Below is a summary of the proposed language for various design elements for each of the infiltration BMPs in the manual, except for tree trench/tree box. Text that is in bold italics represents suggested new language. Plain text is language that already exists in the manual.

1. Contributing drainage area – created a new table which does not address comments made at the meeting. [Link to table](http://stormwater.pca.state.mn.us/index.php/Stormwater_infiltration_BMPs_-_contributing_drainage_area).
2. Site topography and slopes
	1. Infiltration trench/basin, bioinfiltration: Unless slope stability calculations demonstrate otherwise, it is HIGHLY RECOMMENDED that infiltration practices be located a minimum horizontal distance of 200 feet from down-gradient slopes greater than 20 percent, and that slopes in contributing drainage areas be limited to 15 percent.
	2. Permeable pavement: ***Surrounding topography should have a maximum slope of 20%. Permeable pavement should not be used in areas that are steeply sloped (>15%)***
	3. Underground infiltration: ***Do not use underground infiltration where there is a potential to cause or contribute to slope failure. Site on relatively flat terrain (less than a 5 percent slope). Subsurface infiltration systems may be sited on steeper terrain by designing flatter storage cells that step down the steeper slope. Underground infiltration systems are not recommended on slopes steeper than 25 percent (4:1).***
	4. Dry swale with check dam: ***Site topography should allow for the design of a swale with sufficient slope and cross-sectional area to maintain non-erosive velocities. In areas of steep slopes, swales should run parallel to contours.***
3. Soils
	1. Dry swale with check dam: ***Dry swales should have a 30-inch deep bioinfiltration soil mix as specified in the design criteria for bioinfiltration basin webpage.***
	2. Tree trench/tree box: ***Use a bioinfiltration soil mix as specified in the design criteria for bioinfiltration basin webpage.* MPCA note: current tree page recommends Mix D.**
4. Depth to groundwater and bedrock: this language applies to all infiltration practices - A separation distance of 3 feet is REQUIRED between the bottom of the bioretention practice and the elevation of the seasonally high water table ([saturated soil](http://stormwater.pca.state.mn.us/index.php/Glossary#S)) or top of bedrock (i.e. there must be a minimum of 3 feet of undisturbed soil beneath the infiltration practice and the seasonally high water table or top of bedrock). Note that if underlying soils are [ripped](http://stormwater.pca.state.mn.us/index.php/Construction_specifications_for_bioretention#Soil_ripping) to alleviate compaction, the requirement is a 2 foot minimum between the bottom of the ripped zone and a 3 foot minimum from the bottom of the infiltration practice. If there is only a 3 foot separation distance between the bottom of the infiltration practice and the elevation of the seasonally high water table or bedrock, limit ripping depth to 12 inches.
5. Karst this language applies to all infiltration practices: It is HIGHLY RECOMMENDED that infiltration practices not be used in active [karst](http://stormwater.pca.state.mn.us/index.php/Karst) formations without adequate geotechnical testing.
6. Wellhead Protection areas: This language applies to all infiltration practices - It is HIGHLY RECOMMENDED to review the [Stormwater and wellhead protection](http://stormwater.pca.state.mn.us/index.php/Stormwater_and_wellhead_protection) regarding stormwater infiltration in Wellhead Protection Areas.
7. Site locations/minimum setback distances: This language applies to all infiltration practices - **Warning:** The minimum setback distance from a stormwater infiltration system to a community public water-supply well is 50 feet as REQUIRED by the Minnesota Department of Health. The setback is 35 feet to all other water-supply wells. **Caution:** The minimum setbacks in the table below are HIGHLY RECOMMENDED for the design and location of infiltration practices. It will be necessary to consult local ordinances for further guidance on siting infiltration practices. It is HIGHLY RECOMMENDED that [bioinfiltration](http://stormwater.pca.state.mn.us/index.php/Glossary#B) practices not be hydraulically connected to structure foundations or pavement to avoid seepage and frost heave concerns, respectively. If groundwater contamination is a concern, it is RECOMMENDED that groundwater mapping be conducted to determine possible connections to adjacent groundwater wells. The table below provides the minimum recommended setbacks for the design and location of bioretention practices.
