

“Rocky Soils and Treatment Sand Requirements; A Colorado Perspective”

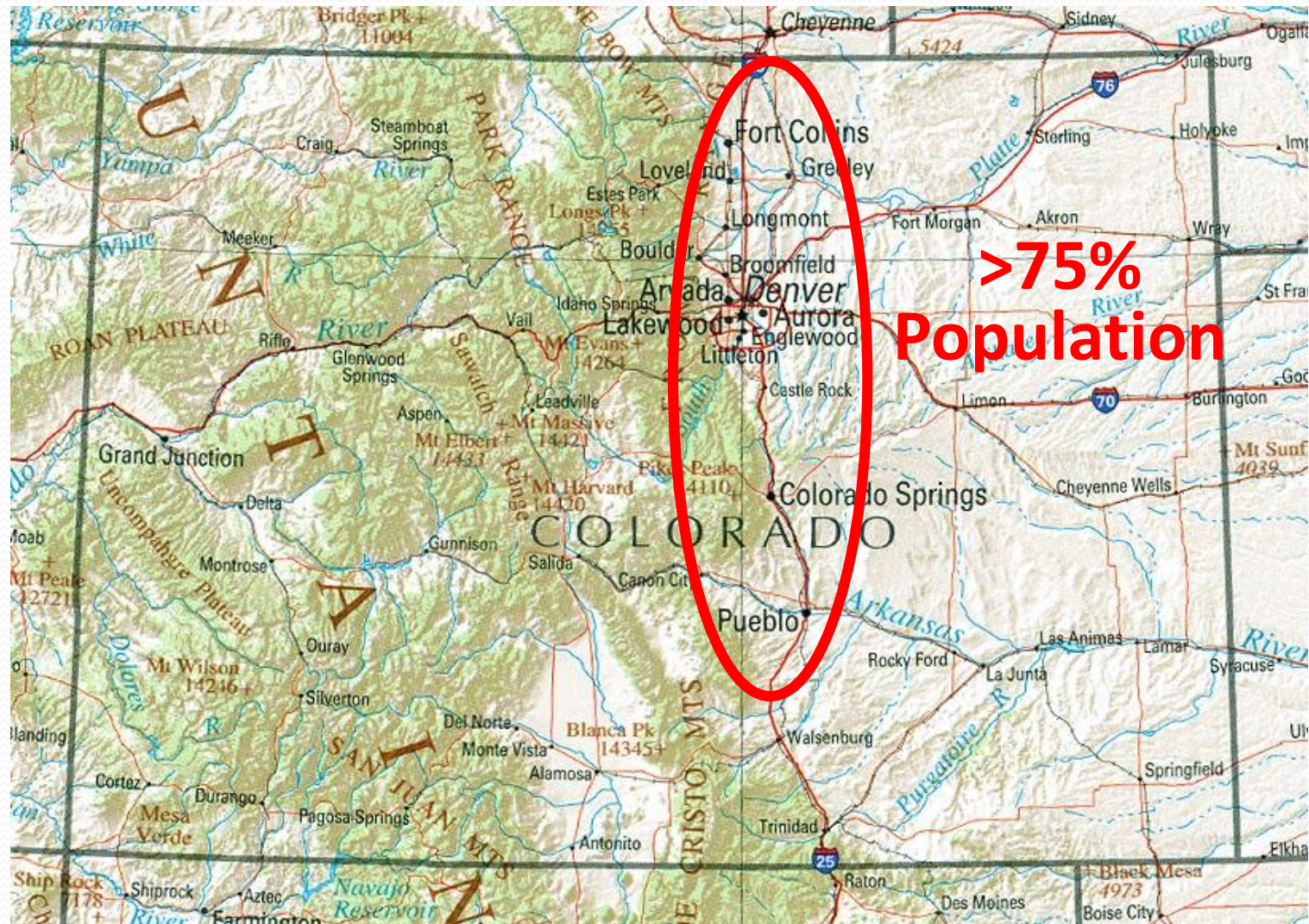
Southwest Onsite Wastewater Conference, 2019

Chuck Cousino, REHS
CDPHE/WQCD,
OWTS Coordinator



COLORADO
Department of Public
Health & Environment

Colorado has a very diverse terrain; diverse soils





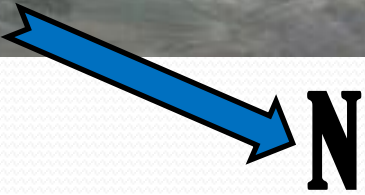
53 Peaks > 14,000'
Highest: Mt. Elbert, 14,439'

Over 2.5 miles higher than Laughlin, AZ

Mountains average ~200" snow/yr.



