B-1222R August 2011

SUCCESSFUL RESTORATION OF SEVERELY DISTURBED LANDS: Identifying Suitable Soil for Salvage Prior to Disturbance

This bulletin provides general information appropriate for all Wyoming ecological sites.

Part of a series by the University of Wyoming Cooperative Extension Service (CES) and Wyoming Reclamation and Restoration Center (WRRC) that describes specific strategies for restoring ecological functions to disturbed Wyoming lands. All the bulletins can be downloaded from the WRRC (http://uwadmnweb.uwyo.edu/wrrc/projects.asp) and CES (http://ces.uwyo.edu/) websites.

For this series, **reclamation** means **restoration** of components that support desired ecological functions, such as livestock grazing, wildlife forage and cover, water quality protection, and aesthetic values

Authors:

Jay Norton, Soil Fertility Specialist, University of Wyoming

Calvin Strom, Research Associate, Wyoming Reclamation and Restoration Center

The Wyoming Reclamation and Restoration Center has soil kits for purchase that contain all the tools for identifying suitable soils, except for determination of sodium content (areas where greasewood or Gardner's saltbush may be present), which should be done in a laboratory if sodium problems are a possibility. Contact the WRRC for more information or to order a kit.

Accurate identification and careful salvage of soil suitable for plant growth are crucial pre-development steps for successful restoration of ecological functions following reclamation activities. This step is often overlooked during the planning process but is important ecologically as well as economically.

The concept of suitable soil is broadly defined as material without physical, chemical, or biological properties that impede or prevent plant growth. It is not limited to materials with ideal plant growth properties and, in fact, most Wyoming soils subject to development and reclamation activities are far from ideal. But, many of Wyoming's soils support important drought- and salt-tolerant plant communities that must be properly restored.

This bulletin provides guidelines to determine the difference between suitable and unsuitable soils for salvage and stockpiling prior to development activities. A soil scientist should be consulted for accurate identification of suitable soils. Describing the pre-disturbance conditions and understanding the range of soil properties required for reestablishment of a viable plant community are the most important components of this activity. See UW CES bulletin **B-1212** for more information regarding pre-disturbance inventory at www.uwyo.edu/cessupport/agpubs/Search_Details.asp?pubid=1501.

The Wyoming Department of Environmental Quality has guidelines for suitable soil for salvage during mining operations (Table 1) that are applicable to other disturbances such as oil and gas operations. It is important to remember Wyoming soils are often naturally within the "unsuitable" range and still able to support important adapted plant communities. Judgment of suitability for salvage must be done on a site-by-site basis. Classifying a soil as being unsuitable based only on a change in color or on a set depth may be inaccurate. Several properties must be considered to judge a soil's suitablility for plant growth.

Table 1: Guidelines for suitable soil as defined by the Wyoming Department of Environmental Quality Land Quality Division (See http://deq.state.wy.us/lqd/guidelns/guide1.pdf).

Parameter and method	***Suitable***	***Marginal[1]***	***Unsuitable***
pH (acidity or alkalinity)	5.5-8.5	5.0-5.5 8.5-9.0	<5.0 > 9.0
EC (mmhos/cm) Soil lab value[2]:	0-8	8-12	>12
Texture by feel[3]	Loam < 28% clay, < 50% sand < 50% silt	Clay loam, sandy loam, silt loam	clay, sand, silt
Gravel (>2mm)(% vol)[3]	<25%	25-35%	>35%
Sodium ion activity (Sodium Adsorption Ratio)(Lab analysis)	0-10	[1]10-12, clay soils 10-15, other soils	>12 >15
Selenium	<0.1 ppm	>0.1 ppm	

1. Many Wyoming soils fall outside the "suitable" range for these properties but still support important plant communities adapted to saline, sodic, or droughty conditions. Soils must be evaluated site by site to assess their suitability to meet site-specific restoration objectives.
2. Field EC meters often use a different scale. Be sure to convert to the laboratory scale according to instructions for any field meter.
3. Texture and gravel content of undisturbed Wyoming soils varies a great deal, but too much sand, gravel, or clay will create difficulties for establishment of reclamation plant species.

