# Chapter 21: Developing Interpretation Criteria

Chapter 19 provided the basic concepts underlying NASIS interpretations: interpretive statements, fuzzy logic (or approximate reasoning), and converting fuzzy logic results to rating classes. Chapter 20 introduced the running of interpretation reports and selecting existing interpretive criteria to run against the selected set data. Chapter 21 demonstrates how to create new criteria. It introduces the NASIS Interpretation Generator and the editors used for building interpretations. With these tools, new interpretations can be created based on documented criteria and current NASIS data. Once the interpretation is created, calculations are automatically performed by NASIS providing the capability of applying new interpretive criteria to soil data. All interpretation data is stored in the local database and available in the Interpretations Explorer. It is essential that Chapters 19, 20 and 21 be read before attempting to develop interpretations. Prior to developing interpretive criteria, there must be an understanding of articulating interpretive statements, fuzzy logic, and converting fuzzy numbers into rating classes.

The NASIS interpretation module is designed for interdisciplinary experts who thoroughly understand the process of developing interpretive criteria. Users must understand the relationships of soil properties to the system or application being evaluated. Expert opinion is required throughout the process of creating interpretive criteria with NASIS. Use of this chapter requires that the user have basic NASIS training on the subjects of navigation, database structure, and object ownership.

Overview of Interpretation Criteria

In NASIS, interpretive results are generated by applying interpretive criteria to soil data. Interpretive criteria are divided into four parts: **Interpretations**, **Sub Rules**, **Evaluations**, and **Properties**. These parts are located in the Interpretations Explorer panel.
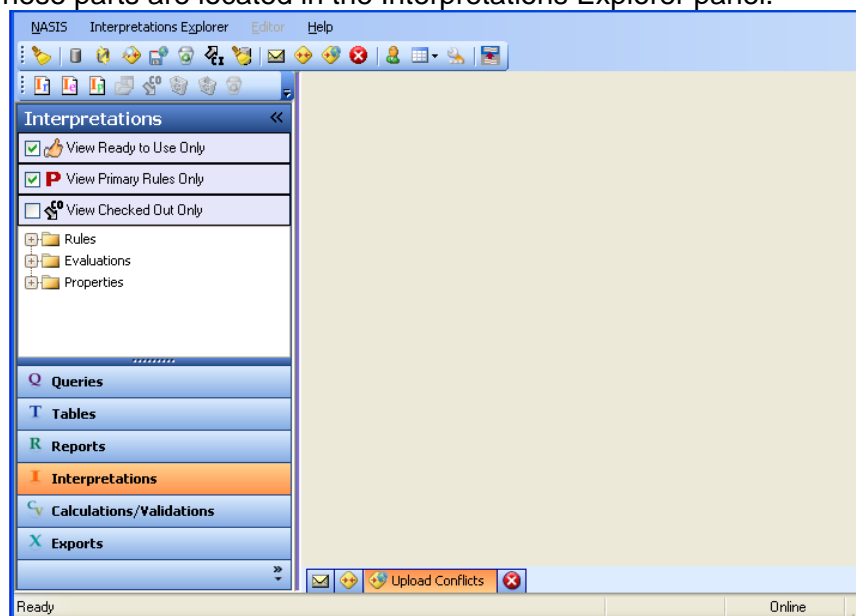
Three Component Concept of an Interpretation

In NASIS, interpretive results are generated by applying interpretive criteria to soil data. Interpretive criteria are divided into three basic parts: *properties*, *evaluations*, and *rules (includes interpretation and sub rules).*
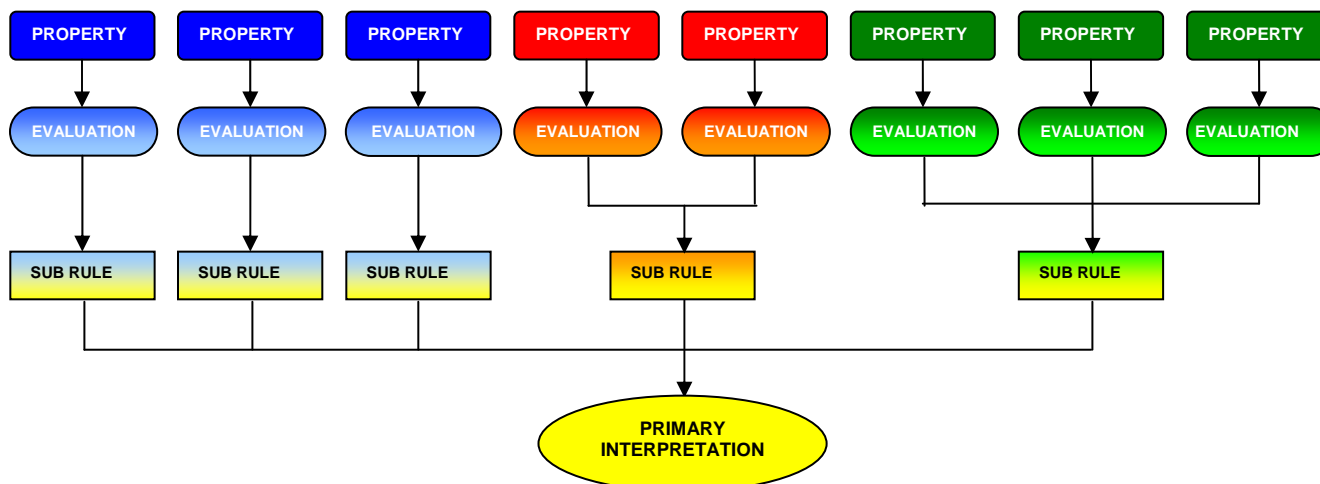
A property is a specification used to extract soil property data from the database. This can be anything from a simple query statement to a complex calculation based on several queries.

An evaluation is some test that will be applied to the data returned from a property to determine the truth of some proposition. Evaluations can be either fuzzy (returning any value between 0 and 1) or crisp (returning only 0 or 1).

Rules are used to combine the results of evaluations and/or other rules to create new propositions. A sub rule provides the results from at least one evaluation or other sub rule. An interpretation is the top level rule that combines the results of all sub rules associated with the specific interpretation.

At the top level, a report can invoke one or more rules and format the resulting values for output.

Properties

A *property* is the specified soil data retrieved from the soil database. The term *property* can also refer to the SQL-like statement that retrieves the soil data. Properties are stored in the Interpretations Explorer under the Property folder and organized by NASIS Site. A property used by an Evaluation must create variables named Low, High or RV. Case does not matter. This allows the evaluation process to search the property's symbol table for the correct entries. It is important to note that the user must also set a choice list field in the property record to tell what the expected return values will be: high-low, high-low-rv, or just rv. The evaluation will expect to find the corresponding variable names.
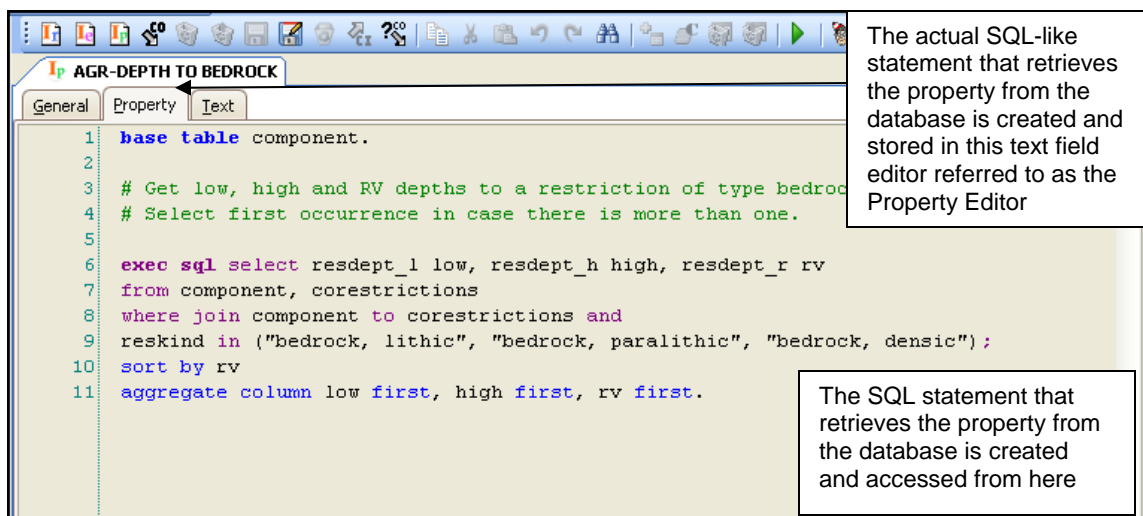

The property record also contains fields to specify the data type and default value for the property results. The data type is either character or numeric, and must correspond to the type of data produced by the property script. The default value is optional. It is used to replace null values in the property results. If a null value is not replaced by a default, the evaluation will interpret the null as an unknown, resulting in a 0 to 1 evaluation range.

Each property must have a "base table". When an evaluation requests data from a property it specifies which row of the base table the data should be produced for, by passing the values of the primary key for that row. It is not possible to mix properties with different base tables in a set of interpretations. The report specifies a base table, and all properties used by the rules and evaluations for that report must use the same base table. A property is written in the text editor as shown in the Figure on the next page.

The actual SQL-like statement that retrieves the property from the database is created and stored in this text field editor referred to as the Property Editor

The SQL statement that retrieves the property from the database is created and accessed from here

Testing Properties

Properties can be run against a single component to test the property. This is done by selecting a single component in the Component table, returning to the Property and choosing to "Run Property Against Local Database" from the Interpretation Menu or the Editor Toolbar (as shown below).
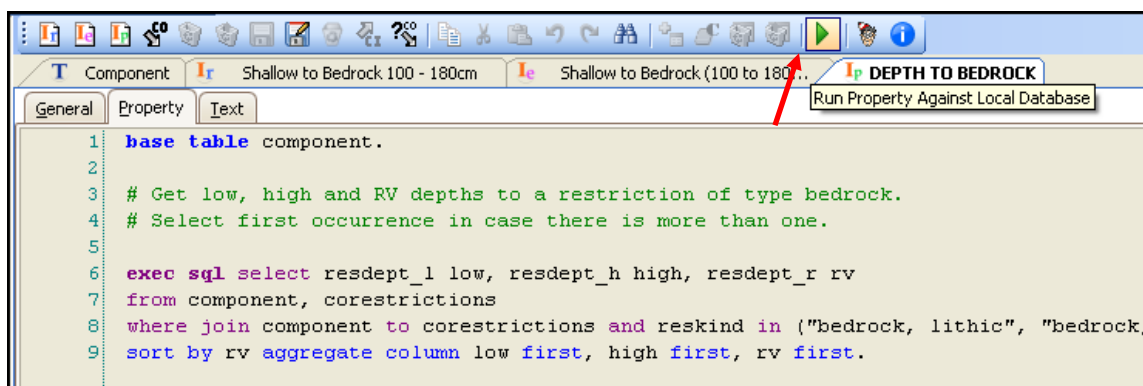

The report provides the results of the property against the specific component. This report is used for testing the validity of the property.
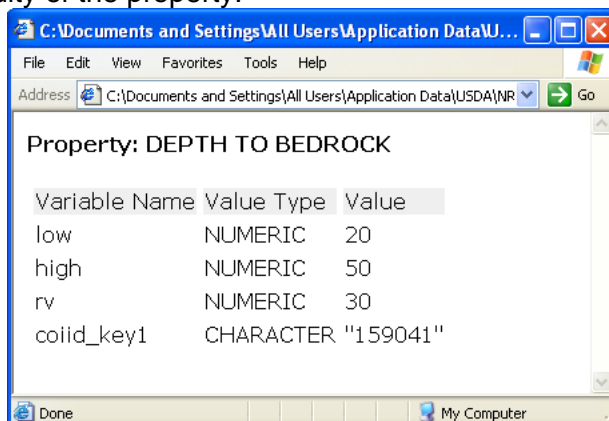
Where Used "Properties"

Properties are developed to be used by more than one evaluation. The "Where Used" icon or menu option is used to identify evaluations using a specific property. This allows the user to identify the impact of any changes made to the property. Highlight the property in the Interpretation Explorer, or with the Property open in the Editor Panel, choose "Where Used" icon or menu option.
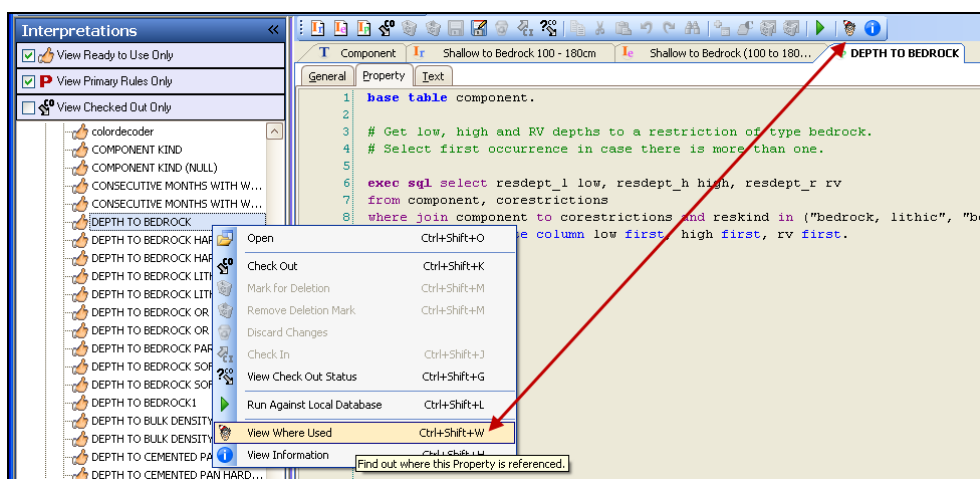

The resulting report identifies the Evaluations using the selected property:

