hr, where there were more than 3 dry days prior to this 3rd rain event. Figure 7D provides data during a 4th rain event of a rainfall of 20 mm/hr, where there were more than 3 dry days prior to this 4th rain event. The abbreviations used in the tables are: Temp: temperature; DO: dissolved

oxygen; CO ND: conductivity; TSS: total suspended solids; TN: total nitrogen; TOC:total organic carbon; TP: total phosphorus.

Figures 8A-D provide simulation data and results of applying the embodiments of Figures 2 or 3 (depending on sedimentator size) to different catchment area sizes. Figure 8A provides data on the dimensions of the sedimentators (S1 - S12) used during the simulation. Figure 8B provides a table correlating the catchment area sizes and the amount of rainwater collected in the second tank, based on the various sedimentators applied. Figure 8C provides a rearrangement of the data of Figure 8B by clustering the catchment areas in groups based on their sizes. Figure 8D provides a table correlating the catchment area sizes and the average duration before the 1st collection of water in the second tank.

Other arrangements of the invention are possible and, consequently, the accompanying drawings are not to be understood as superseding the generality of the preceding description of the invention.

PREFERRED EMBODIMENTS OF THE INVENTION

Particular embodiments of the present invention will now be described with reference to the accompany drawings. The terminology used herein is for the purpose of describing particular embodiments only and is not intended to limit the scope of the present invention. Other definitions for selected terms used herein may be found within the detailed description of the invention and apply throughout the description. Additionally, unless defined otherwise, all technical and scientific terms used herein have the same meanings as commonly understood by one or ordinary skill in the art to which this invention belongs. Where possible, the same reference numerals are used throughout the figures for clarity and consistency.

The term "overflow" used throughout the specification will be understood to refer to the flowing of a fluid out of and over at least one projecting edge or brim of a side or portion thereof, of a container, basin or tank. Such overflow can result from the accumulation of the fluid within the container, basin or tank.

The term "sedimentator" used throughout the specification will be understood to mean a container, basin or tank which is capable of receiving a fluid (includes a

liquid) and adapted to allow for sedimentation and/or the removal of sediments depending on the flow rate of the fluid. A “sedimentator” includes, but is not limited to a sump. A “sedimentator” need not be fully enclosed and can be adapted to allow for the inflow and outflow of liquids.

5 The term “water” used throughout the specification will be understood by a skilled person in the art of the present invention to include, but is not limited to suspensions, solutions and/or emulsions where the main constituent is water. Further, “water” includes but is not limited to rainwater, surface runoffs, roof runoffs, potable and non-potable water.

10 Figure 1 provides an embodiment of a water harvesting system 100 of the present invention and comprises broadly a collection component 170, storage component 180 and distribution component 190. Specifically, water harvesting system 100 comprises a first tank 110 (detention tank 110) and a sedimentator 120 which are part of collection component 170; a second tank 130 (retention tank 130)
15 which is part of storage component 180; and a treatment facility 140 which is part of the distribution component 190. The first tank 110 is adapted to receive from at least one collection channel 151, runoff 150 from for example, ground 160. The system 100 may be provided with more than one collection channels 151 for collecting and directing runoff 150 to the first tank 110. Runoff 150 includes but is
20 not limited to surface runoffs and roof runoffs. However, runoff 150 is preferably surface runoff. Collection channel 151 may also collect water from various sources which include but is not limited to ground, roofs, pavements, vertical landscaping, reservoirs and water treatment plants. Collection channel 151 includes but is not
25 limited to drains and pipes. The collection channel 151 may include a filter screen 152 adapted to effectively remove any large debris and particles picked up by the runoff 150.

 The first tank 110 has a discharge channel 111 operable to discharge preferably via gravity, water accumulated by the collection of runoff 150 in said first tank 110, into a drainage system (not shown) at a controlled rate, thereby
30 attenuating peak discharge rates of water from a site, for example during a storm. A “drainage system” used throughout the specification refers to a system which

removes and/or directs away water from an area to for example a larger body of water such a reservoirs and lakes, or to water treatment plants for water processing. A “drainage system” includes but is not limited to man-made systems such as drains and canals, and natural systems such as streams and rivers.

