

## **A Method of Priming a Drainage Apparatus for Siphoning Liquid, and A Drainage Apparatus**

### **Field & Background**

- 5 The present invention relates to a method of priming a drainage apparatus for siphoning liquid, and a drainage apparatus.

Due to global warming, changes in rainfall weather patterns have been seen in many parts of the world. Some regions experienced prolonged droughts, while  
10 others have had intense, sudden rainstorms which tend to cause flash floods. A flash flood can be defined as: "a flood that rises and falls quite rapidly with little or no advance warning, usually as a result of intense rainfall over a relatively small area". Despite the proliferation of modern technologies, societies are still vulnerable to flash floods, especially so as more and more cities are becoming  
15 megacities and economies are increasingly nurtured by urbanization. Thus when flash floods occur, they can claim the lives of many people, as well as cause widespread damage to property and infrastructure, incurring economic losses.

- 20 A conventional measure typically adopted to cope with flash flooding by building wider drainage canals has however not been effective due to the unpredictability of rainfall patterns brought about by global warming, in terms of the amount of rainfall forecasted to be deposited over a region.

- 25 One object of the present invention is therefore to address at least one of the problems of the prior art and/or to provide a choice that is useful in the art.

### **Summary**

- According to a 1<sup>st</sup> aspect of the invention, there is provided a method of priming  
30 a drainage apparatus for siphoning liquid between first and second reservoirs. The apparatus includes a conduit arrangement having a first opening disposed in the first reservoir, a second opening disposed in the second reservoir and a liquid injection inlet arranged between the first and second openings, and at least one valve for controlling flow of the liquid along the conduit arrangement.  
35 The method comprises directing liquid into the conduit arrangement via the liquid

injection inlet to fill up most of the conduit arrangement as controlled by the valve's configuration; directing liquid into the first reservoir to enable more liquid to enter into the conduit arrangement via the first opening and to flood the conduit arrangement to form a continuous liquid flow path which extends from  
5 the first opening up to at least the second opening, the continuous liquid flow path creating a siphon; and with the first opening kept below the liquid's surface level in the first reservoir, stopping the flow of liquid into the first reservoir to achieve a state of equilibrium of the siphon to prime the conduit arrangement. After the priming and in use, the siphon is triggered when more liquid is added  
10 into the first reservoir which causes the added liquid to be siphoned to the second reservoir via the primed conduit arrangement.

It is to be appreciated that in the above context, the state of equilibrium is defined as the hydrostatic pressure at both ends of the continuous liquid flow  
15 path is in equilibrium and the siphon halts until it is triggered.

Liquid is may include water (such as rainwater, drinking water, sea water, irrigation water etc) and oil etc.

20 Advantages of the proposed method may include allowing the drainage apparatus to be used for transferring/diverting of liquid from a source reservoir to a destination reservoir by using the siphoning effect, without requiring pumps to be installed. As long as the conduits of the drainage apparatus are filled with the liquid, the siphoning effect works automatically to transfer/divert the fluid,  
25 when the fluid pressures in the two reservoirs are not equalized. This benefit means minimal human monitoring and maintenance are required for operating the drainage apparatus.

The method of may include, prior to directing liquid into the first reservoir, further  
30 comprising releasing air trapped in the mostly filled conduit arrangement. The method may also include, prior to directing liquid into the conduit arrangement, further comprising configuring the at least one valve to enable the conduit arrangement to be mostly filled.

The conduit arrangement may include a plurality of conduits arranged in fluid communication, or it may also include a single integral conduit.

According to a 2<sup>nd</sup> aspect of the invention, there is provided a drainage  
5 apparatus for siphoning liquid between first and second reservoirs. The  
apparatus comprises a conduit arrangement having a first opening disposed in  
the first reservoir, a second opening disposed in the second reservoir and a  
liquid injection inlet arranged between the first and second openings for directing  
liquid into to fill up most of the conduit arrangement; and at least one valve for  
10 controlling flow of the liquid along the conduit arrangement; wherein prior to  
using the drainage apparatus for siphoning the liquid, the liquid injection inlet is  
configured to receive liquid to fill up most of the conduit arrangement as  
controlled by the valve's configuration; and wherein the first opening is  
configured to receive more liquid which has been directed into the first reservoir  
15 to flood the conduit arrangement to form a continuous liquid flow path which  
extends from the first opening up to at least the second opening, the continuous  
flow path configured to create a siphon which is at a state of equilibrium to prime  
the conduit arrangement when the flow of liquid into the first reservoir is stopped  
and the first opening is kept below the liquid's surface level in the first reservoir;  
20 whereby after priming and in use, the siphon is triggered when more liquid is  
added into the first reservoir which causes the added liquid to be siphoned to the  
second reservoir via the primed conduit arrangement.