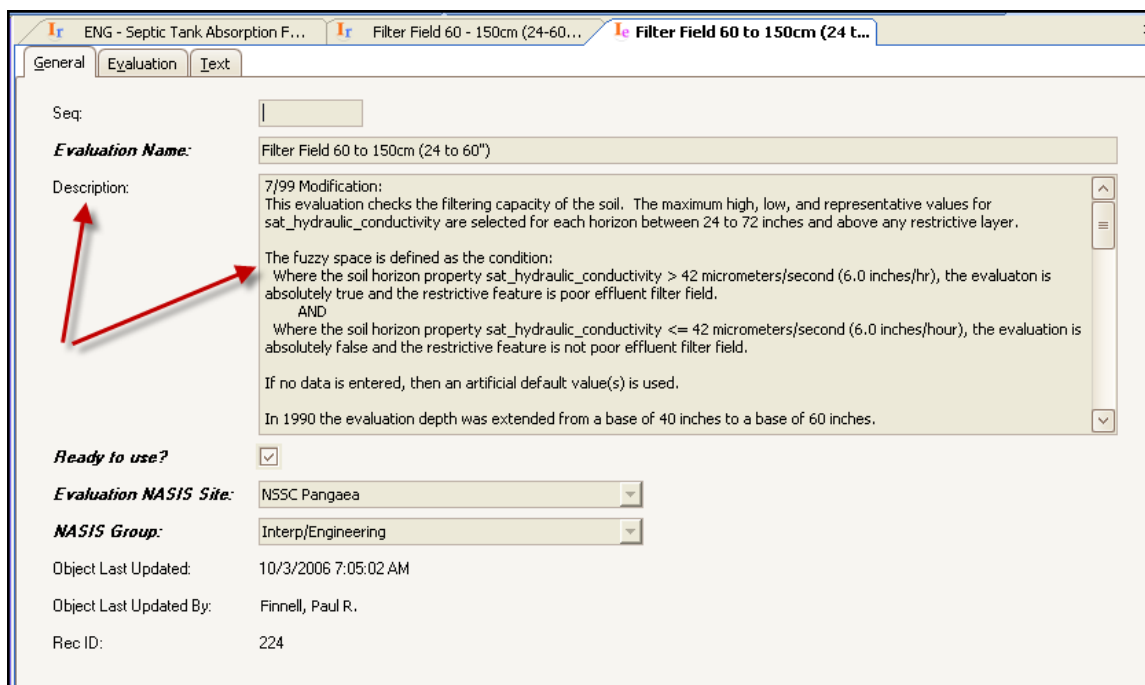| Evaluation Name	Evaluation Site
!Depth to bedrock (hard or soft) 25-50cm - MO2	MLRA02_Office
!Depth to bedrock (hard or soft) 25-50cm - MO2	MLRA08_Office
4brigbrLHH	MLRA12_Office
A.A.A -Biffy BR	MLRA13_Office
ak dm Shallow to Bedrock (100 to 150 cm (40 to 60"))	MLRA17_Office
ak dm Shallow to Bedrock less than 7 feet	MLRA17_Office
AWM-Depth to Bedrock (20-60") 51-152cm	MLRA05_Office
Bedrock	MLRA16_Office
brigbrLHH	MLRA12_Office
Cecil Shallow to Bedrock 12 - 40in (30 to 100cm)	MLRA13_Office
CLS - Bedrock less than 138cm	MLRA05_Office
cp Not Shallow to Bedrock (100 to 150 cm (40 to 60"))	MLRA17_Office
cp Not Shallow to Bedrock (50 to 100cm (20 to 40"))	MLRA17_Office
Depth to Bedrock	MLRA16_Office
Depth to bedrock (100 to 180cm (40 to 72")) - MO2	MLRA02_Office
Depth to bedrock (hard or soft) 50-100cm - MO2	MLRA02_Office
Depth to bedrock (hard or soft) 50-150cm - MO2	MLRA02_Office
Depth to bedrock 25-50cm - HAWAII	MLRA02_Office
Depth to bedrock 36 to 72 inch	NSSC Data
Depth to Rock	MLRA16_Office
FL64E-Depth to Bedrock (<137cm (<54"))	MLRA15_Office
FL64E-Depth to Bedrock (137-182cm (54-72"))	MLRA15_Office

Evaluations

An *evaluation* is an assessment of a particular soil property for its relative impact as a limiting feature. It is the relationship between the property and its impact on the interpretive application. The evaluation is basically a transformation of the data returned from the property into the domain of real numbers from 0 to 1, where 0 means the test is completely false, 1 means the test is completely true, and numbers in between represent the degree of truth. The evaluation can return up to 4 values, representing the lowest and highest evaluations for the full range of the property's values, and the lowest and highest evaluations for the property's representative values.

Evaluations are stored in the Evaluation folder in the Interpretations Explorer and organized by NASIS Site as shown this figure.
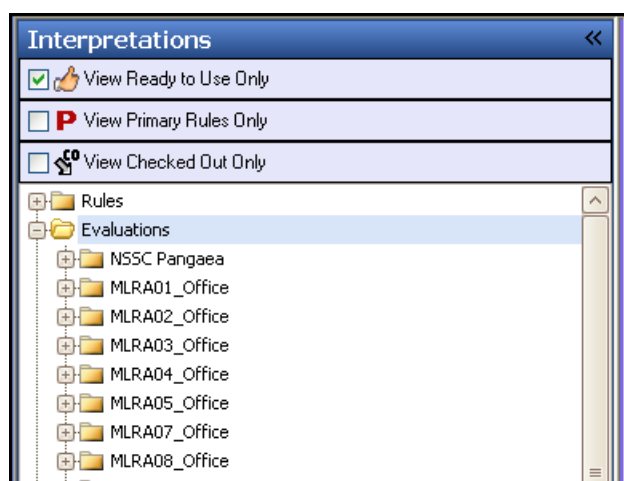
Evaluations are named for the limiting feature. The Evaluation is documented in the Description field under the General tab:

The first step in creating an evaluation is to select a property to be evaluated. The user interface does this with a choice list having a database option, in the same way the user selects other objects like queries or reports. The selected combination of database (NASIS site) and property name uniquely identifies a property record.

The definition of a property specifies the type of data the property returns, which can be either character or numeric. All types of evaluations can be used with numeric data, but ***only a crisp evaluation can be used with character data***. The property definition also specifies whether the property returns a single (representative) value, a range (low and high), or both (all three values). The property may also have a default value, which the evaluation process uses any time the property returns a null value, and a minimum and maximum value for the property's domain.

Property Name:	KSAT HIGHEST MINIMUM ABOVE RESTRICTIVE LAYER 24 to 60
Description:	Finds the lowest value for permeability (K-Sat) in horizons tha and above a restrictive feature.
	Returns values for low, high, and rv: each has a single value.
Data Type:	Numeric
Modality:	High, Low, Representative Value
Units:	UM/S
Minimum:	
Maximum:	
Default Value:	

Using the principles of fuzzy logic (fully explained in Chapter 19), a graph is created to identify the impact in the Evaluation Editor, as shown on the next page. The graph is used to evaluate the soil property and its relative truthfulness of being a limiting feature. For example, if a soil has a Ksat Class of absolutely too rapid (assuming greater than or equal to 42 micrometers per second), the fuzzy value would be 1. If the Ksat is absolutely not too rapid (assuming less than 14 micrometers per second), the fuzzy value would be 0. Fuzzy logic evaluates the property when it falls in the range between absolutely too rapid (1) and absolutely not too rapid (0). For example, if the soil Ksat is moderately slow, it could be plotted as 0.5, meaning that the soil has a 0.5 truthfulness of water movement being absolutely not too rapid (28.00 micrometers per second).
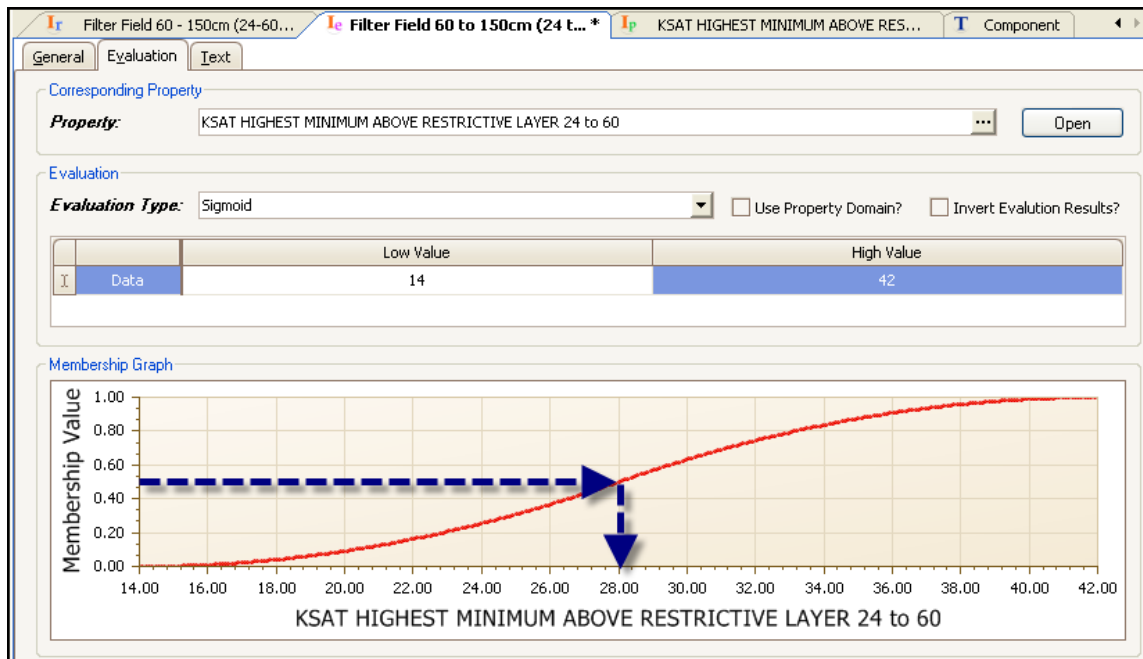
Evaluations specify the ranges used to assess the relative truthfulness of a statement about a soil property. For example, the evaluation criteria set the limits for determining whether the statements "soil Ksat is too rapid" and "soil Ksat is not too rapid" are absolutely not true, absolutely true, or somewhere in between.

Fuzzy logic allows for the relative statements about soil properties. For example, in the traditional view, the logical statement A AND B means that both A and B must be absolutely true for the statement to be true. But with fuzzy logic, each of A and B represent some degree of truthfulness (membership in a class), from absolutely *not* true to absolutely true. The statement A AND B evaluates the minimum truthfulness for either of A and B. For example, if a soil must be deep and dry in March to be suitable for early tillage, and the soil is deep but moist, the statement that the soil is deep is true but the statement that the soil is dry is only partly true. Therefore, the soil is partly suited to early tillage.

This statement about soil behavior can be understood in terms of relative truthfulness. If the soil is very nearly dry, then its degree of truthfulness is very nearly 1 (perhaps 0.9), and it is very nearly suited (0.9) to early tillage. The degree of truthfulness is numerical and can be used in mathematical operations or converted into classes such as slightly limited, somewhat limited, and very limited. Regardless of how you use it, fuzzy logic allows you to make more intuitive, more precise, and more useful interpretations. This concept helps you deal with relative statements about soil properties. If you have not already done so, refer to Chapter 19 for a full discussion of fuzzy logic.

Evaluation Types

There are several evaluation types or curves that can be used to assess a soil property for its relative impact. Both crisp and fuzzy systems curve options are available.

Crisp Curve

The crisp curve is used to represent classed data sets that have well defined definite boundaries. For instance, soils can be evaluated to find those with a depth to bedrock less than or equal to 20 cm as being absolutely "too shallow" (1).
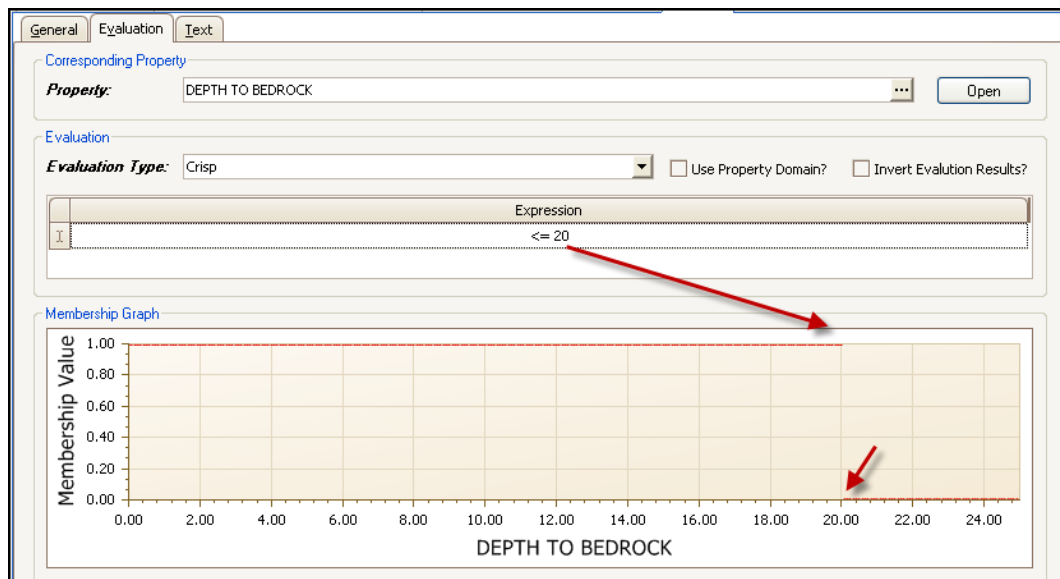
Crisp set evaluations are the only ones that can be used for character data. While it is possible to use the operators <, <=, > or >= they do not make as much sense for character property type.

Sigmoid Curve

The sigmoid curve is used to represent an increasing nonlinear fuzzy data set. The fuzzy set moves from no membership at the left hand side to full membership on the right hand side. The membership function is pivoted around the 50% membership point. This is called the inflection point. This S shaped curve is used to depict natural processes by time.

In this instance the soil is evaluated between the depths of 25 and 100 cm. The depth less than 25 returns a fuzzy value of 1 (absolutely limiting) and the depth greater than 100 returns a fuzzy value of 0 (absolutely not limiting). Values between 25 and 100 are assigned membership values based on the intersection of the sigmoid curve and the soil depth. (Note that the graph is set "Invert Evaluation Results".)
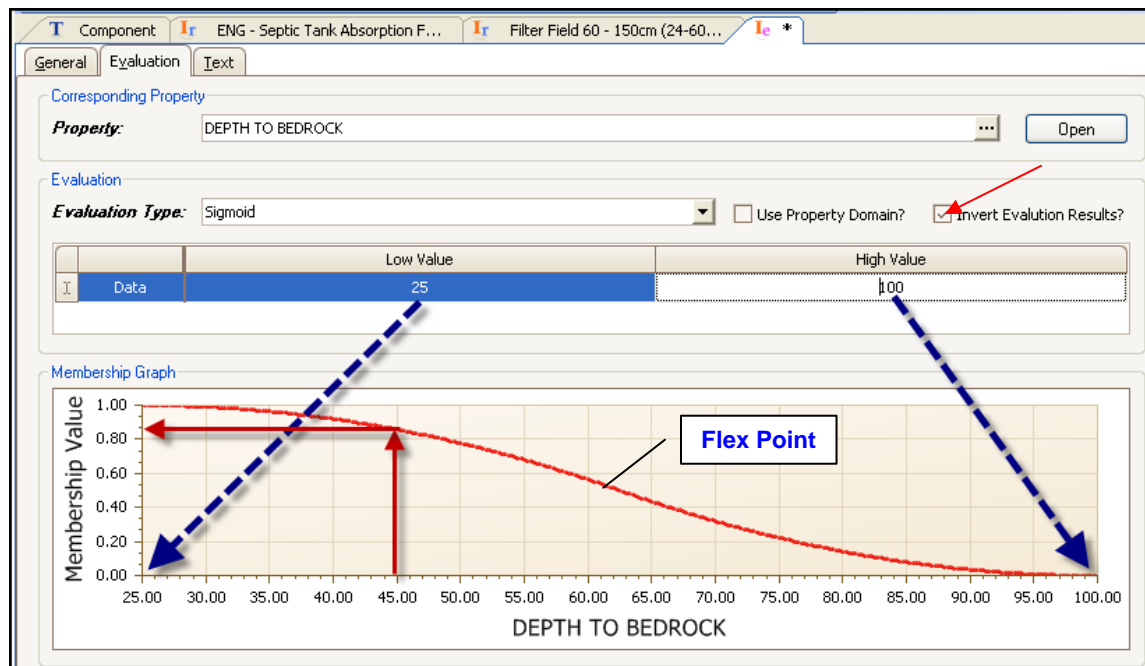
The Sigmoid curve must be used with caution due to the curvature at the beginning and end points. Note that the values between 25.00 and 33.00 have a minor differentiation of the Membership Value. This should be seriously considered when developing an evaluation using a sigmoid curve and the soil properties should be assigned as accurately as possible to identify the absolutes.
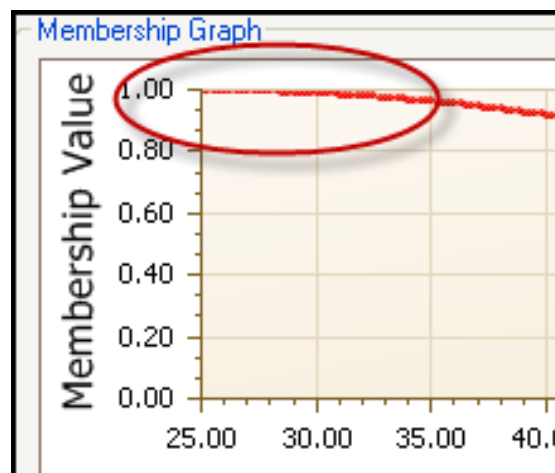
Linear Curve

