COLORADO PROFESSIONALS IN ONSITE WASTEWATER (CPOW)
GUIDELINES FOR THE DESIGN AND INSTALLATION OF NON-PRESSURIZED DRIP DISPERSAL SYSTEMS (NDDS)
REVISION: SEPTEMBER 2016

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 developing these guidelines, the CPOW NDDS Committee (Committee) decided to adopt much of the historic design criteria which had a history of successful function. The Committee developed 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.

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) Sizing of the soil treatment area (STA) shall conform to Section 3.1
3) Trenches shall be excavated into undisturbed soils, unless installed in areas of suitable fill material, or cuts, as described below.

4) 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
5) 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.
6) 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.
7) 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 12% and soils with cobbles.
8) 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.
9) Laterals installed within the trenches shall be 2 inches in diameter.
10) Lateral piping material shall consist of: Schedule 40 PVC; or, Class 200 PVC, SDR 21; or, equivalent.
11) Lateral orifices shall be ¼ inch, at 8" on center, in the six o'clock position.
12) Trench depth shall not exceed thirty (30) inches and trench length shall not exceed one hundred (100) feet. The trench bottom shall be level ± two (2) inches.
13) 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.
14) 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.
15) 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 25-50% of capacity:
16) 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 25-50% of capacity:

17) Design Flow through ADV:

a) An ADV requires a minimum flow rate in order to operate properly. The design engineer shall consult with the ADV manufacturer to assure that the design flow is adequate to assure proper operation of the ADV.

18) 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.

19) 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.

20) 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 accessible cover flush to grade.

21) No irrigation shall be allowed over the soil treatment area.

22) 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.

23) 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.

24) 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]:

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

Where:

NDDS Area: Soil treatment area, in square feet (**<u>Note</u>**: 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 the treatment depth (four feet below the distribution laterals).

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	**Percolation Rate**	**Size Adjustment Factor**
1, 2, 2A, & 3[2]	**N/A**	**N/A,**
3A	**61-75**	**2.2**
4	**76-90**	**1.7**
4A	**91-120**	**1.5**
5	**121+**	**1.4**

[2]These soil types are unsuitable for an NDDS

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.

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 Aggregate

The NDDS Committee reviewed the Colorado Department of Transportation (CDOT) Specifications for aggregate to assess common construction aggregates that can be expected to be available from commercial sources. Of the aggregates in the CDOT

Specifications, three aggregates may be suitable: Class 6 Aggregate Base Course, No. 8 Concrete Aggregate, and Class C Filter Material.

Specifications for each of the three CDOT aggregates are summarized below:

CDOT Class 6 Base Course:

Sieve Size	**Percent Passing Square Mesh Sieves**
	Liquid Limit <30
19 mm (3/4”)	100
4.75mm(#4)	30-65
2.36 mm (#8)	25-55
75 µm (#200)	3-12

CDOT No. 8 Concrete Aggregate:

Sieve Size	**Percent Passing**
12.5 mm (1/2”_	100
9.5 mm (3/8”)	85-100
4.75 mm (#4)	10-30
2.36 mm (#8)	0-10
1.18 mm (#16)	0-5

CDOT Class C Filter Material:

Sieve Size	**Percent Passing**
19 mm (3/4”)	100
4.75 mm (No. 4)	60-100
300 µm (No.50)	10-30
150 µm (No. 100)	0-10
75 µm (No 200)	0-3

The CPOW NDDS Committee recommends that designers of NDDS evaluate the soils’ characteristics to determine the need to specify aggregate in the bottom of the lateral trenches. In “heavy clay soils”, typically Soil Types 4, 4A, and 5, orifice plugging is likely. Installation of aggregate “bedding” below the laterals may reduce orifice plugging. Aggregate “bedding” can provide the additional benefit of a “leveling course” in cases where there is variation in the depth and levelness of the bottom of the lateral trench due to soil clods or larger sized rock fragments.

The CDOT Specifications are intended to provide guidelines for the type of aggregate that may be suitable. The designer may select other materials meeting similar specifications. The depth of aggregate shall be sufficient to fill in irregularities in the bottom of the trench sufficiently to allow the laterals to be installed within the allowable tolerance of + or – 2 inches” and to prevent or minimize the intrusion of those soils’ into the lateral orifices. The minimum depth of the trenches and aggregate depth shall be specified to provide a minimum of 10" of cover over the laterals.

