ALBERTA SUSTAINABLE RESOURCE DEVELOPMENT
GOVERNMENT OF ALBERTA

Grassland Vegetation Inventory (GVI) Specifications

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- *Table 10: Modifiers (Site Type 3: Lentic Alkali)* on page 43 and *Table 11: Modifiers (Site Type 4: Lentic Semi-Permanent to Permanent)* on page 43 were reversed with the incorrect site type number. This was corrected with appropriate references in table of contents and list of tables updated accordingly. Other references throughout the document to the site type numbers appear to be correct.

2011-11-09

- *Table 16:* Addition of Riparian Modifier.
- Explanation of crown closure attribution revised in footnotes on *page 24* and section 4.3.7 on *page 60.*
- Enhanced explanation of *Riparian Modifier* in *Cultivated* site types on *page 47.*
- Water filled *Industrial Pit* added to definition of *Lentic Open water Dugout* on *page 45.*
- Base Feature Hydro update no longer being used as Lentic and Lotic reference *Page 72.*
- Additional information regarding highly contrasting sites or attributes, and thresholds for subdivision of polygons to capture these small but important landscape features *Page 58*.
- Addition of Summer village and Townsite to *Urban* definition *Page 40.*

TERMS OF REFERENCE

This document represents the specifications associated with the use and capture of Grasslands Vegetation Inventory (GVI) data. It is the successor of the previous edition dated June 8, 2009 [ASRD GVI Committee and Landwise Inc. 2009]. The contents of this document have been reviewed thoroughly and should be considered terms appended to any GVI collection contract in which Alberta Sustainable Resource Development (ASRD) is a party, directly or indirectly. These specifications are critical to maintaining the quality and integrity of the GVI programme and must be adhered to in that respect. This condition will be enforced, whether or not this requirement is explicitly stated in the request for proposal, award of services, or other contracts as the general intent is that this document governs the scientific and technical requirements of the delivered GVI datasets, to be overruled only by authorized ASRD Staff or her agent.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

2. INTRODUCTION

The GVI represents the Government of Alberta's comprehensive biophysical, anthropogenic, and land-use inventory of the province's *White Area.* Below, Figure 1 shows the extent of the GVI Phase-1 Project Area, which is a subset of the *White Area*. GVI projects are funded under the Base Data Acquisition component of the Land-use Framework program, which represents the Alberta Government's comprehensive and integrated approach to land use planning and management.

Figure 1. The GVI Phase-1 Project Area

Compilation of the inventory using digital colour-infrared stereo photography commenced in 2006 by Alberta Sustainable Resource Development. The GVI is a more comprehensive and detailed geospatial product when compared to the original *Native Prairie Vegetation Inventory*, completed *circa* 1993. The GVI is intended to meet a

multitude of business needs integral to land-use planning and management in Alberta. It should be stressed that the GVI is not so much a vegetation inventory, as it is a biophysical and land-use inventory. At its core, it is comprised of ecological range sites based on soils information for areas of native vegetation and general land use for areas of non-native vegetation, namely those associated with agricultural, industrial, and residential developments.

Landscape Polygons are the basic map units in the GVI. As with similar thematic data, they represent interpretations of relatively uniform biophysical or anthropogenic areas. Their characteristics are captured in *Sites* records, which have a *Site Type and other properties.* The properties of *Sites* and how to interpret them, including determining the *Site Type* is discussed in sections 3 and 4, respectively. While GVI mappers should aim to delineate polygons that are homogeneous (i.e. with a single or dominant site type), a polygon may have up to four *Site Types*, depending on its complexity and extent, each assigned to a different *Sites* record.

Information for the GVI project will be collected throughout southern Alberta for all land areas, including water bodies, native or natural areas, and agricultural, urban, and other anthropogenic areas. As shown below in Figure 2, land will be classified into one of the 3 *Primary Classes*, one of the 5 *Land Classes*, and one of the 32 *Site Types* for each *Site* considered part of a *Landscape Polygon*. Site types are the main level of classification used in GVI. Lands classified as wetlands are subdivided into Lentic and Lotic *Land Sub-Classes*, while agricultural lands are subdivided into Crop and Tame Pasture *Land Sub-Classes*.

