COLORADO PROFESSIONALS IN ONSITE WASTEWATER (CPOW)
GUIDELINES FOR THE DESIGN AND INSTALLATION OF NON-PRESSURIZED DRIP DISPERSAL SYSTEMS (NDDS)
REVISION: October, 2024

1.0 BACKGROUND

Non-Pressurized Drip Dispersal Systems (NDDS), previously known as Low Pressure Pipe or "Bell-Patt" systems, have successfully been used in Colorado since the early 1980's (Church, 1997). NDDS are typically used in clay soils with poor percolation rates by providing appropriate effluent distribution for absorption with incidental evapotranspiration. The Office of the State Engineer, in a letter dated July 31, 1995, indicated that "it complies with the statutory requirement of returning the effluent to the stream system in which the well is located."

NDDS utilize 2" diameter dispersal pipe with ¼ inch orifices placed at the "6 o'clock" position, spaced at 8" on center. Laterals are installed by using a "trencher" to install shallow (12" to 30" deep) trenches, at two feet on center. A typical trench width is 6"- 8". Laterals within each zone are placed level, from the proximal to the distal ends, and within the zone. Laterals are connected at the proximal ends by a zone manifold. A typical NDDS system is comprised of multiple zones, with the effluent to each supplied from a main manifold, which distributes effluent from the pumped supply line.

In 2014, CPOW assembled a group of industry professionals to develop guidelines to assist in the proper design of NDDS. The CPOW NDDS Committee (Committee) decided to adopt much of the historic design criteria, but included more explicit requirements for soils and separation to a limiting condition. To keep sizing similar to previous systems, the Committee used the sizing formula in Section 43.10.C.4 of Colorado Department of Public Health and Environment (CDPHE) OWTS Regulation 43 and included "adjustment factors". The adjustment factors were calculated by comparing sizes determined using the previous formula with sizes from the sizing formula in Section 43.10 C.4 of Regulation 43.

In 2016, CPOW again assembled a committee to provide updates to the original NDDS design document. These additions included sections on how to address orifice plugging, the use of effluent filters, proper effluent distribution, and modified sizing requirements, among others. A reference to this document was then included in the 2017 update to Regulation 43, Colorado's Onsite Wastewater Treatment System Regulation. After several more years of evaluating the function and longevity of NDDS, a group of industry professionals was again assembled. This group has provided additional modifications to this document.

1.1 **CONDITIONS KNOWN TO CAUSE FAILURES OF NDDS INSTALLATIONS**

1) Rotation of zones does not occur in the designated time frames
2) Systems installed on north-facing slopes
3) Systems installed on sites with extensive tree cover (shaded)

4) Header/distribution manifolds were not installed level, or over-excavation caused piping to settle. Effluent then saturated certain areas of the system
5) Systems installed on sites on excess of 5% slopes. Effluent follows distribution piping to low point if not properly compacted
6) Installed when the soil was above its plastic limit; causing smearing of the sidewall and infiltrative surface, thus a reduction in soil permeability. (see section 3.4.2)
7) Irrigated lawns or landscaping over the area where NDDS is installed
8) Orifice plugging

1.2 DESIGN OPTIONS

As an additional point of information, installers and designers may want to consider alternative designs to NDDS systems that better incorporate current technology to address low permeability soils. Subsurface drip dispersal systems have been used for decades, and over the past several years have been found to be applicable within the onsite wastewater industry. The advantages over an NDDS system are the pressure compensating emitters which achieve equal distribution throughout a soil treatment area (even along sloping terrain), and may allow for longer distribution lines. This type of dispersal takes advantage of evapotranspiration from surface vegetation and very low flow rates within the emitters. The nominal flow rates per emitter allow for unsaturated flow during dosing cycles. The systems are most commonly used in conjunction with higher level treatment systems. The treated effluent reduces the organic loading to the soil, thus reducing clogging of soil pores, thus providing increased permeability. Both drip dispersal and higher level treatment systems are applicable for sites with 3A - 5 soil types.

1.3 MAINTENANCE AND OVERSIGHT

As continued maintenance is a critical component of system longevity, the installation of new NDDS must only occur where the local public health agency requires use permits and implements an oversight program to ensure that the system receives continued maintenance.

2.0 DIAGRAMS

The attached diagrams illustrate a typical NDDS system.