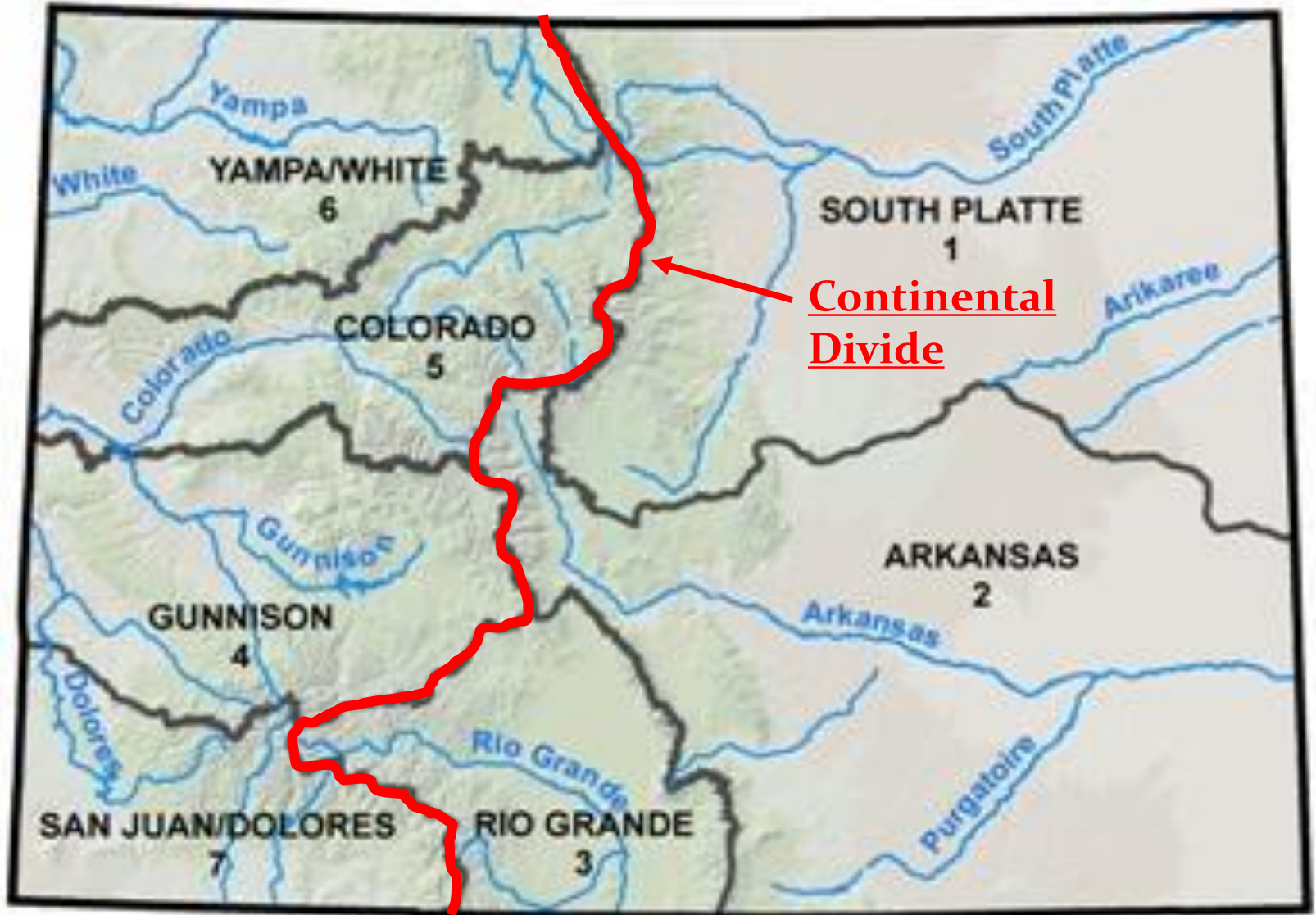
480"/yr.



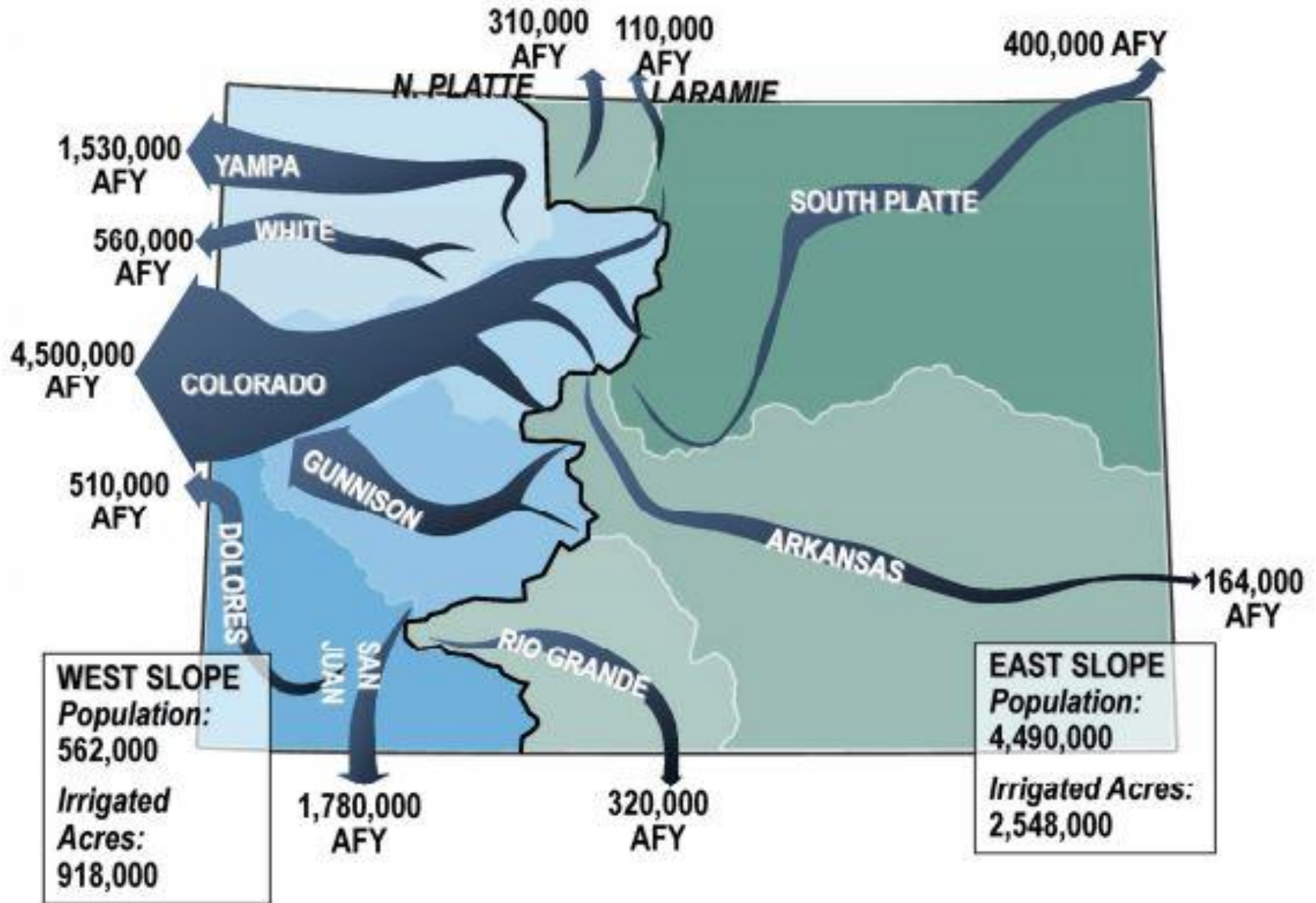
Run-off is a source of water to 18 states



