

TITLE OF INVENTION: WATER HARVESTING AND FLOOD MANAGEMENT SYSTEM

FIELD

[0001] The present invention generally relates to a water harvesting and flood management system, and in particular to a water harvesting and flood management system for harvesting water such as urban water runoff.

BACKGROUND

[0002] The following discussion of the background to the invention is intended to facilitate an understanding of the present invention only. It should be appreciated that the discussion is not an acknowledgement or admission that any of the material referred to was published, known or part of the common general knowledge of the person skilled in the art in any jurisdiction as at the priority date of the invention.

[0003] Many tropical countries experience a hot and wet climate where precipitation volume can vary substantially, ranging from light rainfall to storms during monsoon 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.

[0004] 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.

[0005] 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 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 expended for such water treatment.

[0006] Retention/harvesting tanks can also be used in flood management systems. While such tanks can be used with detention/harvesting tanks, they are generally independent tanks where collected stormwater is divided and channeled to each individual tank for their specific purposes. Retention/harvesting 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.

[0007] Singapore patent No. 10201507989U (hereinafter referred to as 'the Singapore patent') is directed to a water harvesting and flood management system that has two objectives, namely a) to harvest sufficient water to meet the demands of the precinct where the water harvesting system has been installed, and b) to mitigate flood risk by detaining water and slow down runoff discharge to a prescribed flow rate. In Singapore, the Singapore National Water Agency (PUB) prescribes a runoff coefficient of 0.55 in their Code of Practice (COP) on Surface Water Drainage. The water drainage system described in the Singapore patent broadly comprises a first (detention) tank in fluid communication with a second (retention/harvesting) tank and a sedimentator. The sedimentator is located in the first tank and the sedimentator

comprises an aperture adapted to control the rate of water release into the first tank. The first tank is adapted to collect water and release the water at a controlled rate to a drainage system, and the sedimentator is further adapted to allow the water to accumulate and overflow into the second tank for storage, the first tank, the sedimentator and the second tank being adapted to share a side. The system can be located underground within a precinct and can provide for flood management at the precinct as well as allowing for runoff water to be collected for potential uses at that precinct. However, the detention tanks can be relatively large in size (typically from 200m³ to more than 700m³) due to the need to meet runoff requirements such as those specified within the previously mentioned PUB COP. Furthermore, the tanks need to be relatively shallow in depth to thereby facilitate the gravity flow of water discharged from the detention tank into public drains. Hence, the footprint area of the tanks can be generally large resulting in the need for extensive excavation and use of concrete materials. It also limits the land-use application on the installation site as large trees/plants, structural or common use areas that require deeper foundations cannot be located on the land above the tanks.

[0008] It would therefore be advantageous to be able to have a water harvesting and flood management system with reduced space requirements, and/or which allows for the storage of a greater volume of water for harvesting.

SUMMARY

[0009] According to an aspect of the present disclosure, there is provided a water harvesting and flood management system comprising:

a detention tank including an open first drainage orifice, the detention tank being adapted to collect water and release the water at a controlled rate to a drainage system through the first drainage orifice;

a harvesting tank in fluid communication with the detention tank, the harvesting tank being adapted to collect water and release water in a controlled manner to the detention tank;

wherein the harvesting tank includes a drainage arrangement for controlling the

release of water from the harvesting tank to the drainage system, and a level sensor for detecting a water level within the harvesting tank, the level sensor triggering the drainage arrangement to allow water to be released to the drainage system when the level sensor detects the water level within the harvesting tank being at or above a predetermined level, the drainage arrangement preventing the further release of water to the drainage system when the level sensor detects that the water level within the harvesting tank is below the predetermined water level.

[0010] In some embodiments, the drainage arrangement comprises a second drainage orifice within the harvesting tank through which water can be released to the drainage system, and a valve controlled by the level sensor for opening and closing the second drainage orifice.

[0011] In some embodiments, the drainage arrangement comprises a pump system controlled by the level sensor for pumping water from the harvesting tank to the drainage system.

[0012] In some embodiments, the detention tank and harvesting tank is separated by a separation wall.