The linear fuzzy surface is considered to be the simplest representation of a fuzzy data set. The membership value (y) is proportional to the domain value (x). The depth to bedrock less than 25 returns a fuzzy value of 1 (absolutely limiting) and the depth greater than 100 returns a fuzzy value of 0 (absolutely not limiting). Values between 25 and 100 are assigned membership values based on the intersection of the line and the soil depth. (Note that the graph is set "Invert Evaluation Results.)
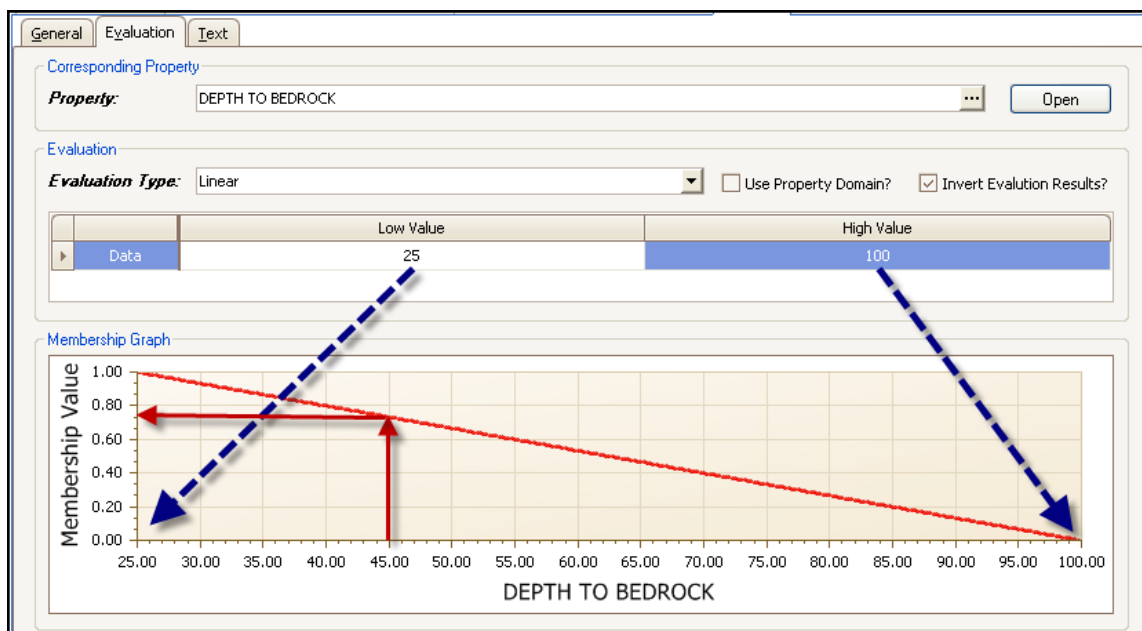
Comparison of the Sigmoid and Linear Curves

Notice the difference in the relationship of the Membership Value and Depth to Bedrock between the Sigmoid and the Linear curves. At a depth of 45 cm, the Sigmoid Curve assigns a Membership Value of 0.875 whereas the Linear Curve assigns a Membership Value of 0.725. Inverse results will appear at the 85 cm depth where the Sigmoid Curve assigns a Membership Value of 0.15 and the Linear Curve assigns a Membership Value of 0.25. Issues such as this should be considered during the planning of the interpretation.

Arbitrary Curve

The arbitrary curve is used when the distribution of the membership values is not directly adaptable to standard curve architectures. Assign the soil properties to the X axis and identify the Membership Value to be assigned for each intersection on the Y axis.
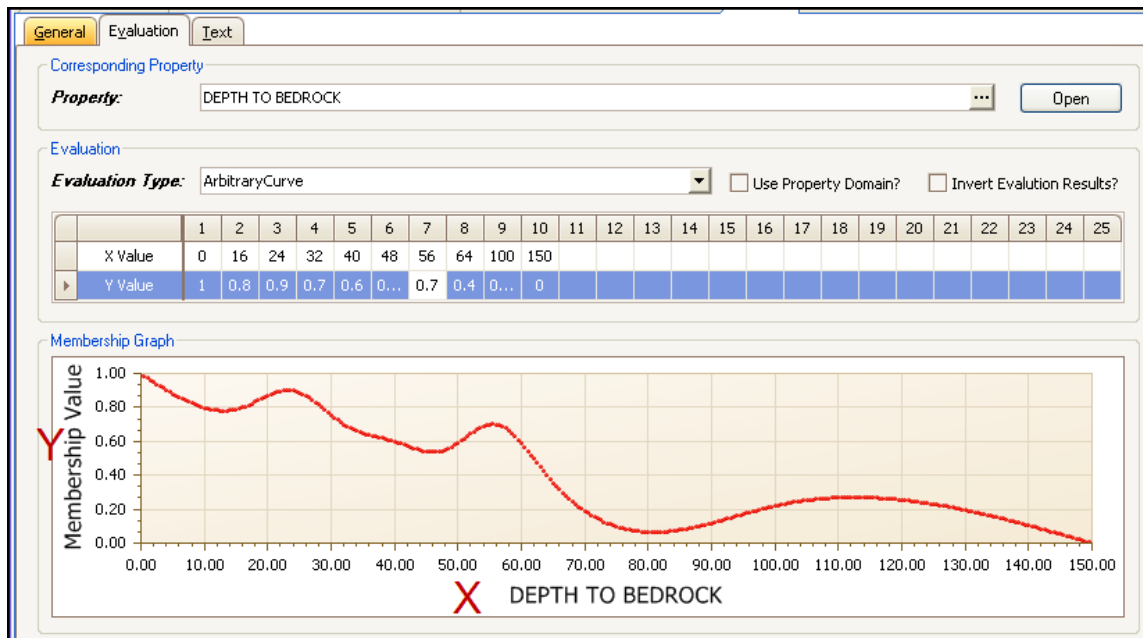
Arbitrary Linear

Similar to the Arbitrary Curve, the arbitrary linear curve is used when the distribution of the membership values needs to be defined more accurately than standard curve architectures are capable of doing. The membership values in related fuzzy data sets may fall to zero or plateau for some part of the set.
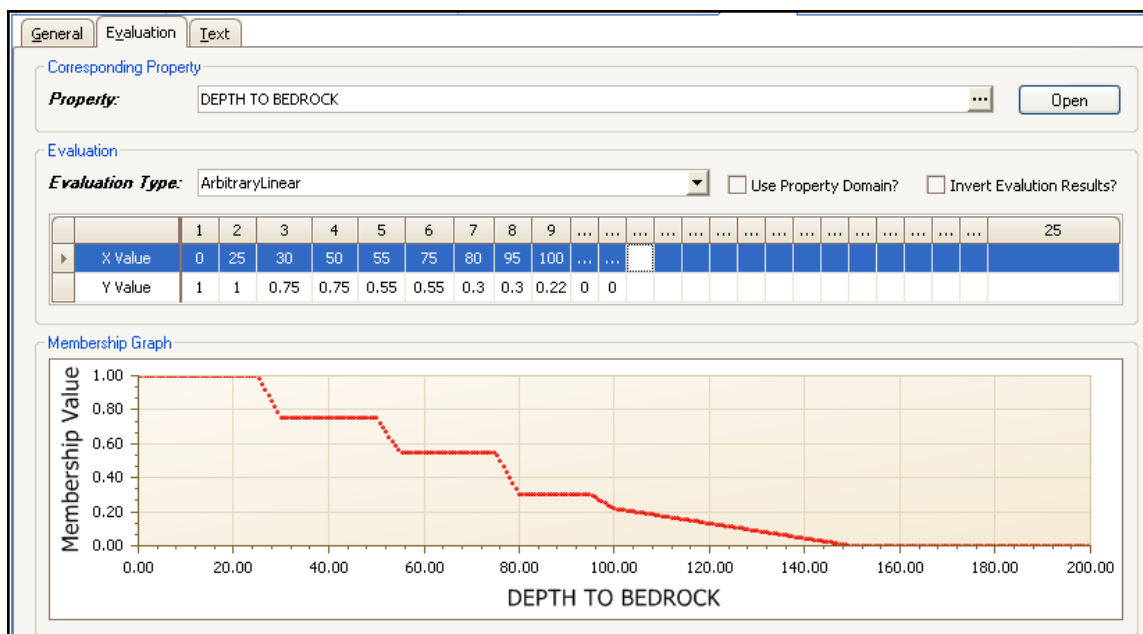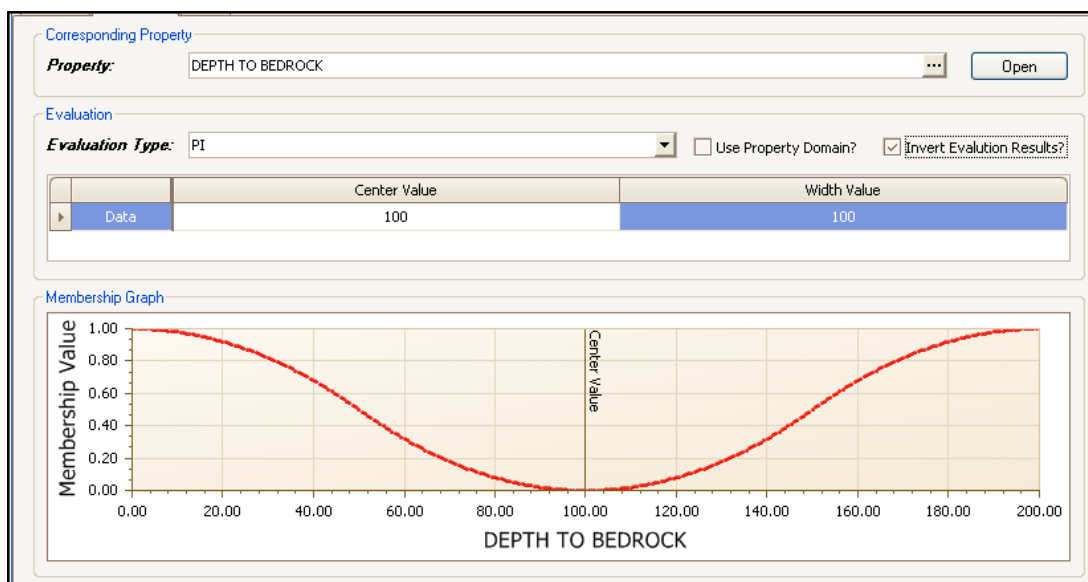
PI Curve

The PI fuzzy set is represented by a curve composed of two sigmoid curves back to back. It has a central point at which it has full membership and going either left or right of this point causes a nonlinear decline in membership value. The PI curve is used to represent a fuzzy data set that approximates a normal distribution (bell shape) around a central membership value. This inverted PI Curve would assign soil depths at 0 and at 200 a membership value of 1 (absolutely limiting) and those between it would evaluate based on the intersection of the curve and the soil depth.

Beta Curve

The beta fuzzy set is represented by a bell type curve. It has a central point at which it has full membership and going either left or right of this point causes a nonlinear decline in membership value.

The shape of the Beta curve is hyperbolic, so it does not approach zero as quickly as a gaussian curve. The beta fuzzy set would be used to represent numbers clustered around a central point but with a different distribution that the PI or Gaussian sets.

To enter a beta fuzzy set you must provide a center value and an inflection point offset . The value at point is 1 and the value at points is 0.5. Further out from the center the value becomes smaller but never reaches exactly zero.
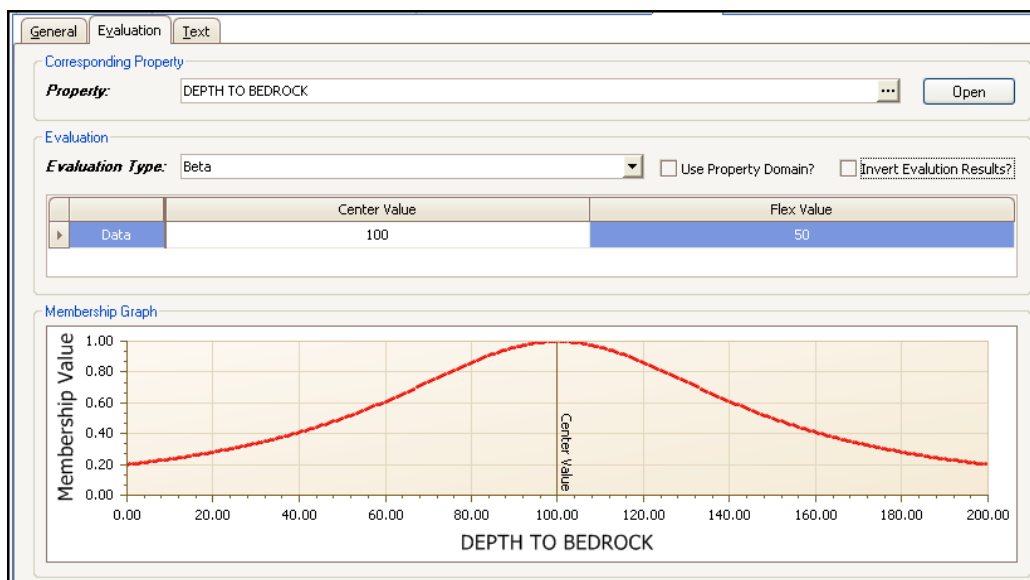
Gaussian Curve

The Gaussian fuzzy set is represented by a bell curve. It has a central point at which it has full membership and going either left or right of this p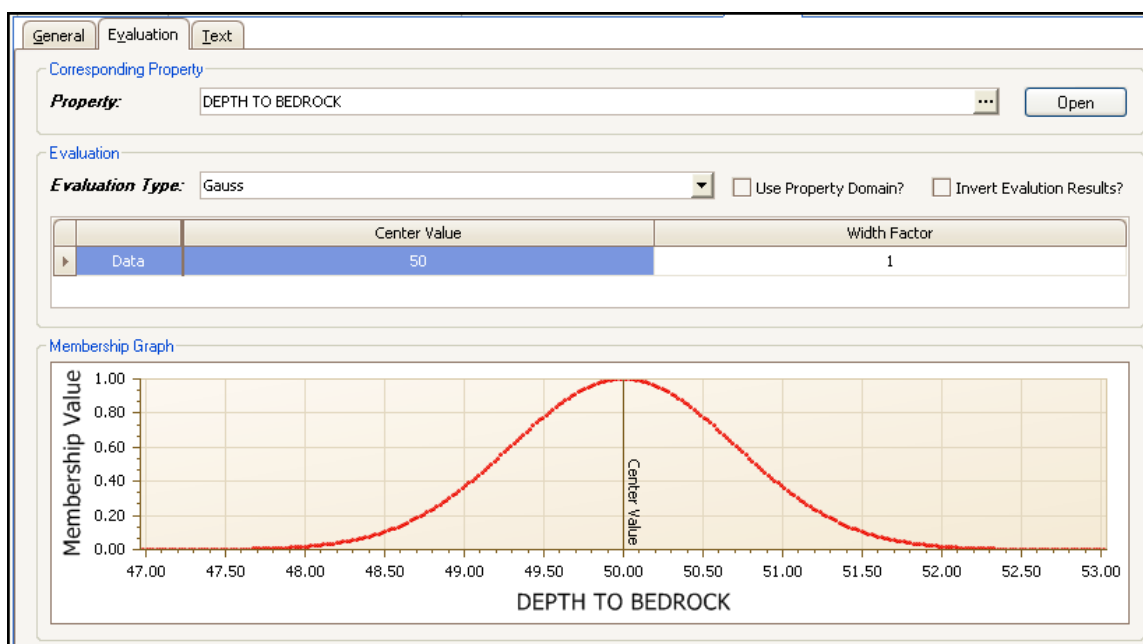oint causes a nonlinear decline in membership value. The curve for a Gaussian fuzzy set looks similar to a PI set but is not as rounded at the top. The Gaussian curve is similar to the beta curve except for the fact that the slope of the bell curve is very steep and possesses relatively short tails. The membership value of the fuzzy data set goes to zero very quickly. This normal Gaussian curve would assign an absolute limiting value of 1 to the depth of 50 cm. All other depths would be assigned membership values based on the intersection of the curve. Mathematically speaking, the sides of a Gaussian curve are an exponential curve, while the Sigmoid curve is a quadratic or parabolic curve.