Snowpack Produces 14 - 16 Million Acre Feet/yr.



Colorado Watershed Map



Flow from the 7 river basins



Colorado River:

Headwaters: La Poudre Pass, Rocky Mtn. Nat. Pk.

1,450 Miles long

Watershed encompasses parts of 7 states

This watershed is a water source for ~40 million people



Varied Terrain

Eastern Plains



Lowest Elevation in Colorado = 3,315'



Great Sand Dunes National Park



Outwash areas; “Platey Structured Soils”



Soils with a high rock content



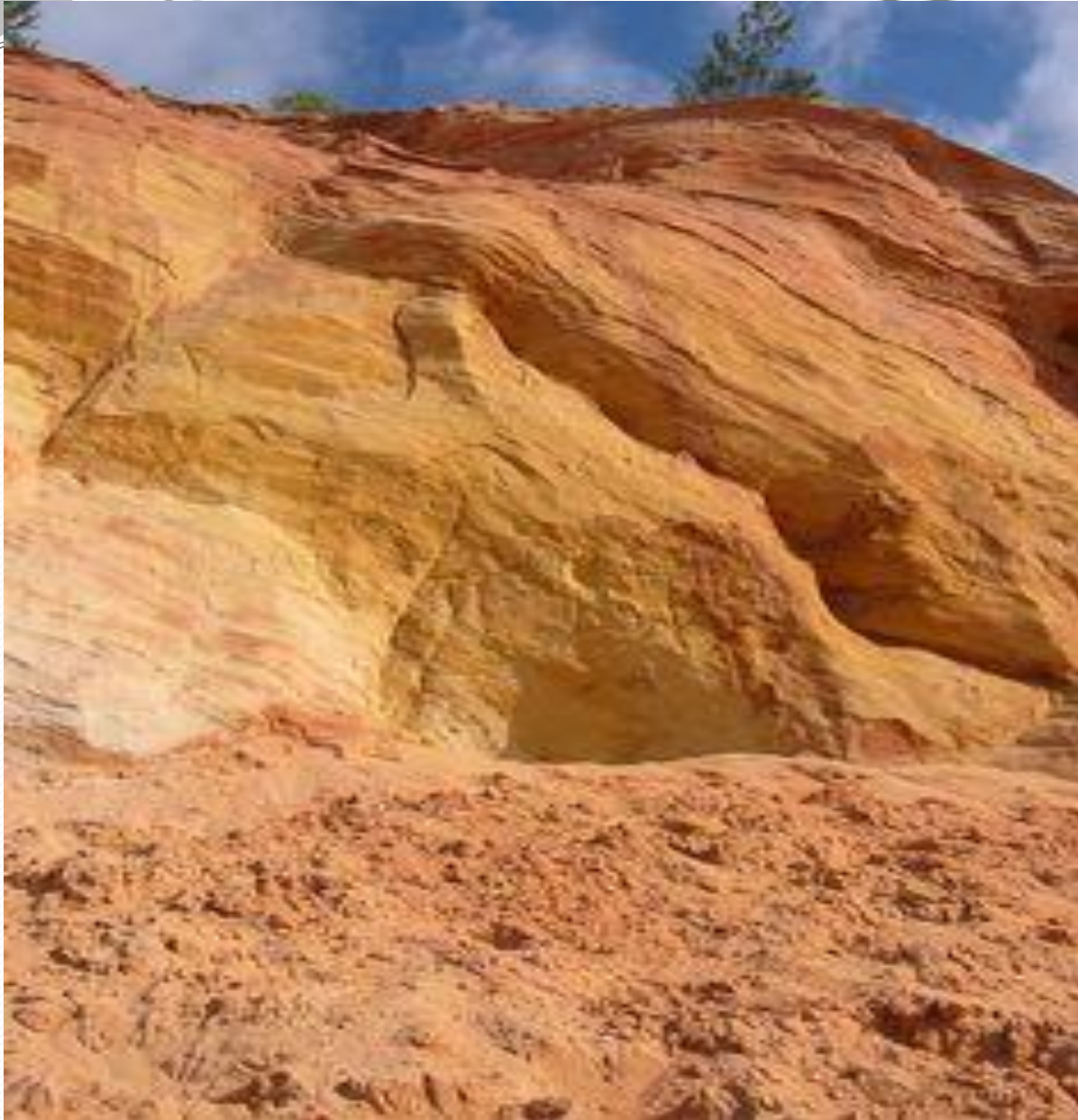
Memorial Rock; 2019



Fractured Bedrock



Decomposed Granite



Sandstone

Onsite, at
10,000 feet



Onsite, at 13,000 feet



“Go” where few have gone before!