5 Depending on application, discharge channel 111 may be replaced by a suitable pump or pumps. The first tank 110 may be suitably shaped to facilitate the discharge of water and sediments out to the drainage system via discharge channel 111. The first tank 110 also has an overflow outlet 113 operable to allow accumulated water in first tank 110 to overflow into the drainage system,
 10 particularly when the first tank 110 reaches to or is close to reaching its full capacity in containing water. In Figure 1, the water harvesting system 100 is be part of an online system where runoff 150 is routed through the sedimentator 120 and the first tank 110. However it will be appreciated that the water harvesting system 100 can be part of an offline system where first tank 110 or sedimentator 120 runs parallel
 15 to the collection channel 151 where any excess runoff 150 in the collection channel 151 can overflow into the first tank 110 or the sedimentator 120. The first tank 110 can have maintenance access from the ground 160. The first tank 110 may be a pre-cast roof tank installed with suitable maintenance hatch to prevent rainwater from entering the first tank 110, other than through collection channels 151. The
 20 first tank 110 shares a side/barrier/wall 112 with sedimentator 120 and second tank 130. Preferably, the volume of the first tank 110 for containing fluids is 355 m^3 . However the volume of the first tank 110 can depend on for example, the size of the catchment area where the water harvesting system 100 is installed.

Sedimentator 120 is located in the first tank 110 and is operable to receive the
 25 runoff 150 from collection channels 151. The sedimentator 120 is preferably located in the first tank 110 to optimise space as the volume of sedimentator 120 can be counted towards the required volume of the first tank. If the sedimentator is located in the second tank 130, the volume of the second tank 130 will have to be increased to ensure that substantially the same volume of water can be collected
 30 as that when the sedimentator 120 is located in the first tank 110. The runoff 150 can be received by the sedimentator 120 from its top and/or one of its sides. Figure

4 illustrates a sedimentator 320 of an embodiment of the present invention capable of receiving runoff 350 from channel 351, from the top of the sedimentator 320. Collection channel 351 is preferably at a higher level to that of sedimentator 320. Sedimentator 120 comprises an aperture 121 and a side 112' which is part of the shared side 112 with the second tank 130. The sedimentator 120 includes but is not limited to a sump and it is adapted to allow for the sedimentation and/or removal of sediments, depending on the flow rate of the runoff 150 into said sedimentator 120. Further, the sedimentator 120 is adapted to create ponding and water accumulation for water to overflow into the second tank 130. As will be explained in more detail below, the inventors have found that the initial portion of surface runoffs are generally dirty, has high turbidity and high level of total suspended particles, and that such surface runoffs become cleaner over the duration it is collected. Therefore, the sedimentator 120 provides a first-flush system where the poorer quality of runoff 150 will enter the first tank 110 to allow the sediments to settle and be washed off into the first tank 110, while allowing the cleaner portion of the runoff 150 to overflow into the second tank 130.

Figure 5 provides a clearer illustration of a sedimentator 320 of the embodiment of Figures 3 and 4. The sedimentator 320 has a side 312' (also known as weir 312') and an aperture 321 (also known as orifice 321). Side 312' is sized to control the amount of water accumulating in the sedimentator 120. In particular, the height 322 of side 312' is sized to control the amount of water accumulating in the sedimentator 320 before said water overflows (overflow B) at an edge of side 312' into the second tank 330. Sedimentator 320 accumulates water and cause the water to overflow at the edge of side 312' into the second tank 330. Preferably the height of side 312' is lower than that of side 312'', such that water will preferentially overflow along the edge of side 312' of the sedimentator 320 rather than at the edge of side 312''. Preferably, the height 322 of side 312' ranges from 0.3 m to 0.8 m.