8. Conveyance
	1. Infiltration trench/basin, bioinfiltration: It is HIGHLY RECOMMENDED that a flow splitter or diversion structure be provided to divert the Vwq to the infiltration practice and allow larger flows to bypass the practice, unless the infiltration practice is sized to retain Vcp, Vp10 or Vp100. Where a flow splitter is not used, it is HIGHLY RECOMMENDED that contributing drainage areas be limited to the appropriate size given the BMP and an overflow be provided within the practice to pass part of the Vwq to a stabilized watercourse or storm drain. It is also HIGHLY RECOMMENDED that overflow associated with the Vp10 or Vp100 storm (depending on local drainage criteria) be controlled such that velocities are non-erosive at the outlet point (to prevent downstream slope erosion), and that when discharge flows exceed 3 cubic feet per second, the designer evaluate the potential for erosion to stabilized areas and infiltration facilities. ***An infiltration device can be designed to accommodate a concentrated influent flow; however, an energy dissipater and/or level spreader may be needed. See the pretreatment section for more information on pretreatment devices.***
	2. Permeable pavement: Permeable pavement designs should include methods to convey larger storms (e.g., 2-year, 10-year) to the storm drain system. The following is a list of methods that accomplish this. Place a perforated pipe horizontally near the top of the reservoir layer to pass excess flows after water has filled the base. The placement and/or design should be such that the incoming runoff is not captured (e.g., placing the perforations on the underside only). Pipe placement should be away from wheel loads to prevent damage. Increase the thickness of the top of the reservoir layer. Create underground detention within the reservoir layer of the permeable pavement system. Reservoir storage may be augmented by corrugated metal pipes, plastic or concrete arch structures, etc. Route excess flows to another detention or conveyance system that is designed for management of extreme event flows. Set the storm drain inlets level with the elevation of the permeable pavement surface to effectively convey excess stormwater runoff past the system. The design should also make allowances for relief of unacceptable ponding depths during larger rainfall events. ***When pervious areas are conveyed to permeable pavement, pre-treatment must be provided.***
	3. Dry swale with check dam: ***The longitudinal slope of the dry swale should be between one and two percent. Steeper slopes (up to five percent) may be used in conjunction with check dams (vertical drop of 6 to 12 inches). Check dams require additional energy dissipation measures and should be placed no closer than at 50 to 100 foot intervals. Outlet protection is required at the discharge point from a dry swale to prevent scour. Dry swales should be sized to convey the 10-year storm with a minimum of 6 inches of freeboard, and channel slopes and backs should be designed to prevent erosive channel velocities. Peak flow velocity for the 2-year, 24-hour design storm shall not exceed 1.5 feet per second and have a maximum flow depth of 12-inches. For larger design storms greater than the 2-year, 24-hour, velocities shall be non-erosive. Non-erosive (3.5 to 5.0 fps) peak velocity for the 1-year storm Safe conveyance of the 10-year storm max ponding time of 48 hr It is important that there be a 2” to 4” drop from the edge of the pavement to the top of the grass or stone in the pre-treatment structure to prevent accumulation of debris and subsequent clogging.***
	4. Underground infiltration: ***All infiltration beds should be designed with an overflow for extreme storm events. Control in the beds is usually provided in the form of an outlet control structure. A modified inlet box with an internal concrete weir (or weir plate) and low-flow orifice is a common type of control structure. The specific design of these structures may vary, depending on factors such as rate and storage requirements, but it must always include positive overflow from the system. The overflow structure is used to maximize the water level in the stone bed, while providing sufficient cover for overflow pipes. Generally, the top of the outlet pipe should be 4 inches below the top of the aggregate to prevent saturated soil conditions in remote areas of the bed. Flow may enter the treatment measure in the following ways: 1. Through a pipe 2. Through a drop inlet or catch basin 3. Through roof leader or other conveyance from building roof***
9. Underdrains
	1. Infiltration trench/basin: ***Perforated elevated underdrains are sometimes used to facilitate infiltration. They do not have an underdrain, however, they should be designed with dewatering provisions in the event of failure. This can be done with underdrain pipe systems that can be pumped out or allowed to gravity drain to the surface. For more information on underdrain design, see Underdrains in the design criteria for bioretention webpage.***
	2. Permeable pavement: Permeable pavements without underdrains infiltrate stormwater and should follow requirements for wellhead protection (EPA recommends a minimum setback of 100 feet from water supply wells). Underground utility lines are best located away from permeable pavement bases. However, if they need to penetrate the base, consideration should be given to waterproofing (depending on the utility) or possible encasement using low-strength flowable concrete fill. Setbacks can be reduced at the discretion of the local authority for designs that use underdrains and/or liners. ***The use of underdrains is recommended when there is a reasonable potential for infiltration rates to decrease over time, when underlying soils have an infiltration rate of less than 1/2-inch per hour, or when soils must be compacted to achieve a desired Proctor density.***