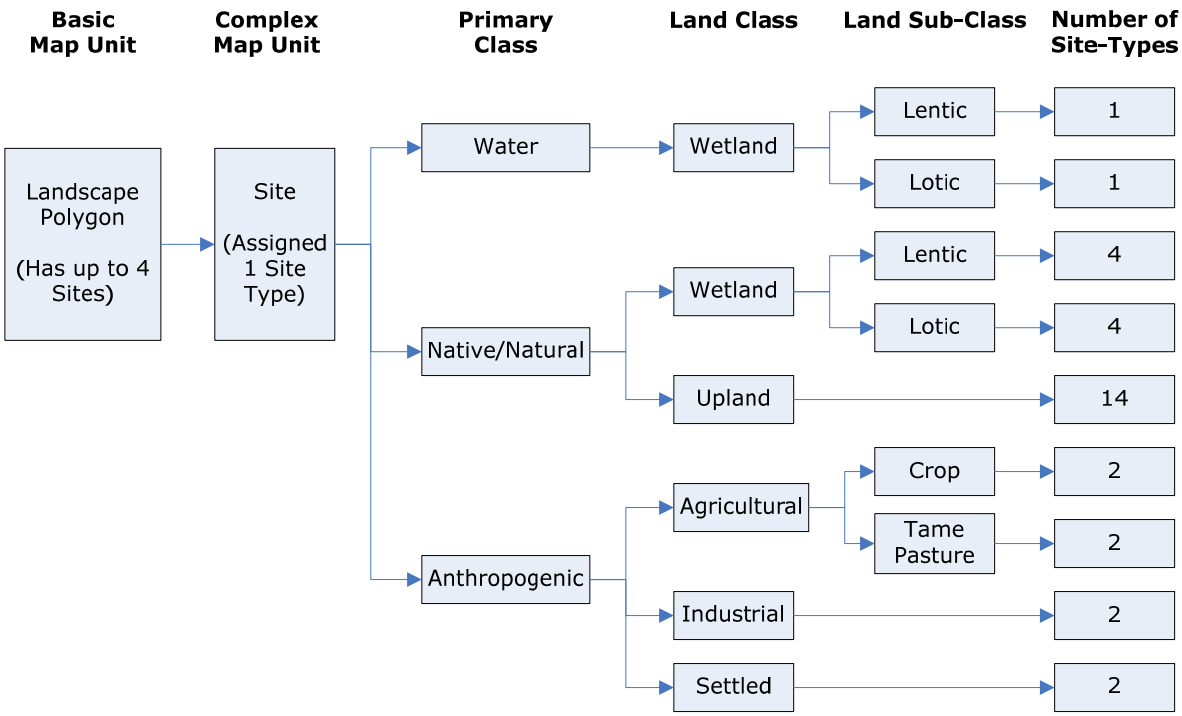


Figure 2: GVI Heirarchical Classification Overview

A description of each of the 32 site types is provided in section 4.3.1. As many of the other bits of information stored in the GVI are dependant on the site type, it is pertinent that attention is paid to the types of content entered in the context of the selected site type when interpreting data. The details of these relationships can be found in section 4. An explanation of the general structure of GVI data in its native format and the definition authority for the meaning of every attribute field within the dataset is included in section 3.

In addition to the *Landscape Polygons*, the GVI contains *Linear Vegetation* and *Point Vegetation* features. The linear features are intended to represent linear occurrences of trees or shrubs along shelterbelts or adjacent to transportation, utility, or other rights of way. The point features are intended to represent individual trees and shrubs or patches of trees and shrubs that are both smaller than the minimum mapping units allowed and make up less than one percent of the total ground cover in a the respective site of the respective polygon that the point is within. More detail on the use of linear and point vegetation features can be found in section 4.5.

3. DATA TABLE AND ATTRIBUTE-FIELD DEFINITIONS

3.1. OVERVIEW

This section provides a description of the GVI data structure and provides definitions for the attribute fields. This should serve as a good introduction to the GVI geodatabase. The various attribute values that can be entered in the data and how to interpret them are described in detail in section 4. It should be noted that this section merely defines the attribute fields and does not give guidance as to how the field should be populated or whether they should be populated at all; this information is contained in section 4.

GVI data are captured as polygons, lines, and points in a geodatabase that provides information on a number of different landscape features. These features (or *Sites*) are described by their *Site Type*. Some *Site Types* may by further described using site-type modifiers. Land-cover characteristics are captured as percentages of the area within a *Site.* Vegetation characteristics are described in general by tree, shrub, herbaceous percent cover, height, and distribution pattern. The geodatabase also allows for specific entries regarding species-type and the percent cover of a species within a *Site* using *Vegetation* records. Line and point layers have also been introduced to delineate landscape features such as shelterbelts. The following material describes each of the feature classes and data tables in the GVI geodatabase. A detailed schema diagram can be obtained from the GVI Programme Manager or the GVI Data Custodian.[1]

3.2. LANDSCAPE POLYGONS

Landscape Polygons are the basic map units in the GVI. As with similar thematic data, they represent interpretations of relatively uniform biophysical or anthropogenic areas. Their characteristics are captured in *Sites* records, primarily classified by the *Site Type* attribute.

ATT_STATUS

- Used to record the quality control status of this feature
- Contents of this field are maintained by quality control processes and should only be modified there (i.e. the GVI Validation Tools or GVI Audit Tools)

CREATED_BY

- The company or individual who created this feature
- This field is maintained by automated processes and does not need to be modified on a per feature basis by contractors

[1] Current contact information for the GVI Programme Manager and for the GVI Data Custodian can be found in the GVI metadata.

CREATED_ON

- Date the feature was submitted or delivered
- Generally, this field is maintained by automated processes and does not need to be modified on a per feature basis by contractors

GLOBALID

- Internally maintained, globally unique identifier string
- This is the primary key and the field that defines the identity of a feature, not the geometry (i.e. two features with identical geometry and identical attributes are different features if this value is different, and they are the same feature if this value is the same – even if the geometry or attribution differs.)

PHOTO_DATE

- Date of capture of the aerial photo this feature is derived from. This is the ground condition currency of this feature.

SOURCE_ID

- A temporary ID field for miscellaneous use
- The contents should not be considered stable at any time, nor are they of meaning to anyone but the user who modifies it.

UPDATED_BY

- The company or individual who updated this feature
- Generally, this field is maintained by automated processes and does not need to be modified on a per feature basis by contractors

UPDATED_ON

- The date a feature was modified after it had originally passed audit and subsequently published. This date reflects a change in the geometry of a feature later from the original capture.
- Generally, this field is maintained by automated processes and does not need to be modified on a per feature basis by contractors

3.3. SITES TABLE

The *Sites* table is where all of the properties of the landscape are stored. This information is split away form the *Landscape Polygons* to allow for normalization of the database structure to accommodate multiple *Sites* records per *Landscape Polygon.* The *Site Type* is an attribute of a *Site*, and is the primary means of classifying the landscape

in the GVI. Descriptions of the site types and the other required attributes are provided in section 4.