3.0 DESIGN AND INSTALLATION STANDARDS

The following design and installation standards will apply to NDDS:

1) NDDS shall be designed by a Colorado Registered Professional Engineer.
2) NDDS shall only be used where soil types 3A-5 exist within three feet of existing grade.
3) Sizing of the soil treatment area (STA) shall conform to Section 3.1

4) Trenches shall be excavated into undisturbed soils, unless installed in areas of suitable fill material, or cuts, as described below.
5) Where irregular topography is present at the location of the STA, as discussed in Section 3.2, such that cut and or fill are necessary, the design engineer shall submit a plan that, at a minimum, addresses the following requirements:
   a. Existing and proposed elevation contours
   b. Type of fill material to be placed
   c. Methods of placement, to include lift thickness and level of compaction
   d. Slope of fill, and or cuts, to assure adequate drainage of precipitation runoff
   e. Preparation of the surface of the existing soil, prior to placement of the fill material
6) The designer shall assess the potential for trench sidewall collapse if trenches are excavated in Soil Type 1 (sand or loamy sand), as discussed in Section 3.3. If the potential exists, the designer shall specify construction means and methods necessary to avoid or minimize trench collapse.
7) Trenching shall not occur when soils are wet enough for the soils to smear. In terms of moisture content, this can be considered to be at or above the "plastic limit" for the soils.
8) Trenching shall be done with a trencher, unless otherwise specified in the engineer design and approved by the local public health agency. Examples of where excavation with a backhoe would be acceptable include, but not be limited to: sandy soils, slopes exceeding 5%.
9) Trenches shall be spaced at 2 feet center to center, and shall be 6-8 inches wide, unless otherwise specified in the engineer design and approved by the local public health agency.
10) Laterals installed within the trenches shall be 2 inches in diameter.
11) Lateral piping material shall consist of: Schedule 40 PVC; or, Class 200 PVC, SDR 21; or, equivalent.
12) Lateral orifices shall be ¼ inch, at 8" on center, in the six o'clock position.
13) The trench bottom shall be level ± two (2) inches. Trench depth shall not exceed thirty (30) inches and trench length shall not exceed one hundred (100) feet, unless otherwise noted below:
   a) Where site conditions necessitate longer laterals, a center manifold must be used. Laterals may extend no more than100 feet in either direction from the manifold. Such conditions may include:
      (i) Where sloping site conditions require the width of the distribution cell to drop greater or equal to 5%.
      (ii) Site limitations due to required setbacks to physical features, such as a dry gulch, surface water, tree line, property line, driveway, floodway, or other such impediments that limit the width of the STA.
14) The designer shall assess the potential for orifice plugging due to clay soils as discussed in Section 3.4. If it is determined that aggregate is necessary in order to minimize the potential for orifice plugging by clay particles, the designer shall specify the gradation and depth of the aggregate.
15) NDDS shall be dosed. Options for effluent distribution include: Manual Rotation using 2-inch or similar ball valves; or automated rotation using an Automatic Distributing Valve (ADV). The designer shall refer to Section 3.5 for a discussion of the factors to consider when selecting the distribution method.
16) Dose Volume: NDDS using manual rotation:

a) The dose volume shall be sufficient to completely fill the following pipe components:
   i) the supply line from the pump to the first primary manifold,
   ii) the primary manifold,
   iii) the supply lines from the primary manifold to the zone manifolds,
   iv) the zone manifolds
b) The dose volume shall be sufficient to fill the perforated distribution laterals to 35% of capacity:

17) Dose Volume-NDDS using an ADV:
   a) The dose volume shall be sufficient to completely fill the following pipe components:
      i) The supply line from the pump to the ADV
      ii) The supply line from the ADV to the zone manifolds
      iii) the zone manifolds
   b) The dose volume shall be sufficient to fill the perforated distribution laterals to 35% of capacity:
18) Design Flow through ADV:
   a) Most ADV require 15 GPM to operate and work at pressures from 25 to 150 PSI (25-288 feet of head). The design engineer shall comply with ADV manufacturer specifications to assure that the design flow is adequate to assure proper operation of the ADV.
19) Pump requirements – While the dose volume must accommodate the pipe volumes listed in items 16 and 17 above, the pump should also be sized to dose the system in a short period of time, thus quickly charging the full length of the distribution laterals. Subsequently for this reason, for superior ADV performance, and for increased velocities through the system, a high head pump providing at least 30 gpm, or a 3/4 hp effluent pump meeting system requirements must be used.
20) Effluent Filter
   a) An effluent filter shall be installed to minimize the potential for suspended solids to enter the distribution laterals and contribute to orifice plugging.
21) The NDDS shall include an "air relief valve" or "snifter" to allow the system to gravity drain back to the tank and into the distribution system, once the pump shuts off. Where the supply line from the pump runs "uphill" to the primary manifold or an ADV, the valve shall be located at the high point in the supply line. Where the supply line from the pump runs downhill to the primary manifold, the valve shall be located inside the tank, to prevent siphoning of effluent from the tank to the supply line.
22) An inspection port, connected to the distal end of one lateral in each zone shall be installed. The inspection port shall extend at least 12" above grade, or may be left "below grade" if placed into a protective housing with an accessible cover flush to grade.
23) No irrigation is allowed over the NDDS installation.
24) Upon completion of the NDDS soil treatment area, the area shall be seeded. Seeding shall be done in a manner that does not damage the system. Recommendations for seed mixes can be obtained from the local Natural Resources Conservation Service and/or the county public works departments responsible for grading, erosion and sediment control permitting. Vegetation that does not require irrigation is recommended.
25) In observing the construction of the NDDS, the engineer or system contractor shall utilize appropriate equipment to assure that the distribution laterals are installed within the elevation tolerances of ± two (2) inches.

26) Four (4) feet of vertical separation is required to a limiting condition or layer, as defined in CDPHE Regulation #43.

3.1 SYSTEM SIZING

The minimum NDDS system area shall be calculated using the following formula[1]:

$$\boldsymbol{NDDS\ Area} = (\boldsymbol{Design\ Flow}\ \div \boldsymbol{LTAR}) \times \boldsymbol{Size\ Adjustment\ Factor}$$

Where:
NDDS Area: Soil treatment area, in square feet (**Note**: For residential systems, the minimum NDDS area shall be no less than 4,000 square feet or 1,000 square feet/bedroom, whichever is greater.)
Design Flow: Flow in gallons per day
LTAR: Long Term Acceptance Rate, in gallons per day per square foot, from Table 10-1 in CDPHE Regulation 43. NDDS shall only be used where soil types 3A-5 exist within three feet of existing grade.

Size Adjustment Factor: From Table 1 below

[1]The minimum area so calculated shall be comprised of the lateral trenches, the area between the lateral trenches, plus an additional one foot outside the outermost distribution laterals and the proximate and distal ends of the laterals. Each lineal foot of distribution lateral shall be the equivalent of two (2) square feet of NDDS area.

TABLE 1: NDDS SIZE ADJUSTMENT FACTORS		
Soil Type[1]	**Percolation Rate**	**Size Adjustment Factor**
1, 2, 2A, & 3	**N/A**	**N/A,**
3A	**61-75**	**2.2**
4	**76-90**	**1.7**
4A	**91-120**	**1.5**
5	**121+**	**1.4**

[1] NDDS must not be installed in soil types 1, 2, 2A and 3

3.2 IRREGULAR TOPOGRAPHY

Where the topography of the ground surface at the proposed NDDS soil treatment area (STA) is irregular, the design engineer may specify cut and fill in order to allow for installation of the distribution laterals within the 12inch to 30-inch depth limits. The extent and depth of cut and fill area shall be minimized, with the overall objective to maintain the minimum and maximum depths of the distribution laterals

3.3 TRENCH SIDEWALL STABILITY IN SANDY SOILS

In cases where all or a portion of the NDDS trenches will be excavated in Soil Type 1 (sand or loamy sand), the designer needs to consider that trenches excavated for distribution laterals may collapse or "cave" during the excavation process. The typical 6"-8" wide trench constructed with a trencher may not be feasible in sandy soils. A possible alternative may be to excavate the trenches with a backhoe. However, sidewall instability may still be a problem. In cases where type 1 or type 2 soils exist in the upper two feet, other design options, such as a mound system, must be considered. NDDS must not be installed in these soil conditions.

3.4 ORIFICE PLUGGING

Problems with orifice plugging have been identified with some NDDS. This problem may be attributed to intrusion of clay particles into the orifices and subsequent biological clogging of the orifices due to water "holding" in the lateral distribution pipe.

It may be possible to reduce orifice plugging by the installation of imported aggregate material in the bottom of the NDDS trenches. The aggregate needs to be sized so that it can be readily placed into the lateral trenches and prevent settlement of the laterals after backfill.