And yet, there are no “unbuildable” sites in Colorado due strictly to soils (as long as you meet local minimum parcel size requirements and setbacks)

Sites with a high content of rock
are a real concern



So how do we address rocky sites?



ON-SITE WASTEWATER TREATMENT SYSTEM REGULATION

REGULATION #43, 5 CCR 1002-43



COLORADO
Department of Public
Health & Environment

Regulation #43, On-site Wastewater Treatment System Regulation

“Effective Date: June 30, 2013”

Changed the focus from,
“Sewage Disposal”
to
“Wastewater Treatment”

And from,
“Flush and Forget”
to
“System Performance and Maintenance”

2013 Regulations for Soil Type “0”

- Soil type 1 (sand) that contains >35% rock
- Soil type 2-5 with > 50% rock

Design requirements:

- 3' deep unlined sand filter for all type “0” soils
- Minimal credit given for pretreatment, or the treatment provided by the sand filter

Questions/Comments received

- “Why don’t we get a sizing reduction for installation of the sand filter?”
- “What you call rock, looks like course sand to me”
- “Even though it’s rocky, the site actually percs at around 30 min./inch. What’s the problem?”
- “When we excavate the soil, it breaks up into a very permeable material; and it looks the same as the sand that we’re importing”

Research

“The suitability of a soil... is based on the total volume and size of the gravel present, and the soil texture.”

“If the volume of the gravel is more than 30% of the total sample, an additional evaluation of the soil is required ...” What is the permeability of the fine earth, and what is the volume of larger rock particles?

On-Site Wastewater Treatment Systems

Soil Particle Analysis Procedure

Texas Cooperative Extension
The Texas A&M University System

Research

SUITABLE:

In Class II* or III* soils, only: soil contains less than 30% gravel;
Or, soil contains more than 30% gravel and 80% of the gravel is smaller than 5.0 mm.

UNSUITABLE:

All other Class II* or III* soils that contain more gravel than is described as suitable.

* Class II and III: Sandy Loam to Clay Loam soils

On-Site Wastewater Treatment Systems

Soil Particle Analysis Procedure

Texas Cooperative Extension
The Texas A&M University System

Research

Decentralized Water Reclamation Engineering; Siegrist, 2017

Notes a reduction in treatment capacity due to rock fragments

- For treatment of domestic STE, it is reasonable to limit the volume occupied by stones (>2-mm diameter) to < 35% of the bulk volume
- For profiles with 35 to 60% rock by volume, it is advised to use a buried sand filter design or provide a higher degree of treatment prior to discharge to the soil

Research

Washington State Department of Health, Rule Development Committee Issue Research Report - Excessively Permeable Type 1A Soil Issues -

- “More than 125 publications, which include peer reviewed journal articles, conference proceedings, text books, master thesis, and government reports were collected and reviewed.”

**Washington State Department of Health,
Rule Development Committee Issue Research Report
- Excessively Permeable Type 1A Soil Issues -**

- “The rapid flow of effluent through macropores decreases treatment because of reduced soil surface and retention time”
- “Inadequate treatment in the unsaturated zone might allow wastewater contaminants to enter the groundwater if no mitigating measures are taken.”
- “Sites with 35% - 50% Rock: Saturated Conductivity, not the rock content, predicts OWTS performance.”

**Washington State Department of Health,
Rule Development Committee Issue Research Report
- Excessively Permeable Type 1A Soil Issues -**

- Sites with 60% - 65% Rock: Hydraulic conductivities are not similar and are influenced by inter-gravel constituents, not gravel content.
- Sites with >65% Rock: Influenced more by the gravel content.
- However, to some extent the movement of wastewater with a high content of rock is not well understood.

So What Does all the Research Tell Us?

- The volume and size of rock in the soil profile has an effect on effluent treatment
- Per the research, 35% rock seems to be a breaking point for an expected basic level of treatment
- The level of treatment changes again with rock percentages in the 50% - 65% range
- We don't want saturated flow
- It's really a moving target; as research is minimal

How does Colorado define rock?

- A particle that is larger than 2mm; #10 sieve (Using USDA soil classification)

How big is the penny?



Measure the diameter.

Between 1.9 and 2.0 cm
Estimate the last digit and the uncertainty.

Particle Sizes Comparison



Comparison of Particle Size Classes in Different Systems

USDA ¹	FINE EARTH									ROCK FRAGMENTS					
	Clay ²		Silt		Sand					Gravel			Cob- bles	Stones	Boulders
	fine	co.	fine	co.	v.fi.	fi.	med.	co.	v.co.	fine	medium	coarse			
millimeters:	0.0002	.002	mm	.02	.05	.1	.25	.5	1	2 mm	5	20	76	250 mm	600 mm
U.S. Standard Sieve No. (opening):				300 ³	140	60	35	18	10	4	(3/4")	(3")	(10")	(25")	

Type “R” Soils

**SOIL WITH HIGH ROCK CONTENT
(2017 Reg. update)**



How does Colorado define a Type R Soil?