To identify suitable soil for salvage at an area planned for disturbance, first dig a shallow soil pit (approximately 20 inches deep) wide enough (12-18 inches) to provide a view of the soil profile. A hand auger or mechanical auger can also be used, but horizons are more difficult to determine with this method. Existing road-cuts, historical excavation, and nearby backhoe pits for drilling mud (prior to use) can also provide clues to topsoil/suitable subsoil depths. Draw a sketch map delineating land forms and changes in plant cover (Figure 1). A typical southwestern Wyoming site, for instance, might have a gentle ridge, a slope, and a swale within an area planned for disturbance. It might also have plant communities dominated by Wyoming big sagebrush (*Artemisia wyomingensis*), western wheatgrass (*Agropyron smithii*) without shrubs, and a large patch of Gardner saltbush (*Atriplex gardneri*). Each landscape position and plant cover type probably indicates different thicknesses and properties of suitable soils. Some of the vegetation/landform map units you've created may have the same thickness of suitable soil so it can be combined after the soil is evaluated. Copy and use the Chart 1 located at the back of this bulletin to describe the depth, color, texture, gravel content, pH, EC, and other properties that help determine the thickness of material suitable for salvage. Take samples from each soil horizon in case laboratory analysis is necessary. Be sure to carefully label sample bags with date, location, pit number, and depth.

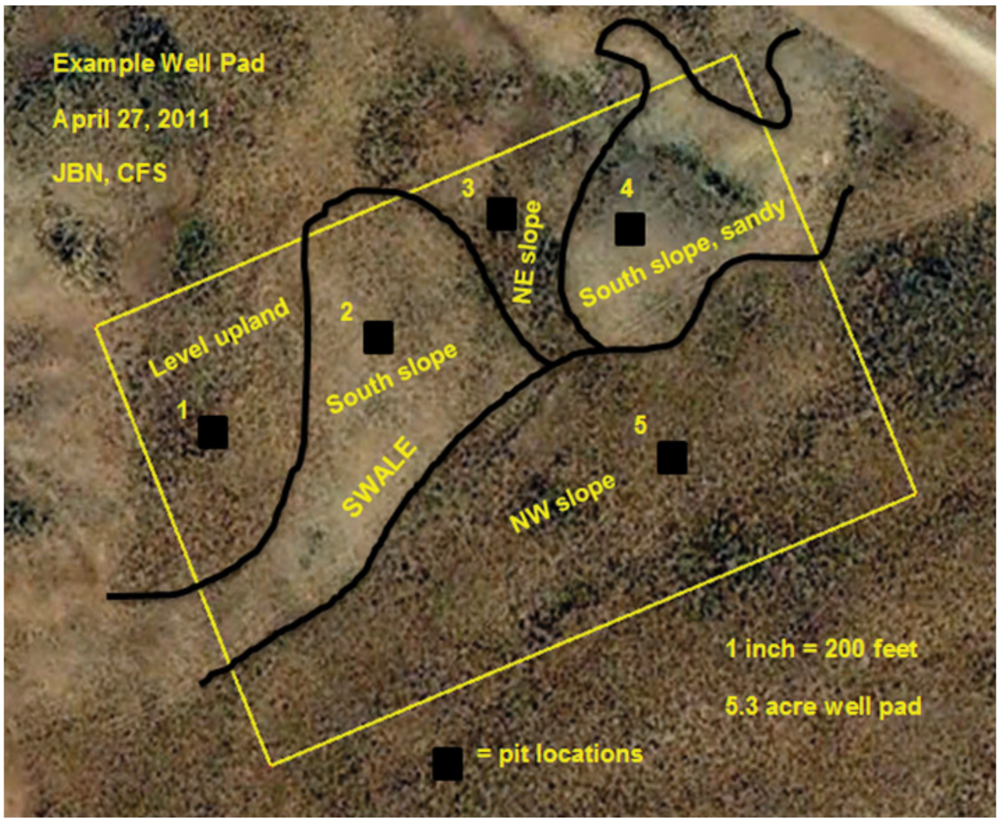


Figure 1: Example of a sketch map for identifying suitable soils on a Google Earth base aerial photograph of a gently rolling, sagebrush-dominated landscape. The small pits should be about 20 inches deep, or deep enough to determine the salvage thickness for suitable soil. More small holes or cores should be taken in each unit to ensure about equal thickness across each one. Fill out description form for each pit/map unit (Chart 1, back page of bulletin) to determine the depth to any of the properties that fall outside the suitable range (Table 1). See Example chart filled out for Pit 1 on this sketch map.

