



US 20130140229A1

(19) **United States**(12) **Patent Application Publication****Allen et al.**(10) **Pub. No.: US 2013/0140229 A1**(43) **Pub. Date: Jun. 6, 2013**(54) **STORMWATER FILTRATION SYSTEMS**

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(21) Appl. No.: **13/680,958**(22) Filed: **Nov. 19, 2012****Related U.S. Application Data**

(63) Continuation of application No. 13/352,977, filed on Jan. 18, 2012, now Pat. No. 8,318,015, which is a continuation of application No. 12/420,486, filed on Apr. 8, 2009, now Pat. No. 8,110,105.

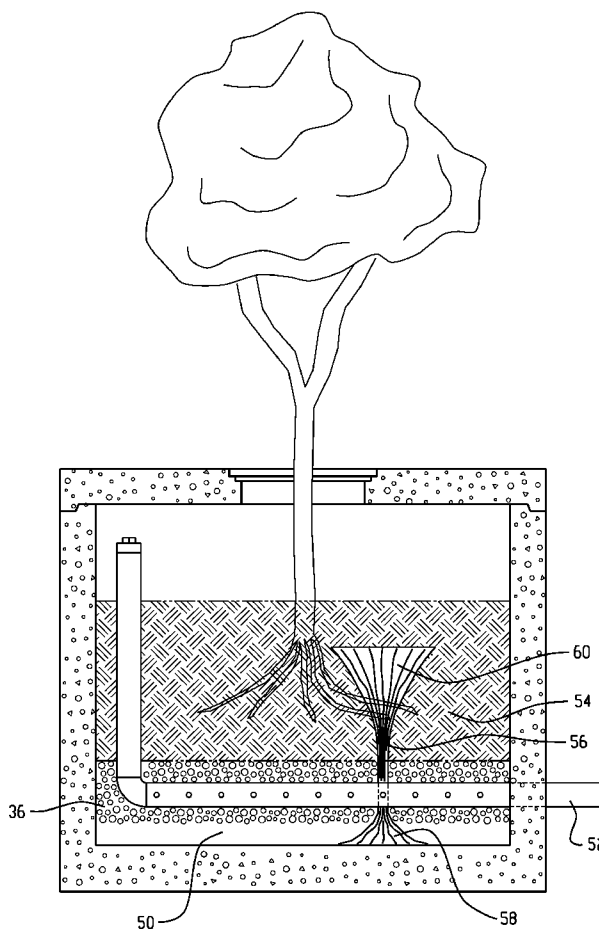
(60) Provisional application No. 61/043,612, filed on Apr. 9, 2008, provisional application No. 61/056,236, filed on May 27, 2008, provisional application No. 61/140,276, filed on Dec. 23, 2008.

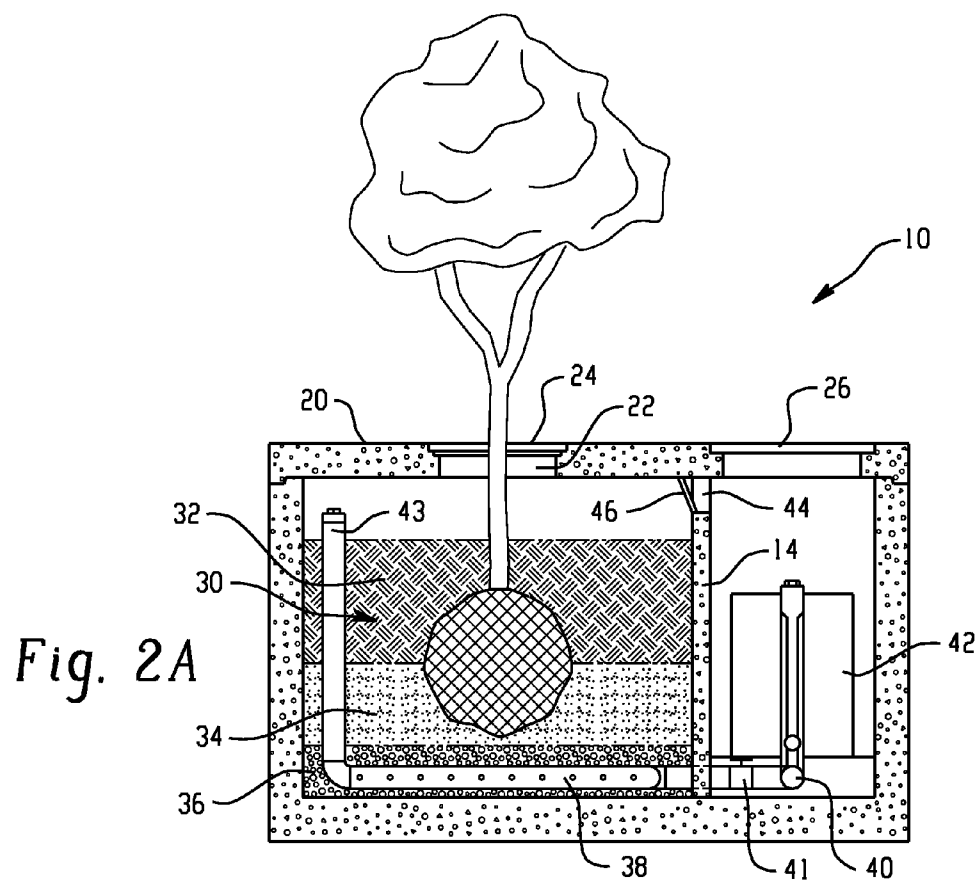
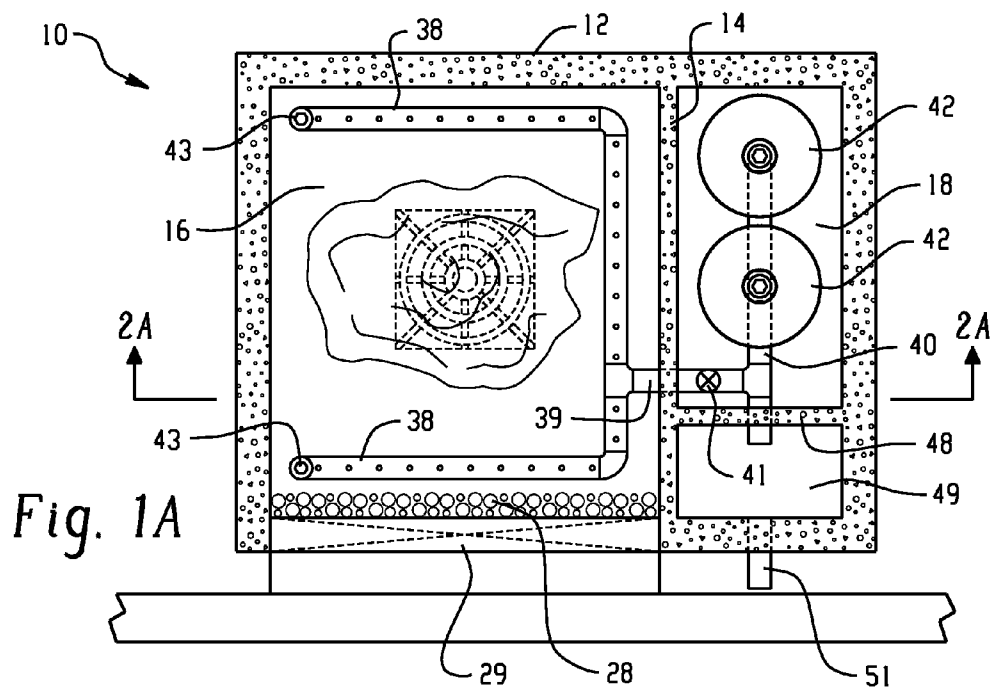
Publication Classification