4 categories were established

- R-0
- R-1
 - Option 1
 - Option 2
- R-2

Soil Type R-0

- R-0 same as Soil Type 0 in 2013 version of Regulation #43
- The “fine earth” portion is a Soil Type 1
 - Sand, Loamy Sand
- Contains More than 35% Rock
 - Rock, defined as being larger than 2 mm
 - Retained on a #10 Sieve

Soil Type R-1

Option 1

- Soil Types: 2-5 from Table 10-1
 - Sandy Loam - Clay
- Contains $\geq 35\%$ up to 65% rock
- Of the rock fraction, more than 50% must be **less than** 20mm (3/4")

Option 2

- Soil Types 2 and 2A from Table 10-1 (Very specific; Sandy Loam, Loam)
- Same amounts of rock as Option 1
- Allows for a “Rip-and-Replace” installation
 - Gradation of the material is strongly suggested

Soil Type R-2

- Soil Type 2 - 5
 - Sandy Loam - Clay
 - Contains more than 65% rock
- OR
- The majority of the rock (in a profile with >35% rock) is **larger than** 20mm (3/4")

Table 10-1A Design Criteria for Soils with High Rock Content (Type "R" Soils) ^{1,2,3,4}

Soil Type, Percentage of Rock, LTAR, Distribution				Required Sand or Media Depth Relative to the Quality of Effluent Applied to the Distribution System				
Soil Type	Percentage and Size of Rock ⁵	Maximum LTAR (Gal./sq.ft./ day)	Type of Distribution Required	Treatment Level 1 ⁶	Treatment Level 2	Treatment Level 2N	Treatment Level 3	Treatment Level 3N
R-0	Soil Type ⁷ 1 with more than 35% Rock (>2mm)	Unlined Sand Filter: 1.0 for "Preferred Sand Media"; 0.8 for "Secondary Sand Media"	Pressure Distribution ⁸	Minimum 3-foot deep Unlined Sand Filter	Minimum 3-foot deep Unlined Sand Filter	Minimum 2.5-foot deep Unlined Sand Filter	Minimum 2.5-foot deep Unlined Sand Filter	Minimum 2-foot deep Unlined Sand Filter
R-1; Option 1	Soil Type ⁷ 2 – 5, >35 - 65% Rock (>2mm); with ≥50% of the Rock <20 mm (3/4 inch)	Use TL1 LTAR from Table 10-1 for the soil type corresponding to the soil matrix, with a maximum LTAR of 0.8	Pressure Distribution ⁸	Minimum 2-foot deep Unlined Sand Filter	Minimum 1-foot deep Unlined Sand Filter	Minimum 1-foot deep Unlined Sand Filter	Sand media not required	Sand media not required
R-1; Option 2	Soil Type ⁷ 2 and 2A, >35 - 65% Rock (>2mm); with ≥50% of the Rock <20 mm (3/4 inch)	The allowable LTAR's are defined in each individual treatment level column in this Table	Pressure Distribution ⁸	Remove, mix, replace 4 feet of existing material; with a maximum LTAR of 0.6	Remove, mix, replace 2 feet of existing material; with a maximum LTAR of 0.7	Remove, mix, replace 2 feet of existing material; with a maximum LTAR of 0.7	Remove, mix, replace 2 feet of existing material; with a maximum LTAR of 0.8	Remove, mix, replace 2 feet of existing material; with a maximum LTAR of 0.8
R-2	Soil Type ⁷ 2 – 5, >65 Rock (>2mm), OR ≥50% of Rock >20 mm (3/4 inch)	Use TL1 LTAR from Table 10-1 for the soil type corresponding to the soil matrix, with a maximum LTAR of 0.8	Timed, Pressure Distribution ⁸	Minimum 3-foot deep Unlined sand filter	Minimum 3-foot deep Unlined Sand Filter	Minimum 2.5-foot deep Unlined Sand Filter	Minimum 2.5-foot deep Unlined Sand Filter	Minimum 2-foot deep Unlined Sand Filter

Soil Type R; Footnotes



1. General guidance for Table 10-1A: The intent of the soil type R-0 is to define a material that consists of a high percentage of rock, or rock fragments, and has a percolation rate of less than 5 mpi. Soil types R-1 and R-2 consist of a high percentage of rock or rock fragments, but have a percolation rate of greater than 5 mpi. Soil types R-0 and R-2 are considered to be a “limiting layer”.

- 2. No sizing adjustments are allowed for systems placed in type “R” soils. The maximum LTAR’s are provided in this table
- 3. The design of type “R” soil treatment systems must conform to sections 43.11.C.2 and 3.
- 4. All systems installed in a type “R” soil must be designed by a professional engineer.
- 5. The percentage of rock may be determined by a gradation conducted per ASTM standards, or an appropriate field evaluation by volume.
- 6. Type “R” soil treatment systems that are designed per the criteria noted in the Treatment Level 1 column of this table do not require O/M oversight by the LPHA.
- 7. The “Percentage and Size of Rock” column references the soil types noted in Table 10-1.
- 8. Design of the pressure distribution system for type “R” soils shall comply with the requirements of sections 43.11.C.2.b, c, e, f, g, h and i.



So what type of sand do we need?



➤ Ideal Treatment Sand Media:

○ An ideal sand media has both large surface area to permit wastewater to have maximum contact with the zoogical film on the particles where most of the treatment is accomplished, and sufficient pore space to allow aeration and unsaturated flow (Ball, 1997). Because sand media treatment is aerobic in nature, the exclusion of fines from the filter media is extremely important to maintain open passages for air.