3.4.1 PLASTIC LIMIT OF SOIL

NDDS must not be installed when the soil is above its plastic limit. The plastic limit of soil is the moisture content at which a fine-grained soil can no longer be remolded without cracking, or rolled into a thread without breaking. The plastic limit is determined by gradually adding water to a soil sample and kneading it until it reaches the desired consistency. Then, the soil is repeatedly rolled out by hand on a non-porous surface in an ellipsoidal shape. If the thread crumbles at a diameter smaller than 3 mm (1/8 in), the soil is too wet, and if it crumbles at a diameter greater than 3 mm, the soil meets the moisture requirements and construction may begin.

3.5 EFFLUENT DISTRIBUTION

Typical NDDS utilize manual valves at the main manifold to allow for alternation of the zones. In a typical NDDS, the valve to one zone is "shut off" for a period of 6 months to one year, to allow it to rest, while the other zone valves are left open. With proper maintenance, the zones are rotated at the designated time periods, leaving one zone closed, while the other zones are open and operational. The problem is that many of owners don't know about the need to rotate the valves, and thus do not rotate the valves as required. As a result, the active zones are overloaded, which may cause premature failure of the NDDS.

The use of an Automatic Distributing Valve (ADV) provides automatic rotation of the zones, with each dose. However, the ADV requires careful installation and inspection (at the time of installation and throughout the life of the system) and maintenance to assure that it is functioning. A poorly installed and/or maintained ADV can be as much as, or more of a problem, than manual valves that are not rotated.

The designer should assess whether or not to specify an ADV on each design. If the designer decides to use an ADV, the manufacturer's minimum requirements for flow and head loss through the ADV need to be accounted for in the design.

4.0 SPECIAL REGIONAL AND LOCAL GEOLOGICAL CONDITIONS

The soils analysis required in Regulation #43 is sufficient to characterize most subsurface conditions; however, for certain conditions, additional research, site evaluation and analysis are necessary. OWTS professionals need to understand the local geological conditions and how those conditions relate to the design, installation and performance of OWTS.
While the standards noted in this document should address the majority of site conditions for the design of a NDDS, it is not the objective of this guidance to inform OWTS professionals how to design or review NDDS for all geological conditions in the State of Colorado. The CPOW NDDS Guidance Committee is aware that there are specific geological conditions which may require slight modifications to these design standards in order to ensure that the NDDS is properly designed. Guidance for these situations should be science based and the information provided should encompass as much technical data as necessary and provide an avenue for consistency for designers and regulators in the future. Subsequent to a request by a few counties, CPOW has provided an example of such a document relative to the Dawson Arkose Formation located within the Denver Basin. For those OWTS professionals practicing within the Denver Basin, the Dawson Arkose information, located in Appendix A, should be carefully reviewed, understood, and applied.

CPOW is available to assist any group which defines a geological condition that falls into the above noted category and warrants additional site-specific criteria.

References:

Church, E. O., "Drip Irrigation Onsite Wastewater Systems – Colorado", Site Characterization and Design of On-Site Septic Systems", ASTM STP 1324, M.S. Bedinger, A. I. Johnson, J. S. Fleming, Eds., American Society for Testing and Materials, 1997)

Natural Resources Conservation Service Field Book for Describing and Sampling Soils, National Soils Survey Center NRCS-USDA, September, 2002 (NRCS Field Book),

July 31, 1995 letter from Office of the State Engineer

Soister, Paul, "Stratigraphy of the Uppermost Cretaceous and Lower Tertiary Rocks of the Denver Basin", 1978