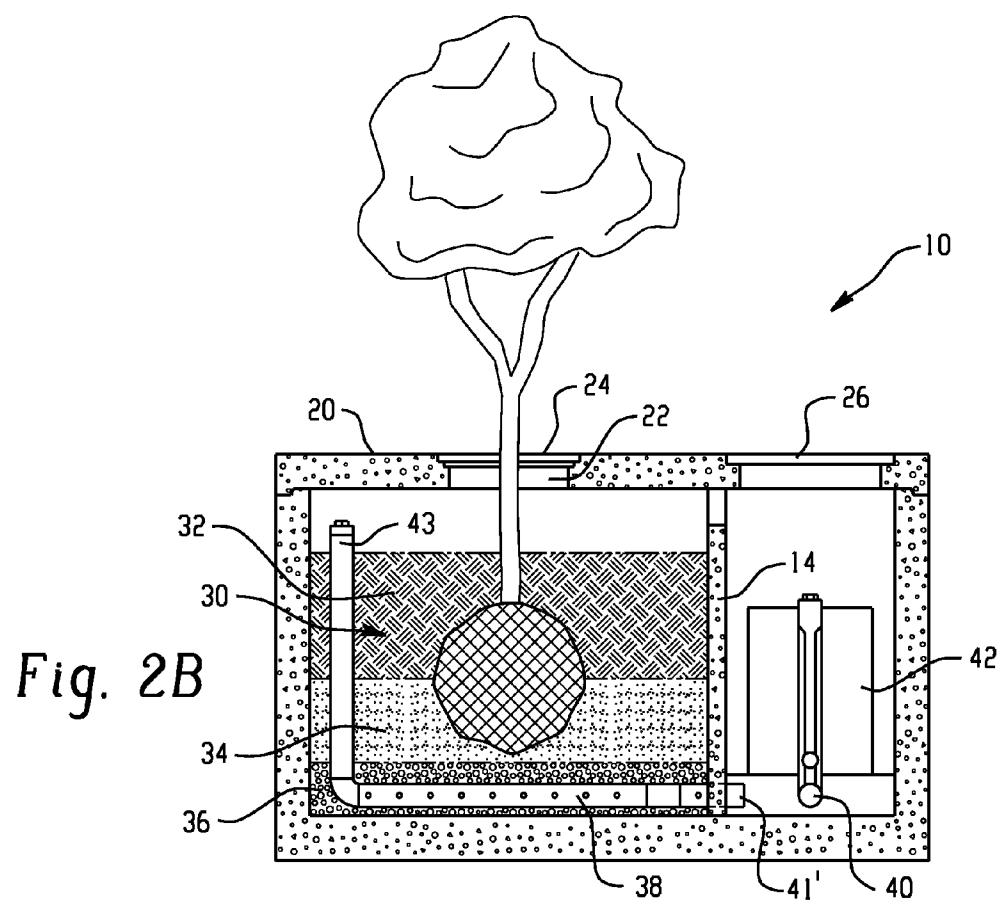
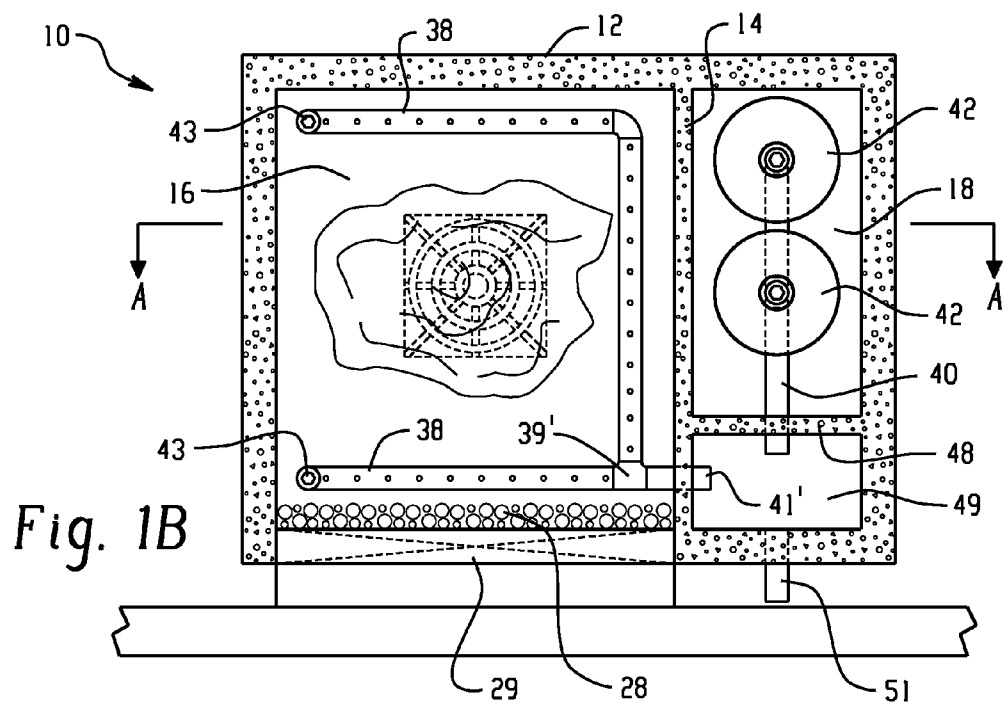
(51) **Int. Cl.**
C02F 3/32 (2006.01)
(52) **U.S. Cl.**
CPC **C02F 3/32** (2013.01)
USPC **210/602**

(57) **ABSTRACT**

A stormwater filtration system suitable for treatment of stormwater runoff in a developed environment uses a primary treatment bay that includes a filtration bed with live plant matter. A second treatment bay treats water that exceeds the maximum throughput of the primary bay. A reservoir stores treated runoff to water the plants during dry weather. Removable trays on the surface of the primary filtration bed provide plants suitable for ground cover. Additional bays expand the filtration bed throughput and accommodate extended root systems. A flow control may be provided for the primary treatment bay.