CREATED_BY

- The company or individual who created this feature
- This may vary from the value entered in the *Landscape Polygons*, by design
- Generally, this field is maintained by automated processes and does not need to be modified on a per feature basis by contractors

CREATED_ON

- Date the feature was submitted or delivered
- This may vary from the value entered in the *Landscape Polygons*, by design
- Generally, this field is maintained by automated processes and does not need to be modified on a per feature basis by contractors

GLOBALID

- Internally maintained, globally unique identifier string

HERB_DISTRIBUTION_PATTERN

- The spatial distribution pattern of the grass or herbaceous species present

HERB_HEIGHT_CLASS

- The height-range category for herbaceous species present

LANDSCAPE_POLYGON_GUID

- This is a GUID matching the GLOBALID of the *Landscape Polygon* that the *Site* record belongs too

MODIFIER_1

- The first site-type modifier
- A modifier provides additional information about a site type

MODIFIER_1_DISTRIBUTION

- The spatial distribution pattern of the portion of the site-type affected by this modifier, relative to the areas covered by the site type
- Note that this is different than if it were relative to the entire polygon

MODIFIER_2

- The second site-type modifier
- A modifier provides additional information about a site type

MODIFIER_2_DISTRIBUTION

- The spatial distribution pattern of the portion of the site-type affected by this modifier, relative to the areas covered by the site type
- Note that this is different than if it were relative to the entire polygon

MODIFIER_3

- The third site-type modifier
- A modifier provides additional information about a site type

MODIFIER_3_DISTRIBUTION

- The spatial distribution pattern of the portion of the site-type affected by this modifier, relative to the areas covered by the site type
- Note that this is different than if it were relative to the entire polygon

PCT_GRASS_OR_HERBACEOUS

- The percent ground covered with grass/herbaceous

PCT_NONVEG

- The percent ground cover that is non-vegetated and not water

PCT_OF_POLYGON

- The percent of the polygon area, to which this site record belongs, that is covered by this site type

PCT_SHRUBS

- The percent ground covered with shrubs

PCT_TREES

- The percent ground covered with trees

PCT_WATER

- The percent ground covered with open water

PHOTO_DATE

- Date of capture of the aerial photo this feature is derived from. This is the ground condition currency of this feature.

SHRUB_CROWN_CLOSURE

- Shrub crown closure refers to the ground area (expressed as a percentage of the Site area) covered by a vertical projection of the shrub crowns onto the ground
- Crown closure includes both the shaded and non-shaded portions under the branches and leaves

SHRUB_DISTRIBUTION_PATTERN

- One of a set of predefined spatial distribution patterns for the shrub species present

SHRUB_HEIGHT_CLASS

- One of a set of predefined height-range categories for shrub species present

SITE_TYPE

- One of the 32 acceptable site types

SITE_TYPE_DISTRIBUTION

- One of a set of predefined spatial distribution patterns describing the arrangement of this site type in the polygon

SOURCE_ID

- A temporary ID field for miscellaneous use
- The contents should not be considered stable at any time, nor are they of meaning to anyone but the user who modifies it

TREE_CROWN_CLOSURE

- Tree or shrub crown closure refers to the ground area (expressed as a percentage of the Site area) covered by a vertical projection of tree or shrub crowns onto the ground. Crown closure includes both the shaded and non-shaded portions under the branches and leaves. If both trees and shrubs are present in a single polygon, a separate crown closure percentage is assigned to each of the tree or shrub types.

TREE_DISTRIBUTION_PATTERN

- One a set of predefined spatial distribution patterns for the tree species present in this site type.

TREE_HEIGHT_CLASS

- One of a set of predefined height-range categories for tree species present

UPDATED_BY

- The company or individual who updated this feature
- This may vary from the value entered in the *Landscape Polygon*, by design
- Generally, this field is maintained by automated processes and does not need to be modified on a per feature basis by contractors

UPDATED_ON

- The date a feature was modified after it had originally passed audit and subsequently published. This date reflects a change in the attribution of a feature later from the original capture.
- This may vary from the value entered in the *Landscape Polygons*, by design
- Generally, this field is maintained by automated processes and does not need to be modified on a per feature basis by contractors

3.4. VEGETATION TABLE

The *Vegetation* table replaces three tables in the former version of GVI, namely: The Tree Species, Shrub Species, and Herb Species tables. This table contain records used to indicate the presence and properties of specific vegetation types found to be present in a given *Site*.

CLASS

- The "class" of the vegetation species
- Trees = 1, Shrubs = 2, Grass/Herbaceous = 3

CREATED_BY

- The company or individual who created this feature
- This may vary from the value entered in the *Landscape Polygons or Sites*, by design

- Generally, this field is maintained by automated processes and does not need to be modified on a per feature basis by contractors

CREATED_ON

- Date the feature was submitted or delivered
- This may vary from the value entered in the *Landscape Polygons or Sites*, by design
- Generally, this field is maintained by automated processes and does not need to be modified on a per feature basis by contractors

GLOBALID

- Internally maintained, globally unique identifier string

PCT_OF_CLASS

- Percent of all vegetation of this class, present in this site type

SITE_GUID

- This is the GUID matching the GLOBALID of the *Site record* that the *Vegetation* record belongs too

SOURCE_ID

- A temporary ID field for miscellaneous use
- The contents should not be considered stable at any time, nor are they of meaning to anyone but the user who modifies it

SPECIES_ID

- The unique species ID associated with a particular class of a particular species. Note that the same species in tree form versus shrub form will have different species ids

UPDATED_BY

- The company or individual who updated this feature
- This may vary from the value entered in the *Landscape Polygons or Sites*, by design
- Generally, this field is maintained by automated processes and does not need to be modified on a per feature basis by contractors

UPDATED_ON

- The date a feature was modified after it had originally passed audit and subsequently published. This date reflects a change in the attribution of a feature later from the original capture.
- This may vary from the value entered in the *Landscape Polygons or Sites*, by design
- Generally, this field is maintained by automated processes and does not need to be modified on a per feature basis by contractors

3.5. LINEAR AND POINT VEGETATION FEATURES

Linear and point vegetation features will be created as separate GIS layers. These represent relatively solitary and rare occurrences of trees and shrubs in the Grassland Natural Region only, which are often significant local habitat features. Points can represent individual or small clusters of various species.

ATT_STATUS

- Used to record the quality control status of this feature
- Contents of this field are maintained by quality control processes and should only be modified there (i.e. the GVI Validation Tools or GVI Audit Tools)

CREATED_BY

- The company or individual who created this feature
- Generally, this field is maintained by automated processes and does not need to be modified on a per feature basis by contractors

CREATED_ON

- Date the feature was submitted or delivered
- Generally, this field is maintained by automated processes and does not need to be modified on a per feature basis by contractors

GLOBALID

- Internally maintained, globally unique identifier string
- This is the primary key and the field that defines the identity of a feature, not the geometry (i.e. two features with identical geometry and identical attributes are different features if this value is different, and they are the same feature if this value is the same – even if the geometry or attribution differs.)