APPENDIX A
SPECIAL REGIONAL GEOLOGICAL CONDITONS IMPACTING THE DESIGN AND INSTALLATON OF NDDS

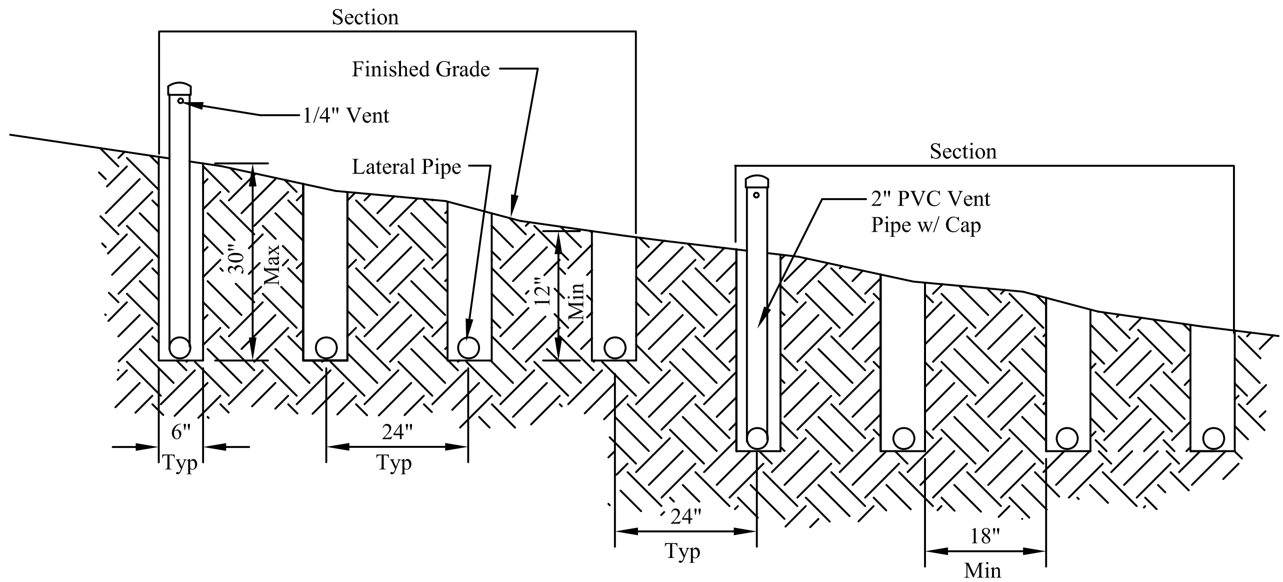
The Dawson Arkose formation is found in the Front Range of Colorado within the hydrogeological area known as the "Denver Basin". Figure 1, in the paper titled "Stratigraphy of the Uppermost Cretaceous and Lower Tertiary Rocks of the Denver Basin" illustrates the extent of the Dawson Arkose. Although cementation of the Dawson Arkose can vary from non-cemented to indurated, in some locations, the Dawson Arkose has the characteristics of Type 3A and 4A soils, from Table 10-1 in Regulation #43. If the Dawson Arkose is present on the site, the site evaluator shall determine whether it is suitable for the installation of NDDS, and provide a statement in the site evaluation report stating the characteristics of the Dawson Arkose that render it suitable.

At a minimum, the site evaluator shall evaluate the following characteristics:

1. Whether the material is fractured and jointed
2. The cementation class of the Dawson Arkose. Using the cementation classes from the Rupture Resistance Table on page 2-50 of the Natural Resources Conservation Service Field Book for Describing and Sampling Soils, National Soils Survey Center NRCS-USDA, September 2002 (NRCS Field Book), the following cementation classes will be considered **suitable:** Non-Cemented (NC), Extremely Weakly Cemented (EW), Very Weakly Cemented (VW), Weakly Cemented (W). The following cementation classes will be considered **unsuitable**: Moderately Cemented (M), Strongly Cemented (ST), Very Strongly Cemented (VS), Indurated (I).
3. The Dawson Arkose material within four vertical feet of the deepest infiltrative surface of the trenches.
4. The soil class from Table 10-1, as determined from the tests, as specified in Regulation #43, in order to determine the associated Long Term Acceptance Rate (LTAR).