The most common use of the Gaussian fuzzy set is to represent numbers in a statistically normal distribution. If you are describing values clustered around a central point, you may be in a situation where a Gaussian curve would work well. Gaussian sets are not as popular as PI curves for representing fuzzy numbers because it is not as easy to predict the shape of the curve for a given width factor.

To enter a Gaussian fuzzy set you must provide a center value and a width factor . Note that the width factor operates in an inverse manner-as the width factor gets larger the curve gets narrower. The value at point is 1 and as you go out from the center the value becomes very small but never reaches exactly zero.

Triangle

The Triangular fuzzy set is represented by a triangle. It has a central point at which it has full membership and going either left or right of this point causes a linear decline in membership value. The triangular curve spreads the membership values evenly across the domain (x axis) and the contour is defined through linear interpolation.
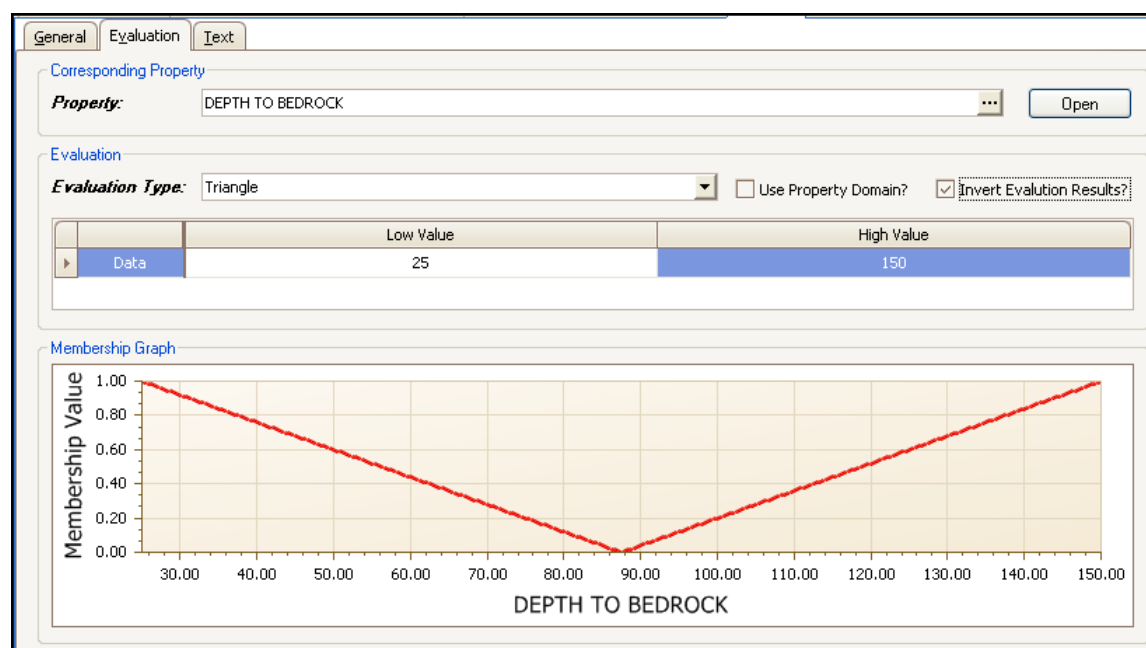

To enter a triangular fuzzy set you must provide a low value and a high value. The center point of the triangle is assumed to be half way between the low and high values, and has a membership value of 1. The inverted triangle above assigns a membership value of 1 (limiting) to those soils with bedrock depths less than 25 cm and any greater than 150 cm. The depth of 88 cm is assigned a membership value of 0 (not limiting).

Trapezoidal

The Trapezoidal fuzzy set is similar to a triangle fuzzy set, but instead of having a single point at full membership, there are a range of points at full membership. Moving either left or right of this range causes a linear decline in membership value. The trapezoidal curve is a triangular curve truncated by a plateau. The width of the plateau is proportional to the number of

membership values that are true. To enter a trapezoidal fuzzy set you must provide a low value and a high value and the minimum and maximum values for the top plateau.
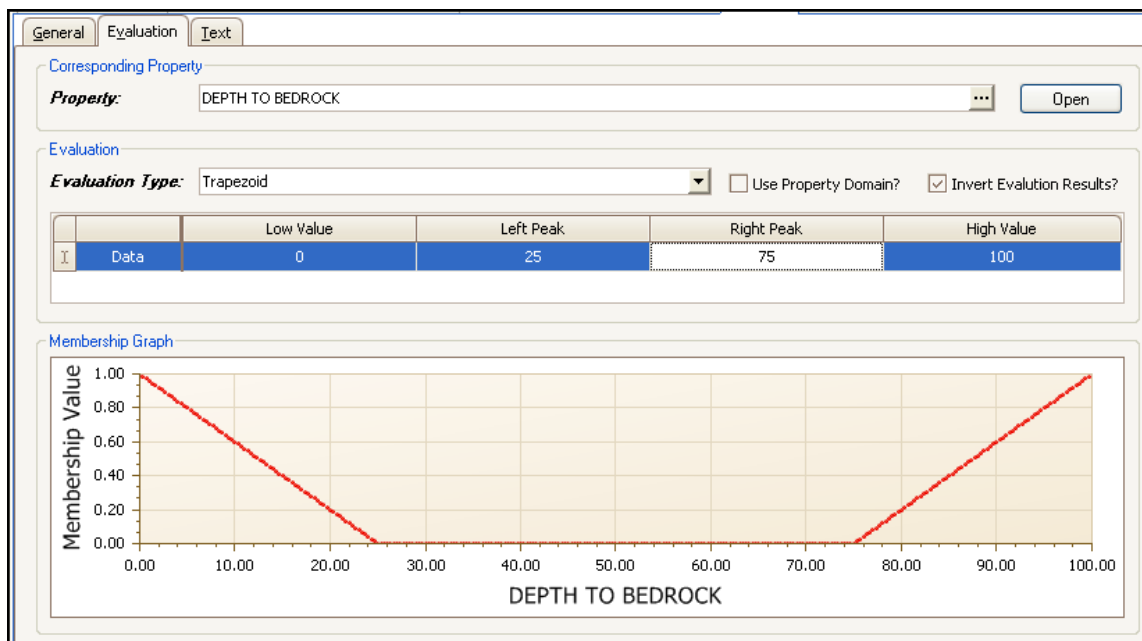
Is Null

The Is Null evaluation is used to assign a value to those properties that are used in the interpretation but are not populated in the database. Simply, a null field can be assigned any single value inclusively between 0 and 1.
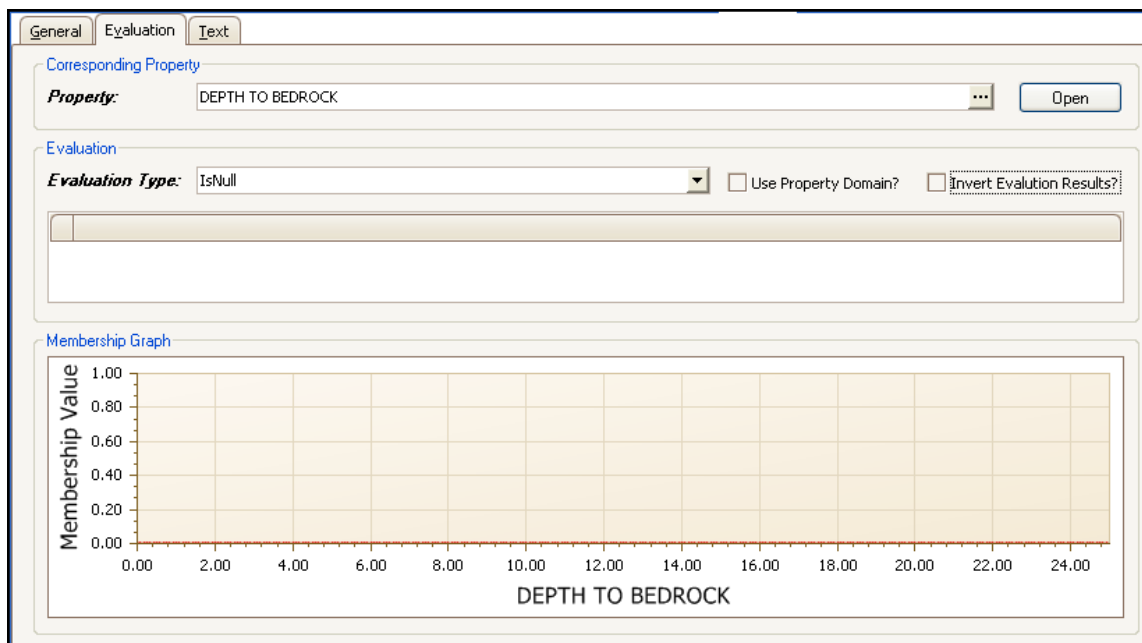
Testing Evaluations

Evaluations can be run against a single component to test the results of the evaluation. This is done by selecting a single component in the Component table, returning to the Evaluation and choosing to "Run Evaluation Against Local Database" from the Interpretation Menu or the Editor Toolbar (as shown below).
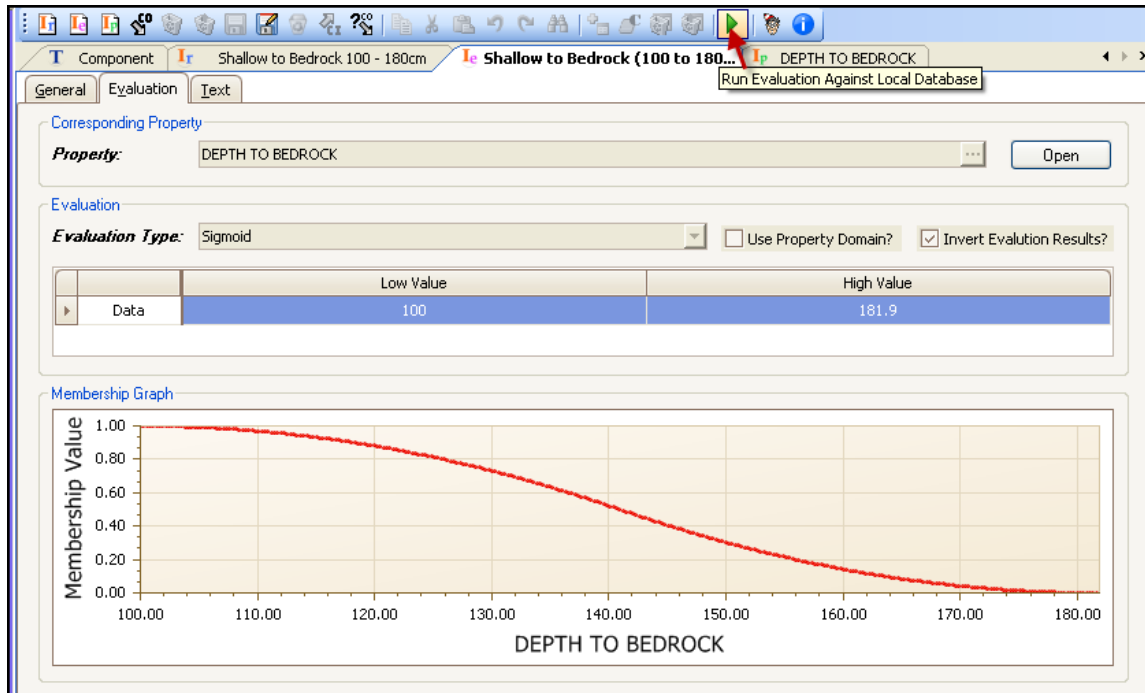
The resulting report is used to test the Evaluation results:

Using Multiple Values

When multiple input values are provided from a property, the evaluation returns a range of membership values. The following cases can occur.

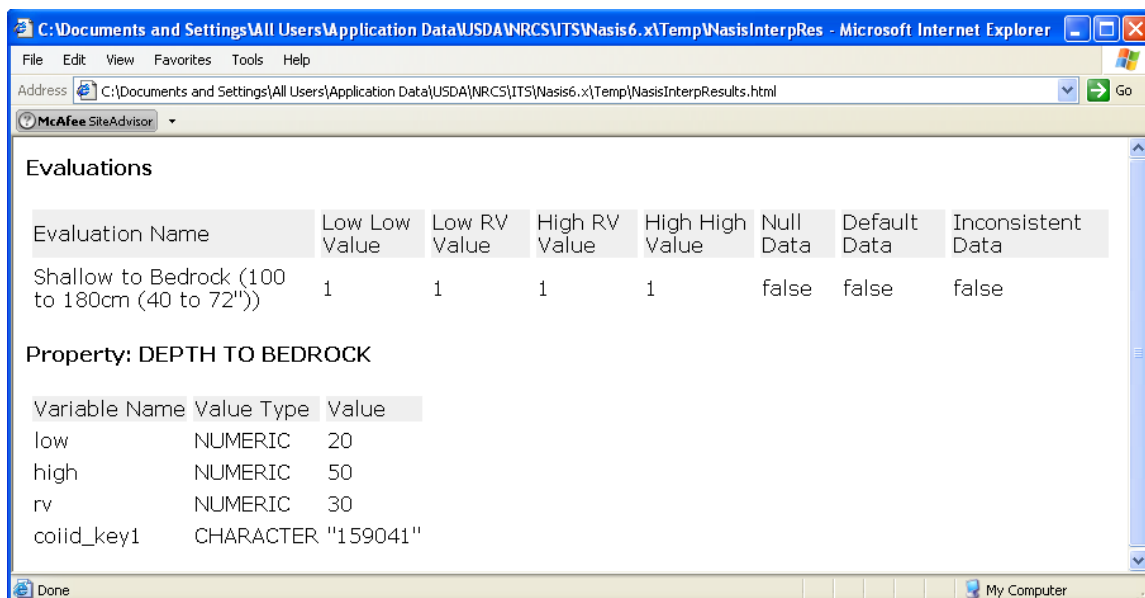If a property provides ranged data with a low and high value, the two values are evaluated separately. The lower membership value is called the "low-low" result and the higher value is called the "high-high". Note that the lower input value does not necessarily produce the low-low result. Depending on the evaluation function the smaller input value could produce a higher membership value, which would then become the high-high result. A property can also return data from more than one database row at once, so there could be several low and high inputs. Still, the lowest result is the low-low and the highest is the high-high.