[0013] In some embodiments, water from the harvesting tank can overflow over the separation wall to the detention tank.

[0014] In some embodiments, the water harvesting and flood management system further comprises a sedimentator for receiving water from a runoff water collection channel and for delivering water to the harvesting tank.

[0015] In some embodiments, a filter screen is provided between the sedimentator and the harvesting tank.

[0016] In some embodiments, the detention tank has a volume of about 896m³.

[0017] In some embodiments, the harvesting tank has a volume of about 224m³.

[0018] In some embodiments, the first and second drainage orifices have an open area of about 0.13m².

[0019] In some embodiments, the level sensor closes the second drainage orifice

when the water level is about 1.7m.

[0020] According to another aspect there is provided a method of harvesting water using a water harvesting and flood management system as described above; the method comprising

- a) delivering water to the harvesting tank;
- b) opening the second drainage orifice when the level sensor senses the water accumulated within the harvesting tank is at or above a predetermined level to thereby drain the water to a drainage system;
- c) releasing water from the harvesting tank to the detention tank if the water level within the harvesting tank continues to rise so that the water within the detention tank can be drained through the first drainage orifice to the drainage system; and
- d) closing the second drainage orifice when the water level within the harvesting tank falls back to below the predetermined level.

[0021] Other aspects and features will become apparent to those of ordinary skill in the art upon review of the following description of specific embodiments in conjunction with the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] In the figures, which illustrate, by way of example only, embodiments of the present invention,

[0023] [Figure 1] shows a schematic view of a water harvesting system according to the present disclosure;

[0024] [Figure 2] respectively shows a schematic view of a prior art water harvesting system according to the Singapore patent and a schematic view of a water harvesting system according to the present disclosure;

[0025] [Figure 3a to 3d] respectively show a schematic view of a prior art water harvesting system according to the Singapore patent showing water flow therein and

a graph showing the change in water flow rate and water level within the harvesting and detention tanks over time at different stages of operation of the prior art water harvesting system;

[0026] [Figure 4a to 4e] respectively show a schematic view of a water harvesting system according to the present disclosure and a graph showing the change in water flow rate and water level within the harvesting and detention tanks over time at different stages of operation of the water harvesting system; and

[0027] [Figure 5] respectively show graphs of the flow rates over time within the prior art water harvesting system of the Singapore patent and the water harvesting system of the present disclosure to thereby compare the difference in the required detention tank volume for each system.

[0028] 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.

DETAILED DESCRIPTION

[0029] Throughout this document, unless otherwise indicated to the contrary, the terms “comprising”, “consisting of”, “having” and the like, are to be construed as non-exhaustive, or in other words, as meaning “including, but not limited to”.

[0030] Furthermore, throughout the specification, unless the context requires otherwise, the word “include” or variations such as “includes” or “including” will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

[0031] Example 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 of 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.

[0032] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as is commonly understood by a skilled person to which the subject matter herein belongs.

[0033] 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.

[0034] 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.

[0035] 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.

[0036] Referring initially to [Fig. 1], there is shown an example embodiment of a water harvesting system 2 according to the present disclosure (hereinafter referred to as the ‘UWHS 2.0’ system) having a sedimentator 9, and a harvesting tank 15 and detention tank 17 separated by a separation wall 16 within the UWHS 2.0 system 2. The UWHS 2.0 system 2 is shown located under the ground surface 3 so that runoff water from the surrounding area can flow into drains 5 located at the ground surface 3. The runoff water can then pass through a collection channel 7 to the sedimentator 9 of the UWHS 2.0 system 2. The sedimentator 9 is separated by a filter screen 11 from the harvesting tank 15, the filter screen 11 preventing any large debris and particles picked up by the runoff water from entering the harvesting tank 15. During

rainfall episodes, runoff water can pass from the sedimentator 9 to the harvesting tank 15 such that runoff water will progressively fill the harvesting tank 15. Water can overflow into the detention tank 17 over an upper edge 18 (see [fig. 2]) of the separation wall 16 when the water level within the harvesting tank 15 is above the height of the separation wall 16. The detention tank 17 is provided with an open first drainage orifice 25 for allowing water within the detention tank 17 to drain into a public drainage system (not shown). There may preferably be a gravity flow of water from the drainage orifice 25 to the drainage system. A water pump is also located within the harvesting tank 15 to allow for water stored within the harvesting tank 15 to be pumped to a treatment plant 19 via an outlet line 23, where the water can be treated so that the water can be suitable for other uses at the precinct or elsewhere.