According to a 3<sup>rd</sup> aspect of the invention, there is provided a drainage  
25 apparatus adapted to siphon liquid between first and second reservoirs. The  
apparatus comprises first and second openings; a conduit arrangement; and at  
least one valve arranged along the conduit arrangement to control flow of the  
liquid in the conduit arrangement via the first and second openings. The first  
and/or second opening is configured to be at least twice the diameter of the  
30 conduit arrangement.

The first opening may be disposed in the first reservoir and arranged to face the  
floor of the first reservoir. The second opening may be disposed in the second  
reservoir and arranged to face the floor of the second reservoir.

The second opening may be disposed in the second reservoir and arranged to face away from the floor of the second reservoir.

5 There may be more than one valve and the valves include check valves and return valves. At least some of the valves may be configured to enable air trapped in the conduit arrangement to be released therefrom.

10 The conduit arrangement may include a plurality of conduits arranged in fluid communication, or the conduit arrangement may include a single integral conduit.

15 If the conduit arrangement has a plurality of conduits, the plurality of conduits may include first and second conduits respectively configured with the first and second openings, a portion of the first and second conduits being positioned at a same liquid level. The apparatus may further comprise a drainage conduit being arranged at the second reservoir. Preferably, the drainage conduit is disposed to be spaced apart from the outlet by approximately 300 mm. Other distances are possible, 200mm, 400mm, 500mm etc.

20 The apparatus may include the first and second reservoirs the first and second reservoirs, in particular when a contractor is engaged to construct the reservoirs as well as to install the drainage apparatus.

25 Preferably, the second opening is configured to be at least three times, or four times the diameter of the conduit arrangement.

30 The conduit arrangement may include a transverse portion extending between the first and second reservoirs, the transverse portion having a series of undulations arranged therealong. This traverse portion may extend to great lengths depending on how far apart the two reservoirs are. As an example, the traverse portion may have a length of at least 1000 metres.

According to a 4<sup>th</sup> aspect of the invention, there is provided a flood control system comprising the drainage apparatus based on the 2<sup>nd</sup> or 3<sup>rd</sup> aspect of the invention.

5 It should be apparent that features relating to one aspect of the invention may also be applicable to the other aspects of the invention.

These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described hereinafter.

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### **Brief Description of the Drawings**

Embodiments of the invention are disclosed hereinafter with reference to the accompanying drawings, in which:

Figure 1 shows a schematic of a drainage apparatus, according to a first  
15 embodiment;

Figure 2 shows a flow diagram for a method of priming the drainage apparatus of Figure 1;

Figure 3 shows a schematic of the drainage apparatus of Figure 1, subsequent to performance of the method shown in Figure 2;

20 Figure 4 shows a schematic of another drainage apparatus, according to a second embodiment;

Figure 5 shows a schematic of a further drainage apparatus, according to a third embodiment;

Figure 6 shows a schematic of yet another drainage apparatus, according to a  
25 fourth embodiment;

Figure 7 shows a schematic of an alternative drainage apparatus, according to a fifth embodiment;

Figure 8 shows a schematic of yet a further drainage apparatus, according to a sixth embodiment; and

30 Figure 9 shows a schematic of a drainage apparatus, according to a seventh embodiment.

### **Detailed Description of Preferred Embodiments**

Figure 1 shows a schematic of a drainage apparatus 100 according to a first  
35 embodiment, which is adapted to siphon liquid between first and second

reservoirs 102, 104. Each of the first and second reservoirs has walls 102a, 102b, 104a, 104b, and a floor 102c, 104c. The floors 102c, 104c of the first and second reservoirs 102, 104 are located on a same level. For clarity, the definition of the drainage apparatus 100 in this instance excludes the first and second reservoirs 102, 104. Examples of the first and second reservoirs 102, 104 include wells, drains, canals or the like, while the liquid includes water. In this instance, the first reservoir 102 defines a source from which the liquid is to be siphoned, and the second reservoir 104 defines a destination to which the siphoned liquid is to be discharged. Also, the first reservoir 102 has an opening 1022 from which the liquid can be received and collected into the first reservoir 102 (e.g. rainwater falling into the first reservoir 102 through the opening 1022). The second reservoir 104 may be sheltered, and has a drainage pipe 1042 (configured with a return valve 1044) located through one of the walls 104b for draining away excess liquid discharged into the second reservoir 104 to prevent overflowing thereof. The drainage pipe 1042 is coupled to other reservoirs which are not shown in Figure 1 due to space constraints. It is to be appreciated that the drainage apparatus 100 may also be known as a "liquid transfusion and waterworks system". In the first embodiment, the drainage apparatus 100 is included as part of a flood control/anti-flooding system (not shown), that can be deployed to address flooding of drains or canals during occurrence of flash floods.