PCT_CONIF_TREES

- The percentage of the vegetation that is comprised of coniferous trees

PCT_DECID_TREES

- The percentage of the vegetation that is comprised of deciduous trees

PCT_SHRUBS

- The percentage of the vegetation that is comprised of shrubs

PHOTO_DATE

- Date of capture of the aerial photo this feature is derived from. This is the ground condition currency of this feature

SHRUB_HEIGHT_CLASS

- The category describing the range of shrub heights present

SOURCE_ID

- A temporary ID field for miscellaneous use
- The contents should not be considered stable at any time, nor are they of meaning to anyone but the user who modifies it

TREE_HEIGHT_CLASS

- The category describing the range of tree heights present

UPDATED_BY

- The company or individual who updated this feature
- Generally, this field is maintained by automated processes and does not need to be modified on a per feature basis by contractors

UPDATED_ON

- The date a feature was modified after it had originally passed audit and subsequently published. This date reflects a change in the attribution of a feature later from the original capture.
- Generally, this field is maintained by automated processes and does not need to be modified on a per feature basis by contractors

4. INTERPRETATION REFERENCE GUIDE

4.1. OVERVIEW OF REQUIREMENTS

This section describes the options available as valid entries for the various attribute fields in the GVI. As such, it should be used as a guide to help in the process of selecting the correct value to match the photo interpretation. It should be noted that only attribute fields that are to be populated by contractors are discussed in detail in the following sub-sections.

The tables below indicate which attribute fields are to be populated (required) and which are not to be populated or changed by mappers (prohibited). For all of the required fields, the rules governing allowable values are enforced by the geodatabase, with the exception of NULL values, which are permitted by design, for temporarily use only. In the event that the geodatabase domain-validation functionality is bypassed by using third-party data entry tools, the "Attributes Requiring Data Entry" tables (below) serve as a check.

These tables are representative of some of the rules enforced by the GVI validation tools. The business rules imposed through the validation process may be updated from time-to-time to reflect the original intent of the GVI more accurately. The validation tools used to evaluate data submissions will be made available to all parties to allow equitable understanding of deliverable requirements.

Global IDs and Object IDs are excluded from the following tables, as they are not editable using ArcGIS functionality, and shall not be manually modified.

4.2. LANDSCAPE POLYGONS

The attribute fields within the *Landscape Polygons* feature class should not be modified by contractors; all are for administrative purposes and are managed by ASRD. While GVI mappers should aim to delineate polygons that are homogeneous (i.e. with a single or dominant site type), a polygon may be assigned up to four *Sites* records, depending on its complexity and extent, each assigned a different *Site Type*. This process of adding additional, less dominant site types is referred to as "complexing" a polygon. Below, Table 1 summarizes the attribute fields that are to be populated manually and those that are prohibited.

There are a number of considerations when delineating polygons, including whether to subdivide (split) units. In most cases, highly contrasting features (Anthropogenic vs. Native\Natural, Uplands vs. Wetlands, treed vs. nontreed) will provide obvious breaks in the landscape for polygon delineation. Difficulties arise where smaller but potentially significant or distinct landscape features are encountered. These parameters are described in Section 4.3.5 (p.58).

Table 1. Attributes Requiring Data Entry (Landscape Polygons)

Attribute Field	Manual Data Entry Required	Input or Modification Prohibited
Source ID		✓
Created-By User		✓
Created-On Date		✓
Updated-By User		✓
Updated-On Date		✓
Photo Date	✓	
10-TM Area		✓
10-TM Perimeter		✓
Attribution Status[2]		✓

4.3. SITES TABLE

This sub-section provides information on each of the values that can be entered for each of the required attributes present in the *Sites* table. It should be noted that many attribute values in the *Sites* table are dependant on the value entered for the *Site Type*. As a result, the *Site Type* should always be selected prior to populating the other attributes. Additionally, it should be noted the difference between a site and a site type: A site is a full record in the *Sites* table and represents a collection of information about a portion of a *Landscape Polygon*; a site type is just one of the attributes of a site along with several others. Below, Table 2 summarizes the attribute fields that are to be populated manually and those that are prohibited.

[2] This field is populated automatically when the data is validated using the GVI Validation Tools. In general it should not be changed manually.

Table 2. Attributes Requiring Data Entry (Sites Table)

Attribute Field	Manual Data Entry Required	Input or Modification Prohibited
Source ID		✓
Created-By User		✓
Created-On Date		✓
Updated-By User		✓
Updated-On Date		✓
Photo Date	✓	
Landscape-Polygon GUID[3]	✓	
Site Type	✓	
Percent of Polygon	✓	
Site-Type Distribution Pattern	✓	
Site-Type Modifier 1	✓	
Modifier 1 Distribution Pattern	✓	
Site-Type Modifier 2	✓	
Modifier 2 Distribution Pattern	✓	
Site-Type Modifier 3[4]	✓	
Modifier 3 Distribution Pattern	✓	

[3] The Landscape Polygon GUID is the foreign key that relates the Site record to the Landscape Polygon it belongs to. This value matches the Global ID of the corresponding Landscape Polygon, is utilized by the relationship class, and should not be manually edited other than to create or modify a relationship.