[0037] The abovenoted features are also shared by the water harvesting system described in the Singapore patent. [Fig. 2] shows a water harvesting system 1 according to the Singapore patent (hereinafter referred to as the 'UWHS 1.0 system') with the UWHS 2.0 system 2 according to the present disclosure. The UWHS 2.0 system 2 has further features that provide advantages over the earlier system. The further features include a level sensor 23 provided with the harvesting tank 15 for determining when the water accumulating within the harvest tank 15 has reached a predetermined level. The harvesting tank 15 is further provided with a drainage arrangement in the form of a second drainage orifice 27, and a control valve (not shown) for selectively opening and closing the second drainage orifice 27. The control valve may normally keep the second drainage office 27 closed, and may be triggered by the level sensor 23 to open the second drainage orifice 27 when the level sensor 23 detects that the water level within the harvesting tank 15 is at or above a predetermined level. The position of the level sensor 23 within the harvesting tank 15 determines the water level at which the control valve is actuated. Water passing through the second drainage orifice 27 may then be delivered by gravity to the public drainage system. Furthermore, the open area of the first and second drainage orifices 25,27 may be about half the open area of the drainage orifice 35 of the detention tank 31 of the UWHS 1.0 system 1. It is also envisaged that the drainage arrangement be in the form of a pump system for pumping water from the harvesting tank 15 to the drainage system.

[0038] The UWHS 1.0 system 1 is designed according to the PUB design guide to cope with a 10 years return period, with the harvesting tank 33 situated adjacent to the detention tank 31. The simulation shown in [figs. 3a to 3d], [figs. 4a to 4e] and [fig. 5] show how it is possible for the UWHS 2.0 system 2 to have a smaller detention tank volume while still coping with the 10 years return period. Furthermore, the smaller detention tank volume allows the harvesting tank 15 to have a higher volume than the harvesting tank 33 of the UWHS 1.0 system 1. The simulation is based on the UWHS 1.0 system 1 having a total volume of 986m^3 , with the harvesting tank 33 having a volume of 90m^3 , and the detention tank 31 having a volume of 896m^3 when designed to cope with the 10 year return period. The UWHS 2.0 system 2 when designed according to the same 10 year return period will by comparison have a smaller total tank volume of 896m^3 , with the detention tank 17 having a smaller volume of 672m^3 , and the harvesting tank 15 having a larger volume of 224m^3 . These volumes are therefore used in the simulations. It is however to be appreciated that the detention and harvesting tank volumes for the UWHS 2.0 system 2 can in practice vary from the abovenoted volumes depending on the actual flood management and water harvesting requirements of the precinct where the UWHS 2.0 system 2 is to be installed.

[0039] These simulations were based on the following scenario:

- The harvesting tank is assumed to be full to simulate the 'worst case scenario'
- Catchment = 3ha
- $C_{\text{post}} = 0.95$
- $C_{\text{target}} = 0.55$
- $Q_{\text{peak}} = 0.93\text{ m}^3/\text{s}$
- $Q_{\text{target}} = 0.89\text{ m}^3/\text{s}$
- UWHS 1.0 system Orifice area = 0.26 m^2
- UWHS 2.0 system Orifice area = 0.13 m^2

- UWHS 2.0 level sensor = closes when the water level in harvesting tank drops below 1.7 m
- Maximum water level height in harvesting tank = 2m

[0040] [Figs. 3a to 3d] respectively show a schematic diagram of the UWHS 1.0 system 1 showing the water flow therein and a graph showing the change in water flow rate and water level within the harvesting and detention tanks 33,31, with each figure showing different stages of operation of the UWHS 1.0 system 1 over time. The adjacent graph plots different information relating to the water level and flow rates within the UWHS 1.0 system 1, namely, the harvesting tank water level (m) 50, detention tank water level (m) 52, inflow rate (m^3/s) 54, and total outflow rate (m^3/s) 56. A vertical dotted line 58 indicates that time at which the flow conditions shown in the adjacent schematic diagram occurs.