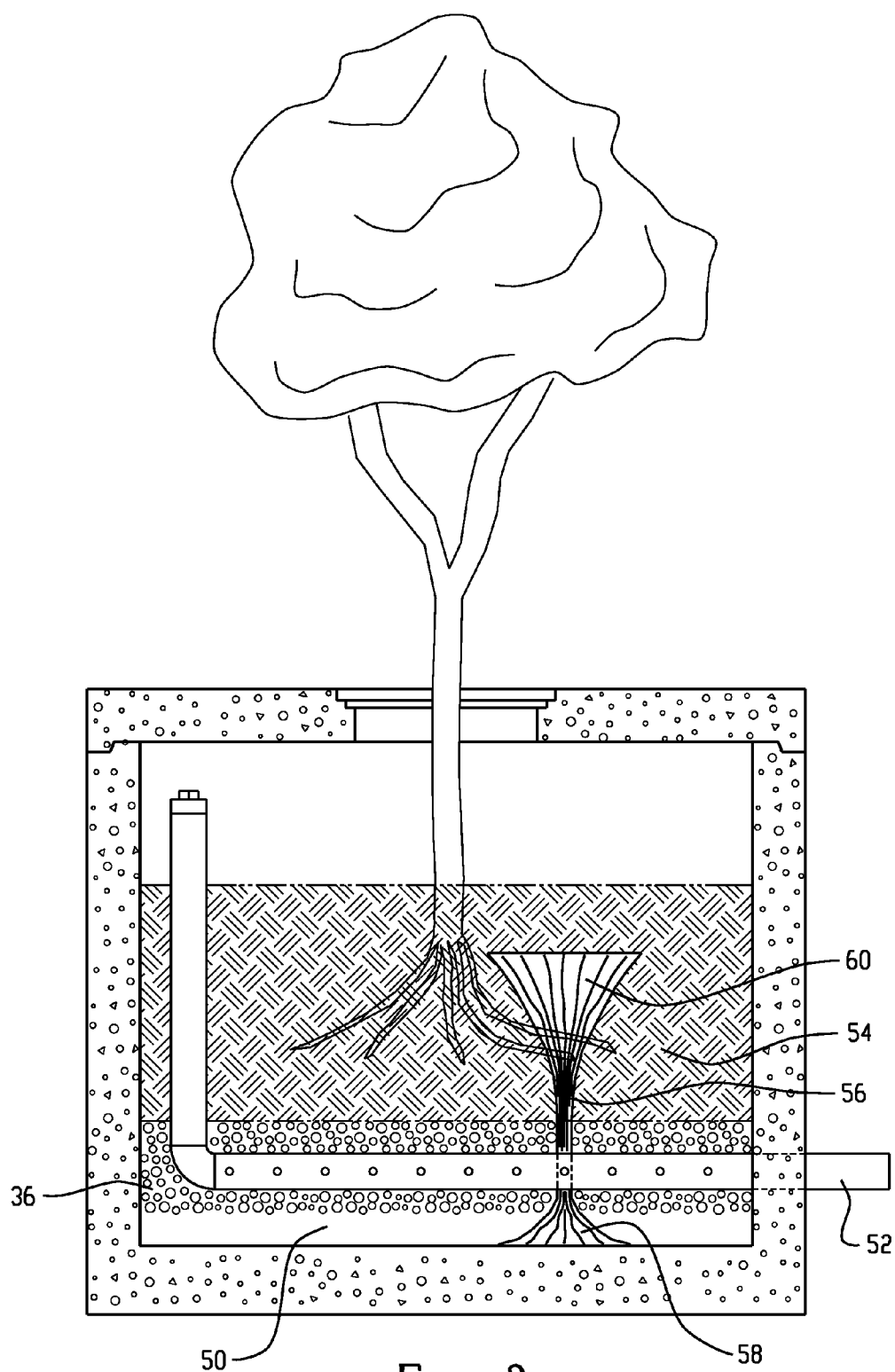


Fig. 3

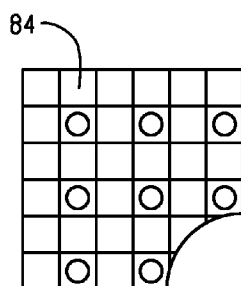


Fig. 4C

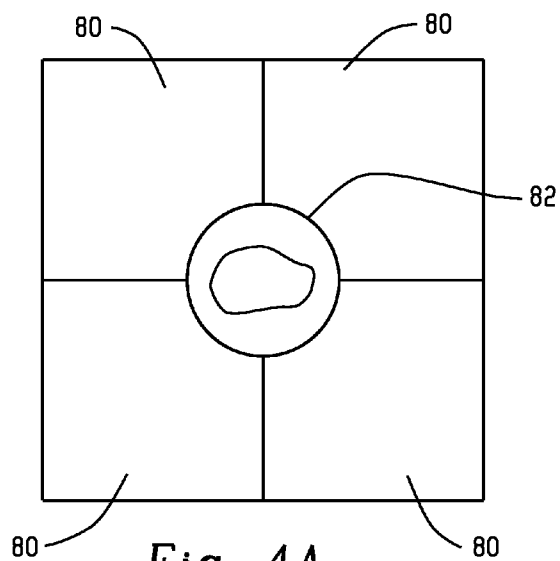


Fig. 4A

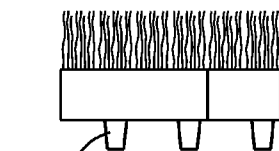


Fig. 4D

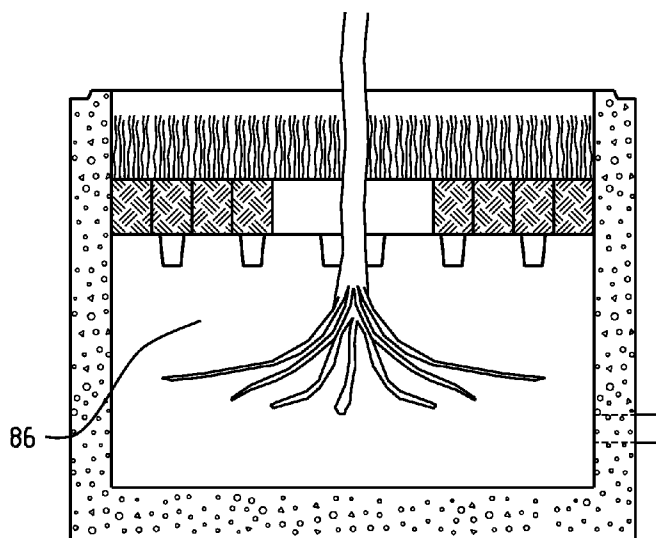


Fig. 4B

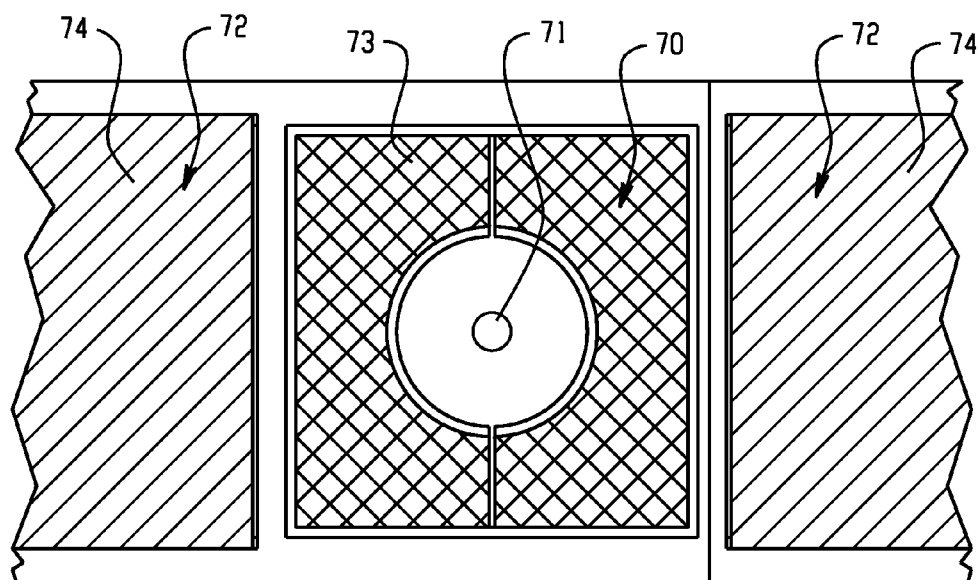


Fig. 5A

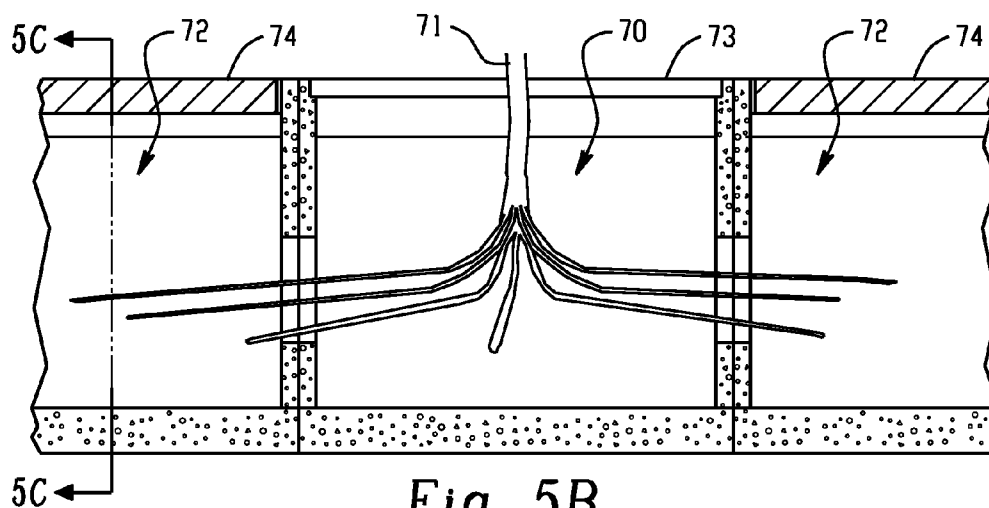


Fig. 5B

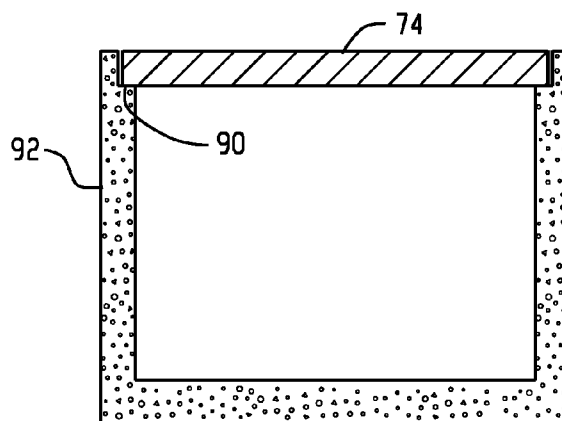


Fig. 5C

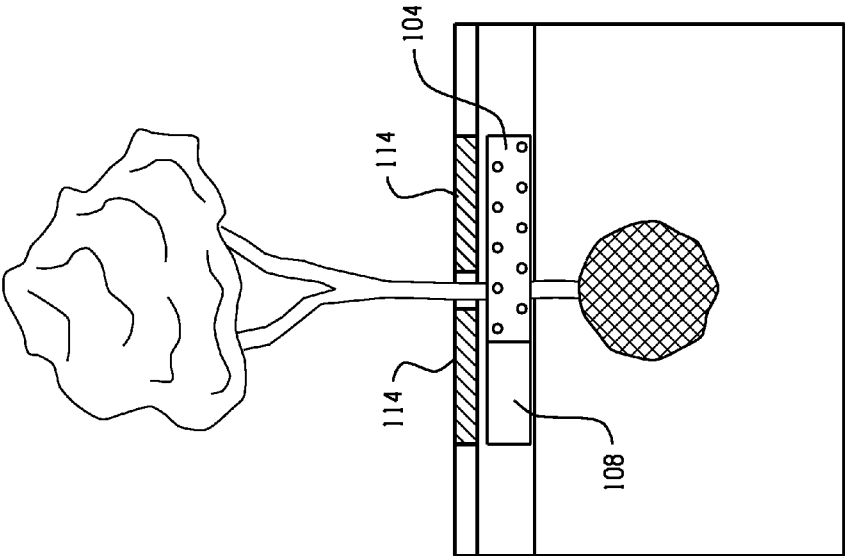


Fig. 6B

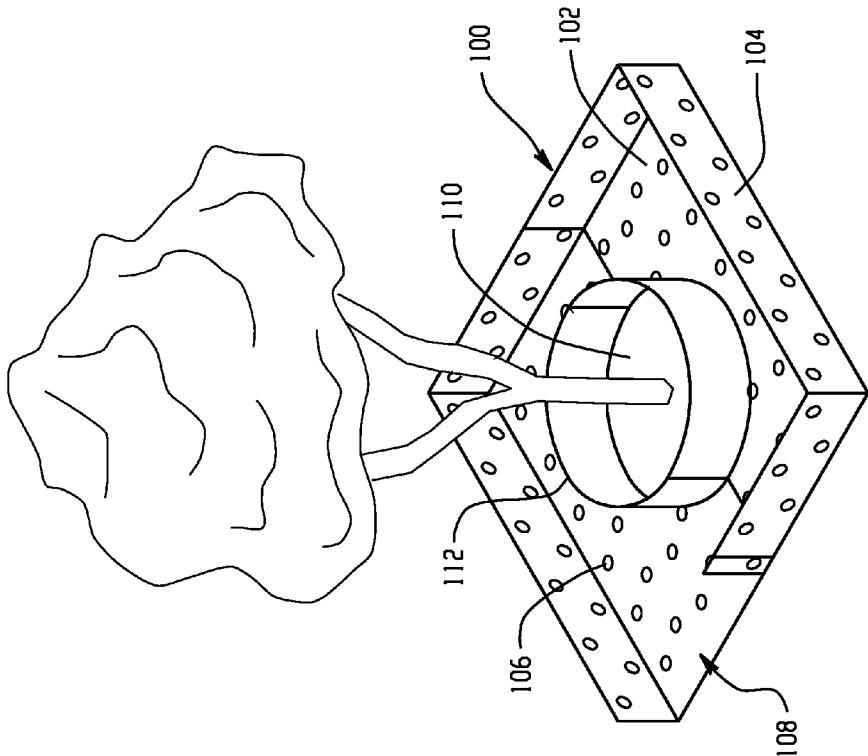


Fig. 6A

Fig. 7B

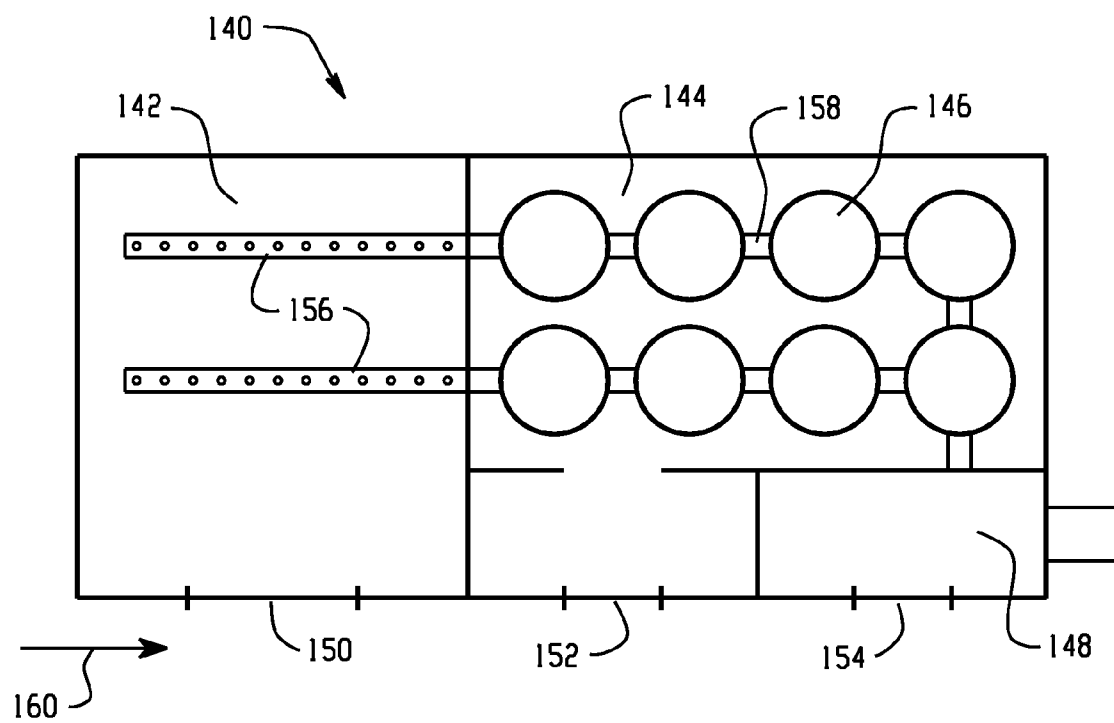


Fig. 8

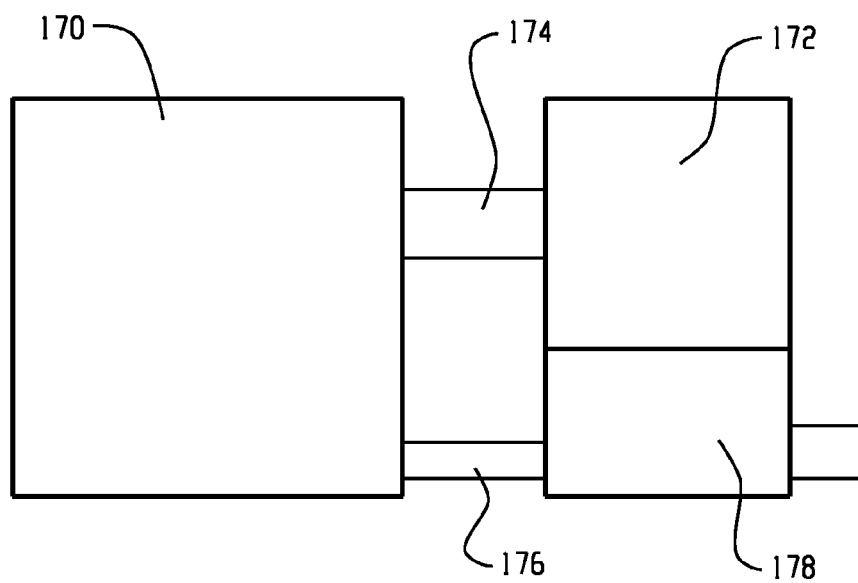


Fig. 9

STORMWATER FILTRATION SYSTEMS

CROSS-REFERENCES

[0001] This application claims the benefit of U.S. Provisional Application Ser. Nos. 61/043,612, filed Apr. 9, 2008, 61/056,236 filed May 27, 2008 and 61/140,276 filed Dec. 23, 2008, each of which is incorporated herein by reference.

TECHNICAL FIELD

[0002] This application relates generally to stormwater filtration systems and, more particularly, to systems incorporating live plant material into the filtration process.

BACKGROUND

[0003] Stormwater can be a form of diffuse or non-point source pollution. It can entrain pollutants, such as garbage, sediment, organic matter, heavy metals, and organic toxins, and flush them into receiving water bodies. As a consequence, natural bodies of water that receive stormwater may also receive pollutants.