The aperture 321 is sized and shaped to control the rate of water flow (outflow A) into the first tank 310. The aperture 321 may be annular, elliptical and/or elongate depending on the application. The aperture 321 could also be in a shape

of a rhombus depending on the application. In Figure 5, aperture 321 has a general annular shape with a diameter 323 which ranges from 0.1 m to 0.25 m. If the diameter 323 is less than 0.1 m, there is a risk of the aperture 321 being blocked up. It will be appreciated that the size of aperture 321 may be varied by control means common in the art, for example via manual or remote adjustment mechanisms. If the aperture 321 has an elliptical, elongate or rhombus shape, the diameter 323 will be taken to refer to at least one of the dimensions in such shapes, for example, the length of the minor/major axis in the ellipse. The aperture 321 can comprise suitable protrusions having chamfered edges, which surround the circumference of aperture 321, where such protrusions extend toward the first tank 310. Such protrusions facilitate the flow of water and sediments out of the sedimentator 320, such that sediments do not accumulate in the sedimentator 320. A suitable channel may also be created at the base of the sedimentator 320, where one end of said channel meets aperture 321. Such channel can increase the rate of water flow from aperture 321 so that sediments can be effectively and efficiently flow out from sedimentator 320. Depending on the application, the aperture 321 may be positioned at any side of sedimentator 320. The aperture 321 is preferably at a position lower than that of the top edge of side 312' so that water entering sedimentator 320 will exit aperture 321 first before overflowing at side 312'. Further, the sedimentator 320 may include one or more apertures 321. Preferably, the sedimentator 320 is shaped and/or its sides angled, to direct the runoff 350 towards the aperture 321, for example, the base of the sedimentator 320 may be suitably sloped towards the aperture 321.

Further, the base area of sedimentator 320 is sized to control the amount of water accumulating in the sedimentator 320. For example, the larger the base area, the more volume of water the sedimentator 320 can contain. The base area of sedimentator 320, taken to be the multiple of side 322' and side 322'', can range from 1 m² to 36 m². Preferably, the minimum volume of sedimentator 320 for containing fluids is 22 m³. It is appreciated that the dimensions of the diameter 323, side 322 and base area 322', 322'', and/or their ratios with respect to one another, depend on several factors which include but is not limited to the size of the

catchment area, the surface runoff coefficient, the rainfall pattern of the rain event, the length of collection channels 351 and permeability of the ground 360.

Returning to Figure 1, the second tank 130 is adapted to receive overflow water from the sedimentator 120. Preferably, the volume of the second tank 130 for containing fluids depends on the size of the catchment area where the water harvesting system 100 is installed and also on the possible scope of use. The second tank 130 is in fluid communication with a treatment facility 140. The treatment facility 140 may be located on or off site. The treatment facility 140 can comprise treatment system 141 having the necessary components for the treatment of water, storage tank 143 for storing the treated water, and pumps 142 for pumping the treated water out via distribution channels 144 for non-potable use. Depending on application, the treatment facility 140 can be excluded from the water harvesting system 100.

Figure 2 provides another embodiment of the water harvesting system 200 comprising a first tank 210, sedimentator 220, second tank 230 and treatment facility 240. First tank 210 substantially shares a side 212 with second tank 230 and the two tanks are generally at the same level such that the tanks will appear are a single unitary tank in an external perspective view, where side/wall/barrier 212 will be an internal barrier. In such an embodiment, a skilled person may consider the present invention to be a single tank having two compartments in fluid communication with each other, wherein the compartments are substantially separated by an internal side/wall/barrier. The sedimentator 220 shares a side 212' with a portion of the side 212 of the second tank 230, where said sedimentator 220 is preferably located at a top portion of side 212. The fact that the sedimentator 220 is located at a top portion of side 212 better utilises the space in first tank 210 unlike the embodiment of Figure 1. In particular, elevation of the sedimentator 220 creates more space beneath the base of said sedimentator 220 such that the water flowing out of sedimentator 220 via aperture 221 can be released into a much larger space in the first tank 210 compared to that in first tank 110 in Figure 1. This allows the sedimentator 220 to maintain a relatively constant flow rate of the water into first tank 210, unlike in the embodiment in Figure 1 where the water released

by the sedimentator 120 quickly accumulates at the base of first tank 110 because the sedimentator 120 is located at or near the base of first tank 110, thereby creating opposing pressure for more water to flow out of the sedimentator 120. Hence in the event of a heavy rainfall, the sedimentator 120 and first tank 110 will quickly fill up and water will easily overflow into the second tank 130. Such water would be of poor quality because the sedimentator 120 will no longer be effective to separate water of different qualities. Accordingly, elevation of sedimentator 220 maintains the effectiveness of said sedimentator 220 as an effective means of separating water of different qualities, and reduces the likelihood of poor quality water from entering second tank 230.