[4] Not used at this time and should always be set to 0 – Not Applicable

Attribute Field	Manual Data Entry Required	Input or Modification Prohibited
Percent Trees	✓	
Percent Shrubs	✓	
Percent Grass or Herbaceous	✓	
Percent Water	✓	
Percent Bare Ground	✓	
Tree Height Class	✓	
Tree Crown Closure[5]	✓	
Tree Distribution Pattern	✓	
Shrub Height Class	✓	
Shrub Crown Closure[6]	✓	
Shrub Distribution Pattern	✓	
Herbaceous Height Class[7]	✓	
Herbaceous Distribution Pattern[8]	✓	

4.3.1. Site Types

There are 33 options available as valid entries in the database for the site type. The 33 values include zero, which corresponds to "Not Set" and is the default, and the remaining 32 site types described below, in detail. It should be noted that when the site type is set to "Not Set", the other attributes cannot be set to anything but "Not Applicable" or 0% as the case may be. "Not Set" is not a valid site type permissible in

[5] Not captured at this time, but must be set to the same value as percent cover
[6] Not captured at this time, but must be set to the same value as percent cover
[7] Not captured at this time, but must be set to the default value is of zero 0 – "Not Applicable".
[8] Not captured at this time, but must be set to the default value of 0 – "Not Applicable".

the delivered data. Detailed descriptions of the 32 valid site types are listed under the following three categories in Table 3, Table 6, and Table 7:

- Open-Water Wetland and Native/Natural Wetland site types (10)
- Native/Natural Upland site types (14)
- Anthropogenic site types (8)

In addition, Table 3, Table 6, and Table 7 list the Primary Class, Land Class, and Land Sub-Class hierarchy that each site type falls under.

Open-Water Wetland and Native/Natural Wetland Site Types

The GVI classification system uses five lentic and five lotic site types to describe wetlands. Lentic, or "still water", wetlands occur in basins and lack a defined channel and floodplain. They occur in depressions and have a defined basin edge. Lotic or "riparian wetlands" are associated with running water systems found along rivers, streams, and drainage-ways, with defined channels and floodplains [Thompson et al., 2003]. The channel is an open conduit that periodically or continuously carries flowing water, and dissolved and suspended material. These first ten site types are outlined below in Table 3.

Table 3. Site-Types (Open-Water and Native/Natural Wetland Site Types)

Primary Class	Land Class	Land Sub-Class	Site Type	Short Code	ID
Native/ Natural	Wetland	Lentic	Lentic (Temporary)	LenT	1
			Lentic (Seasonal)	LenS	2
			Lentic (Alkali)	LenA	3
			Lentic (Semi-Permanent to Permanent)	LenSP	4
Water	Wetland	Lentic	Lentic (Open Water)	LenW	5
		Lotic	Lotic (River)	LtcR	6
Native/ Natural	Wetland	Lotic	Lotic (Coniferous)	LtcC	7
			Lotic (Deciduous)	LtcD	8
			Lotic (Shrub)	LtcS	9
			Lotic (Herbaceous)	LtcH	10

Relationships with Other Classification Systems

Late summer airborne colour infrared imagery is preferred in differentiating a relatively temporary Lentic site type from those that are relatively more permanent. In GVI, Lentic site types are distinguished based on what is apparent on the available

colour infrared aerial imagery (i.e. presence/absence and patterns of water, vegetation, and salt precipitates at the time of photography) rather than on the long-term analysis of hydrologic and biotic parameters used by the other wetland classification systems.

The soft-copy photogrammetric methods of differentiating the site types all rely on a pre-determined connection between the visual cues supporting the interpretation (availability of water and the resulting abundance of chlorophyll in living vegetation) and the existing classification systems. The following discussion describes some of the connections between the GVI lentic and lotic site types and their equivalents in other wetland classification systems. The connections between the lentic site types and the Stewart and Kantrud system [Stewart et al., 1971] and between the lotic site types and the Thompson and Hansen system [Thompson et al., 2003] are described followed by a detailed listing of the defining features of each site type.

The selection of a particular lentic site type depends on water depth and the length of time water is typically retained. Four of the lentic site types occur in the Native/Natural Primary Class:

- Lentic Temporary,
- Lentic Seasonal,
- Lentic Semi-permanent to Permanent, and
- Lentic Alkali

The fifth lentic site type, *Lentic Open Water*, occurs in the *Water* Primary Class. This differs slightly from the Stewart and Kantrud system [Stewart et al., 1971], which used six corresponding classifications. A cross-reference between the Stewart and Kantrud wetland classification system, the U.S. Fish and Wildlife Water-Regime Modifier, and the GVI Site Type is provided below in Table 4. Stuart and Kantrud Lentic vegetation zones include, in order from shallowest to deepest water: are low-prairie, wet meadow, shallow-marsh, peripheral deep marsh, and permanent-open-water.

In addition, GVI captured in 2009 or later further classifies lentic site types according to the appropriate wetland class within the Canadian Wetland Classification System [National Wetlands Working Group, 1997]. This information is recorded in the form of modifiers for the temporary, seasonal, semi-permanent-to-permanent and alkali lentic sites types. More information on the specifics of these modifier values and the relationship to the Canadian Wetland Classification System is provided in section 4.3.2 *Site-Type Modifiers* beginning on page 42 of these specifications.

Table 4. Cross-Reference of GVI Lentic Site Types, Stewart and Kantrud Wetland Zones, and U.S. Fish and Wildlife Water-Regime Modifiers

GVI Lentic Site Type	Stewart & Kantrud Wetland Zone	U.S. Fish & Wildlife Water-Regime Modifier
Lentic (Temporary)	Low-prairie	Rarely flooded
Lentic (Temporary)	Wet meadow (If dried out)	Temporarily flooded
Lentic (Seasonal)	Wet meadow	Seasonally flooded
Lentic (Seasonal)	Shallow marsh	Seasonally flooded
Lentic (Semi-permanent to Permanent)	Deep marsh	Semi-permanently flooded, intermittently exposed
Lentic (Alkali)	Intermittent-alkali	Intermittently flooded
Lentic (Semi-permanent to Permanent)	Permanent-open-water	Permanently flooded
Lentic (Alkali)	Fen (alkaline bog)	Saturated

Table 5. Cross-Reference of GVI Lotic Site Types and Thompson and Hansen Defining Characteristics