The drainage apparatus 100 includes a conduit arrangement, which comprises a plurality of conduits 106a-e arranged in fluid communication, and a plurality of valves 108, 110 arranged along in at least some of the conduits 106a-e. In this embodiment, the conduits are PVC pipes although other suitable materials may be used depending on the applications, for example metallic pipes. Also, although a plurality of valves 108, 110 are described, this may not be so as long as there is at least one valve. An example of the conduits 106a-e is water pipes. It is to be appreciated that the plurality of conduits 106a-e are detachably coupled to enable convenient assembly and disassembly, if required (e.g. facilitate easy transportation). Also, in this instance, the plurality of conduits 106a-e includes a set of first to fifth conduit members 106a-e (with substantially uniform diameters) whilst the plurality of valves 108, 110 includes a check valve 108 and a set of six return valves 110a-f. For description brevity, the first to fifth

conduit members 106a-e will be referred to as first to fifth conduits 106a-e below.

It is to be appreciated that the first conduit 106a includes an inlet 112 for the plurality of conduits 106a-e for siphoning the liquid, while the fifth conduit 106e includes an outlet 114 for the plurality of conduits 106a-e for discharging the siphoned liquid. The first conduit 106a is arranged to be positioned in the first reservoir 102, and is of generally L-shaped. The first conduit 106a includes an L-shaped portion having a vertical arm 106a1 and a horizontal arm 106a2 which is coupled orthogonally to the vertical arm 106a1. The vertical arm 106a1 of the L-shaped portion of the first conduit 106a rises above the walls 102a, 102b of the first reservoir 102, whilst an inverted U-shaped portion 103 extends from a free end of the horizontal arm 106a2 of the L-shaped portion of the first conduit 106a. The inverted U-shaped portion 103 is configured with the inlet 112 which acts as a liquid receiving point for the plurality of conduits 106a-e. The inverted U-shaped portion 103 has a vertical part 103a which is orthogonal to the horizontal arm 106a2 and this is important to prime the drainage apparatus 100 as will be apparent later. The inlet 112 is arranged to face the floor 102c of the first reservoir 102; in other words, the inlet 112 is in an inverted configuration which prevents air from being introduced into the plurality of conduits 106a-e during siphoning which can detrimentally disrupt the siphoning action itself. Further, the inlet 112 is also about at least two times the diameter of the first conduit 106a, as shown in Figure 1 to reduce the possibility of air from entering first conduit 106a. It is also to be appreciated that the inlet 112 is located substantially near to the floor 102c of the first reservoir 102. In addition, the inverted U-shaped portion 103 includes the check valve 108, which permits flow liquid only in a direction from the inlet 112 to the outlet 114 of the plurality of conduits 106a-e. A free end 106a12 of the vertical arm 106a1 of the L-shaped portion of the first conduit 106a is releasably closed with an air release cap 116, which can be removed to enable any air trapped in the first conduit 106a (when filled with liquid) to be released. Also, the vertical arm 106a1 of the L-shaped portion of the first conduit 106a rising above the surrounding walls 102a, 102b of the first reservoir 102 is fluid communicably coupled to the second conduit 106b.

The second conduit 106b is largely similar in structure to the first conduit 106a, except that the inverted U-shaped portion 103 is omitted. The second conduit 106b includes an L-shaped portion having a vertical arm 106b1 and a horizontal arm 106b2 which is coupled orthogonally to the vertical arm 106b1. The horizontal and vertical arms 106b2, 106b1 of the L-shaped portion of the second conduit 106b are respectively configured with the first and second return valves 110a, 110b. The horizontal arm 106b2 of the L-shaped portion of the second conduit 106b is coupled to the vertical arm 106a1 of the L-shaped portion of the first conduit 106a. Further, the second return valve 110b is arranged in the vertical arm 106b1 of the L-shaped portion of the second conduit 106b at a position above where the second conduit 106 is fluid communicably coupled to a first end 106c1 of the third conduit 106c. Similarly, a free end 106b12 of the vertical arm 106b1 of the L-shaped portion of the second conduit 106b is releasably closed with a liquid insertion cap 118, which is removable for filling the plurality of conduits 106a-e with liquid. It is to be appreciated that the liquid insertion cap 118 is located proximal to the second return valve 110b.

The third conduit 106c is arranged transverse to the vertical arm 106b1 of the L-shaped portion of the second conduit 106b, and has a series of undulations along the length of the third conduit 106c. In particular, the third conduit 106c extends between the first and second reservoirs 102, 104. It should be appreciated that the third conduit 106c may extend a greater distance, for instance from metres to kilometres (e.g. at least 1000 metres) depending on a distance apart between the first and second reservoirs 102, 104. Also, substantially at the middle of the third conduit 106c is a rising vertical arm 106c2 configured with the third and fourth return valves 110c, 110d, which are arranged spaced apart. Preferably, the rising vertical arm 106c2 is located at a highest point of the drainage apparatus 100. The third return valve 110c is positioned above the fourth return valve 110d. The third return valve 110c is normally closed whereas the fourth return valve 110d is normally opened. During priming of the drainage apparatus which will be described below, these return valves 110c, 110d enable air trapped within the conduits to be released. The vertical arm 106c2 may include a viewing window to check if there is air trapped below the third return valve 110c and if there is an air gap, the fourth return valve 110d is closed and the third return valve 110c is opened and liquid injected

into the rising vertical arm 106c2 to displace the trapped air from the vertical arm 106c2. Thereafter, the third return valve 110c is closed and the fourth return valve 110d opened.