Figure 3 provides another embodiment of the present invention where the height 322 of the sedimentator 320 is greater than that of height 122, 222 in the embodiments of Figures 1 and 2 respectively. However, like the embodiment in Figure 2, first tank 310 substantially shares a side 312 with second tank 330 and the two tanks are generally at the same level such that the tanks will appear are a single unitary tank in an external perspective view, where side/wall/barrier 312 will be an internal barrier. Height 322 being longer, will provide the sedimentator 320 with a larger volume to collect and contain water before said water begins overflowing into second tank 330. This will be suitable for a water harvesting system 300 installed in a substantially large catchment area and/or an area which experiences high rainfall, so that the sedimentator 320 is able to cope with the increased amount of runoff 350 collected.

Unless otherwise stated, the other components in the embodiments of Figures 2 and 3 are the analogous with the components in the embodiment of Figure 1.

In other embodiments, the sedimentator 120, 220, 320 may be located between the first tank 110, 210, 310 and the second tank 130, 230, 330, where the tanks do not share a side/wall/barrier 112, 212, 312 and the sedimentator 120, 220, 320 may act as a conduit between said tanks.

Figures 6A and 6B provide another embodiment of the present invention where a water harvesting system 400 is part of an offline system. The water harvesting system 400 comprises a first tank 410, a sedimentator 420 and a

second tank 430. The sedimentator 420 is in fluid communication with a collection channel 451 such that a portion of runoff 450 flowing through the collection channel 451 is capable of flowing into the sedimentator 420. Runoff 450 enters and accumulates in sedimentator 420. As more runoff 450 enters sedimentator 420, the sedimentator 420 will cause the accumulation of water and cause water to overflow into the second tank 430 over side 412' of the sedimentator 420. The height 422 of side 412' is sized to control the amount of water accumulating in the sedimentator 420 before said water overflows at an edge of side 412' into the second tank 430. Further, the base area of sedimentator 420 is sized to control the amount of water accumulating in the sedimentator 420. The second tank 430 collects the water from the overflow of runoff 450 for storage and/or water treatment. As more runoff 450 accumulates in the sedimentator 420 and collection channel 451, the amount of runoff 450 will exceed the combined volume and capacity of sedimentator 420 and collection channel 451, such that excess runoff 450 will overflow into the first tank 410 which has a discharge channel (not shown) operable to discharge preferably via gravity, water into a drainage system. The first tank 410 can also have an overflow outlet (not shown) operable to allow accumulated water in first tank 410 to overflow into the drainage system, particularly when the first tank 410 reaches to or is close to reaching its full capacity in containing water.

Where appropriate and required, apertures/orifices in the different embodiments can be closed or their sizes adjusted manually or remotely by controls means common in the art. The water harvesting system 100, 200, 300, 400 can include suitable gratings, strainers and/or anti-mosquito devices at any openings/apertures/orifices.

Other than in the treatment facility 140, 240, 340 (not shown in Figures 6A and 6B), the water harvesting system 100, 200, 300, 400 generally makes use of gravity for the collection and flow of rainwater, surface runoff and/or sediments through the collection component 170, 270, 370, 470 and the storage component 180, 280, 380, 480. Generally, use of gravity reduces the use of parts required to make the system work, for example pumps to convey the water and/or sediments from one component to another. In this manner, the water harvesting system 100,

200, 300, 400 can require less maintenance and be less costly to manufacture and maintain. As the water harvesting system 100, 200, 300, 400 generally makes use of gravity, the system or a portion thereof is preferably located underground, i.e. below the top level of a ground 160, 260, 360. The level of ground 160, 260, 360 may be above or below sea level.

In Operation

With reference to the embodiment of Figure 2, when in operation, runoff 250 from ground 260 is directed toward the collection channels 251 which in turn channels the runoff 250 to the sedimentator 220 in the first tank 210. Runoff 250 includes but is not limited to water from ground, roofs, pavements, vertical landscaping, reservoirs and water treatment plants. Large debris and/or particles may be removed by filter screen 252. Water and sediments in the sedimentator 220 are released at a rate controlled by aperture 221 into the first tank 210. However, the rate of flow of water out of aperture 221 is preferably slower than that of the rate of water entering sedimentator 220 such that the sedimentator 220 is filled up faster than it is emptied.