○ Source: State of Washington Dept. of Health, "Sand/Media Specifications"

➤ Is the ASTM C33 specification appropriate for OWTS?

- Concrete sands are designed to minimize voids, and usually have a high Uniformity Coefficiency (4 - 6) to pack and offer strength and stability
- Developed for the manufacturing of concrete, sands meeting the ASTM C-33 specification have a fairly broad and even size distribution (Ball, 1997). This size distribution allows the smaller sand particles to fill the spaces between large particles, resulting in smaller and more convoluted pores spaces. When used for filter media, this condition encourages clogging of remaining void spaces with suspended solids and biological growth (Boller and Kavanaugh, 1995; Darby et al. 1996)

Specifications for imported treatment sand

- Single Pass Sand Filters; Converse, Jan. 1999 (Wisconsin)
 - D10, 0.3 – 0.5 mm (Effective size)
 - Uniformity Coefficient, <4
- Intermittent Sand Filters; State of Washington, 2012
 - D10, >0.3 mm
 - Uniformity Coefficient, <4
 - Fines (#200 sieve), <3%

Research of “Available” Sand In CO

- Obtained sand gradations from pits across the state to review sand media specifications and availability.
- The results from our survey indicated the following:
 - Initially, 32 Gradations submitted for review
 - <20% met the 2013 spec for imported sand media
 - 47% are older than 1 year
 - 44% meet effective size req's. of Reg. 43 (0.25 – 0.6 mm)
 - However, 100% fall between an effective size of 0.15 – 0.6 mm
 - Range: 0.16 – 0.34 mm

Research of “Available” Sand

- Results, (cont.):
 - 28% meet uniformity coefficient req's. of Reg. 43 (<4)
 - But, 90% fall below a uniformity coefficient of <7
 - 40% meet 2013 req. of <1% fines
 - But, 100% meet <3% fines

- What is available that will work?

- Subsequently our regulations created options for “Preferred Sand” and “Secondary Sand”

Requirements for imported treatment sand

- 2013 Regulation req: (*industry standard material*)
 - Effective size (ES): 0.25 – 0.60 (D10; sieve where only 10% pass)
 - Uniformity Coefficient (UC): < 4.0 (D60 / D10)
 - Or, C-33 concrete sand with ≤ 1% fines (200 sieve)

- Current Reg.: “Preferred Sand Media” (*Good stuff!*)
 - Same ES/UC as 2013 req’s.; with allowance for up to 3% fines

- Current Reg.: “Secondary Sand Media” (*More readily available*)
 - Effective size: 0.15 – 0.60 (D10; 10% passing, on gradation)
 - Uniformity Coefficient: < 7.0 (D60 / D10)
 - Up to 3% fines

- 87% of the pits sampled meet the standards for Secondary Sand

Requirements for imported treatment sand

- 2013, only one requirement for all imported sand; Rarely available
- 2017 Regs provide for the use of more locally available materials
- Revisions now provide two options:
 - **“Preferred”** sand
 - Similar specifications within previous requirement
 - Same application rate; 1.0 gal./sq.ft./day
 - **“Secondary”** sand
 - Provides for a wider range of media size; thus,
 - Lower LTAR due to less void space; 0.8 gal./sq.ft./day



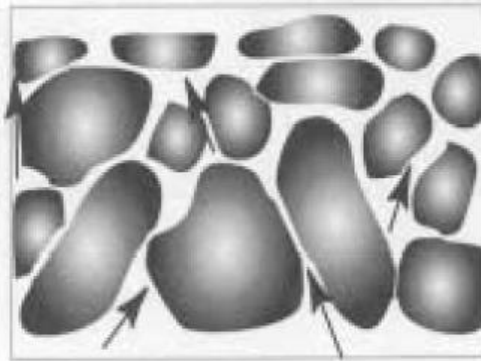
Sand type is determined by a gradation;
Ultimately defining:

- Uniformity Coefficient
- Effective size

Uniformity Coefficient: Size uniformity between particles

Low Uc

P.E.: Poorly, narrowly graded sand
or

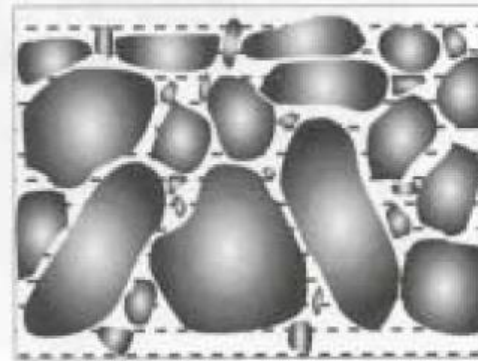


Well Sorted
(Geologist)

Large pore space allows rapid oxygen diffusion and unsaturated flow around the sand particles.

High Uc

widely graded sand or well graded (P.E.)



Poorly Sorted
(Geologist)

Inclusion of small particles filling interspaces between large particles encourages clogging.

Determined by: D_{60} / D_{10} calculation

Just think of marbles





What is the Effective Size?