GVI Lotic Site Types	Defining Characteristics [Thompson and Hansen, 2003]
Lotic River	No Equivalent
Lotic Coniferous	Coniferous trees present and successfully reproducing more than 25 trees per ha.
Lotic Deciduous	Manitoba Maple or Aspen Poplar present and successfully reproducing more than 25 trees per ha, OR deciduous trees other than Manitoba Maple or Aspen Poplar with a combined canopy cover of greater than 25%.
Lotic Shrub	Willows (Salix species), with a combined canopy cover of greater than 10%.
Lotic Herbaceous	Sedge (Carex species)

Defining Characteristics of Lentic Site Types

Lentic Temporary, Lentic Seasonal, Lentic Alkali, and Lentic Semi-permanent to Permanent site types are only mapped if they are in a native/natural state, that is, they

have not been recently cultivated or broken. If these sites have been hayed for native species without requiring cultivation then these would be mapped as native/natural lentic site types. If these lentic features exist in a native/natural state in a predominantly agricultural area they will be mapped out as a separate polygon if they are 1.0 hectare or greater suggested minimum area or 0.8 hectares absolute minimum. Otherwise, these lentic site types will be as attributed in an agricultural site type dominant polygon, provided each lentic feature make up at least 5% of the polygon cover.

2. Lentic Temporary – LenT

    - Describes wetlands where surface water is usually retained for only a brief period in the early spring before the bottom ice seal disappears and occasionally for several days after heavy rainstorms in late spring, summer, and fall

    - The deepest part of the pond basin is dominated by the "Dry Wet-Meadow" or Low-Prairie zones

    - Typically dominated by low-prairie or dead wet-meadow vegetation and no salt (saline) crust

3. Lentic Seasonal – LenS

    - Describes wetlands with surface water persisting for more than three weeks and usually disappearing by early July

    - The deepest parts of seasonal wetlands are dominated by the shallow-marsh zone. Peripheral wet-meadow and low-prairie zones are usually present.

    - Lentic Seasonal basins in GVI have relatively lush vegetation compared to Lentic Temporary due to a higher water table. They typically do not have a visible salt (saline) crust.

4. Lentic Alkali – LenA

    - Describes wetlands that hold surface water for variable time periods ranging from a few weeks to several months

    - Vegetation cover is variable-to-none and there is a distinct salt (saline) crust. On colour-infrared imagery, these crusts are typically bright white representing concentrated, precipitated alkali salts, and/or from foxtail barley tassles.

5. Lentic Semi-permanent to Permanent – LenSP

    - Describes marshes and lakes where water persists throughout the year in most years, except during periods of extreme drought.

    - Dominated by the deep-marsh and shallow-marsh zones marked with emergent vegetation such as cattails and bulrushes

    - Wet-meadow and low-prairie zones are usually present, and isolated marginal pockets of fen-zones occasionally occur and may be delineated separately

- Lentic Semi-permanent to Permanent site types often occur adjacent to Lentic (Open Water).

- Beaver ponds and still-water wetlands like oxbows may represent Lentic (Semi-permanent to Permanent) and/or Lentic (Open Water) site types.

6. Lentic Open Water – LenW

   - Describes permanent open-water areas that are larger than 1.0 hectare and occasionally 0.8 hectares (absolute minimum).

   - Bordering zones may include peripheral deep-marsh, shallow-marsh, wet-meadow, low-prairie, and fen zones that should be mapped as appropriate lentic site types.

   - Lentic wetlands that are larger than 1.0 hectare, but where the individual zones (Open Water and shallow- and deep-marsh zones) are smaller than 1.0 hectare, the entire unit will be mapped as the Lentic (Semi-permanent to Permanent) site type.

   - The Lentic Open Water site type requires the use of modifiers to further define native/natural versus artificial conditions. The appropriate modifiers are Native/Natural Lake, Reservoir, Dugout, or Beaver Pond. The Lentic Open Water/Reservoir site type/modifier must be distinguished from the Developed/Lagoon site type/modifier. See section 4.3.2 *Site-Type Modifiers* beginning on page 42 of these specifications.

Defining Characteristics of Lotic Site Types

The selection of a particular lotic site type depends on the presence of different vegetation or open water. For locations where flooding is not frequent, the native/natural upland site types like Overflow, Shallow-to-Gravel, Gravel, or others are more applicable, as vegetative growth is reduced and does not remain green for the prolonged periods characteristic of Lotic site types. Seeps and springs are part of a lotic system, as water is discharging or flowing. Beaver ponds and still-water wetlands in lotic systems are described in GVI as lentic site types with special modifiers. Lotic site types are subject to frequent flooding, and therefore the vegetation growth is typically more productive than on adjacent uplands. Floods typically occur more often than once every ten years.

7. Lotic River – LtcR

   - The Lotic River site type will only be used for the open water of rivers that are generally wider than 20 metres. This conforms to the double-line base features hydrography representing water-edge to water-edge

   - If islands occur within the river channel, they will be taken out as separate polygons if they are larger than 0.16 hectares in size

   - Islands smaller than 0.16 hectares will be described as separate site types within a polygon dominated by the Lotic River site type if each of these site types make

up 5% or more of the entire polygon. If they are less than 5% of the polygon, they may qualify to be represented by small cover percentages (e.g. shrub, herbaceous. non-vegetated) of the Lotic River site type.

- A Lotic River site type can also be used to represent a major canal greater than 20 metres wide and greater than 500 metres in length, which is an exception to the Native/Natural condition. Smaller canals are not delineated but may contribute to the percent-water cover or other covers to the surrounding site type in a polygon.

- Shoreline covers of trees, shrubs, herbaceous and/or non-vegetated can be included to Lotic River cover especially where the double lines from the Hydrography Polygons do not correspond from waters edge to waters edge and includes some terrain as evident on the imagery.

8. Lotic Coniferous – LtcC

    - Lotic Coniferous is not a common site type in the *Grassland Natural Region*. These are sites where coniferous trees are present and successfully reproducing and there are 25 or more trees per hectare or 10 or more trees per acre (Table 5). Conifers are sometimes found on steep north-facing slopes outside the lotic zone. Confers growing on adjacent upland site types outside of the lotic zone would not be included as part of Lotic Coniferous.