Variable-Depth Salvage

Qualified personnel should identify suitable topsoil depths prior to the disturbance of the site. This information is included in the salvage plan and provided to the earth works contractor. The salvage depths are reviewed with the machine operators, and a copy of the salvage plan for the site is given to the operators.

Topsoil depth can be identified through staking and leaving pedestals for reference (see photo at right). There are also AutoCAD programs available for use with GPS units mounted on the machinery used for stripping topsoil. This process requires taking numerous soil cores in the area to determine topsoil depths.

Then enter the depths and coordinates into the AutoCAD program. This information is uploaded to the controller in the scraper, which will strip the soil at variable depths preventing the mixing of unsuitable soil in areas with thin and variable topsoil depths.

Sample soil description chart for figure 1.

Suitable soil identification. Date: April 27, 2011 Investigators: JBN, CFS

Location: Wyoming

Site name or number: Example Well Pad, Pit 1 Landscape position and dominant plant cover: Level upland, Wyoming big sagebrush, thickspike wheatgrass

Depth inch or cm	Color	Clay % Sand % Text. class	Gravel content (%)	pH	EC (salt)	$CaCO_3$ (efferv., descrip)	Comments (structure, etc.)
0-3	10YR3/3 Dark brown	10% 40% loam	15	8.0	7 (lab)	Audible	granular
3-9	10YR4/4 Dark yellowish brown	18 32 Silt loam	15	8.5	8	Weak fizz	blocky
9-15	10YR5/4 Yellowish brown	29 30 Clay loam	20	8.5	16	Violent	Angular blocky
15-23	10YR4/4 Dark yellowish brown	15 30 Silt loam	30	8.5	17	Violent	Massive

Notes:

Suitable soil to 9 inches; high salts below that indicated by effervescence and EC. EC was confirmed by soil lab. Probes holes in surrounding area of the same map unit confirmed depth to violent effervescence of 8 to 10 inches.

Depth: Note and measure soil horizons by changes in color, structure, texture, hardness, or other attributes. Collect a small sample from each horizon and place in a tray (**Figure 2**) or in piles on a sheet of metal, tarp, or plywood. Circle in (inches) or cm (centimeters) to indicate which unit is used on **Chart 1**. Near-surface horizons are typically the most suitable soils for plant growth for two reasons: 1) plants add organic materials that improve water and nutrient supplying potential; and 2) rainfall translocates salts and clays to deeper horizons. In arid soils, this suitable layer that is both enriched and leached is often very thin (two to three inches) but still exists. The suitable layer is often thinnest or even non-existent on ridgetops and deepest in swales.

Unless you are working on a very topographically uniform site, it will become obvious that stripping topsoil at a constant depth is not an effective way to salvage suitable soil. The depth may be zero on part of a site and 18 inches or more on other parts. Even on topographically uniform sites, soil types and associated salvage depths can vary. In a 5-acre disturbance, there may be three or more soil types that vary in their suitability and thickness. Pockets of suitable material that can be feasibly salvaged, based on equipment limitations, are important.

Color: Color alone does not indicate suitability for salvage but is a good indicator of horizon changes. Use a Munsell color chart to denote hue (indicates its relation to red, yellow, green, blue, and purple), value (indicates its lightness), and chroma (indicates its strength); these indicators determine color. The color chart provides information about soil components; darker colors are an indicator of organic matter content. Many Wyoming range soils have very low organic matter content (< 2%), but slightly darker colors can often be detected in surface horizons.