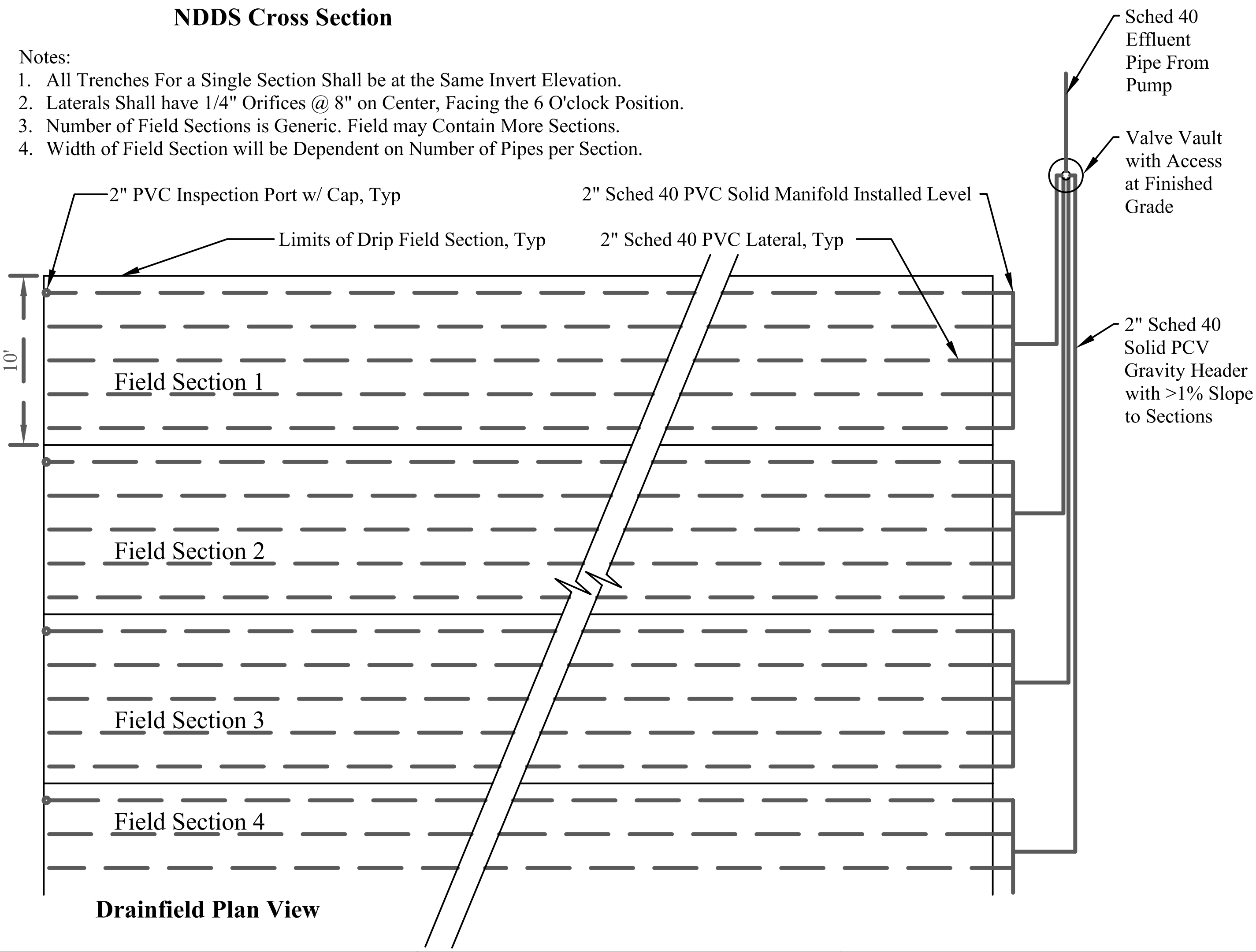
The table below summarizes characteristics 1 and 2 above. A "yes" answer to either question below means the material is unsuitable for the installation of a NDDS.

DAWSON ARKOSE CHARACTERISTIC	**ANSWER (A YES ANSWER MEANS THE DAWSON ARKOSE IS UNSUITABLE)**
1. Is material fractured and/or jointed?	Yes / No
2. Is the cementation class, M, ST, VS, or I?	Yes / No



NDDS Cross Section

Notes:
1. All Trenches For a Single Section Shall be at the Same Invert Elevation.
2. Laterals Shall have 1/4" Orifices @ 8" on Center, Facing the 6 O'clock Position.
3. Number of Field Sections is Generic. Field may Contain More Sections.
4. Width of Field Section will be Dependent on Number of Pipes per Section.