    - The Lotic Coniferous site type will mainly occur in the Montane Natural Subregion, but may also occur in the Northern Fescue and Foothills Parkland Natural Subregions. There may also be rare isolated occurrences in the Foothills Fescue. White spruce (*Picea glauca*) is the most typical conifer species in this site type.

9. Lotic Deciduous – LtcD

    - Described as sites where deciduous trees other than Manitoba Maple or Aspen Poplar (i.e. Plains Cottonwood or Balsam Poplar) are present, are successfully reproducing, and have a combined canopy cover greater than 25%. Where Manitoba Maple and Aspen Poplar are present and successfully reproducing there should be more than 25 trees per ha or 10 or more trees per acre (Table 5). Deciduous trees growing on adjacent upland site types would not be included as part of Lotic Deciduous.

    - This site type occurs in all Natural Subregions in the GVI. Depending on which Natural Subregion the area is within, the vegetation species that characterize this site type may differ. For example, Plains Cottonwood (*Populus deltoides*) occurs mainly in the Dry Mixedgrass and Mixedgrass Natural Subregions, while Balsam Poplar (*Populus balsamifera*) occurs mainly in the Foothills Fescue, Northern Fescue, and Foothills Parkland Natural Sub-regions. Aspen poplar (*Populus tremuloides*) occurs in all Natural Subregions of the GVI project area, but to a lesser degree in the Dry Mixedgrass and Mixedgrass Natural Subregions.

10. Lotic Shrub – LtcS

- While Thompson and Hansen 2003 (Table 5) base their classification on Willow and Non-Willow occurrences, for GVI a combined shrub canopy cover of at least 10% is required for the Lotic Shrub site type to apply. Shrubs growing on adjacent upland site types will not be included as part of Lotic Shrub.

11. Lotic Herbaceous – LtcH

- Any Lotic site that does not fit into Lotic River, Lotic Coniferous, Lotic Deciduous, and Lotic Shrub is classified as Lotic Herbaceous. This typically represents an area of graminoid and forb cover that can range from 0% to 100%. As an example, Lotic Herbaceous can represent an essentially bare area in the lotic zone where the herbaceous canopy cover is 5% and the combined components of non-vegetated (bare soil, wood, and cobbles and stones) are 95%.

- Non-vegetated, unstable sand/gravel bars within river channels are not delineated. However, islands in stream channels that have stabilized and show evidence of vegetation cover are mapped down to 0.16 hectares, and can be classified as Lotic Coniferous, Lotic Deciduous, Lotic Shrub, and/or Lotic Herbaceous.

Native/Natural Upland Site Types

Native upland areas can be categorized into range sites based on recognizable soil and landscape features [Wroe et al., 1988]. Fourteen such site types are generally defined according to their typical landform/landscape features, by soil chemistry and/or moisture, or by their soil textures. Detailed characteristics of the 14 upland Native/Natural site types in the GVI are provided in *Interpretation Guides* specific to each Natural Subregion. GVI contractors are advised to study the details of the 14 upland site types, or ecological/range sites, in the *Range Plant-Community Guides* [Adams et al. 2003, 2004a, 2004b] and in the other identified reference materials (i.e. relevant soil surveys, GVI training material). Below, Table 6 lists the 14 upland site types followed by the defining characteristics of each.

Table 6. Site-Types (Native / Natural Upland Site Types)

Primary Class	Land Class	Land Sub-Class	Site Type	Short Code	ID
Native/ Natural	Upland	Not Applicable	Subirrigated	Sb	11
			Overflow	Ov	12
			Clayey	Cy	13
			Loamy	Lo	14
			Sandy	Sy	15
			Limy	Li	16
			Sand	Sa	17
			Blowouts/Solonetzic	BlO	18
			Choppy Sandhills	CS	19
			Thin Breaks	TB	20
			Shallow to Gravel	SwG	21
			Saline Lowland	SL	22
			Gravel	Gr	23
			Badlands/Bedrock	BdL	24

Defining Characteristics

12. Subirrigated – Sb

- Distinguished from Lentic and Lotic sites by having water close to the surface but not confined to distinct basins like Lentic sites or flowing on the surface in well defined channels like Lotic sites. Finger-like linear sub-surface flow patterns are evident in subirrigated sites and no basin is present.
- Often occurs in the lower inter-dune areas associated with Choppy Sandhills sites and Sand plains where there is sub-surface flow and a high water table. Subirrigated sites also occur in low areas of Gravel and Shallow to Gravel plains.
- Water table is close to the surface during growing season, but rarely above
- Often indicated by patches or bands of lush vegetation
- Does not have a defined depressional edge
- Subirrigated overrides all other native/natural upland site types like Loamy, Sandy, Sands, Clayey, Shallow to Gravel and Gravel if there is visible evidence of lush vegetation growth in localized or confined areas with a high water table. (like buried channels or toe-slopes)

13. Overflow – Ov

    - Often occurs in valley bottoms in association with lotic site types and are typically below steeper valley slopes. Overflow sites are generally confined to fan-and-apron landscapes, but they can also occur in terraced settings near streams. Lotic sites commonly have more lush vegetation growth due to a high water table and regular flooding in the riparian zone, while Overflow sites are typically higher and drier.

    - Areas subject to water spreading, sheetflow or slope-wash

    - For locations where flood frequency is less than once every ten years

14. Clayey – Cy

    - Clayey sites are often associated with glaciolacustrine and lacustrine landforms (i.e. level to undulating plains).

    - Includes clayey-textured soils like silty clay, sandy clay, clay, and heavy clay

    - Generally >40% clay

    - Reliance on soil survey information is important when identifying this site type.

15. Loamy – Lo

    - Loamy is often associated with morainal landforms (i.e. undulating to hummocky terrain).

    - Includes loam, silt loam, silt, clay loam, sandy clay loam, and silty clay loam soils

    - Reliance on soil survey information is important when identifying this site type.