5 A second end 106c3, opposite to the first end 106c1, of the third conduit 106c is fluid communicably coupled to the fourth conduit 106d, which is in turn coupled to the fifth conduit 106e. The manner in which the fourth conduit 106d is coupled to the fifth conduit 106e is a mirror arrangement of how the second conduit 106b is coupled to the first conduit 106a, and hence not repeated for  
10 brevity sake. It is to be appreciated that the fourth conduit 106d is structurally similar to the second conduit 106b (and has the fifth return valve 110e), except that a free end 106d12 of the vertical arm 106d1 of the fourth conduit 106d is coupled to the second end 106c3 of the third conduit 106c. Particularly, the fourth conduit 106d includes an L-shaped portion having a vertical arm 106d1  
15 and a horizontal arm 106d2 which is coupled orthogonally to the vertical arm 106d1.

The fifth conduit 106e is arranged to be positioned in the second reservoir 104, and is structurally similar to the first conduit 106a, except that the inverted U-shaped portion 103 is omitted, and replaced by an upward facing portion 106e3  
20 and the fifth conduit 106e is also configured with the sixth return valve 110f, instead of the check valve 108. The fifth conduit 106e includes an L-shaped portion having a vertical arm 106e1 and a horizontal arm 106e2 which is coupled orthogonally to the vertical arm 106e1. The upward facing portion 106e3 is  
25 coupled orthogonal to the horizontal arm 106e2 and this angled arrangement is similar to the angled arrangement near the inlet 112 in the first reservoir 102 i.e. the arrangement between the vertical part 103a and the horizontal arm 106a2. Both of these arrangements are configured to prime the drainage apparatus 100 i.e. to achieve a state of equilibrium for the liquid in the drainage apparatus 100,  
30 as will be apparent later. The outlet 114 on the fifth conduit 106e, which acts as a liquid discharging point for the plurality of conduits 106a-e, is configured to face opposite to and away from the floor 104c of the second reservoir 104. Additionally, the outlet 114 is about at least two times the diameter of the fifth conduit 106e to prevent liquid from being sucked back into the fifth conduit 106e  
35 after being discharged therefrom, and to reduce the possibility of introducing air

bubbles into the fifth conduit 106e. Further, the drainage pipe 1042 is disposed at least 300 mm above the outlet 114. Like the inlet 112, the outlet 114 is located substantially near to the floor 104c of the second reservoir 104. It is also to be appreciated that the drainage pipe 1042 of the second reservoir 104 is positioned at a higher liquid level (in the second reservoir 104) than where the outlet 114 is positioned. It is further to be appreciated that the horizontal arm 106a2 of the L-shaped portion of the first conduit 106a and the horizontal arm 106e2 of the L-shaped portion of the fifth conduit 106e are respectively positioned in the first and second reservoirs 102, 104 at a same liquid level.

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Figure 2 shows a flow diagram for a method 200 of deploying the drainage apparatus of Figure 1. Water is used as an example of the liquid in the description of this method 200. Prior to executing the method 200, the first and second reservoirs 102, 104 are initially empty, and the plurality of conduits 106a-e is also empty. In addition, the six return valves 110a-f are initially configured as closed.

The method 200 begins at step 202, where the first, second and fifth return valves 110a, 110b, 110e are opened to enable water to be introduced into the plurality of conduits 106a-e through the free end 106b12 covered by the liquid insertion cap 118 to mostly fill the plurality of conduits 106a-e with the water. Thus, the liquid insertion cap 118 is to be removed for the plurality of conduits 106a-e to be filled. The liquid insertion cap 118 is screwed back once the plurality of conduits 106a-e is filled. This step 202 is also known as "priming", as filling up the plurality of conduits 106a-e creates hydrostatic pressure therewithin to subsequently enable siphoning of the water from the first reservoir 102 to the second reservoir 104. Once step 202 is completed, the air release caps 116 are removed to enable any air trapped (as bubbles) in the water, during filling the plurality of conduits 106a-e, to be released, in a step 204. Needless to say, the air release caps 116 are screwed back on once the trapped air bubbles are released.