When released into the first tank 210, water and sediments gradually fill up the first tank 210. As the first tank 210 is intended to control discharge rates into the drainage system and manage flooding, water and sediments flow out of the discharge channel 211 at a controlled rate. Therefore in the event of heavy rainfall such as during a storm, first tank 210 can attenuate peak discharge rates of water from a site or catchment area. Should the water level in the first tank 210 rise to a level close to the top of the first tank 210, the water and/or sediments can be released into the drainage system via overflow outlet 213, generally located at a top portion of first tank 210. The overflow outlet 213 is useful in the event of extremely high rainfall and/or the discharge channel 211 is blocked thereby causing a malfunction in the water harvesting system 200 which will require the relevant maintenance/repair.

As sedimentator 220 fills up, the water level in the sedimentator 220 rises to a level beyond that of a top edge of side 212', which will cause the water to overflow

into second tank 230. If the water harvesting system 200 is functioning properly, the water overflowing into the second tank 230 will generally be of better quality compared to the water entering the sedimentator 200 because the sediments would have settled or be released into the first tank 210. Better quality water will require less treatment for non-potable use and can expand the uses of such water since most sediments have been removed by the sedimentator 220 and first tank 210. Further, it may be possible for the water to not require treatment for it to be used for daily non-potable uses such as washing cars and watering plants. Nonetheless, the water accumulating in second tank 230 can be channelled to the treatment facility 240 for water treatment, storage and/or distribution.

In the event of a malfunction such a blockage of aperture 221 or discharge channel 211, the inlet from collection channel 251 to the first tank 210 can be closed or its size adjusted manually or remotely by control means common in the art.

With reference to Figures 6A and 6B, when in operation, a portion of runoff 450 in collection channel 451 flows into sedimentator 420. Runoff 450 includes but is not limited to water from ground, roofs, pavements, vertical landscaping, reservoirs and water treatment plants. Large debris and/or particles may be removed by a filter screen. As more runoff 450 enters sedimentator 420, the sedimentator 420 will cause the accumulation of water which will cause water to overflow at side 412' into second tank 430. As more runoff 450 accumulates in the sedimentator 420 and collection channel 451, the amount of runoff 450 will exceed the combined volume and capacity of sedimentator 420 and collection channel 451, such that excess runoff 450 will overflow into the first tank 410 which has a discharge channel (not shown) operable to discharge preferably via gravity, water into a drainage system. The discharge channel is sized to control the rate of water discharge into the drainage system so as to attenuate peak discharge rates of water from a site or catchment area during for example, events of heavy rainfall. As the first tank 410 reaches to or is close to reaching its full capacity in containing water, excess water can flow out from the first tank 410 via an overflow outlet (not shown).

Study on Surface Runoff Water Quality

Figures 7A-D provide data on a study on surface runoff water at a particular area, where at periodic intervals of about 5 minutes, surface runoff samples were collected and analysed. It was observed that the water of the surface runoff during the first 5 minutes is generally of a poor quality with for example, high turbidity, total suspended solids (TSS), total nitrogen (TN) and total organic carbon (TOC). After the first 10 minutes, the quality of water generally remains consistent.

Further, Figure 7D shows that surface runoff has higher TSS, turbidity, TN and TOC compared to rainwater collected from rooftops.

It was also observed that water quality is poorer for days with longer dry weather periods prior to the rainfall event.

Simulation Results

Figures 8A-D provide simulation data on the correlation of catchment area sizes, volume of water collected in the second tank and the average duration before the 1st collection of water in the second tank. The simulation was based on the assumption that there is 1 rainfall event per rainday lasting not more than an hour = 12.2mm/hr.

Applying the exclusion principle, sedimentators (sumps) S3 and S5 are not suitable due to insufficient water collection. In particular, it appears that attempts to increase duration by increasing weir (side 112', 212', 312') height or orifice (aperture 121, 221, 321) size results in little or no water collected as shown in S3 and S5. Further, increasing orifice size reduces water collection significantly even for large catchment areas. Increasing weir height show no difference in during for large catchment areas.