[0004] In an effort to address the environmental problems posed by polluted format traps and filters for stormwater have been developed.

[0005] Stormwater filtration cartridges, such as those described in U.S. Pat. Nos. 5,707,527, 6,027,639, 6,649,048, and 7,214,311, pull stormwater through a filtration bed that removes pollutants prior to discharge into a receiving water body. Improvements to such cartridges have produced highly effective filters that allow for significant throughput, as described in the references cited above, while also allowing for easy installation and replacement of the modular cartridge units,

[0006] Another known method of stormwater filtration involves the installation of horizontally-disposed filtration beds using a mixture of materials often including organic compost. Stormwater runoff directed into these beds is filtered in an action not unlike natural soil. Live plant material is sometimes added to take advantage of its pollutant uptake as well as for aesthetic value. While mixtures for these filtration beds can be developed that accommodate a higher throughput of stormwater than natural soil, the level of throughput is still limited by the area of the bed and nature of the filtration bed material. Additionally, in areas where rainfall is sporadic, the stormwater received may not be sufficient to maintain the live plant matter therein.

[0007] It would be desirable to develop a contained, aesthetic stormwater treatment system using a filtration bed including live plants that nonetheless allows for higher throughput when necessary and adequate filtration of that higher throughput to the extent practical.

[0008] It would also be desirable to develop a stormwater treatment system that can maintain the live plants therein during periods of low rainfall without excessive irrigation needs.

[0009] Additional desired improvements to stormwater treatment systems with live plant matter include methods to easily place and later remove plant matter suitable for ground cover, and supplemental beds that expand the area of treatment and can accommodate the extended root systems of the live plants found in the filtration bed.

SUMMARY

[0010] A stormwater filtration system is provided that includes a first or primary treatment bay with live plant matter in a filtration bed, and a second overflow or secondary treatment bay that receives and treats stormwater that exceeds the capacity of the first treatment bay.