	3. Underground infiltration: ***Perforated pipes along the bottom of the bed can be used to evenly distribute runoff over the entire bed bottom. Continuously perforated pipes may connect structures (such as cleanouts and inlet boxes). Pipes should lay flat along the bed bottom and provide for uniform distribution of water. Depending on size, these pipes may provide additional storage volume.***
	4. Dry swale with check dam: ***Design dry swales to completely empty between storms. Where soils do not permit full dewatering between storms, place a longitudinal perforated underpipe on the bottom of the swale bed. The inter-event period used in design to dewater the swale must be no more than 72 hours.***
10. Space required
	1. Infiltration trench/basin: add to existing language ***The maximum storage volume statically stored within the infiltration practice must completely drawdown within 48 hours. An emergency spillway and/or backup underdrain should be constructed if the infiltration device is unable to dewater within 48 hours.***
	2. Permeable pavement: ***Any external drainage area contributing runoff to permeable pavement should generally not exceed twice the surface area of the permeable pavement***
	3. Dry swale with check dams: ***The maximum allowable temporary ponding time within a channel shall be less than 48 hours. Hydraulic Residence Time (HRT) must be a minimum of 9 minutes. Total system must be sized to contain WQv. ponding plus soil media (dry swale)***
11. Slope of the practice
	1. Underground infiltration: ***Surface grading should be relatively flat, although a relatively mild slope between 1% and 3% is recommended to facilitate drainage. Infiltration beds may be placed on a slope by benching or terracing infiltration levels. The slope of the infiltration bed bottom should be level or with a slope no greater than 1%. A level bottom assures even water distribution and infiltration.***
	2. Dry swale with check dams: ***The channel bottom width should be between two and eight feet for construction considerations, water quality treatment, and to minimize the potential for re-channelization of flow. Bottom width of 6ft maximum. Bottom slope of 1% to 2% without check dams, up to 5% with check dams. 4 to 8 feet (widths up to 16 feet are allowable with dividing berm/structure such that neither channel width exceeds 8 feet). If the site slope is greater than 2%, check dams may be needed to retain the water quality volume within the swale system.***
	3. Permeable pavement: ***The bottom slope of a permeable pavement installation should be as flat as possible (i.e., 0% longitudinal slope) to enable even distribution and infiltration of stormwater. However, a maximum longitudinal slope of 1% is permissible if an underdrain is employed. Lateral slopes should be 0%. It is recommended that the surface and subsoil have a 0% slope and the surface have a 0.5% slope if it is at all possible.***
12. Side slopes
	1. Bioinfiltration, infiltration basin/trench, underground infiltration: ***It is HIGHLY RECOMMENDED that the maximum side slopes for an infiltration practice is 3:1 (h:v).***
	2. Dry swale with check dam: ***Dry swales should have a trapezoidal or parabolic cross-section with relatively flat side slopes (3:1 H:V maximum, 4:1 or flatter recommended for maintenance). Channels shall be designed with moderate side slopes (flatter than 3:1) for most conditions. 2:1 is the absolute maximum side slope.***
	3. Permeable pavement: ***Runoff from adjacent areas is directed away from the porous pavement by grading the surrounding landscape away from the site or by installing trenches to collect the runoff.***
	4. Trees: ***vertical walls***
13. Depth
	1. Infiltration trench/basin, bioinfiltration, underground infiltration: The depth of an infiltration practice is a function of the maximum drawdown time and the design infiltration rate. ***It is HIGHLY RECOMMENDED that the soil permeability rate be determined by field testing. When the drawdown time for a bioinfiltration system is 48 hours, the maximum ponding depth is 18 inches for Hydrologic Soil Group (HSG) A soils; 18 inches for SM (HSG B) soils; 14.4 inches for loam, silt loam and MH (HSG B) soils; and 9.6 inches for HSG C soils. If field tested rates for any soil exceed the rate for A soils in the manual (1.63 inches per hour), the maximum ponding depth is 18 inches. When the drawdown time is 24 hours, the above maximum ponding depths are reduced by a factor of 2. Any captured depth beyond the infiltration amount needs to be removed from the BMP within 48 hours via an emergency spillway designed to overflow at the top of the storage volume and/or a backup underdrain to enhance infiltration through the basin.***
	2. Dry swale with check dam: ***Surface storage of WQV with a maximum ponding depth of 18 inches for water quality treatment. Safely convey 2-year storm with non-erosive velocity. Adequate capacity for 10-year storm with 6 inches of freeboard. Maximum ponding depth of 12 inches during WQ storm, 6” of freeboard required for 10-year storm (or 100-year storm if applicable). Flow depth = 4 inches maximum at the WQF.***
14. Groundwater protection
	1. Infiltration trench/basin, bioinfiltration, permeable pavement, dry swale with check dam: It is REQUIRED that runoff from potential stormwater hotspots (PSHs) not be infiltrated unless adequate pre-treatment has been provided. Infiltration of runoff from confirmed hotspot areas, industrial areas with exposed significant materials, or vehicle fueling and maintenance areas is PROHIBITED.