Clay and sand contents: Use texture by feel to estimate clay and sand contents and the texture triangle to determine textural class. Guidelines for two methods (the texture triangle and flow chart) are included in this bulletin, but this takes practice and training by a professional soil scientist. Clay and sand content are important indicators of soil water infiltration rates and plant-available water holding capacity. Too much clay causes very slow infiltration leading to runoff and erosion, cloddiness and hardness, and low available water that is held too tightly for plants to access. Too much sand causes rapid drying and droughty conditions.

Gravel content: Sieve a handful of soil through a 2-mm screen and estimate the proportion that stays on the screen. The Munsell soil color book contains a section for determining particle sizes. High gravel content causes droughtiness, but, since many Wyoming soils are gravelly throughout the profile, the overall suitability depends on the pre-disturbance determination of gravel content at or near the surface.

pH: Use a pH meter or kit to determine the soil pH. pH indicates alkalinity or acidity of the soil. Wyoming soils are typically alkaline and, if high in sodium, can have very high pH levels that inhibit plant growth, even for native, salt tolerant species. pH greater than 8.5 is an indication of high sodium content. Soil with a pH this high should be carefully excluded from salvage, unless the site has an adapted plant community.

Figure 2. Soil horizons are subtle but easier to see arranged next to one another in a tray.

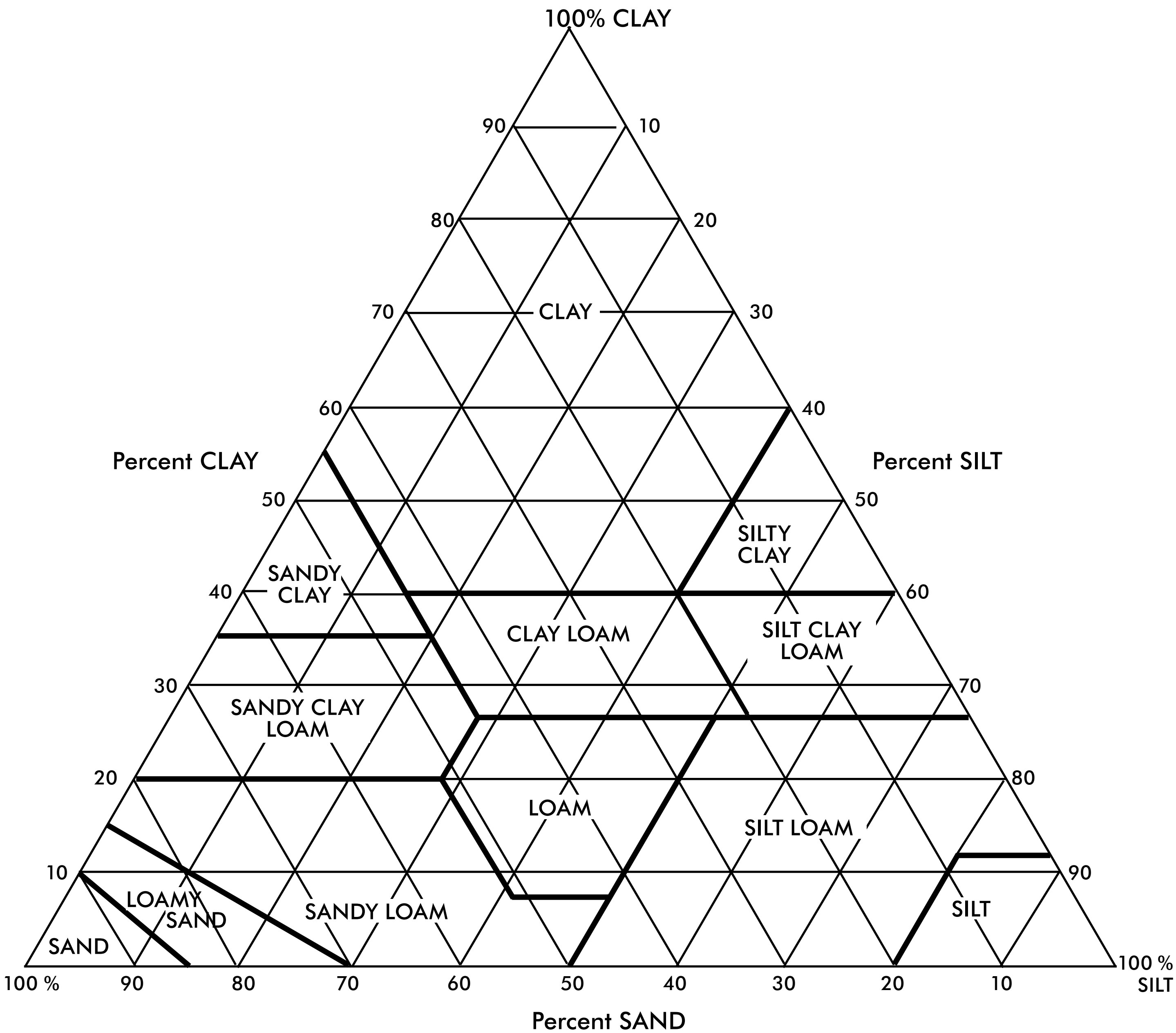
EC: Electrical conductivity can be measured by using a field meter or from laboratory analysis. EC is an indicator of salt content. Wyoming and other semiarid and arid areas typically have high salt contents but also have plant species adapted to those higher salt contents. Subsurface soils are typically enriched in salts above the limits for plant growth because of translocation (eluviation and illuviation processes).