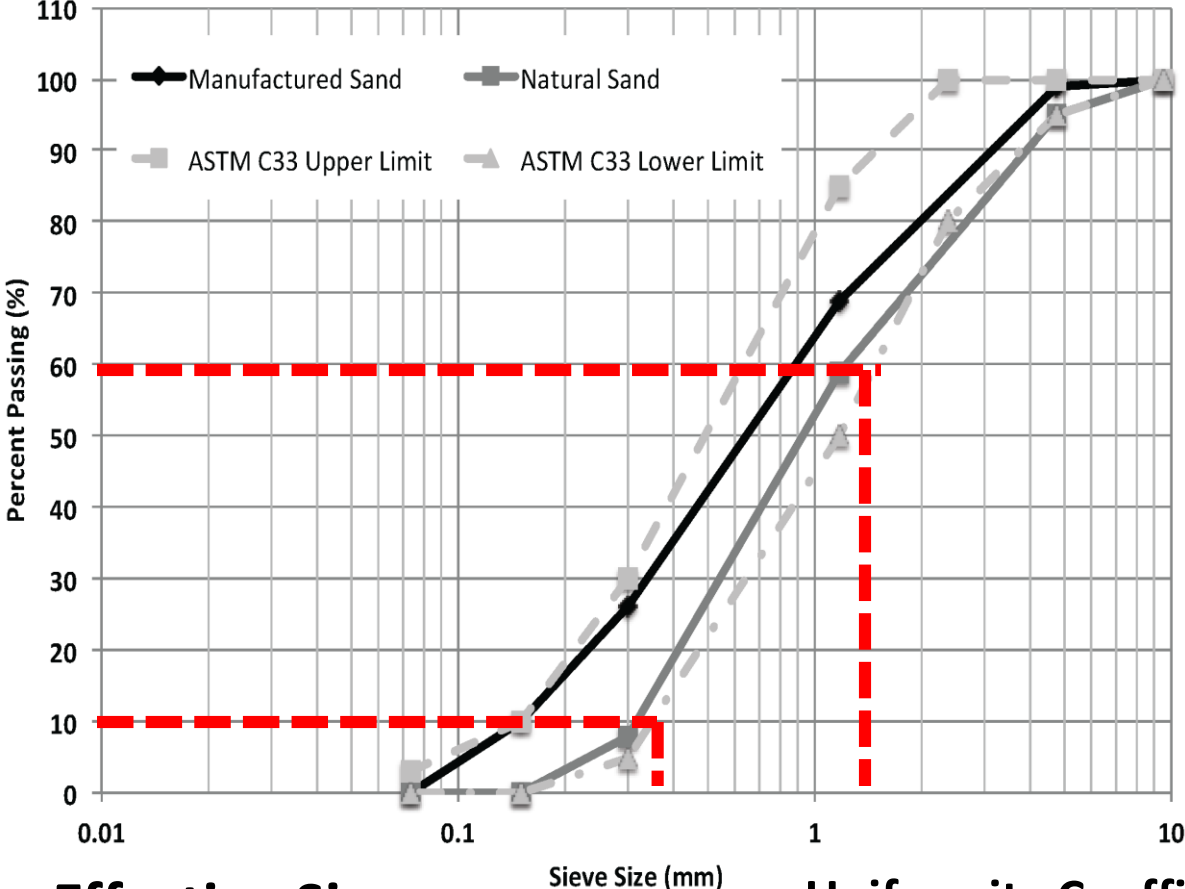
The effective size of a given sample of sand is the particle size (in millimeters) where 10% of the particles in that sample are smaller, while 90% are larger.

Usually this is denoted as the D10.

Sample Dry Weight		Sample Wet Weight		Moisture	
1518.9		1812.5			
				C-33	Lea
Sieve	Wt. Retained	% Retained	% Passing		Spec
2 1/2"					
1 1/2"					
1"					
3/4"	0	0.00	100.00		
1/2"					
3/8"	0	0.00	100.00	100%	
#4	0	0.00	100.00	95-100%	
#8	12.9	0.85	99.15	80-100%	
#16	107.8	7.10	92.90	50-85%	
#30	607.3	39.98	60.02	25-60%	
#50	1255.2	82.64	17.36	5-30%	
#100	1480.1	97.45	2.55	0-10%	
#200	1503.5	98.99	1.01	0-3%	
Total					