	2. Underground infiltration: It is REQUIRED that runoff from potential stormwater hotspots (PSHs) not be infiltrated unless adequate pre-treatment has been provided. Infiltration of runoff from confirmed hotspot areas, industrial areas with exposed significant materials, or vehicle fueling and maintenance areas is PROHIBITED. ***Underground infiltration systems can also increase the risk of groundwater contamination in comparison to surface infiltration systems by providing a more direct pathway between sources of pollutants at the ground surface and the underlying aquifer. Consequently, pollutants that are accidentally or intentionally spilled at the ground surface, or pollutants present in stormwater runoff, are more able to reach the groundwater aquifer.***
15. Aesthetics
	1. Infiltration trench/basin: Infiltration basins can be effectively integrated into the site planning process, and aesthetically designed as attractive green spaces planted with native vegetation. Infiltration trenches are less conducive to site aesthetics, but the surface of trenches can be designed with turf cover crops if desired. ***Concerning infiltration practices with exposed filter media, keep adjacent vegetation from forming an overhead canopy above infiltration practices, in order to keep leaf litter, fruits, and other vegetative materials from clogging the filter media.***
	2. Bioinfiltration: ***Bioinfiltration basins can be effectively integrated into the site planning process, and aesthetically designed as attractive green spaces planted with native vegetation.***
	3. Underground infiltration: ***Subsurface Infiltration is also appropriate in either existing or proposed open space areas. Ideally, these areas are vegetated with native grasses and/or vegetation to enhance site aesthetics and landscaping. Aside from occasional clean-outs or outlet structures, Subsurface Infiltration systems are essentially hidden stormwater management features, making them ideal for open space locations.***
16. Landscaping
	1. Infiltration trench/basin: ***Add bioretention text and links in this statement. Vegetation should be selected based on a specified zone of hydric tolerance. Plants for Stormwater Design - Species selection for the Upper Midwest is a good resource. Native plant species should be specified over non-native species. Hardy native species that thrive in our ecosystem without chemical fertilizers and pesticides are the best choices. If woody vegetation is placed near inflow locations, it should be kept out of pretreatment devices and be far enough away to not hamper maintenance of pretreatment devices. For turf, sod is recommended over seed.***
	2. Underground infiltration: ***Adequate soil cover (generally 12 - 18 inches) should be maintained above the infiltration bed to allow for a healthy vegetative cover. Open space overlying infiltration beds can be vegetated with native grasses, meadow mix, or other low-growing, dense vegetation. These plants have longer roots than traditional grass and will likely benefit from the moisture in the infiltration bed, improving the growth of these plantings and, potentially increasing evapotranspiration.***
	3. Dry swale with check dam: ***Native grasses are preferred for enhanced biodiversity, wildlife habitat, and drought tolerance. Grass species should be sod-forming, resistant to frequent inundation, rigid and upright in high flows, and salt tolerant if located along a roadway. Dry swales should be planted with species that produce fine and dense cover and are adapted to varying moisture conditions. Swales shall be planted with native vegetation or seeded with turf grass. A specific planting guide shall be prepared for each project. A companion (cover) crop may be necessary for establishing native vegetation. Depending on location of the swale, vegetation shall be selected that is tolerant of road salt and wetness. A planting medium that can support the selected vegetation shall be installed. Use of native and salt-tolerant plants recommended. Follow MnDOT guidelines Table 3876-1 Stormwater Facilities Seed Mix No. 33-262 for Dry Swales.***
17. Check dams (only applies to swales with check dams)
	1. ***The maximum check dam height shall be 12 inches, and the average ponding depth throughout the channel should be 12 inches.***
	2. ***Check dams shall be composed of wood, concrete, stone, or other non-erodible material. The check dam should be designed to facilitate easy mowing (gravel check dams are discouraged).***
	3. ***Check dams must be firmly anchored into the side-slopes to prevent outflanking; check dams must also be anchored into the channel bottom a minimum of 6 inches.***
	4. ***Check dams must be designed with a center weir sized to pass the channel design storm peak flow (10-year storm event if an on-line practice).***
	5. ***Armoring may be needed at the downstream toe of the check dam to prevent erosion.***