In a next step 206, more water is introduced into the first reservoir 102, which consequently provides sufficient fluid pressure to cause the water to flow into the inlet 112, pass the check valve 108 and mix with the water filled in the plurality

of conduits 106a-e. In a further step 208, the sixth return valve 110f is opened. Due to the continued provision of water (and thus increased fluid pressure) in the first reservoir 102, the water is then caused to move through the plurality of conduits 106a-e and discharges via the outlet 114 into the second reservoir 104 by way of the siphoning action. That is, a continuous liquid flow path which extends from the inlet 112 to at least the outlet 114 is formed, and the continuous liquid flow path creates a siphon. The provision of the water at the first reservoir 102 is stopped when a level of the water collected in the first and second reservoirs 102, 104 equalizes, i.e. a state of equilibrium of the siphon is achieved as per step 210, where the plurality of conduits 106a-e is then considered primed. It is to be appreciated that the state of equilibrium is defined as the hydrostatic pressure at both ends of the continuous liquid flow path is in equilibrium and the siphon halts until triggered. This state of equilibrium in the context of the schematic of the drainage apparatus 100 is depicted in Figure 3. It is to be appreciated that the level 152 of the water in the first reservoir 102 covers and submerges the inlet 112, while in the second reservoir 104, the level 154 of water fills up at least to the brim of the outlet 114. In other instances where a level of water in the second reservoir 104 however covers and submerges the outlet 114, this level of the water collected is below the position of the drainage pipe 1042, as will be appreciated. The drainage pipe 1042 is disposed at least 300 mm above the outlet 114. Once the method 200 is executed, the drainage apparatus 100 is considered operational for the purpose of transferring/diverting any further excess water that subsequently collects in the first reservoir 102 to the second reservoir 104 to prevent overflowing or flooding at the first reservoir 102.

In use, the drainage apparatus 100 may be deployed as part of the flood control/anti-flooding system and the first reservoir 102 is located at a vicinity which is prone to flooding, whereas the second reservoir 104 is arranged at a distance (e.g. may be a few kilometres away) away from the first reservoir 102.

An example scenario for usage of the drainage apparatus 100 (after being deployed using the method 200) is briefly described here to illustrate its operation. When a heavy storm occurs, large amounts of rainfall water are collected in the first reservoir 102 and with the drainage apparatus 100 being

already setup for operation, the large amounts of rainfall water are therefore diverted from the first reservoir 102 to the second reservoir 104 by being siphoned through the plurality of conduits 106a-e. It is to be appreciated that the second reservoir 104 will not be filled because any excess rainfall water  
5 diverted to the second reservoir 104 is also drained away via the drainage pipe 1042 (to other reservoirs), once the water level in the second reservoir 104 rises to at where the drainage pipe 1042 is located. Once the storm has stopped, conditions in the first and second reservoirs 102, 104 then return to a state, whereby both water levels in the first and second reservoirs 102, 104 are  
10 substantially at the same level.. So in this way, using the drainage apparatus beneficially prevents overflowing or flooding at the first reservoir 102.

Arranging the horizontal arm 106a2 of the L-shaped portion of the first conduit 106a and the horizontal arm 106e2 of the L-shaped portion of the fifth conduit  
15 106e at the same liquid level has an advantage of creating a drainage apparatus which automatically starts the transfer of the liquid or stops the liquid transfer depending on the amount of water in the first reservoir 102. When there is no water being channelled into the first reservoir 102, the siphoning action will stop when the level of the water collected in the first and second reservoirs 102, 104  
20 equalizes, i.e. a state of equilibrium of the siphon is achieved as per step 210 as explained above. In this way, this ensures that there is always liquid within the drainage apparatus to prime the drainage apparatus. When water starts to flow into the first reservoir again (for example, when rain starts to fall again), the siphon is triggered and the water transfer re-starts.

25 If the horizontal arm 106e2 of the fifth conduit 106e is arranged lower than the horizontal arm 106a2 of the first conduit 106a, this water transfer would be continuous until the water in the drainage apparatus is drained out. In other words, if no water is being directed into the first reservoir, the siphoning action  
30 would continue to discharge the liquid within the drainage apparatus that is needed for the priming of the apparatus and this is not ideal as this will require the drainage apparatus to be primed again.

Further embodiments of the invention will be described hereinafter. For sake of  
35 brevity, description of like elements, functionalities and operations that are

common between the embodiments are not repeated; reference will instead be made to similar parts of the relevant embodiment(s).