If a property provides representative values, they are evaluated separately from the low and high values. The lowest result of this group is the "low-rv" value, and the highest is the "high-rv" value. If only one representative value is provided, the low-ry and high-ry results are equal.

Evaluations

Evaluation Name	Low Low Value	Low RV Value	High RV Value	High High Value	Null Data	Default Data	Inconsistent Data
Shallow to Bedrock (100 to 180cm (40 to 72"))	1	1	1	1	false	false	false

If a null value is provided from a property, and there is no default value defined, the result is considered to be "unknown", meaning that its membership value could be anything from 0 to 1 (unless the NULL evaluation type is used). If a null occurs in the low or high input columns, the low-low becomes 0 and the high-high becomes 1. If the null occurs in the representative value column, the low-ry becomes 0 and the high-ry becomes 1. In addition, if any nulls are provided from a property a "Null Data" flag is set in the evaluation result, which can be used during rule processing to handle cases where the absence of data is significant.

Where Used "Evaluations"

Evaluations are developed to be used by more than one Rule. The "Where Used" icon or menu option is used to identify rules using a specific evaluation. This allows the user to identify the rules that will be impacted due to any changes made to the evaluation. Highlight the evaluation in the Interpretation Explorer, or with the Evaluation open in the Editor Panel, choose "Where Used" icon or menu option.
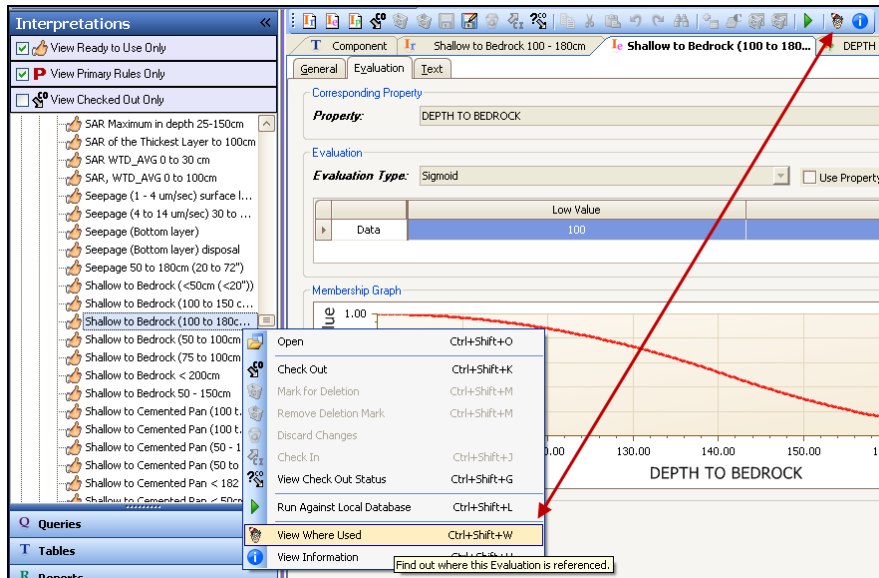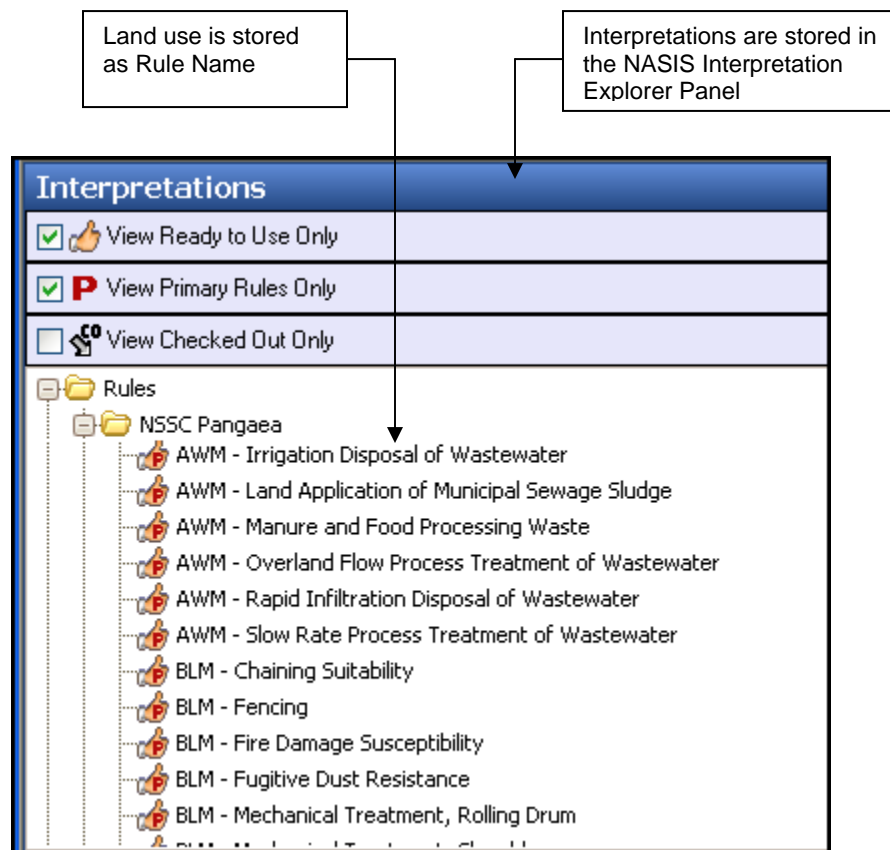

The report provides the Property name used in the Evaluation and the Rule(s) using the specific evaluation.
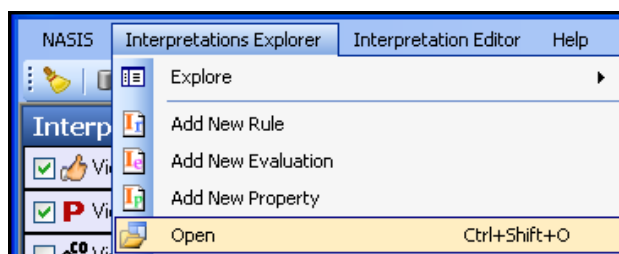
NASIS interpretations

An *Interpretation* or primary rule is a root rule in NASIS. The interpretation uses *Evaluations* and *Sub Rules* to derive interpretive values. The interpretation is a logical statement about land use, limiting features, and the relationship among limiting features. The land use is identified in the Rule Name, as depicted in the image below. The interpretation's limiting features and the relationship among them (relative weights and interactions) are depicted graphically with a special Rule Editor (see page 22). NASIS interpretations are stored in the Interpretation Explorer panel, organized by the NASIS Site and identified by the letter "**P**" in the graphical "thumbs up" icon.

Land use is stored as Rule Name

Interpretations are stored in the NASIS Interpretation Explorer Panel

Interpretations

☑ 👍 View Ready to Use Only

☑ **P** View Primary Rules Only

☐ 🐾 View Checked Out Only

⊟ 📂 Rules
    ⊟ 📂 NSSC Pangaea
        👍 AWM - Irrigation Disposal of Wastewater
        👍 AWM - Land Application of Municipal Sewage Sludge
        👍 AWM - Manure and Food Processing Waste
        👍 AWM - Overland Flow Process Treatment of Wastewater
        👍 AWM - Rapid Infiltration Disposal of Wastewater
        👍 AWM - Slow Rate Process Treatment of Wastewater
        👍 BLM - Chaining Suitability
        👍 BLM - Fencing
        👍 BLM - Fire Damage Susceptibility
        👍 BLM - Fugitive Dust Resistance
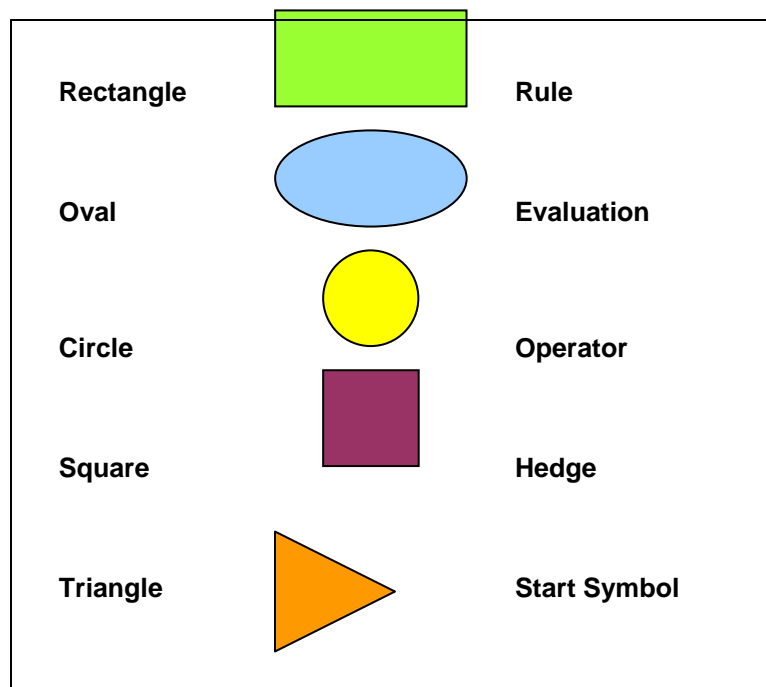   👍 BLM - Mechanical Treatment, Rolling Drum

Limiting features, the relationships among the Sub Rules and evaluations, and their link to the interpretation are depicted in a special Rule Editor accessed when the interpretation is opened in the Editor Panel. Interpretations are loaded into the Editor Panel by using the "open" on the Interpretations Explorer menu, using the right click menu, double-clicking the specific interpretation, or using the hot keys "Ctrl+Shift+O".

| NASIS | Interpretations Explorer | Interpretation Editor | Help |

📇 Explore ▶

🔳 Add New Rule

🔳 Add New Evaluation

🔳 Add New Property

📂 Open   Ctrl+Shift+O

Rule Editor Symbols

The Rule Editor lets you illustrate the interpretation or sub rule graphically with symbols called rule components. Refer to the figure below for a description of each rule component.

Rectangle		Rule

Rectangle — Rule

Oval — Evaluation

Circle — Operator

Square — Hedge

Triangle — Start Symbol

Rule Components and Symbols.

Start State

Every rule begins with a start state. The start symbol is shown as an upside down triangle in the rule editor. There can be just one component attached to the start state.

Operators

Operators are shown as circles in the rule editor. Operators require at least one other component to be attached as operands. Many operators require a specific number of operands and are highlighted as "incomplete" until the correct number of operands is attached.

Hedges

Hedges are shown as squares in the rule editor. All hedges pass on the weight of their children, except for the weight hedge which sets it to some value other than 0.

Evaluations

An evaluation is shown as an oval in the rule editor. A rule can refer to an evaluation of a database property. In fact this is how rules are connected to the database.

Rules

A rule is shown as a rectangle on the rule editor. A rule can use the result of another rule as part of its definition. This is a rule reference. Rules cannot be recursive. If A is a rule then A cannot be referenced either directly or indirectly by rule A.

NASIS User Guide

For an interpretation, its' limiting features and the relationships among them (relative weights and interactions) are depicted graphically in a special Rule Editor

Choice of operators include AND, OR, SUM, AVERAGE, and others

In the Rule Editor, the rules, in this case Sub Rules, are shown as rectangles

Ir ENG - Septic Tank Absorption F...

General | Rule | Rating Classes | Text

Zoom: 75%

START → OR

(NSSC Pangaea) Permafrost

(NSSC Pangaea) Flooding Very Rare/Rare Freq. Somewhat Limited

(NSSC Pangaea) Ponded > 4 hours

(NSSC Pangaea) Shallow to Bedrock 100 - 180cm

(NSSC Pangaea) Shallow to Cemented Pan 100 - 180cm

(NSSC Pangaea) Wet, Ground Water Near the Surface (120 - 180cm)

(NSSC Pangaea) Filter Field 60 - 150cm (24-60")

(NSSC Pangaea) Percolation 60 - 180cm (24-72")

(NSSC Pangaea) Slope 8 to > 15%

(NSSC Pangaea) Total Subsidence > 60cm (24")