CDOT Class 6 base course contains 3-12% "fines" which is comprised of silts and clays. Once the NDDS is placed into use, the silt and clay particles will concentrate at the base of the aggregate layer on top of the infiltrative surface on the bottom of the trenches. This may create a layer that is more limiting than the underlying soils at the infiltrative surface. Due to the limiting layer formed by the silt and clay particles in the aggregate material, the designer shall only use this material where the soils at the infiltrative surface are Type 4A or 5.

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 successively rotated, leaving one valve closed on each zone while the other valves are open. The problem is that the majority of owners don't know about the need to rotate the valves, and/or don't rotate the valves. 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 recommendations 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 to 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

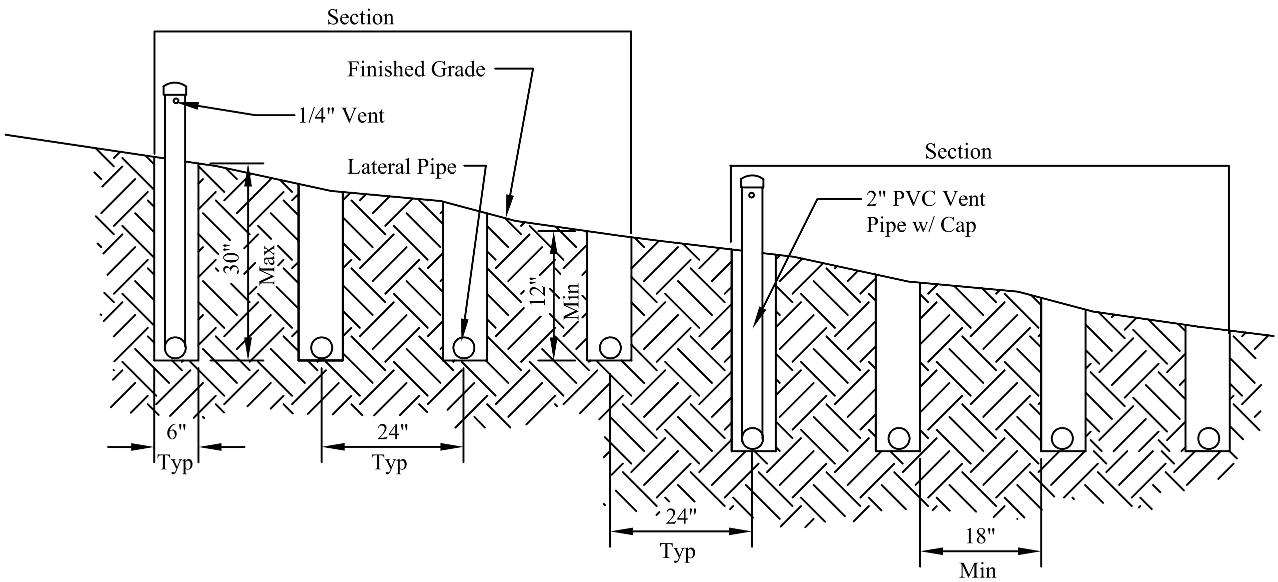
The Dawson Arkose formation is found in the Front Range of Colorado within the hydrogeological area known as the "Denver Basin". Figure 1, in the paper titled "Stratigraphy of the Uppermost Cretaceous and Lower Tertiary Rocks of the Denver Basin" illustrates the extent of the Dawson Arkose. Although 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).