According to a second embodiment, there is proposed another drainage  
5 apparatus 300 shown in Figure 4. The second and fourth conduits 106b, 106d  
described in the first embodiment are omitted in this embodiment. Further  
differences between this drainage apparatus 300 and the drainage apparatus  
100 of Figure 1 are as follow. It is also highlighted that components of the  
10 drainage apparatus 300 of Figure 4 similar to those in the drainage apparatus  
100 of Figure 1 follow similar reference numerals, but with 3000 added as  
reference numeral. There are seven return valves 3110a-f, 302 in the drainage  
apparatus 300 of Figure 4, and the positions of the first six return valves 3110a-f  
have been re-arranged compared to in the first embodiment. The first conduit  
3106a further includes first and second return valves 3110a, 3110b arranged in  
15 the vertical arm 3106a1 of the L-shaped portion of the first conduit 3106a,  
between the free end 3106a12 of the vertical arm 3106a1 of the L-shaped  
portion and a point of the L-shaped portion where the first conduit 3106a is  
coupled to a connecting conduit 304. Specifically, the connecting conduit 304 is  
a plain transverse member and does not include any return valves or the liquid  
20 insertion cap 3118, and is coupled at one end 304a to the first conduit 3106a,  
and at an opposite end 304b to the third conduit 3106c. It is to be appreciated  
that the connecting conduit 304 is arranged to be positioned above the walls  
102a, 102b of the first reservoir 102. As opposed to in the first embodiment, the  
third conduit 3106c is now arranged to be of generally U-shaped. Specifically,  
25 the third conduit 3106c includes a U-shaped portion having a left (vertical) arm  
3106c1, a right (vertical) arm 3106c2 and a horizontal arm 3106c3 which is  
coupled orthogonally to the left and right arms 3106c1, 3106c2 at their base.  
The liquid insertion cap 3118 is included at the left arm 3106c1 of the U-shaped  
portion of the third conduit 3106c, which is coupled to the connecting conduit  
30 304. The third return valve 3110c is arranged proximal to the liquid insertion cap  
3118. The right arm 3106c2 of the U-shaped portion of the third conduit 3106c  
is bent at a free end and coupled to the fifth conduit 3106e; and the bent portion  
of the right arm 3106c2 includes the fourth return valve 3110d. A horizontal arm  
3106c3 of the U-shaped portion of the third conduit 3106c, connecting the left  
35 and right arms 3106c1, 3106c2, is arranged to be positioned at a level below the

floors 102c, 104c of the first and second reservoirs 102, 104. Further, it is to be appreciated that the bent portion of the right arm 3106c2 is located above the walls 104a, 104b of the second reservoir 104, similar to the connecting conduit 304. The fifth conduit 3106e now includes the fifth and sixth return valves  
5 3110e, 3110f in the vertical arm 3106e1 of the L-shaped portion of the fifth conduit 3106e, while also including the seventh return valve 302 in the horizontal arm 3106e2 of the L-shaped portion of the fifth conduit 3106e. The fifth return valve 3110e is located above the sixth return valve 3110f.

10 According to a third embodiment, an alternative drainage apparatus 400 is proposed as per Figure 5, which is largely similar to the drainage apparatus 300 of Figure 4, but with minor differences. It is highlighted that like components of the drainage apparatus 400 of Figure 5 are similarly labelled as those of the drainage apparatus 300 of Figure 4. In particular, for the third embodiment, the  
15 connecting conduit 304 couples to the first and third conduits 3106a, 3106c at a much lower vertical position such that the connecting conduit 304 is now arranged to pass through the wall 102b of the first reservoir 102. This is also similarly the case for the bent portion of the right arm 3106c2 of the U-shaped portion of the third conduit 3106c, which is now arranged to pass through the  
20 wall 104a of the second reservoir 104 to be coupled to the fifth conduit 3106e. In addition, unlike in Figure 4, the fourth return valve 3110d is now arranged to be positioned in the horizontal arm 3106a2 of the L-shaped portion of the first conduit 3106a.

25 According to a fourth embodiment, yet a further variant drainage apparatus 500 is shown in Figure 6, which is largely similar to the drainage apparatus 300 of Figure 4, but with minor differences. So for referencing convenience, like components of the drainage apparatus 500 of Figure 5 are similarly labelled as those of the drainage apparatus 300 of Figure 3. For the fourth embodiment, the  
30 horizontal arm 3106c3 of the U-shaped of the third conduit 3106c, connecting the left and right arms 3106c1, 3106c2, is now arranged to be positioned at a level below the height of the walls 102a, 102b, 104a, 104b of, but above the floors 102c, 104c of the first and second reservoirs 102, 104. In addition, the fifth conduit 3106e is now also configured with an inverted U-shaped portion 501  
35 which extends from the free end of the horizontal arm 3106e2 of the L-shaped

portion of the fifth conduit 3106e, similar to how the first conduit 106a is arranged in the first embodiment. Of course, this inverted U-shaped portion 501 is configured with the outlet 3114. Further, the check valve 3108 is omitted and replaced by an eighth return valve 502, which is arranged to be in the horizontal  
5 arm 3106a2 of the L-shaped portion of the first conduit 3106a. Also, this embodiment is configured such that liquid can be transferred/diverted from the first reservoir 102 to the second reservoir 104, or vice versa, improving the versatility of the drainage apparatus 500 of this embodiment. It is to be appreciated that the drainage pipe 1042 of the second reservoir 104 is omitted  
10 during to the said improved capability of the drainage apparatus 500.