[0011] In a further aspect, the first or primary treatment bay and overflow or secondary treatment bay are enclosed in a common vault structure, which includes an inlet for stormwater to enter the vault and first treatment bay, means for untreated overflow stormwater to enter the overflow treatment bay from the first treatment bay, and an outlet for treated water to leave the vault.

[0012] In another aspect, a outlet bay is provided in combination with the first treatment bay and second treatment bay, and water entering the system is directed into an inlet compartment in an upper portion of the outlet bay before entering the first treatment bay or secondary treatment bay.

[0013] In another aspect, a removable root tray containing small plants suitable for ground cover is provided which interfaces favorably with a filtration bed including live plant matter.

[0014] In yet a further aspect, a stormwater filtration system is provided that includes both a first vault including a filtration bed with live plant matter and also secondary vaults, which vaults may be configured to accommodate the extended root structure of the plants of the first vault.

[0015] An optional feature would be to incorporate a wetwell that collects treated water that can later be wicked to root zone(s) during dry periods.

[0016] The details of one or more embodiments are set forth in the accompanying drawings and the description below. Other features, objects, and advantages will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] FIG. 1A shows one embodiment of a treatment system from above.

[0018] FIG. 2A is a side elevation view of the system of FIG. 1A.

[0019] FIG. 1B shows another embodiment of a treatment system from above.

[0020] FIG. 2B is a side elevation view of the system of FIG. 1B.

[0021] FIG. 3 is a side elevation view of the a treatment bay including a reservoir,

[0022] FIG. 4A shows a configured root tray system from above.

[0023] FIG. 4B is a side elevation view of a treatment bay including a root tray system.

[0024] FIG. 4C is a top-down view of a root tray.

[0025] FIG. 4D is a side elevation view of a root tray system including reservoirs.

[0026] FIG. 5A is a top-down view of a filtration system including secondary vaults or bays with porous pavers.

[0027] FIG. 5B is a side elevation view of the filtration system of FIG. 5A.

[0028] FIG. 5C is a side elevation view orthogonal to FIG. 5B along line A-A.

[0029] FIGS. 6A and 6B are views of an embodiment including a top pan.

[0030] FIGS. 7A-7B illustrate a further embodiment of a treatment system,

[0031] FIG. 8 is a schematic depiction of an embodiment of a treatment system including separate inputs for the primary, secondary and outlet bays; and

[0032] FIG. 9 is a schematic depiction of a treatment system using distinct vault structures.

DETAILED DESCRIPTION

[0033] In one aspect shown in FIGS. 1A and 2A, a filtration system 10 is provided in a concrete vault 12 that has an internal vertical wall 14 dividing the vault into a primary treatment bay 16 and an overflow or secondary treatment bay 18. A top wall 20 of the unit is also formed of concrete. Other materials could be used to form the vault, and the two bays could be formed as separate structures or vaults placed side-by-side and connected by corresponding adjacent wall openings and/or piping.

[0034] The primary treatment bay side of the top wall includes an opening 22 and associated tree ring 24 through which the trunk or stem of a tree or herbaceous plant extends. A manhole or hatch 26 above the overflow treatment bay gives access to the filtration means located therein. Dimensions for the vault could vary as needed. The overflow treatment bay 18 shown utilizes a suitable stormwater filter cartridge 42, such as the StormFilter product available from Contech Stormwater Solutions, Inc. of West Chester, Ohio, and described in U.S. Pat. No. 7,214,311. Other possible cartridges that could be used include the Perk Filter available from Kristar Enterprises Inc. of Santa Rosa, Calif. or the CDS or MFS filtration cartridges also available from Contech Stormwater Solutions, Inc. It is also recognized that the overflow treatment bay 18 could utilize other forms of stormwater filtration devices, including non-cartridge type devices. Upflow type filters could also be used. In certain embodiments, the filtration means of the overflow treatment bay is readily replaceable, as is the case with the cartridge-type filters.

[0035] Preferably, the treatment capacity of the overflow bay is substantially greater than the treatment capacity of the filtration bed bay. For example, the treatment capacity of bay 18 may be at least two times greater than the treatment capacity of bay 16, and more preferably at least two and a half times greater (e.g., three, four or six times greater). In order to accomplish such a result, it is beneficial for the overflow treatment bay to utilize a different type of filtration device (e.g., self-contained filtration units in the form of cartridges) than the filtration bed of bay 16. In one example, the filtration bed bay may be configured to have a treatment flow capacity of between about 12 and 20 gallons per minute, and the overflow treatment bay may be configured to have a treatment flow capacity of between about 40 and 50 gallons per minute.

[0036] As shown, the filtration system 10 is of a size and structure suitable for placement in an urban environment, such as along a street or parking area to receive surface runoff or next to a building to receive the roof runoff. The vault prevents accumulated stormwater from destructively interfering with adjacent urban systems, and the generally self-contained configuration allows for easy placement as part of existing stormwater drainage solutions. The filtration system may be modified in configuration, structure, or size to accommodate the specific stormwater treatment needs of a target area without deviating from the invention as described and claimed herein.

[0037] Referring again to FIGS. 1A and 2A, water flows into the primary treatment bay via a curb inlet opening 29 and

onto a band of rip-rap 28 to reduce water speed and erosion. In one embodiment, the tree is planted within a multi-layer bed 30 in the treatment bay. A top layer 32 of the bed may be 12 to 24 inches of a 60% (by volume) CSF leaf media or variant—40% (by volume) sand mix. The CSF leaf media component is made exclusively of composted, fallen deciduous leaves in granulated form, and is available from Contech Stormwater Solutions, Inc., of West Chester, Ohio. A next layer 34 of the bed may be 6 to 18 inches of sand. A bottom layer 36 may be 6 to 10 inches, or more, of gravel, which contains and covers a perforated pipe or pipe system 38 that collects water that has filtered through the bed.

[0038] In another embodiment only two layers are provided. For example, an upper layer formed by a media mixture consisting essentially of 18-33% (e.g., 25%) by volume of pelletized leaf compost (e.g., CSF), 50-65% (e.g., 57%) by volume pelletized pumice, 10-25% (e.g., 18%) by volume sand and less than 1% by volume water absorbent crystal material. The upper layer may be, for example, 25 to 35 inches deep (e.g., 28" deep). The upper layer may sit upon a lower gravel layer that is, for example, 4 to 8 inches deep (e.g., 6" deep).

[0039] Other variations in the make-up of the bed 30 are possible and contemplated, including beds with more or fewer layers, beds of uniform composition throughout their depth, and beds that utilize other materials.

[0040] The pipe system 38 includes an outlet segment 39 that runs through the dividing wall 14 into the secondary treatment bay 18 and joins with the outlet conduit 40, at a downstream side of the cartridges 42, for subsequent flow to the outlet of the vault. An outlet control valve 41 is positioned to control flow through the primary treatment bay to a desired flow rate according to applicable regulatory requirements. An outlet control orifice could be used in place of the valve 41, with the orifice sized to limit flow. Where a valve is used, the valve could be made as a one way valve that prevents reverse flow from the secondary treatment bay to the primary treatment bay. The valve or orifice 41 is located on the secondary treatment bay side but could readily be located on the primary treatment bay side. The pipe system 38 also includes one or more cleanouts 43 that extend upward above the top of the bed for accessibility. The cleanout access could alternatively be located on the secondary treatment bay side of the system. The valve or orifice feature could also be incorporated into systems that include only a primary treatment bay, without any secondary treatment bay.