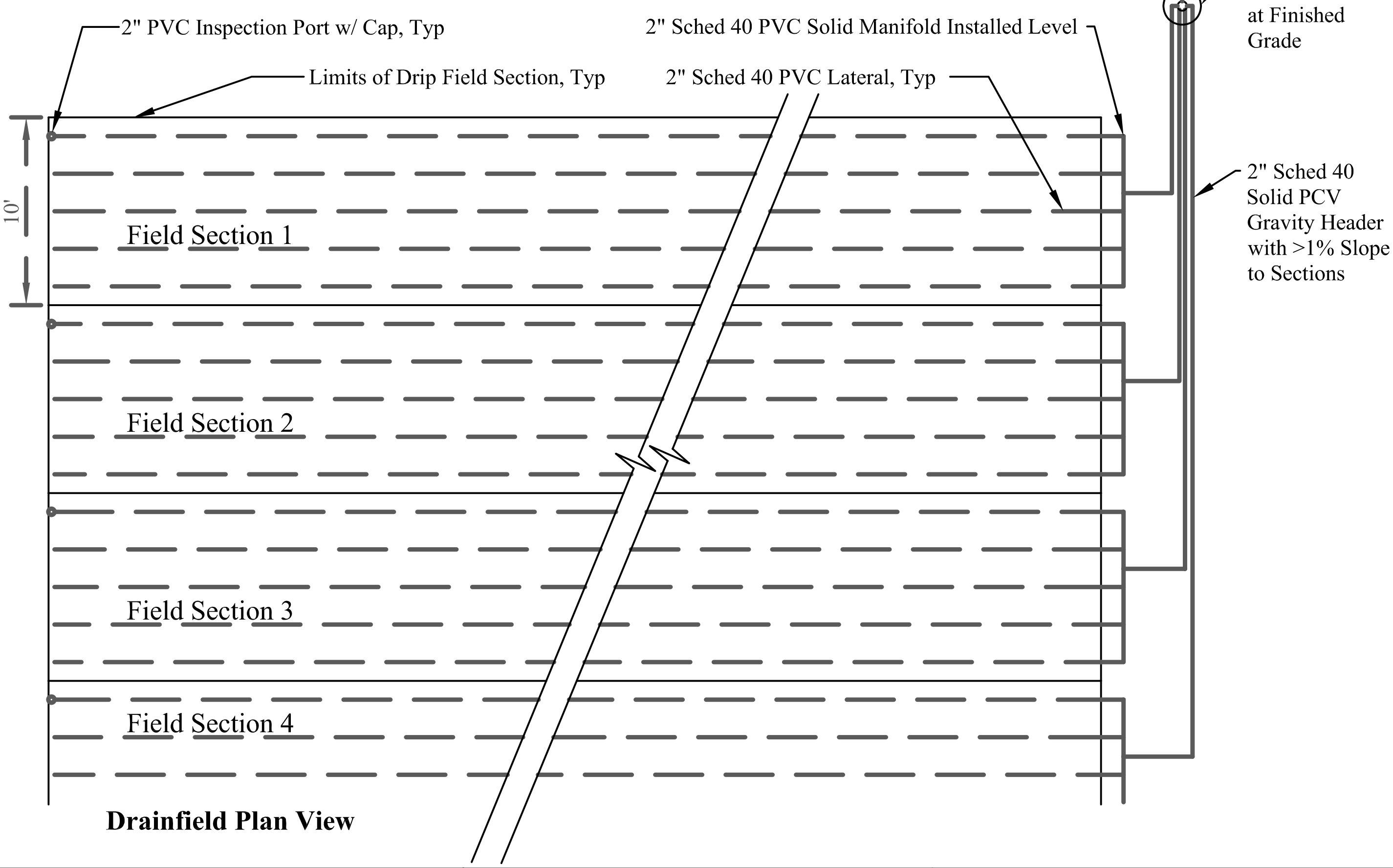
The table below summarizes characteristics 1 and 2 above. A "yes" answer to either question below means the material is unsuitable for the installation of a NDDS.