Calcium carbonate: $CaCO_3$ is a salt that causes effervescence when a diluted solution of hydrochloric acid is applied to the soil. Though most arid soils fizz at the surface, a zone of enrichment below the surface can usually be detected. It indicates accumulation of other salts as well. Visible veins and nodules of white $CaCO_3$ indicate very high contents (violent reaction to acid solution) of this and other salts typically beyond the limit of suitable soil.

Sodium Adsorption Ratio (SAR): The soil SAR is the concentration of sodium relative to magnesium and calcium calculated from cation concentrations in a saturated paste extract, which must be done in a soil lab. High pH values indicate a need to have this analysis run by a laboratory (collect at least 1 quart of soil in a sample bag). High exchangeable sodium, high pH, and low calcium and magnesium combine to cause the soil to disperse, meaning that individual soil particles act independently. The dispersion of soil particles destroys soil structure and prevents water movement into and through the soil by clogging pore spaces and causing severe crusting.

Other attributes to note: Structure refers to aggregates or peds. Well-formed granular or blocky structure typical of surface and near-surface soils provides pores that facilitate movement of water and air to plant roots. Compacted zones, shallow bedrock, or other root-limiting layers are important features that should be noted.

Texture by Feel



1. Clay:
   a. Moisten a golf-ball size handful of soil to make a firm ball.
   b. Attempt to "ribbon" by squeezing between thumb and forefinger to make a flat tape-like ribbon of soil.
   c. If ribbon reaches 1 inch long without breaking, soil has >28 percent clay.
   d. If ribbon reaches 2 inches, soil has >40 percent clay.

2. Sand:
   a. Pinch off and round a BB- to pea-sized piece of the moistened soil ball.
   b. Place in the center of a clean palm and apply water to over saturate.
   c. Swirl with finger tip and carefully pour off fines until clean sand remains.
   d. Estimate proportion of original piece remaining by volume = percent sand.