[0041] The dividing wall 14 is formed to include an secondary path 44 to the secondary treatment bay. The secondary path may be a pathway at or near the top of the wall. The pathway may include an inclined screen 46 (e.g., made of stainless steel with aperture size of about 5 mm). Excessive flows into the primary treatment bay (i.e., flows that exceed the treatment capacity of the primary treatment bay) will result in an overflow into the secondary bay 18, where the overflow stormwater moves through one or more filter cartridges 42 for treatment. The water treated by the cartridges 42 meets the water treated by the primary treatment bay 16 downstream from both treatment means for mutual outflow. A bypass weir 48 is located in the secondary treatment bay 18 such that flows into the secondary treatment bay 18 in excess of the flow capacity of the filter cartridges 42 will pass directly to an outlet bay 49 and then to the vault outlet 51. In the illustrated embodiment the outlet conduit 40 delivers the treated water to the outlet bay 49.

[0042] FIGS. 1B and 2B depict an alternate embodiment of a stormwater filtration system in which the outlet segment 39' of the perforate pipe system extends through wall 14 and delivers water directly into the outlet bay 49 for subsequent flow through outlet 51. A flow control orifice 41' is sized to act as a limit on flow rate through the bed of the primary chamber 16 (e.g., to a level below the initial infiltration capacity of the bed). The outlet conduit 40 passes through the weir wall 48 to deliver filtered water from the cartridges into the outlet bay 49 for subsequent flow through outlet 51.

[0043] Referring now to FIG. 3, in connection with a stormwater filtration system that utilizes live plant material such as a tree, an advantageous feature may be provided in the form of a lower water reservoir 50 (e.g., below the outlet of the treatment bay) that is, in certain embodiments, either within a layer of open rock material or separated from the bay by a frame and fabric. Other structures for forming the reservoir could be provided. The bay outlet 52 is located above the reservoir 50 to assure that the reservoir is not drained as a result of the outlet path 52. Instead, stormwater that enters the unit filters through the bed 54 and some amount will collect in the reservoir 50. In one implementation, a venting pipe (not shown) may extend upward from the reservoir 50 in order to reduce the likelihood of anaerobic conditions occurring in the reservoir if the filtration bed becomes occluded.

[0044] During drier conditions, the bed 54 containing the live plant material may not receive sufficient water to maintain the live plant material. However, the reservoir can be used to maintain the plant material by providing a wick-type structure 56 with a lower end 58 positioned in the reservoir to absorb water and an upper end 60 positioned in proximity to the root material. In one embodiment, the wick-type structure could be as simple as a rope material with upper and lower ends being frayed. Capillary action of the wick-type structure draws water from the reservoir into the bed as the bed dries out. Alternatively, an active transport system such as a fluid pump or other irrigation feature may be used in place of the wick-type structure. In some cases, the configuration of the soil and live plant material may allow access to the water without the need for any additional structure. For arid and semi-arid regions, native plants or dry tolerant plants should be considered.

[0045] This reservoir feature could be combined with the two bay system of FIGS. 1 and 2 or any other embodiment described herein, in which case the perforated pipe system 38 should be located above the reservoir 50. The size and depth of the reservoir 50 could be configured to match with the anticipated duration of dry periods of the installation location and/or the water needs of the particular live plant material that is used.

[0046] It is recognized that instead of, or in addition to the tree, other live plant material could be used, including grasses and shrubs. The opening 22 and associated tree ring 24 may be replaced by another opening and configuration suitable for the live plant material used. Another option would be to provide the primary treatment bay without any live plant material. For example, a rock surface could overlay the filter bed, particularly where irrigation is unavailable or undesirable. This plant free embodiment could still utilize a water reservoir and wicking apparatus to reduce runoff volumes and encourage biotic activity in the soil.

[0047] Referring now to FIGS. 4A-4D, an additional feature that can be provided in such stormwater filtration systems is a root tray structure. Specifically, a tray or trays 80, which

may be formed of plastic, may be provided for holding plant material at a top portion of a treatment bay. The trays may be formed and located to provide a passage 82 for a tree trunk as shown. Alternatively, other passages may be built into the tray structures to accommodate larger plants such as trees or shrubs that are used in the filtration bed. The trays may be formed with an internal grid structure 84 to provide structural integrity. The bottoms of the tray include openings to allow water to pass downward to the main bed 86 and to allow root growth into the main bed 86. The trays may also be provided with lower water reservoirs 88 for dry conditions.

[0048] The root tray structure is filled with earthen material and may include plants with shallow roots or fibrous roots systems, such as grass or other ground cover. The trays 80 may be designed to accommodate smaller plants known to perform a particular function, such as filtration of specific contaminants, or to provide an additional aesthetic benefit, such as smaller flowering plants. The tray system is easily replaceable in the event that replacing the plant matter therein is desired, such as the failure of the plant material growing therein, or aesthetically-motivated seasonal alteration of the surface of the treatment bay.

[0049] Use of the root tray structure and associated plant matter for ground cover may motivate the use of a more open structure for a treatment bay than that illustrated in FIGS. 1-2. For example, as shown in FIG. 4B, the upper wall of the vault may be primarily or entirely absent to place the plants in open communication with the outside environment. The system can be configured to receive runoff through the top opening from sheet flow or at pointed locations after flow energy reduction via riprap.

[0050] Referring to FIGS. 6A and 6B, a top pan concept is shown. Specifically, at the top of the filter bed a pan structure 100 could be used for erosion control. The pan structure 100 includes a base 102, upturned sidewalls 104 and plurality of openings 106 to permit water flow to the filtration bed. The pan structure may receive water directly from the curb inlet via a break or gap 108 in the upturned sidewall 104, or the pan structure may be placed alongside the rip rap. While shown as a single piece with the tree trunk extending upward through an opening 110 therein, the opening having an upturned sidewall 112, it is recognized that the pan structure could be formed of two or more pieces that meet at the tree trunk opening, so that the pan structure could be more readily removable. The tray may be installed atop the filter bed, around the tree trunk and below the metal grates 114 that provides the opening for the tree. Where the pan footprint is substantially the same as that of the metal grate 114, removal of the pan may be more readily achieved by removal of the grate, and access to the pan for cleaning is also facilitated. However, variations are possible. How much surface area of the bed is covered by the pan may depend on how large the grates are. Large rectangular grates could allow the entire bed to be covered (if desired). The pan could also be manufactured with different tree/plant openings. For example, one centered opening for a tree is shown, patterns of multiple openings for smaller plants could be provided.