(NSSC Pangaea) Large Stones - Fract. >3in, 24.9 to >50%, Wght. Av. 0-40

(NSSC Pangaea) Seepage Bottom Layer, Not Aridic

(NSSC Pangaea) Unstable Fill

Rule Editor Depicting Sub Rules

The existing interpretation must be "Checked out" before edits can be made. After being checked out, a menu option lets you edit to add operator, hedge, sub rule and/or evaluation.
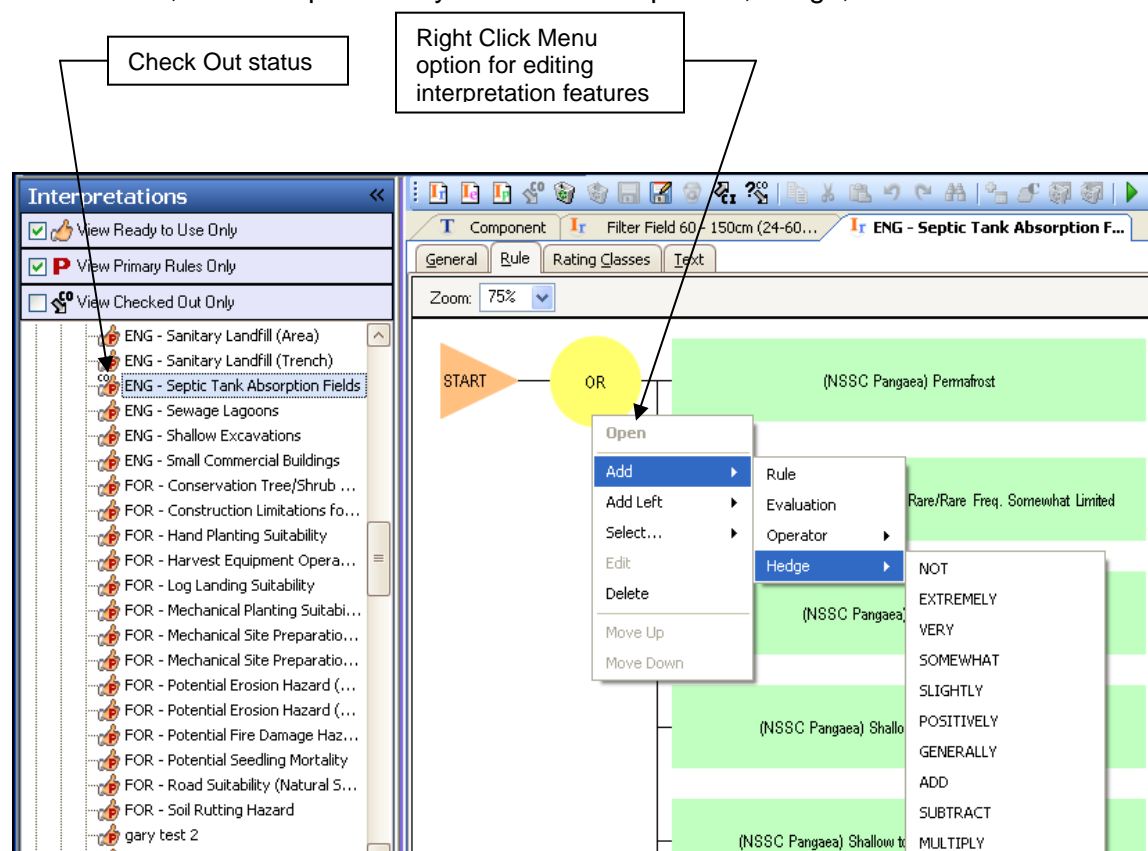
If the Interpretation is checked out, the Sub Rules can be opened by double clicking on the particular sub rule or using the right click menu and Open:
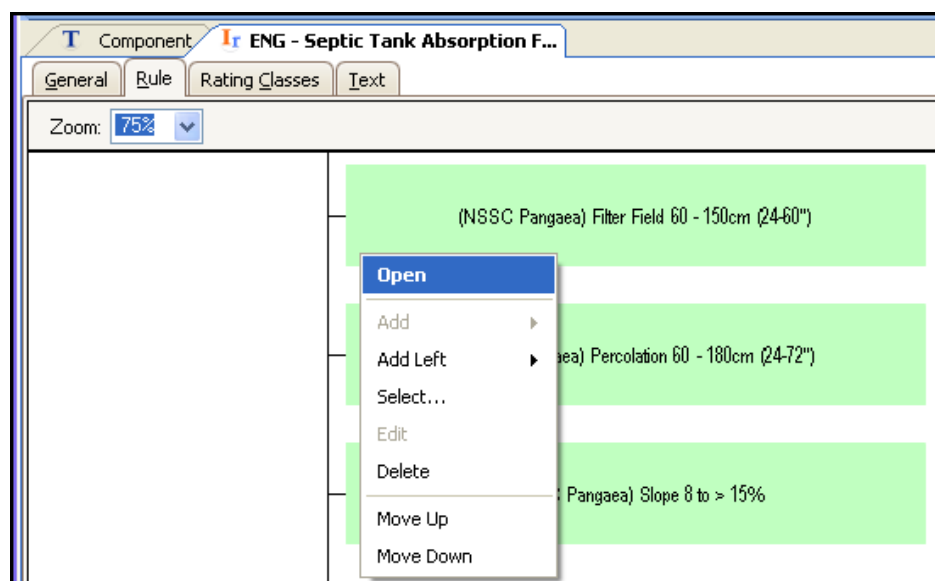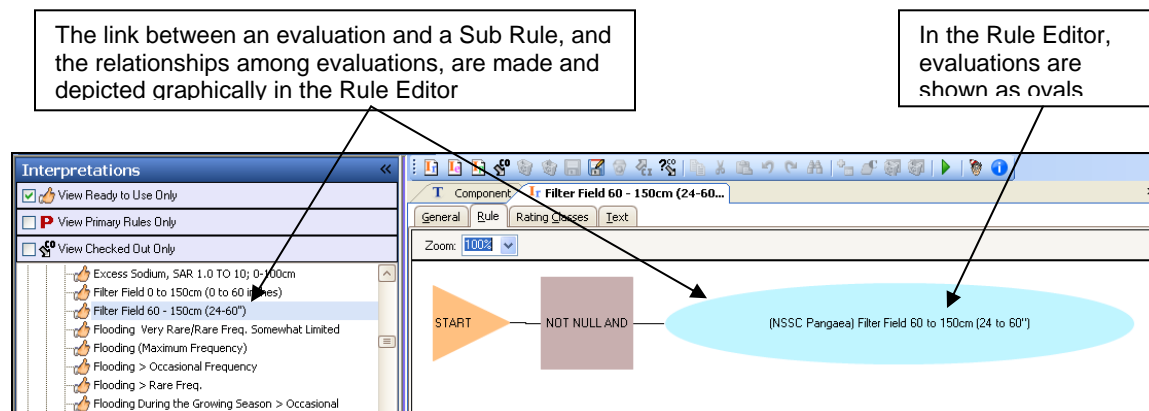
Sub Rules

A *Sub Rule* is a logical statement about one limiting feature. A Sub Rule says nothing about the land use; therefore, the same Sub Rule can be used in building different interpretations. Sub Rules are aggregated into an interpretation and are considered the basis, or building blocks, of an interpretation. Like interpretations, Sub Rules are stored in the Rule table, as shown in the image below. The limiting feature is stored as the Rule Name. A naming guideline helps you distinguish Sub Rules from interpretations.
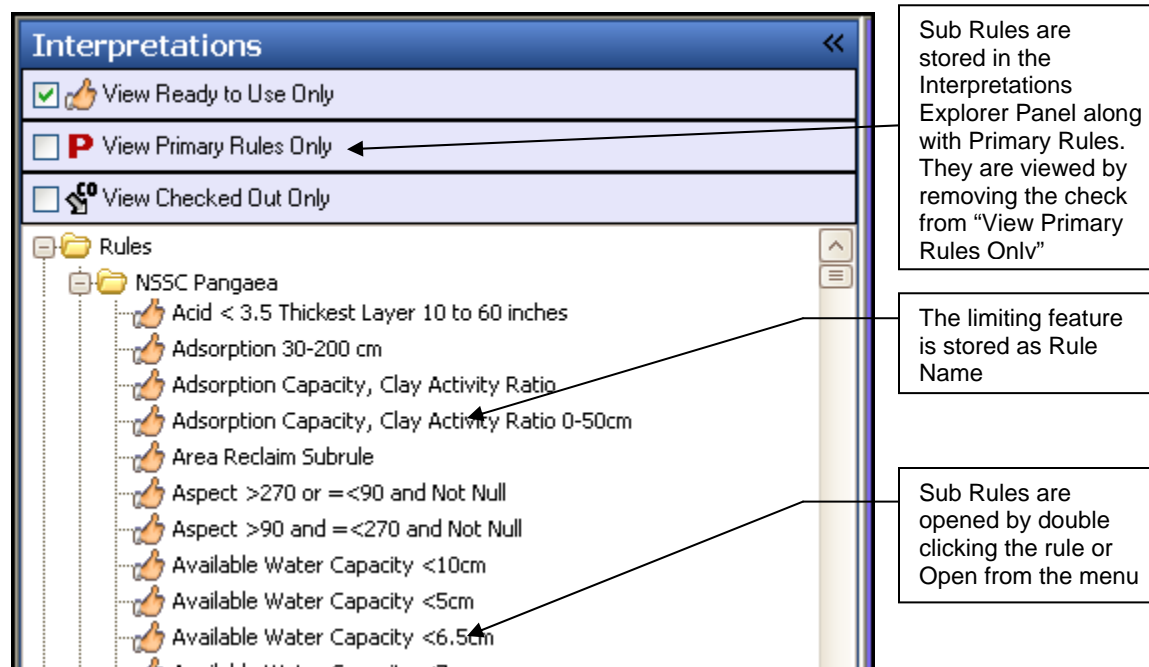
Interpretations Explorer Panel Displaying Sub Rules

Sub Rules have at least one evaluation linked to them. The linked evaluation(s) are depicted graphically in the Rule Editor shown in the image below.

Rule Editor Showing Link to Evaluation

In order to report out interpretive results, an evaluation must be linked to a Sub Rule. The Sub Rule gives you the flexibility of reusing evaluations for different interpretations.

Testing Sub Rules

The results of a Sub Rule can be tested against a single component using the "Run Against Local Database" option found on the Interpretations Explorer menu or the right click menu.
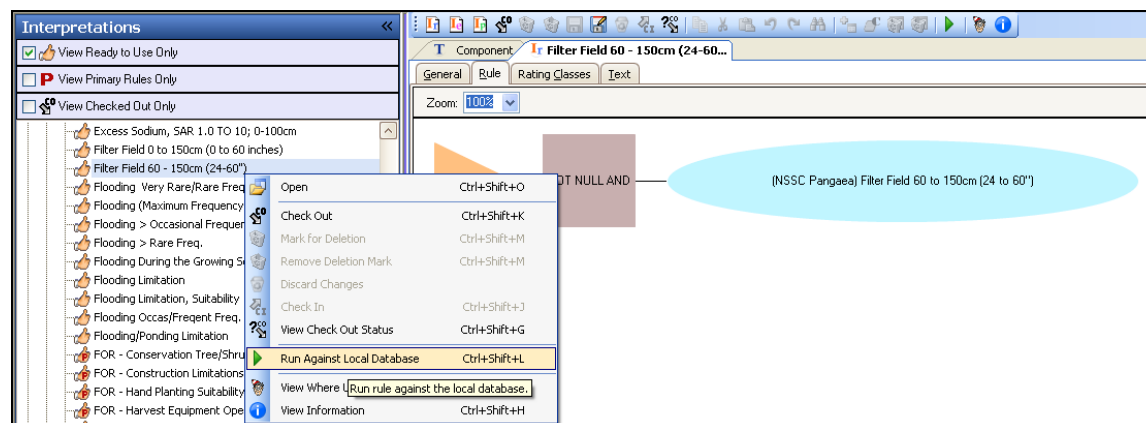
The resulting report is used to verify the results of the Sub Rule, Evaluation(s) and Property(s).

Address: C:\Documents and Settings\All Users\Application Data\USDA\NRCS\ITS\Nasis6.x\Temp\NasisInterpResults.html

Interpretation: Filter Field 60 - 150cm (24-60")

Sub-rule Name	Depth	Low Low Rating	Low RV Rating	High RV Rating	High High Rating	Null Data	Default Data	Inconsistent Data
Filter Field 60 - 150cm (24-60")	0	No filtering capacity limitation (0)	No filtering capacity limitation (0)	No filtering capacity limitation (0)	Filtering capacity (1)	false	false	false

Evaluations

Evaluation Name	Low Low Value	Low RV Value	High RV Value	High High Value	Null Data	Default Data	Inconsistent Data
Filter Field 60 to 150cm (24 to 60")	0	0	0	1	false	false	false

Property: KSAT HIGHEST MINIMUM ABOVE RESTRICTIVE LAYER 24 to 60

Variable Name	Value Type	Value
hzdept_r	NUMERIC	41, 69, 122
hzdepb_r	NUMERIC	69, 122, 203
ksat_l	NUMERIC	14.10999966, 14.10999966, 42.33000183
ksat_r	NUMERIC	28, 45, 92
ksat_h	NUMERIC	42.33000183, 141.1100006, 141.1100006
depth	NUMERIC	250
min_depth	NUMERIC	203
in_range	NUMERIC	1, 1, 1
low	NUMERIC	14.10999966
high	NUMERIC	42.33000183
rv	NUMERIC	28
coiid_key1	CHARACTER	"158660"

Operators

The operator defines the interactions between the limiting features (sub rules). Refer to Chapter 19 Introducing Interpretations page 19.5 for an explanation of the Operators "OR" and "AND".
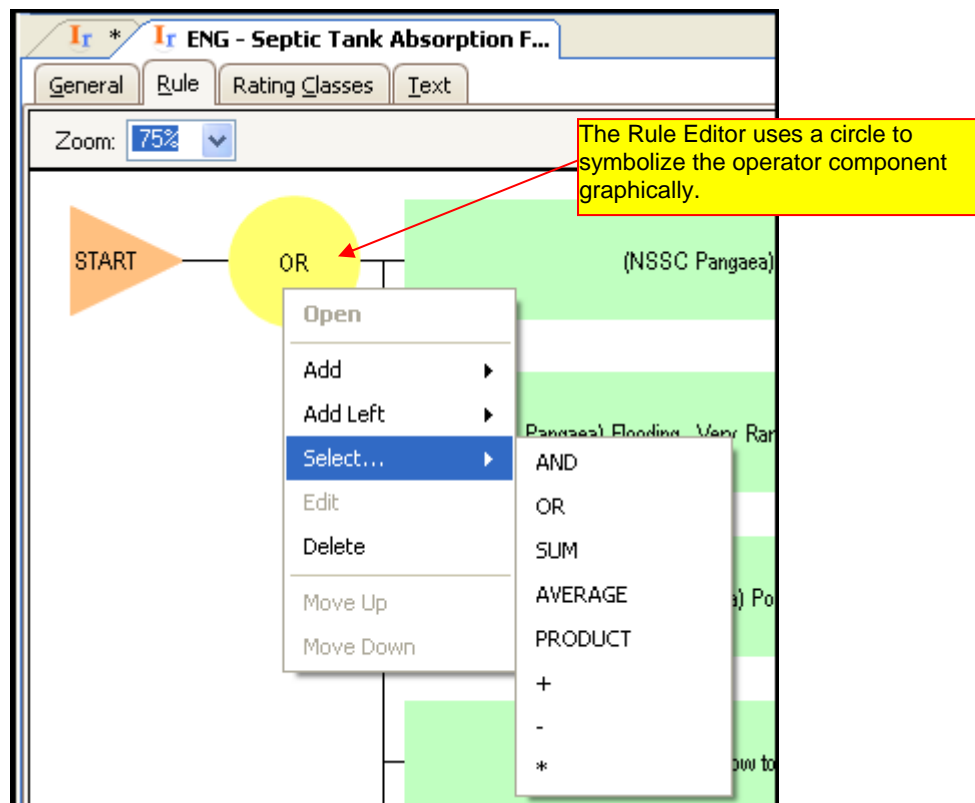
Regardless of the Operator used, the reported value is never a negative number nor is it ever greater than 1.
The "**AND**" operator will review the Membership Value numbers assigned to each sub rule and select the **Minimum** value to report for the interpretation.
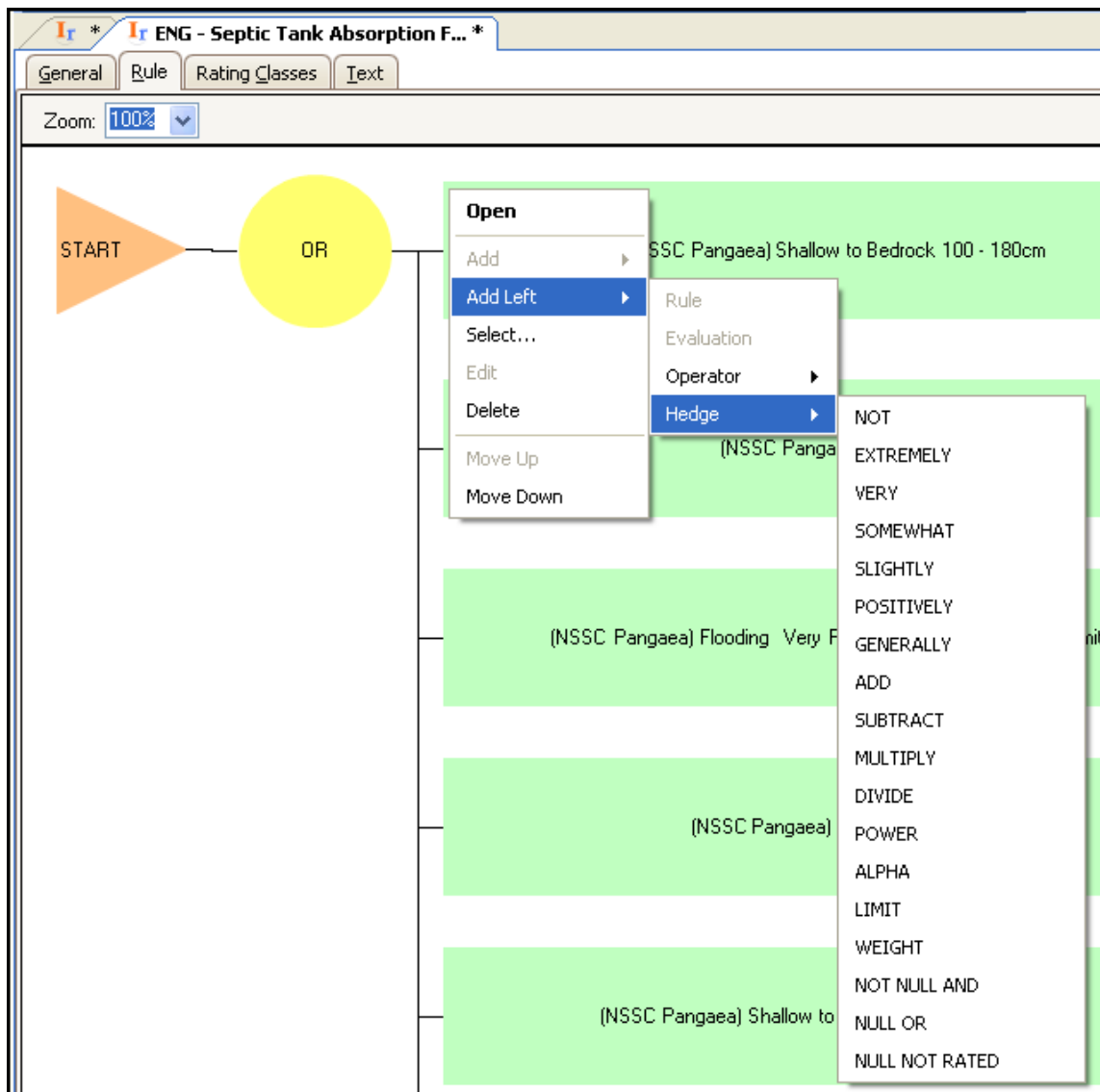
*The "**OR**" operator will review the Membership Value numbers assigned to each sub rule and select the **Maximum** value to report for the interpretation.*