[0041] In [Fig. 3a], the harvesting tank 33 is assumed to be full in the worst case scenario. At the onset of rainfall, water begins flowing into the harvesting tank 33 and overflowing the separation wall 37 into the detention tank 31. As the water slowly builds up in the detention tank 31, water also begins to drain out through the open drainage orifice 35. The water is discharged through the drainage orifice 35 at a slow flow rate due to the low water head as there is still only a relatively low level of water within the detention tank 31. As more rainwater enters the UWHS 1.0 system 1 as shown in [fig. 3b], water builds up within the detention tank 31. The increase in water level within the detention tank 31 as shown in plot 52 results in an increase in the water head which increases the discharge rate from the drainage orifice 35 as shown in plot 56. As the water within the detention tank 31 continues to rise as shown in [fig. 3c], the water is discharged through the drainage orifice 35 at close to its maximum flow rate. When the water level in the detention tank 31 peaks as shown in [fig. 3d], the water is being discharged at its maximum flow rate as shown in plot 56. Once the rainfall subsides, the detention tank 31 will continue to empty while the harvesting tank 33 remains full of water.

[0042] [Figs. 4a to 4d] respectively show a schematic diagram of the UWHS 2.0 system 2 showing the water flow therein and a graph showing the change in water flow rate and water level within the harvesting and detention tanks 15,17, with each

figure showing different stages of operation of the UWHS 2.0 system 2 over time. The adjacent graph plots different information relating to the water level and flow rates within the UWHS 2.0 system 2, namely, the harvesting tank water level (m) 60, detention tank water level (m) 62, inflow rate (m^3/s) 64, and outflow rate from the harvesting tank (m^3/s) 66, the outflow rate from the detention tank (m^3/s) 68, and the total outflow rate (m^3/s) 70. A vertical dotted line 72 indicates that time at which the flow conditions shown in the adjacent schematic diagram occurs.

[0043] [Fig. 4a] shows the flow situation in the UWHS 2.0 system 2 as water is being collected at the onset of rainfall. Water begins flowing into the harvesting tank 15, and the second drainage orifice 27 is opened by the valve to discharge water at high flow rates when the level sensor 23 detects the rise in the water level. During the first 3 minutes of the simulation, the flow rate of the water being discharged from the harvesting tank 15 is higher than the flow rate of water entering the harvesting tank 15. The second drainage orifice 27 is therefore momentarily closed by the control valve before opening again when the water level rises. This sudden drop in outflow rate is shown at the start of plot 70. As more water continues to enter the UWHS 2.0 system 2, the harvesting tank 15 completely fills up, and water commences to overflow over the separation wall 16 into the detention tank 17 as shown in [fig. 4b]. Water also commences being discharged through the open first drainage orifice 25 of the detention tank 17. As the water builds up within the detention tank 17 as shown in [fig. 4c], the discharge rate from the first drainage orifice 25 also correspondingly increases with the increasing water head. The discharge of water also continues at the open second drainage orifice 27. When the rainfall subsides, the water level in both the detention and harvesting tanks 17,15 will drop as shown in [fig. 4d]. Once the water level within the harvesting tank 15 drops below the level sensor 23, the second drainage orifice 27 will close to thereby retain the remaining water within the harvesting tank 15 as shown in [fig. 4e]. The remaining water within the detention tank 17 then drains out through the open first drainage orifice 25 until the detention tank 17 is emptied.