Typical data from sand gradation analysis

Michigan



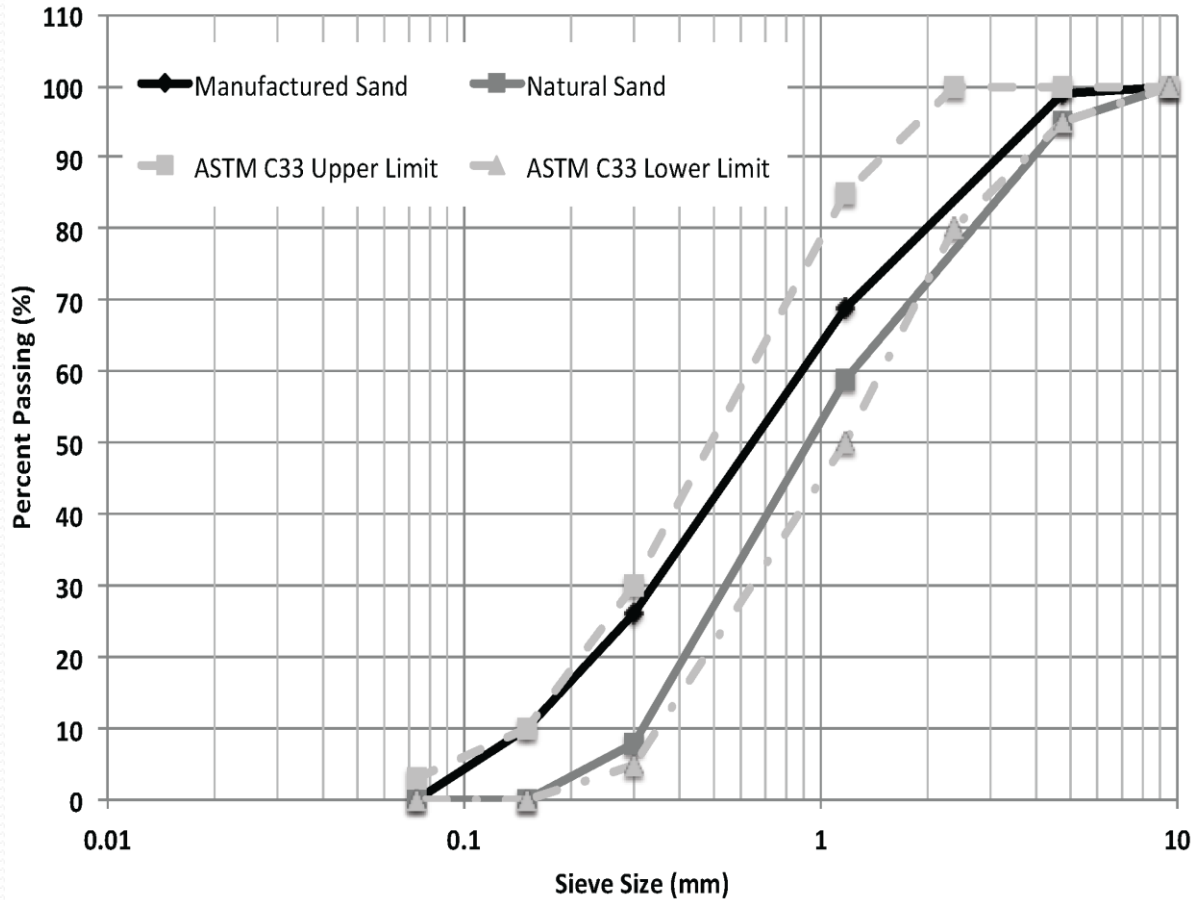
Effective Size

$$D_{10} = 0.38$$

Uniformity Coefficient

$$D_{60}/D_{10}$$
$$1.5 / 0.38 = 3.95$$

Michigan



Left Half of Curve

Failed preferred; Passed Secondary

Mfgr. Sand

Failed preferred; Passed Secondary

Far Right Side of Curve

Passed preferred sand

C33 Sand; Range

Gradation Submittal Required

A gradation, dated no more than 30 days prior to installation, must be submitted to the permitting agency



But at the end of the day...



You can't make everyone happy

What other treatment units are available to use instead of imported sand?

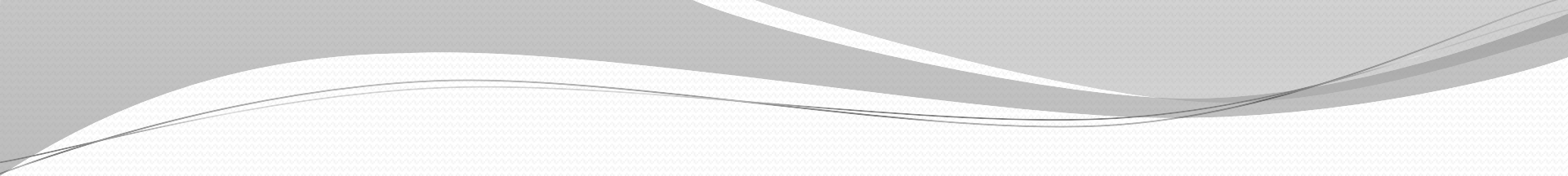
Sand is required in all cases, except where the effluent is treated to at least TL3 standards in a Type R-1 soil.
(CBOD: 10mg/l TSS: 10mg/l TN: 20mg/l)

What does the review/approval process for proprietary treatment products in Colorado entail?

The mfr. must define what effluent quality their product is designed to produce

Table 6-3 Treatment Levels

Treatment Level	BOD ₅ (mg/L)	CBOD ₅ ¹ (mg/L)	TSS (mg/L)	Total Nitrogen (mg/L)
TL1 ²	180	-	80	60-80
TL2	-	25	30	N/A ³
TL2N	-	25	30	>50% reduction ⁴
TL3	-	10	10	N/A ³
TL3N	-	10	10	20 mg/L



If a proprietary treatment product is submitted to meet a specific treatment level, a report with test procedures and data must be submitted to the Division to demonstrate that it can meet the treatment level for which the approval is being requested on a consistent basis in actual installations.

Field Performance Testing

- a. Testing must be performed by a neutral third party.
- b. Testing for residential applications must be performed on a minimum of 12 single-family homes under normal operating conditions unless otherwise noted below:
- c. If NSF /ANSI 40 (TL2), or NSF/ANSI 245 (TL2N) certification is provided, then the number of sites can be reduced to six
- d. Sampled quarterly for a minimum of one year

Must address adjustments or modifications to the treatment process to compensate for increased elevation

Must address adjustments or modifications to the treatment process to compensate for cold temperatures

Testing may be conducted in other states, but must address requirements

Colorado OWTS Webpage

Google: “Colorado On-site Wastewater”; “Clean water...gov”

Maroon Bells



www.soraus.com



Looking for a Region 9 rep. on the SORA Board

- Nevada
- Arizona
- California
- Hawaii

www.cpow.net

CPOW

Colorado Professionals in Onsite Wastewater

Thank You Questions?

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