According to a fifth embodiment, another alternative drainage apparatus 600 is shown in Figure 7, which is largely similar to the drainage apparatus 500 of Figure 6, except that the inverted U-shaped portion 501 of the fifth conduit  
15 3106e is now omitted, and the outlet 3114 is positioned in the same manner as described in the first embodiment. In addition, the eighth return valve 502 is omitted, and replaced with the check valve 3108, similar to the arrangement in the first embodiment.

20 According to a sixth embodiment, a variant drainage apparatus 700 is shown in Figure 8, which is largely similar to the drainage apparatus 400 of Figure 5. The only difference is that the horizontal arm 3106c3 of the U-shaped portion of the third conduit 3106c is now arranged to be positioned on a same level as both the connecting conduit 304 and the bent portion of the right arm 3106c2 of the U-  
25 shaped portion of the third conduit 3106c. That is, the horizontal arm 3106c3 of the U-shaped portion of the third conduit 3106c (as in the third embodiment), the connecting conduit 304 and the bent portion of the right arm 3106c2 of the third conduit 3106c together forms a straight transverse member, which is labelled collectively in this sixth embodiment with reference numeral 702.

30 According to a seventh embodiment, a further drainage apparatus 800 is proposed and shown in Figure 9, which is similar to the drainage apparatus 700 of Figure 8, except that the outlet 3114 arrangement follows the configuration (using the inverted U-shaped portion 501) as described per the drainage  
35 apparatus 500 of Figure 6. It is also to be appreciated that the drainage pipe

1042 of the second reservoir 104, and the check valve 3108 are omitted in the seventh embodiment. The seventh embodiment is particularly configured such that liquid can be transferred/diverted from the first reservoir 102 to the second reservoir 104, or vice versa. Thus the versatility of the said drainage apparatus  
5 800 is improved.

It is to be appreciated that the method 200 of Figure 2 is applicable to all of the second to seventh embodiments as described above.

10 The proposed drainage apparatus 100, 300-800 discussed in afore embodiments advantageously enables transferring/diverting of liquid from a source reservoir to a destination reservoir by way of siphoning, without requiring usage of any pump or any moving part, thus saving costs. In addition, as long as the conduits of the drainage apparatus 100, 300-800 are filled with the liquid, the siphoning action  
15 will work to automatically divert the liquid, when the fluid pressure in the two reservoirs are not equalized. This means minimal human monitoring and maintenance are required for operation of the drainage apparatus 100, 300-800. Therefore, the drainage apparatus 100, 300-800 beneficially helps to prevent overflowing and flooding at the source reservoir (which may be a monsoon drain  
20 for example). Further, the drainage apparatus 100,300-800 may be used to channel water from a water storage facility to a water treatment facility.

The described embodiments should not however be construed as limitative. For example, the number of the return valves or check valves used is not limited as  
25 described above; any number of the return valves or check valves may be used, depending on the requirements of an application. This applies similarly to the number of conduits to be used, and is not limited to those described in the foregoing embodiments. Further the valves may be automatically (instead of manually) configured. In addition, the plurality of conduits 106a-e need not be of  
30 uniform diameters; each conduit may have a different diameter. Moreover, other suitable types of arrangements of the conduits are possible so long the siphoning effect is deployed and maintained to enable liquid transfer between the first and second reservoirs 102, 104. Furthermore, the drainage apparatus 100, 300-800 may also include the first and second reservoirs 102, 104.  
35 Additionally, the second reservoir 104 may be deeper than the first reservoir

102. Also, the inlet 112 and outlet 114 may be arranged to be three times or four times the diameter of the conduit arrangement. The conduit arrangement may also be a single integral conduit, rather than a plurality of conduits 106a-e. It has been found that the greater the depth of the first and second reservoirs  
5 102,104, the stronger is the siphoning action. Thus, the depth of the first and second reservoirs may be planned depending on the expected rate by which water needs to be transferred from the first reservoir to the second reservoir or vice versa. Although the embodiments described having a plurality of valves, which is preferred, but it should be mentioned that only one valve may be  
10 required.

While the embodiments describe only two reservoirs but it should be appreciated that a number of reservoirs may be "cascaded" together to form a network of reservoirs with first reservoir transferring water to a second reservoir, and water  
15 is transferred from the second reservoir to a third reservoir and so on and so forth.

Indeed, the flexibility of the drainage apparatus to be used in all sorts of imaginable terrain. For example, the embodiment of Figure 4 or 5 allows the pipe  
20 316c3 to be buried underground or under water (such as beneath the ocean bed) to perform the water transfer.

While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered  
25 illustrative or exemplary, and not restrictive; the invention is not limited to the disclosed embodiments. Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practising the claimed invention.