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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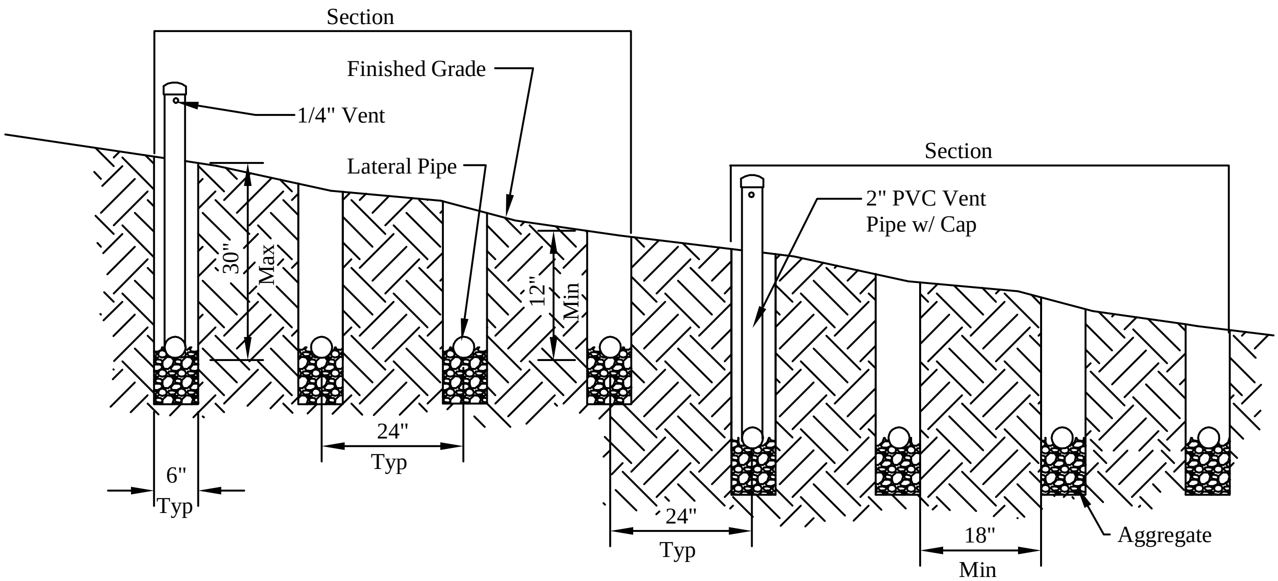
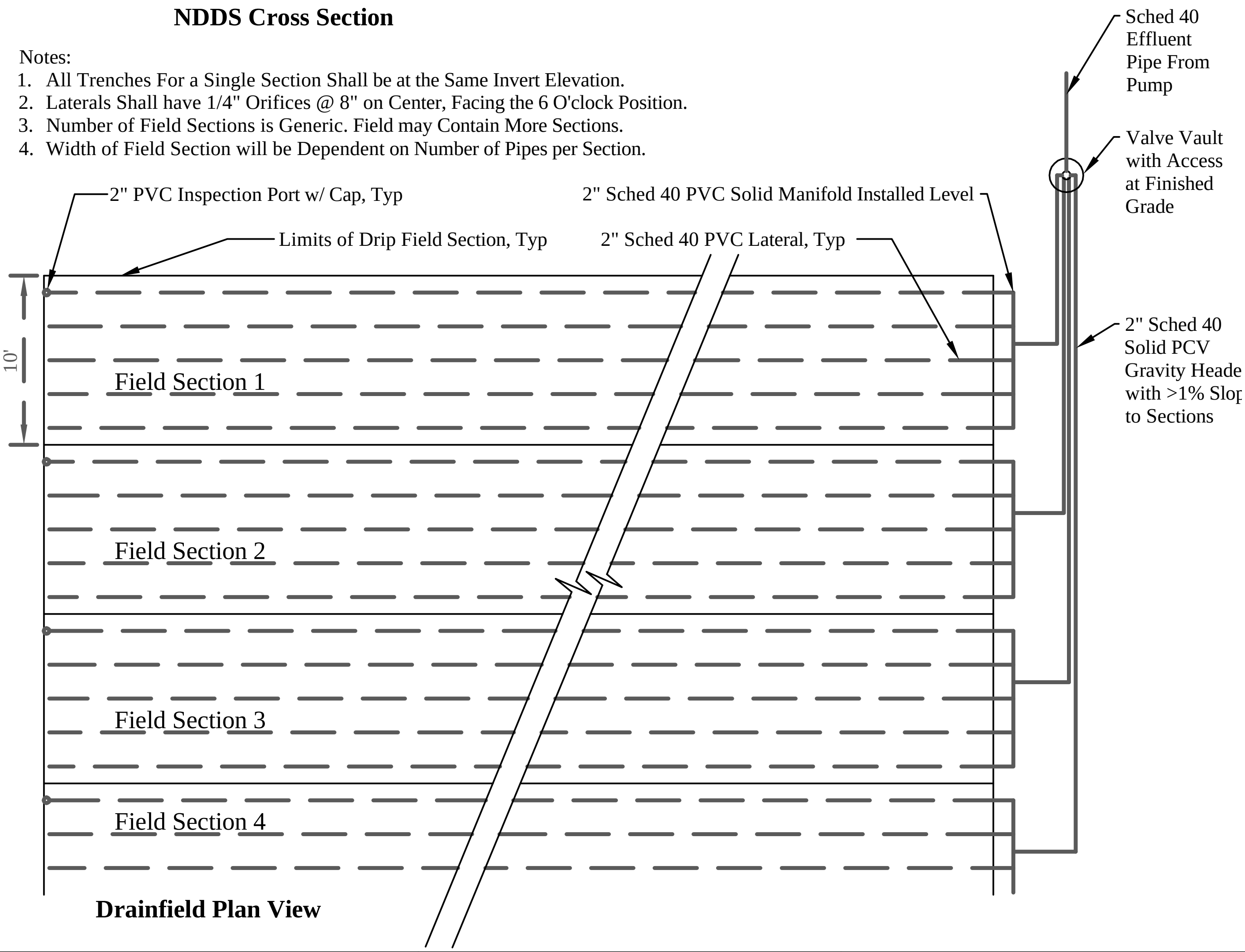
Non-Pressurized Drip Dispersal System (NDDS)