[0044] In [Figure 5], the graphs of the UWHS 1,.0 system 1, and UWHS 2.0 systems are shown together to thereby compare the difference in the required detention tank volume for each system. The required detention tank volume 80 is

depicted by the shaded area between the inflow rate (m^3

[0045] /s) plot and the total outflow rate (m^3/s) plots on each graph, the area of the shaded area providing the required detention tank volume. This shows that the UWHS 2.0 system according to the present disclosure requires a smaller detention tank volume than would be required for the prior art UWHS 1.0 system 1. This is due to the higher outflow rate of the UWHS 2.0 system 2 as compared to the UWHS 1.0 system 1 at the onset of rainfall.

[0046] The water harvesting system according to the present disclosure can help to reduce the space requirements for the detention and harvesting tanks which can free up space above ground for more diverse uses of that land. Furthermore, the water harvesting system according to the present disclosure can also allow for a greater volume of water to be stored for harvesting thus further encouraging and enhancing water conservation needs.

[0047] It should be appreciated by the person skilled in the art that the above invention is not limited to the embodiment described. It is appreciable that modifications and improvements may be made without departing from the scope of the present invention.

[0048] It should be further appreciated by the person skilled in the art that one or more of the above modifications or improvements, not being mutually exclusive, may be further combined to form yet further embodiments of the present invention.

CLAIMS

[Claim 1] A water harvesting and flood management system comprising:

a detention tank including an open first drainage orifice, the detention tank being adapted to collect water and release the water at a controlled rate to a drainage system through the first drainage orifice;

a harvesting tank in fluid communication with the detention tank, the harvesting tank being adapted to collect water and release water in a controlled manner to the detention tank;

wherein the harvesting tank includes a drainage arrangement for controlling the release of water from the harvesting tank to the drainage system, and a level sensor for detecting a water level within the harvesting tank, the level sensor triggering the drainage arrangement to allow water to be released to the drainage system when the level sensor detects the water level within the harvesting tank being at or above a predetermined level, the drainage arrangement preventing the further release of water to the drainage system when the level sensor detects that the water level within the harvesting tank is below the predetermined water level.

[Claim 2] A water harvesting and flood management system according to claim 1, wherein the drainage arrangement comprises a second drainage orifice within the harvesting tank through which water can be released to the drainage system, and a valve controlled by the level sensor for opening and closing the second drainage orifice.

[Claim 3] A water harvesting and flood management system according to claim 1, wherein the drainage arrangement comprises a pump system controlled by the level sensor for pumping water from the harvesting tank to the drainage system.

[Claim 4] A water harvesting and flood management system according to any one of the preceding claims, wherein the detention tank and harvesting tank is separated by a separation wall.

[Claim 5] A water harvesting and flood management system according to claim 4, wherein water from the harvesting tank can overflow over the separation wall to the

detention tank.

[Claim 6] A water harvesting and flood management system according to any one of the preceding claims, further comprising a sedimentator for receiving water from a runoff water collection channel and for delivering water to the harvesting tank.

[Claim 7] A water harvesting and flood management system according to claim 6, wherein a filter screen is provided between the sedimentator and the harvesting tank.

[Claim 8] A water harvesting and flood management system according to any one of the preceding claims, wherein the detention tank has a volume of about 896m³.

[Claim 9] A water harvesting and flood management system according to any one of the preceding claims, wherein the harvesting tank has a volume of about 224m³.

[Claim 10] A water harvesting and flood management system according to claim 2, wherein the first and second drainage orifices have an open area of about 0.13m².

[Claim 11] A water harvesting and flood management system according to claim 10, wherein the level sensor closes the second drainage orifice when the water level is about 1.7m.

[Claim 12] A method of harvesting water using a water harvesting and flood management system according to any one of the preceding claims; the method comprising

- e) delivering water to the harvesting tank;
- f) triggering the drainage arrangement when the level sensor senses the water accumulated within the harvesting tank is at or above a predetermined level to thereby drain the water to a drainage system;
- g) releasing water from the harvesting tank to the detention tank if the water level within the harvesting tank continues to rise so that the water within the detention tank can be drained through the first drainage orifice to the drainage system; and
- h) stopping the drainage arrangement when the water level within the harvesting

tank falls back to below the predetermined level.