3. Silt: by subtraction.

4. Textural class: Use sand and clay percents to find textural class on triangle.

Soil Texture by Feel

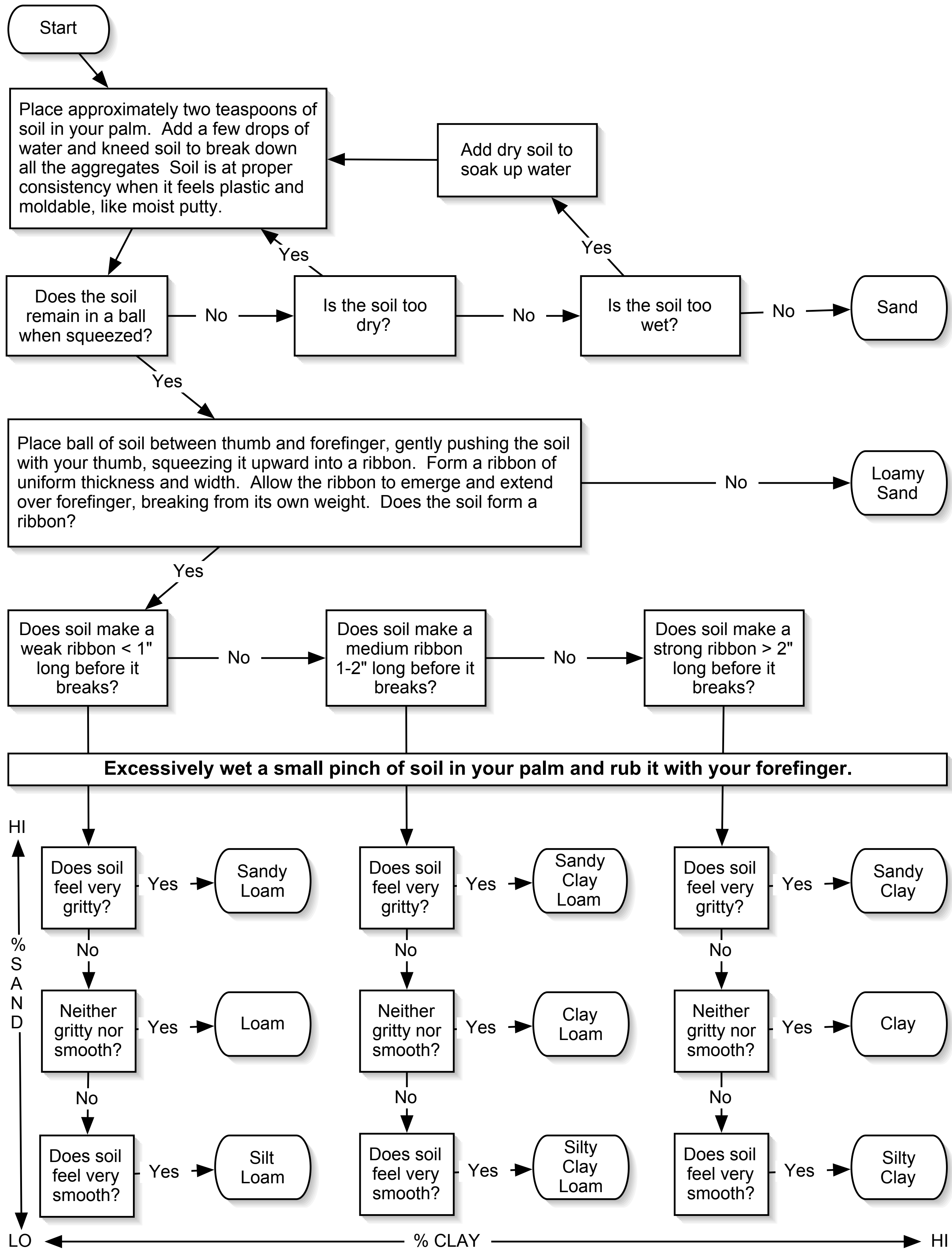


Chart 1

Suitable soil identification. Date: ____________ Investigators: ____

Location: ____

Site name or number: ______________________________ Landscape position and dominant plant cover: ______________________

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Depth in or cm	Color	Clay % Sand % Text. class	Gravel content (%)	pH	EC (salt)	$CaCO_3$ (efferv., descrip)	Comments (structure, etc.)

Notes:

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For more information:

Wyoming Reclamation and Restoration Center: http://uwadmnweb.uwyo.edu/wrrc/projects.asp

References:

Natural Resources Conservation Service: http://soils.usda.gov/

Sodic Soils: Distribution, Properties, Management, and Environmental Consequences. Sumner, M.E., Naidu, R. eds. Oxford University Press 1998

Wyoming Department of Environmental Quality (Land Quality Division): http://deq.state.wy.us/lqd/

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