	6. ***Check dams shall be spaced based on channel slope, as needed, to increase residence time, provide storage volume, or meet volume attenuation requirements. The ponded water at a downhill check dam should not touch the toe of the upstream check dam.***
	7. ***Each check dam should have a weep hole or similar drainage feature so it can dewater after storms.***
	8. ***Individual channel segments formed by check dams should generally be at least 25 to 40 feet in length.***
	9. ***Follow MnDOT Guidelines 2573.3 Construction Requirements for ditch check installation***
18. Safety – insert infiltration basin language into all infiltration practices: ***Dry wells, infiltration trenches and subsurface infiltration systems do not pose any major safety hazards. Infiltration basins should have similar side slope considerations as ponds and wetlands. Warning: If a dry well or infiltration trench is greater than five feet deep, it is REQUIRED that OSHA health and safety guidelines be followed for safe construction practices.***
19. Maximum flow path – insert bioinfiltration language into all infiltration practices: ***Flow path length is important only if high flows are not bypassed. Below are recommendations from other states or localities.***

***•North Carolina: The geometry of the cell shall be such that width, length, or radius are not less than 10 feet. This is to provide sufficient space for plants.***

***•Virginia: Length of shortest flow path to overall length is 0.3 for Level 1 Design and 0.8 for Level 2 Design***

***•Dakota County Soil and Water Conservation District: Where off-line designs are not achievable, bioretention practices shall be designed to route high flows on the shortest flow path across the cell to provide the least disturbance and displacement of the Water Quality Volume to be treated. Energy dissipation to avoid high flow velocity turbulence is required.***

1. Use of multiple cells – insert bioinfiltration language into all infiltration practices: ***(In comparison to multiple cells, one large bioretention cell will often perform just as well as multiple smaller cells if sized and designed appropriately. One large cell is generally less costly than multiple smaller cells. This is due to the simpler geometry and grading requirements of one large cell, as well as a reduction in piping and outlet structures. Multiple smaller cells do however provide greater redundancy, i.e. if one large cell fails, more function is lost than if just one of multiple cells fail. Multiple cells are also more feasible than one large cell in steep terrain (slopes greater than 5 percent), where they can be terraced to match the existing grade. Provided access is maintained to each cell, multiple cells typically results in less and easier maintenance.)***
	1. Underground infiltration add: ***If using a proprietary system, determine the number of cells based on the manufacturer's design.***
	2. Tree trench/tree box, add: ***Multiple tree box filters can be used along a street in separate boxes or as a single extended unit. Determine number of trees required based on drainage area.***
2. Snow considerations
	1. Infiltration trench/basin, bioinfiltration: Considering management of snow, the following are recommended: Plan a plow path during design phase and tell snowplow operators where to push the snow. Plan trees around (not in) plow path, with a 16 foot minimum between trees. Plan for snow storage (both temporary during construction and permanent). Don’t plow into infiltration practices routinely. Infiltration practices should be last resort for snow storage (ie only for during very large snowevents as “emergency overflow”). Snow storage could be, for example, a pretreatment moat around an infiltration practice, i.e. a forebay for snow melt.
	2. Underground infiltration: same language as above but add ***The surface (above the stone bed) should be compacted as minimally as possible to allow for surface percolation through the engineered soil layer and into the stone bed.***
	3. Dry swale with check dam: Chloride use on source areas tributary to a swale can be reduced or eliminated by minimizing the amount of compound used, using alternative de-icers or using clean sand.
	4. Permeable pavement: Plowed snow piles should be located in adjacent grassy areas so that sediments and pollutants in snowmelt are partially treated before they reach all permeable pavements. Sand is not recommended for winter traction over permeable pavements. If sand is applied, it must be removed with vacuum cleaning in the spring. Traction can be accomplished on PICP using jointing stone materials, some of which will find its way into the joints by springtime. A significant winter advantage of permeable pavements is that they require less deicing materials than their impervious counterparts. Use of deicing material on permeable pavement is therefore not recommended. ***As with any type of pavement surface, frost heave is a concern where freezing temperatures are prevalent in the winter months. To reduce the possibility of frost heave, the base layer should be placed at 65% of the frost line. (17, J, and UNHSC 2009)***