## Claims

1. A method of priming a drainage apparatus for siphoning liquid between first and second reservoirs, the apparatus including a conduit arrangement having a first opening disposed in the first reservoir, a second opening disposed in the second  
5 reservoir and a liquid injection inlet arranged between the first and second openings, and at least one valve for controlling flow of the liquid along the conduit arrangement, wherein the conduit arrangement includes a plurality of conduits arranged in fluid communication, and the plurality of conduits include first and second conduits respectively configured with the first and second openings, a portion of the first and  
10 second conduits being positioned at a same liquid level, the method comprising:

directing liquid into the conduit arrangement via the liquid injection inlet to fill up most of the conduit arrangement as controlled by the valve's configuration;

directing liquid into the first reservoir to enable more liquid to enter into the conduit arrangement via the first opening and to flood the conduit arrangement to  
15 form a continuous liquid flow path which extends from the first opening up to at least the second opening, the continuous liquid flow path creating a siphon; and

with the first opening kept below the liquid's surface level in the first reservoir, stopping the flow of liquid into the first reservoir to achieve a state of equilibrium of the siphon to prime the conduit arrangement,

20 whereby after the priming and in use, the siphon is triggered when more liquid is added into the first reservoir which causes the added liquid to be siphoned to the second reservoir via the primed conduit arrangement.

2. The method of claim 1, wherein prior to directing liquid into the first reservoir,  
25 further comprising releasing air trapped in the mostly filled conduit arrangement.

3. The method of claim 1, wherein prior to directing liquid into the conduit arrangement, further comprising configuring the at least one valve to enable the conduit arrangement to be mostly filled.

30 4. A drainage apparatus for siphoning liquid between first and second reservoirs, the apparatus comprising:

a conduit arrangement having a first opening disposed in the first reservoir, a second opening disposed in the second reservoir and a liquid injection inlet arranged

between the first and second openings for directing liquid into to fill up most of the conduit arrangement; and

at least one valve for controlling flow of the liquid along the conduit arrangement; wherein prior to using the drainage apparatus for siphoning the liquid,

5 the liquid injection inlet is configured to receive liquid to fill up most of the conduit arrangement as controlled by the valve's configuration;

wherein the first opening is configured to receive more liquid which has been directed into the first reservoir to flood the conduit arrangement to form a continuous liquid flow path which extends from the first opening up to at least the second  
10 opening, the continuous flow path configured to create a siphon which is at a state of equilibrium to prime the conduit arrangement when the flow of liquid into the first reservoir is stopped and the first opening is kept below the liquid's surface level in the first reservoir; and

wherein the conduit arrangement includes a plurality of conduits arranged in  
15 fluid communication, and the plurality of conduits include first and second conduits respectively configured with the first and second openings, a portion of the first and second conduits being positioned at a same liquid level;

whereby after priming and in use, the siphon is triggered when more liquid is added into the first reservoir which causes the added liquid to be siphoned to the  
20 second reservoir via the primed conduit arrangement.

5. A drainage apparatus adapted to siphon liquid between first and second reservoirs, the apparatus comprising:

first and second openings;

25 a conduit arrangement; and

at least one valve arranged along the conduit arrangement to control flow of the liquid in the conduit arrangement via the first and second openings,

wherein the first and/or second opening is configured to be at least twice the diameter of the conduit arrangement; and

30 wherein the conduit arrangement includes a plurality of conduits arranged in fluid communication, and the plurality of conduits include first and second conduits respectively configured with the first and second openings, a portion of the first and second conduits being positioned at a same liquid level.

35 6. The apparatus of claim 5, wherein the first opening is disposed in the first reservoir and arranged to face the floor of the first reservoir.

7. The apparatus of claim 5 or 6, wherein the second opening is disposed in the second reservoir and arranged to face the floor of the second reservoir.

5 8. The apparatus of claim 5 or 6, wherein the second opening is disposed in the second reservoir and arranged to face away from the floor of the second reservoir.

9. The apparatus of any of claims 5 to 8, wherein there are more than one valves and the valves include check valves and return valves.

10

10. The apparatus of claim 9, wherein at least some of the valves are further configured to enable air trapped in the conduit arrangement to be released therefrom.

11. The apparatus of any of claims 5 to 10, further comprising a drainage conduit  
15 being arranged at the second reservoir.

12. The apparatus of claim 11, wherein the drainage conduit is disposed to be spaced apart from the second opening by approximately 300 mm.

20 13. The apparatus of any of claims 5 to 12, further comprising the first and second reservoirs.

14. The apparatus of any of claims 5 to 13, wherein the second opening is configured to be at least three times the diameter of the conduit arrangement.

25

15. The apparatus of any of claims 5 to 14, wherein the second opening is configured to be at least four times the diameter of the conduit arrangement.

16. The apparatus of any of claims 5 to 15, wherein the conduit arrangement  
30 includes a transverse portion extending between the first and second reservoirs, the transverse portion having a series of undulations arranged therealong.

17. The apparatus of claim 16, wherein the transverse portion has a length of at least 1000 metres.

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18. A flood control system comprising the drainage apparatus of any of claims 4 to 17.