*The "**SUM**" operator will review the Membership Value numbers assigned to each sub rule and **add all value** to report for the interpretation.*

*The "**AVERAGE**" operator will review the Membership Value numbers assigned to each sub rule, sum the values and divide by the number of values to report for the interpretation.*

*The "**PRODUCT**" operator will review the Membership Value numbers assigned to each sub rule and **multiply** the values to report for the interpretation.*

The "**+**", "**-**" and "*****" operators are used to add, subtract or multiply the Membership Values between sub rules to report for the interpretation.

The mathematical definition of the "PRODUCT" operator.

Hedges

A hedge is a mathematical transformation (such as a square, square root, reciprocal, or cube), in the form of an adjective statement, that changes the meaning of an evaluation. For example, if the statement is the "soil is steep", then the hedge "very" can be applied which performs the mathematical function "square." The hedge is assigned using the right click menu. In this scenario, using an existing interpretation, the sub rule is highlighted and the right click menu is used to add a hedge to "Add Left". Creating a new interpretation, the "Add" option is used to add the hedge.

Once the hedge is added, it can be modified using the Right click menu and "Select…" command.

The Rule Editor uses a square to symbolize the hedge component graphically.

The hedge options are included in the Rule Editor.
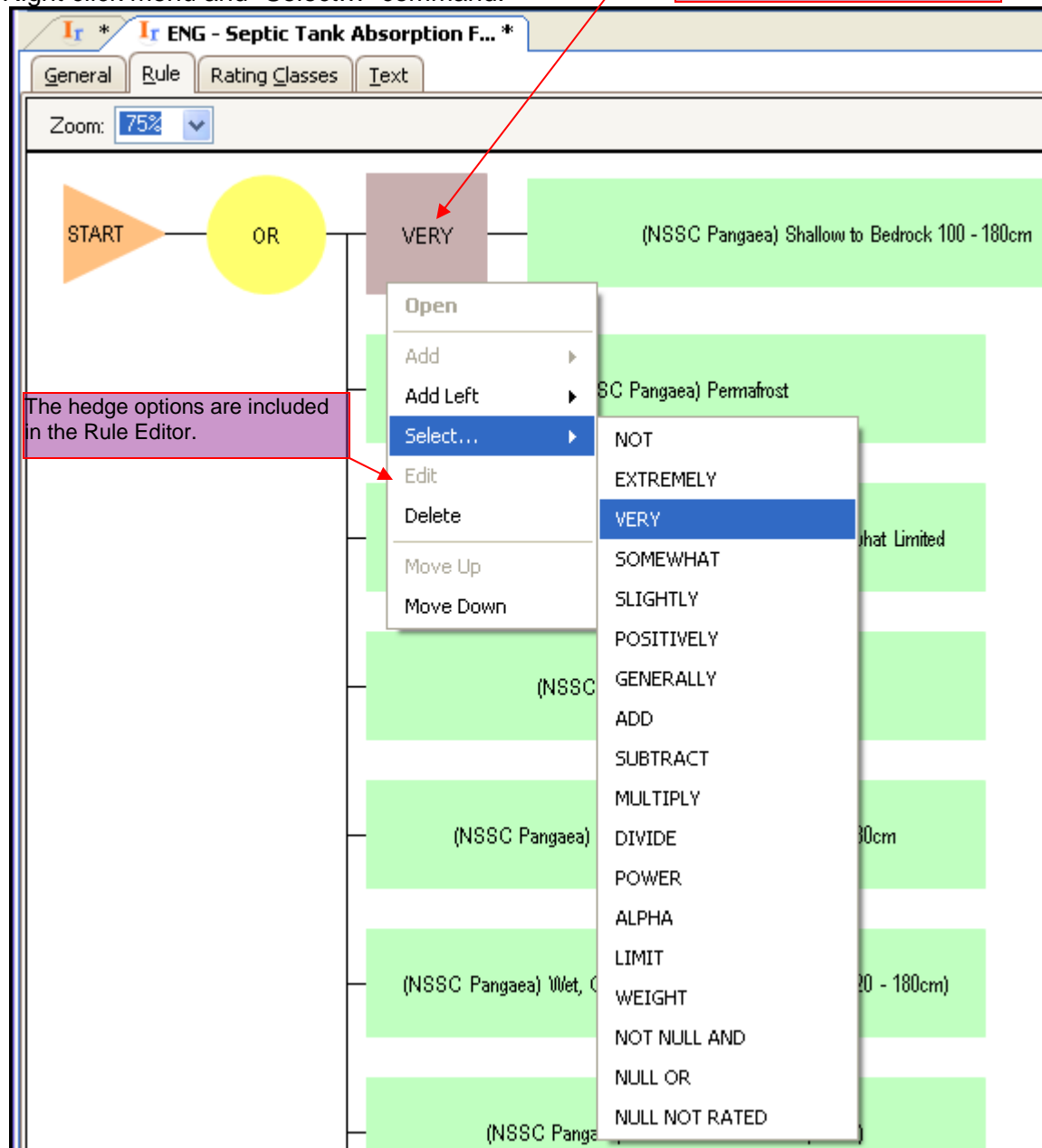
A hedge:
- is placed after the operator,
- is placed before the sub rule in an interpretation,
- is placed before an evaluation in a sub rule, and
- can be edited after it's placed in the rule.

Although all of these hedges have a default value, they can be edited and their parameter changed to reflect the user's needs. ***Regardless of the hedge used, fuzzy numbers cannot be negative and cannot exceed a value of one.*** Thus, if the "SUM" operator is used and the sum of the fuzzy numbers exceeds a value of one, then 1.0 will be reported. This condition is known as "saturation." Consider the needs of the interpretation when using hedges.

"Null" hedges

The ability to take full advantage of the capabilities of the NASIS interpretation generator requires the database to be completed populated with accurate scientific data for the soil properties that are included in the interpretive criteria.

Dealing with the fact that there are soil properties that are not populated in a component requires an understanding of the following definitions.

Null value: A condition in which no data is returned, regardless of whether the value is absent because a row does not exist, a specific column is not populated in a row that does exist, or the conditions exclude the return of a value that does exist in the database.

Determinate null: A null value in the database for which *a legitimate conclusion can be determined* regarding its membership in the interpretive set. It implies meta-knowledge about the guidelines and conventions used to populate the database, especially with regard to recording non-existent features of a component in the database. An example would be depth to bedrock. If depth to bedrock is not populated in the database: then depth to bedrock can be assumed to be greater then the depth of observation and therefore, the soil would not be a member of the group of soils that has depth to bedrock as a restrictive feature.

Indeterminate null: A null value in the database for which ***no*** *legitimate conclusion can be determined* regarding its membership in the interpretive set. An example would be the percent clay of any soil layer. If percent clay is not populated in the database: then no logical assumption can be made because percent clay could be anything within its domain of values (0 to 100).

For any specific interpretation, if physical, chemical, or morphological characteristics required by the interpretive criteria are populated, the requirement is to generate an interpretive result for that component. This means that miscellaneous areas such as dune land, river wash, rock outcrop, and even water can be interpreted if the specific interpretive criteria require only the limited characteristics that might be populated for these components.

For any specific interpretation, if any required characteristic is not populated there are two outcomes:

1. If no legitimate conclusion can be determined regarding its membership in the interpretive set (indeterminate null), then return a "not rated" result for that component.
2. If a legitimate conclusion can be determined regarding its membership in the interpretive set (determinate null), then return a result based on the legitimate conclusion.
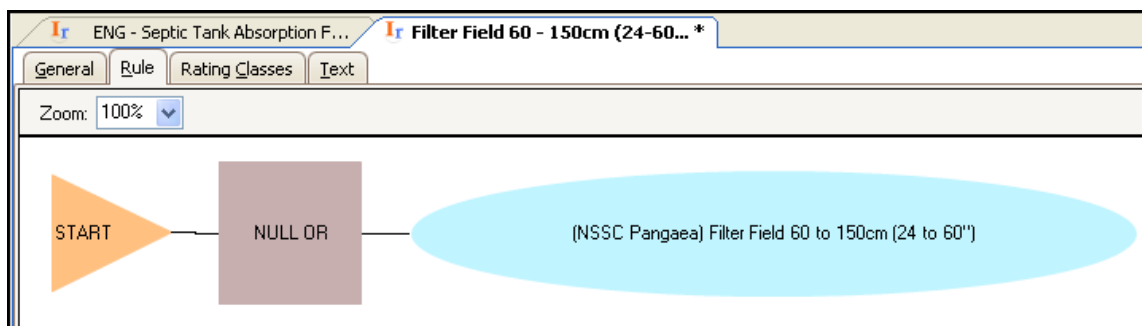
The ultimate goal is to have a completely populated database so that these types of decisions do not have to be made. The interpretation relies on a populated database to report its result. It is required for any specific interpretation that if the physical, chemical, or morphological characteristics required by the interpretive criteria are populated, then an interpretive result must be generated for that component. Null data fields require the user to make conscious decisions on its resulting impact of the interpretation.

In order for the above requirements to be fulfilled, one of the following "null" hedges (e.g. NOT NULL AND, NULL OR, or NULL NOT RATED) should be used in all sub rules.

The **"NOT NULL AND"** hedge assigns a Membership Value of 0 (not limiting) to null data elements encountered by the linked evaluation. In this "Shallow to Bedrock" sub rule, if the Component Restriction depth is not populated, then the membership value of this sub rule is assigned as 0 a non limiting value.
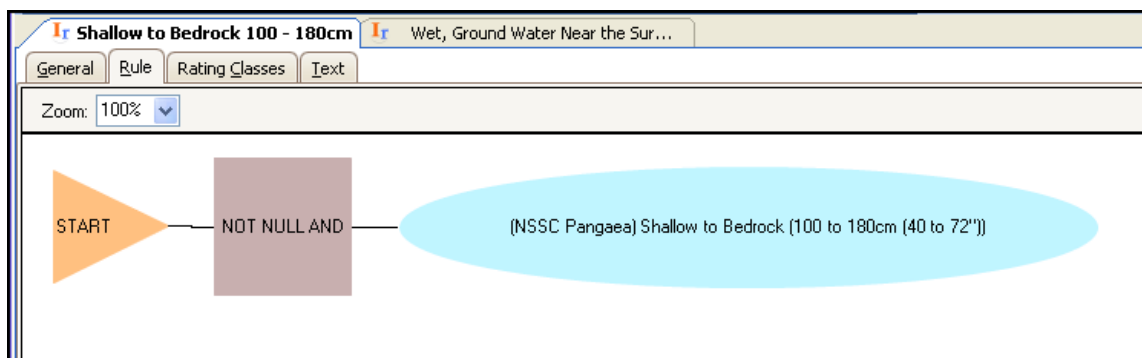
The "**NULL OR**" hedge assigns a fuzzy value of 1 (limiting value) to null data elements encountered by the linked evaluation. In this sub rule looking at the Ksat, if Ksat is not populated then the sub rule is assigned a membership value of 1, a limiting value.