Drainfield Plan View

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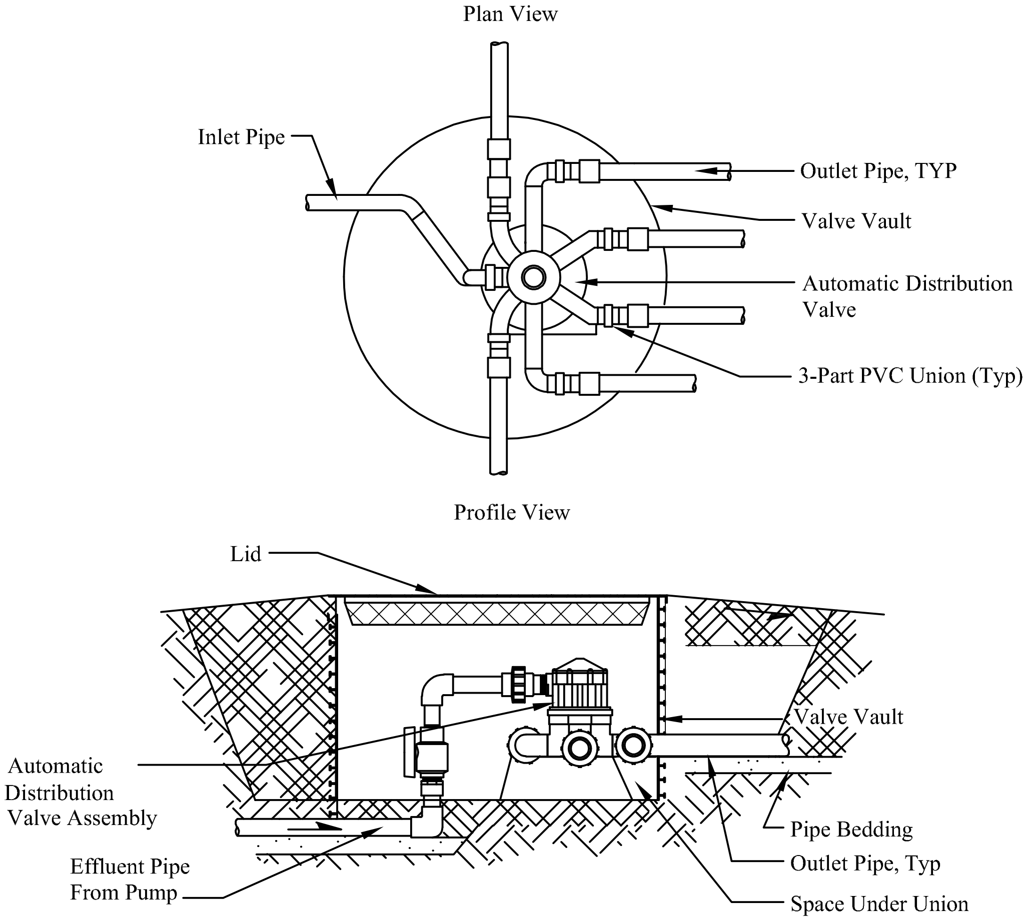
Non-Pressurized Drip Dispersal System (NDDS)

Diagram 1: NDDS Plan and Cross Section

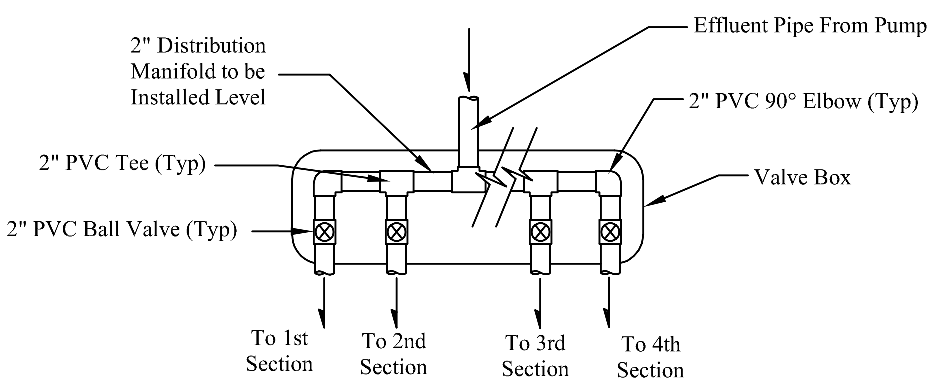
Automatic Distribution Valve (ADV)



Notes:

1. ADV Shall be Installed at the High Point of the System. Min 1% Slope Shall be provided to Drain Effluent from ADV to Field and Septic Tank.
2. Valve Vaults / Boxes shall be Installed to Allow Access from Finished Grade.

Distribution Manifold & Valves



CPOW Colorado Professionals in Onsite Wastewater	**Non-Pressurized Drip Dispersal System (NDDS)**	**Diagram 2: Effluent Distribution Options**