[0051] In another aspect, a stormwater filtration system including live plant material may involve multiple vault chambers, or a larger vault with multiple bays, designed to extend over a larger area or footprint. In some implementations these additional vault chambers or bays may be configured to accommodate extended root structures. As shown in FIGS. 5A-C, primary vault chamber or bay 70 includes a tree

71 implanted in the filter bed therein. The tree is accommodated by a tree ring **73** and grate structure that cover the bay. Adjacent to the primary treatment bay **70** are multiple secondary vault chambers or bays **72** designed to accommodate the extended root system of the tree and provide additional filtration over a wider area.

[0052] The secondary vault chambers or bays **72** may be covered by a porous pavement material **74** which allows stormwater to enter. In one embodiment, interlocking concrete pavers can be used. The porous pavement material can be formed into a sidewalk or other surface appropriate for human use in an urban environment. The secondary vault chambers or bays **72** may initially contain little or no root structure when a young tree is installed, but may be built to accommodate the tree's root structure as it matures (e.g., the vault wall or walls separating the bay **70** from respective bays **72** may include openings therethrough to allow passage of the roots). To better accommodate root growth, the secondary vault chambers **72** may include a gap between the porous pavers and the surface of the soil, so that root expansion is unlikely to damage or displace the pavers. The pavers can be supported on inner ledges **90** formed by the walls **92** of the vault so as to provide required structural reliability while maintaining the gap. The porous pavers may be removable for easy maintenance or replacement of the porous pavement material, or to allow for removal or replacement of the filtration bed or the tree therein.

[0053] Depending on the nature of the filtration system, the walls separating the primary and secondary vault chambers may include openings to accommodate the root system, or may be partially or entirely absent. The vault chambers may be part of a tandem structure or may be distinct and modular in construction. In one embodiment, the same shape and material is used for each vault chamber, both primary and secondary, with differing top wall coverings to accommodate the differing live plant matter in the filtration beds. In another embodiment, the primary vault chamber may be structurally distinct from the secondary vault chamber.

[0054] Any of the structures disclosed above may be included in the primary and secondary vault chambers shown here, including the inlet and outflow means, the secondary treatment bay, the reservoir and wick system, and the root tray system. The filtration beds may be of similar composition or may differ between the primary and secondary vault chambers. A variety of perforated pipe configurations may connect the chambers.

[0055] Referring to FIGS. 7A-7B, another embodiment is shown in which stormwater enters the vault unit through an inlet opening **100** into an inlet tray or compartment **102** above the outlet in the outlet bay **104**. The water leaves the tray and flows laterally into the primary treatment bay **106** via opening **108** in wall **110**. Water traveling downward through the primary treatment bay bed enters a pipe system **112** and is directed into the outlet bay **104** through primary bay outlet **114**. Once in the outlet bay water can exit the unit via outlet opening **116**. Water that enters the primary treatment bay in excess of its treatment capacity rises and spills into the secondary treatment bay **117** via overflow opening **118** to pass to the filter cartridges **119**. The secondary treatment bay is sealed from the outlet bay by a metal (or other) wall **120**, except that water passing through the filters enters a pipe **122** and then flows to the secondary bay outlet **124**, which flows into the outlet bay **104**. If the water inflow to the unit exceeds the combined capacity of both the primary treatment bay and

the secondary treatment bay, the water will rise higher in the primary treatment and cause the water level in the inlet tray **102** to rise. The inlet tray **102** is configured with an overflow path **126** directly into the lower portion of the outlet bay **104**, and water can flow over a top of the tray directly into the outlet bay for exiting the unit without passing through either the primary treatment bay or the secondary treatment bay. The lower edge of the overflow path **126** is above the lower edge of the overflow opening **118** in the wall **110**.

[0056] In one example, the inlet tray or compartment **102** may be formed as a metal tray structure mounted to the wall of the vault. The floor component **130** may be removable such that, during installation, and prior to completion of the unit, the floor component may be left out of the unit such that stormwater entering the inlet compartment proceeds directly down to the outlet **116** of the outlet bay **104** without entering the primary treatment bay **106**. Once the unit is ready it can be brought online by installing the floor structure.

[0057] In an alternative arrangement, the unit shown in FIGS. 7A and 7B could be modified such that the overflow opening **118** in the wall **110** is eliminated (i.e., no direct overflow path from bay **106** to bay **117**) and an overflow path **132** directly from the inlet compartment **102** to the bay **117** is provided. In such an arrangement, the incoming water in excess of the primary treatment bay flow capacity would not enter the primary treatment bay in order to travel to the secondary treatment bay.

[0058] Referring to the schematic of FIG. 8, in another alternative embodiment a system **140** includes a primary treatment bay **142** with an associated filtration bed and live plant material, a secondary treatment bay **144** with filter cartridges **146** and an outlet bay **148**. A first vault inlet **150** leads directly into the primary bay **142**, a second vault inlet **152** leads into the secondary bay **144** and a third vault inlet **154** leads directly into the outlet bay **148**. The outlet piping system **156** of the primary bay **142** connects to the piping **158** that receives filtered stormwater from the cartridges **146** and flows into the outlet bay **148**. This arrangement eliminates the overflow paths within the vault, and instead uses a flow control defined by the three openings so that flow in flow direction **160** excess of the primary bay capacity will move downstream to second inlet **152**, and flow in excess of the combined capacity of the primary bay **142** and secondary bay **144** will move downstream to third inlet **154**.

[0059] The schematic of FIG. 9 is illustrative of a system in which the primary treatment bay **170** and secondary treatment bay **172** are formed by separate vault structures that are interconnected by piping **174** for overflow to the secondary bay **172** and piping **176** for delivering bed filtered water to an outlet bay **178**.

[0060] It is to be clearly understood that the above description is intended by way of illustration and example only and is not intended to be taken by way of limitation. For example, another advantageous feature would be to stratify the plant root zones to accommodate a deeper and more complex root zone to promote infiltration, nutrient uptake and plant transpiration. In addition, use of different plant species to create the root zone stratification can also be used to manage the filter bed surface to reduce clogging with complex stem structures which by mechanisms of shrinking, swelling, mechanical movement by wind, new growth and senescence promotes continuously open pores and openings in the soil surface. Moreover, while the primary embodiment shown and described above include a vault structure in which the pri-

mary treatment bay includes a solid bottom wall, it is recognized that the solid bottom wall could be made porous, or with one or more openings, or even eliminated in applications where it would be desirable to have some treated water infiltrate into the ground below the device. The outlet bay could similarly be formed to allow such infiltration. Other variations are possible.

What is claimed is:

1-42. (canceled)

43. A method of treating stormwater, comprising:

providing a vault including a filtration bed therein, a top of the filtration bed exposed to air via an upper opening of the chamber, the filtration bed including live plant matter planted therein, the filtration bed including an initial infiltration capacity;

initially receiving stormwater to be treated at a location adjacent the filtration bed;

subsequently flowing the stormwater through the filtration bed into a pipe system within the filtration bed; and limiting flow through the filtration bed to a level that is less than an initial infiltration capacity of the filtration bed.

44. The method of claim **43** wherein the pipe system defines a flow construction to perform the limiting step.

45. The method of claim **43** including:

flowing at least some stormwater through a porous pavement material.

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