The "**NULL NOT RATED**" hedge will considers the soil characteristic so important that if the field is NULL, then the interpretation can not run to completion and provide a result. In this sub rule for slope percentage, if the slope is not populated, this hedge will assign "Not rated" to the sub rule and the interpretation will end.
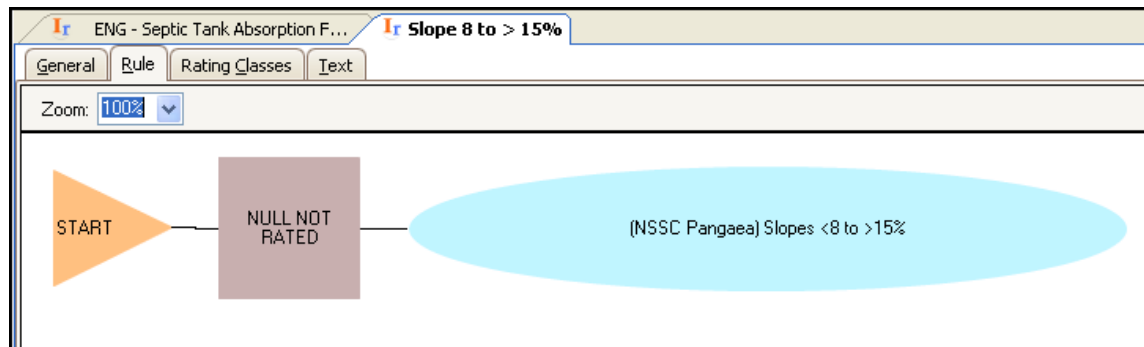
Mathematical Hedges

The "**NOT**" hedge performs a reciprocal mathematical transformation of the linked evaluation.

```
Hedge: NOT (NOT A => 1 - A)
```

The "**EXTREMELY**" hedge cubes the evaluation linked to it.

```
Hedge: EXTREMELY (EXTREMELY A => A^3)
```

The "**VERY**" hedge squares the evaluation linked to it.

```
Hedge: VERY (VERY A => A^2)
```

The "**SOMEWHAT**" hedge raises the linked evaluation to the 0.5 power.

```
Hedge: SOMEWHAT (SOMEWHAT A => A^0.5)
```

The "**SLIGHTLY**" hedge raises the linked evaluation to the 0.3 power.

```
Hedge: SLIGHTLY (SLIGHTLY A => A^0.3)
```

The "**POSITIVELY**" hedge squares the linked evaluation, multiplies it by two, and subtracts the resulting quotient from one when the evaluation variable is less than 0.5. When the evaluation variable is greater than or equal to 0.5 the "POSITIVELY" hedge squares it and multiplies it by two.

```
Hedge: POSITIVELY (POSITIVELY A => if A<0.5, 1-2*A^2 else 2*A^2)
```

The "**GENERALLY**" hedge raises the linked evaluation to the 0.5 power, multiplies it by 0.8, and subtracts the resulting quotient from one when the evaluation variable is less than 0.5. When the evaluation variable is greater than or equal to 0.5 the "GENERALLY" hedge raises it to the 0.5 power and multiplies it by 0.8.

```
Hedge: GENERALLY (GENERALLY A => if A<0.5, 1-0.8*A^0.5 else 0.8*A^0.5)
```

The "**ADD**" hedge adds a user specified number to the fuzzy result of the evaluation.

```
Hedge: ADD (A ADD 0.500000 => A + 0.500000)
```

The "**SUBTRACT**" hedge subtracts a user specified number from the fuzzy result of the evaluation.

```
Hedge: SUBTRACT (A SUBTRACT 0.500000 => A - 0.500000)
```

The "**MULTIPLY**" hedge multiplies the linked evaluation by a user specified number.

```
Hedge: MULTIPLY (A MULTIPLY 2.000000 => A * 2.000000)
```

The "**DIVIDE**" hedge divides the linked evaluation by a user specified number.

```
Hedge: DIVIDE (A DIVIDE 2.000000 => A / 2.000000)
```

The "**POWER**" hedge raises the linked evaluation to the power of four.

```
Hedge: POWER (A POWER 4.000000 => A^4.000000)
```

The "**ALPHA**" hedge sets the linked evaluation to zero if it is less than a threshold fuzzy number specified by the user.

```
Hedge: ALPHA (A ALPHA 0.100000 => if (A < 0.100000) A = 0)
```
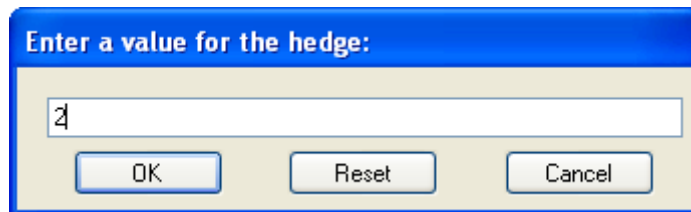
The "**LIMIT**" hedge sets the result of the evaluation to the number if it is greater than the limiting number.

```
Hedge: LIMIT (A LIMIT 0.900000 => if (A > 0.900000) A = 0.900000)
```

The "**WEIGHT**" hedge gives the linked evaluation a multiplier of two in order to increase its importance in the rule.

```
Hedge: WEIGHT (A WEIGHT 2.000000 => A WEIGHT 2.000000)
```

The ADD, SUBTRACT, MULTIPLY, DIVIDE, POWER, WEIGHT, ALPHA, LIMIT and WEIGHT are user defined hedges. A parameter box appears when these are selected and the user then assigns the hedge value.

Enter a value for the hedge:

2

OK   Reset   Cancel

Rating Classes

Rating classes translate the numerical Membership Value into an adjective class name. Rating classes are assigned to sub rules to identify property limitations. Rating classes are assigned to interpretation rules to identify the interpretation rating class.

Sub Rule rating class

A *Sub Rule* is a logical statement about one limiting feature. Since this sub rule deals with one limiting feature, then the rating class will identify that limiting feature. The Membership Value passed to the sub rule from the evaluation is translated from a numeric to a character class. In this instance, the sub rule receives the membership value from the "Slopes <8 to >15%" evaluation. That number is passed through the rating class and its number is assigned a class.

In this example, the membership value between 0.00 and 0.60 is converted to the class "No slope limitation"; values greater than 0.60 and less than 1.00 are converted to the class "Slope"; and the value of 1.00 is converted to "Too steep". These terms are those used to define the restrictive features in an interpretation report.

Each sub rule contains a rating class that translates its membership value to a rating class name for reporting for the interpretation report.

Naming Convention: Rating class names for all rules are to be "Sentence case". Only the first letter in the first word of the name is capitalized. Rating names for sub rules are to be brief, but descriptive, providing detail to the property limiting feature.

There is a "NULL NOT RATED" hedge in the "Slope 8 to >15%" sub rule. As explained earlier, this hedge will rate the interpretation as "Not Rated" if the slope is not populated. This class assignment is identified as the "Not Rated Phrase:" on the General tab for each sub rule. This assignment is made only if the specific sub rule contains a "NULL NOT RATED" hedge.

Interpretation rating class

An *Interpretation* or primary rule is the root rule in NASIS. The interpretation uses *Evaluations* and *Sub Rules* to collectively derive interpretive values. The interpretation is a logical statement about land use, limiting features, and the relationship among limiting features. The Interpretation is a collection of sub rules. Each sub rules contains its rating class for identifying the specific property limitation.
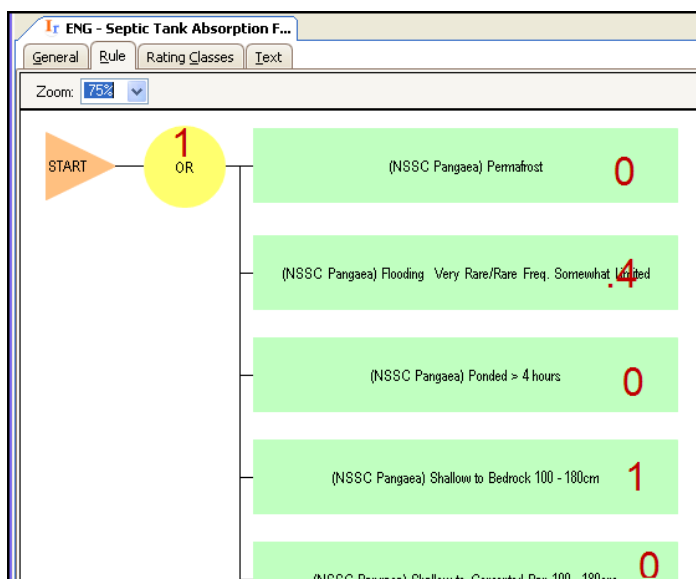
The Interpretation collects the information to identify the rating class for the interpretation. The OR operator will accept the maximum membership value from all the sub rules.

That value is then assigned a rating class name based on the classes assigned in the Rating Classes for the Interpretation.

The adjective printed for the Interpretation Rating Class of "1" will be "Very Limited".

The resulting rating classes appear in the interpretation report as an interpretation rating class and property limiting features.

Naming Convention:

Rating class names

All rule rating class names are to be "Sentence case". Only the first letter in the first word of the name is capitalized.

Interpretation Rating Class Names were historically "Slight", "Moderate" and "Severe", but later changed in NASIS to "Not limited", "Somewhat limited" and "Very limited". Deviations from the norm should be seriously considered before being assigned. All rating names should be as brief as possible.

Rule Names:

Interpretation Names (Sub rules): interpretations are prefixed with discipline abbreviations:

> Ag Waste Management (AWM)
> Agronomy (AGR)
> Forestry (FOR)
> Grazing Land (GRL)
> Recreation (REC)
> Standard Engineering (ENG)
> Urban (URB)
> Waste Management Systems (WMS)
> Water Quality (WAQ)
> Wildlife (WLF)

Special National Interpretations:
> Military (MIL)
> Department of Homeland Security (DHS)

Under no circumstances are these National Interpretations to be copied or modified to create local interpretations by states.

Local Interpretations:

Local interpretations created by states are to be named in order to identify the state. The local interpretation name will be suffixed with a space, followed by an open parentheses, the two letter state code in upper caser, followed by a closed parentheses; for example "ENG – Septic Tank Absorption Field (GA)".

Sub Rule names: a brief name is used to identify the limiting feature.

Documentation:

The Interpretation will contain documentation in the Description field under the General tab detailing each sub rule, its evaluations and the properties used in each evaluation. The interpretation documentation will be complete for all sub rules, evaluations and properties used within the Primary Rule.

The sub rule will contain documentation with the details of its specific evaluation(s) and its specific properties. This documentation is written into the Description field under the General tab.

Testing Interpretations

The results of an Interpretation can be tested against a single component using the "Run Against Local Database" option found on the Interpretations Explorer menu or the right click menu.
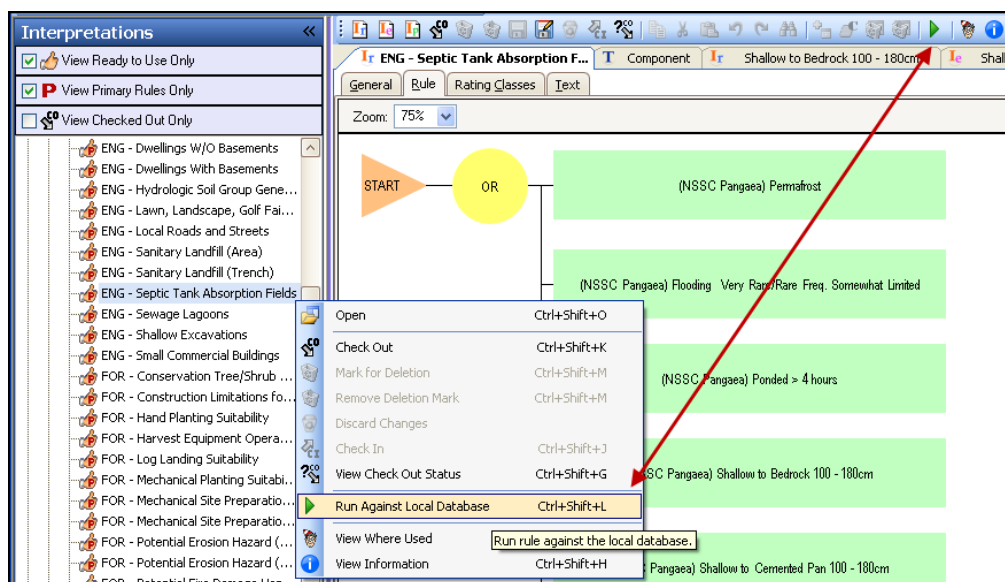
The resulting report is a detailed report providing the results of all sub rules, all evaluations and all properties associated with the interpretation.

Where Used "Rules"

Rules are developed to be used by more than one Rule. The "Where Used" icon or menu option is used to identify rules using a specific evaluation. This allows the user to identify the impact to other evaluations and rules when changes are made to the specific rule. Highlight the rule in the Interpretation Explorer, or with the Rule open in the Editor Panel, choose "Where Used" icon or menu option.

Ownership of interpretations, rules, evaluations, and properties

Rules, subrules, evaluations, and properties are owned objects in NASIS. They are data and have ownership associated with them, as do queries and reports and any other NASIS object. Therefore, they can be copied, reviewed, or linked to any rule, subrule, evaluation, or property. Since they have ownership, they can only be edited by members of the group that owns the data. Whether using locally or nationally created interpretive criteria, choose an interpretive report and run it, the soils data in the selected set is applied to the criteria to derive interpretation results.

Summary

The figure below illustrates that sub rules focus on one limiting feature and must link to at least one evaluation. Sub Rules say nothing about the land use. Therefore, they can be used in different interpretations. Sub Rules are aggregated into an interpretation and are considered the basis, or building blocks, of an interpretation. An evaluation is the relationship between a soil property's value and its relative truthfulness of being a limiting feature.
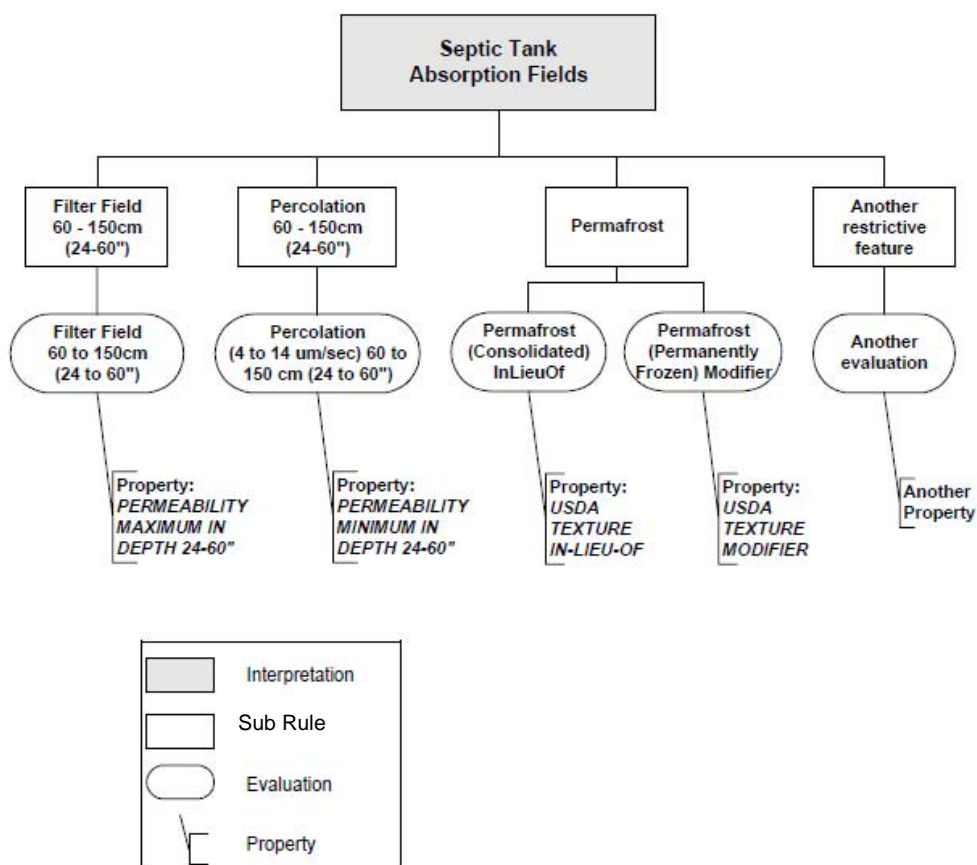
Relationships Among Interpretive Criteria