For <1.1Ha catchment areas, sedimentators with a lower weir height and orifice diameter than S4 appears to be the most appropriate with a reasonable amount of water collected in the second tank and having a reasonable average duration before the 1st collection of water such that the water quality may be considered acceptable. This is in view of the above study where the water of the

surface runoff during the first 5 minutes is generally of a poor quality, therefore it is preferable to collect water in the second tank close to or after a duration of 5 minutes of water flow into the sedimentator. In view of the same considerations, S4 also appears most appropriate for 1.1 to 1.25Ha catchment areas, S9 appears most appropriate for 1.25 to 1.6Ha catchment areas while S12 appears most appropriate for >1.6Ha catchment areas. However S12 may run the risk of collecting insufficient water in the retention tank given its large base area and volume. Hence S9 is recommended instead.

It is to be understood that the above embodiments have been provided only by way of exemplification of this invention, such as those detailed below, and that further modifications and improvements thereto, as would be apparent to persons skilled in the relevant art, are deemed to fall within the broad scope and ambit of the present invention described. In particular, the following additions and/or modifications can be made without departing from the scope of the invention:

- The tanks and sedimentator can have different shapes, e.g. cylindrical, and need not be cuboidal;
- The first tank 110, 210, 310 may have more than one discharge channel 111, 211, 311 and overflow outlet 113, 213, 313;
- The size of the tanks depend on the application;
- The sedimentator may be located between the tanks or in the second tank;
- The size of the apertures/orifices may be varied by control means common in the art, for example manual or remote adjustment mechanisms;
- Apertures/orifices are closable where applicable; and
- The number of rainwater harvesting systems 100, 200, 300 installed in an area may depend on for example, the size of the area.

Furthermore, although individual embodiments have been discussed it is to be understood that the invention covers combinations of the embodiments that have been discussed as well.

The invention described herein may include one or more range of values (e.g. height and diameter). A range of values will be understood to include all values within the range, including the values defining the range, and values adjacent to the range which lead to the same or substantially the same outcome as the values immediately adjacent to that value which defines the boundary to the range.

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Claims

1. A water harvesting system comprising a first tank in fluid communication with a second tank, wherein the first tank is adapted to collect water and release the water at a controlled rate to a drainage system, and wherein the first tank is further adapted to allow the water to accumulate and overflow into the second tank for storage.

2. The water harvesting system of claim 1 further comprising a sedimentator for receiving the water and releasing the water via an aperture into the first tank.

3. The water harvesting system of claim 2, wherein the sedimentator is adapted to control the rate of water release via the aperture into the first tank, and wherein the sedimentator is adapted to allow the water to accumulate and overflow into the second tank.

4. The water harvesting system of claim 3, wherein the sedimentator has a side for water to overflow into the second tank and the height of the side ranges from 0.3 m to 0.8 m.

5. The water harvesting system of claims 3 or 4, wherein the aperture has a cross-sectional diameter of 0.1 m to 0.25 m.

6. The water harvesting system of any one of claims 3 to 5, wherein the sedimentator has a base area of 1 m² to 36 m².

7. The water harvesting system of any one of claims 2 to 6, the first tank, the sedimentator and the second tank are adapted to share a side.

8. The water harvesting system of claim 7, wherein the sedimentator is located in the first tank.

9. The water harvesting system of claim 8, wherein the sedimentator is located at a top portion of the shared side with the second tank.

5 10. The water harvesting system of any one of the preceding claims, the system comprising at least one collection channel.

11. The water harvesting system of claim 10, wherein the at least one collection channel comprises a filter screen.

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12. The water harvesting system of any one of the preceding claims, wherein the first tank comprises an overflow outlet adapted to allow water to overflow into the drainage system.

15 13. The water harvesting system of any one of the preceding claims, wherein the water comprises surface runoff.

14. The water harvesting system of any one of the preceding claims, wherein the second tank is adapted to release the stored water to a water
20 treatment facility.

15. The water harvesting system of any one of the preceding claims, wherein the system is located underground.

25 16. A water harvesting system comprising:

A sedimentator adapted to receive water from a collection channel;

A first tank adapted to receive water from the collection channel, and adapted to release the water at a controlled rate to a drainage system; and

A second tank,

30 Wherein the sedimentator is adapted to accumulate water and cause the water to overflow into the second tank.