Diagram 1: NDDS Plan and Cross Section



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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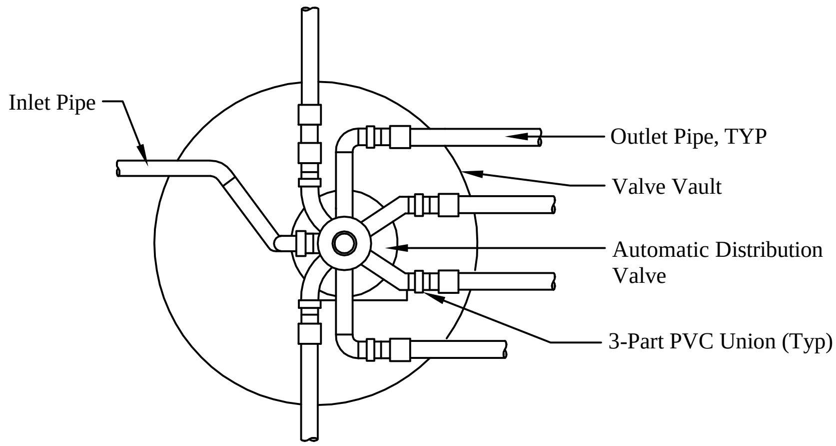
Non-Pressurized Drip Dispersal System (NDDS)

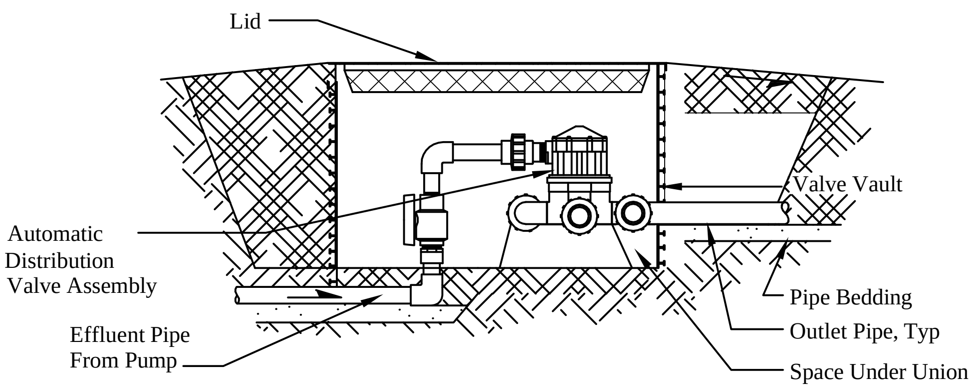
Diagram 2: NDDS Plan and Cross Section w/ Aggregate

Automatic Distribution Valve (ADV)

Plan View



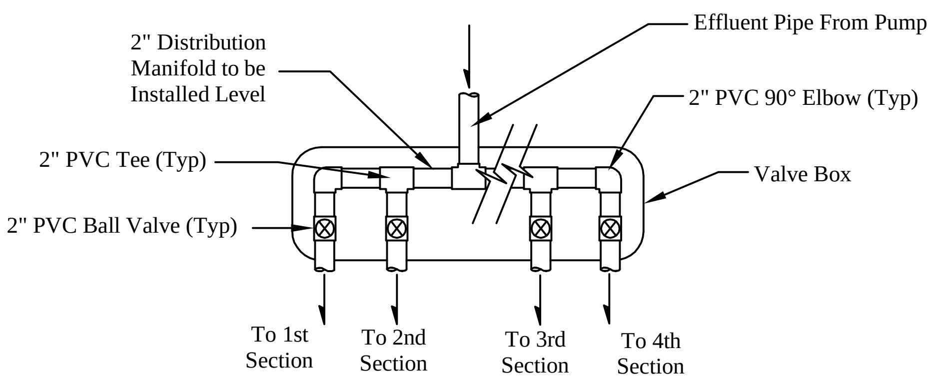
Profile View



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



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Non-Pressurized Drip Dispersal System (NDDS)

Diagram 3: Effluent Distribution Options