16. Sandy – Sy

    - Sandy typically ranges from morainal to glaciofluvial areas (i.e. undulating plains).

    - Includes sandy-loam-textured soils

    - Reliance on soil survey information is important when identifying this site type.

17. Limy – Li

    - Limy sites generally occur on water shedding slopes developed on glacial till (i.e. tops of hummocky knolls), and eroded side slopes, upper and crest positions of moderate to steep coulee or valley sides, but not including areas with bedrock exposures (i.e. Badlands/Bedrock and Thin Breaks sites).

    - Occasionally found in relatively level glaciolacustrine deposits where a high water table prevents free lime from being leached down through the soil profile.

- Is NOT characterized by white surficial deposits (as with LenA and SL) or light mottles (as with BlO)

- Generally do not occur on eolian sands or other coarse materials like gravels, which promote leaching resulting in deeper free lime.

- Eroded or immature soils with free lime ($CaCO_3$) at or within 15 cm of the soil surface. Soil pH generally greater than 7.5

18. Sand – Sa

- Typically associated with glaciofluvial (i.e. undulating plains) or eolian landforms (i.e. low-relief dunes less than 10% slope)

- Includes loamy sand and sand soils.

- Sand site type often occurs in association with Choppy Sandhills and is often in areas of more undulating terrain in the midst of well developed dunes typical of Choppy Sandhills.

- Reliance on soil survey information is important when identifying this site type.

19. Blowouts/Solonetzic Order – BlO

- Usually occur in swales or at slope inflections within plains; can be in valley bottoms or on inclined surfaces.

- Occurs in areas with Solonetzic (hardpan) soils

- There are seldom areas of 100% Blowouts/Solonetzic Order site type.

- Usually occur with Loamy sites, where the Loamy sites occur interspersed between Blowouts/Solonetzic Order pitted areas.

- Often associated with Bearpaw Shale bedrock less than 5 metres from the surface or in areas of former groundwater discharge

- Blowouts/Solonetzic Order sites are also commonly associated with Overflow sites, Thin Breaks sites, and to a lesser extent Saline Lowlands sites and Sandy sites.

- Pits typical of Blowouts/Solonetzic Order sites are exposures of hardpan, from centimetres to a few metres in extent. On colour-infrared imagery, pitted Blowouts/Solonetzic Order sites are highly speckled or mottled. Imagery may or may not show eroded pits.

- Reliance on soil survey information is important when identifying this site type.

20. Choppy Sandhills – CS

- Dunes typical of Choppy Sandhill sites typically have stronger topography at least on one side of the dunes. Choppy Sandhills dunes can be parabolic or linear

parallel to the direction of the prevailing winds and often have an asymmetric cross section with one slope much steeper than the opposite side.

- Tree, shrub, herbaceous and bare soil covers in Choppy Sandhills are often very patchy.

- Represent loamy sand and sand soils with a duned land surface

- Choppy Sandhills are often associated with Sub-irrigated sites.

- Regular, low-relief dunes (<10% slope) do not necessarily interpret to Choppy Sandhills as the definition may suggest, and would be more appropriately classified as Sand.

- Eroded exposed areas of bare sands often the result of extensive wind erosion are to be classified as Choppy Sandhills with an Active Erosion modifier. Stabilized areas of Choppy Sandhills where there is no evidence of erosion and a stable surface cover of vegetation are designated as Choppy Sandhills without any modifier.

21. Thin Breaks – TB

- Thin Breaks are often associated with Badlands/Bedrock, Limy, and Overflow and can be considered a transition between Limy and Badlands/Bedrock. They typically occur on moderate to steep valley slopes including slumps. They can also occur as plains with thin surficial sediments (less than 1 metre thick) overlying bedrock.

- The amount of vegetation on Thin Breaks is intermediate between Limy and Badlands/Bedrock.

- Areas with soft or hard bedrock at or near the soil surface (within 1 metre); partially vegetated; thin, eroded, and immature soils on gentle to steep landscapes, including slumped or failed slopes.

- Reliance on soil survey information is important when identifying this site type especially on plains.

22. Shallow to Gravel – SwG

- Often occur on terraces, valley bottoms and occasionally as caps on remnant bedrock uplands. Terraces with gravels close to the surface (Shallow to Gravel) or at the surface often show evidence of exposed gravels and sparse vegetation growth. Shallow to Gravel is commonly associated with the Sands, Sandy, Loamy and Gravel site types.

- May be confused with Overflow on older, stabilized point bars and terraces above an active lotic riparian zone. These old point bars and terraces no longer are influenced by the high water table in the lotic zone and usually have a layer of alluvial or slope wash at the surface. If this overlay is deep (>50 cm) over coarse gravely material then the site type would be Overflow. If less than 50 cm and

greater than 20 cm then the site type designation would be Shallow to Gravel (SwG) and less than 20 cm the site type would be Gravel (Gr).

- Represents soil with 20 to 50 cm of a sandy or loamy surface overlying a gravel or cobble- rich substrate.

- Reliance on soil survey information is important when identifying this site type.

- Active lotic or riparian zones with gravels at or near the surface will be classified as some lotic site type (LtcC, LtcD, LtcS and/or LtcH) and not with SwG or Gr site types.

23. Saline Lowland – SL

- Saline Lowlands are areas with negligible vegetation due to high electrical conductivity (salts) and/or sodium-adsorption ratio limitations.

- The Saline Lowland site type is not technically a wetland but occurs where the groundwater is at or very close to the surface, and is associated with saline groundwater discharge or overland flow.

- Vegetation cover in a Saline Lowland can be variable and patchy or can be dominated by sparse to negligible cover.

- These site types may also represent discharge zones downstream of highly saline springs. Saline Lowlands can be confused with Lentic Alkali, a wetland site type in a defined basin. Saline Lowlands typically occur in lower slope positions (but not "basinal" typical of Lentic Alkali), where salt deposits accumulate over relatively flat and extensive areas.

- Blowout/Solonetzic Order site types usually are located in upland positions and have a "speckled" appearance on the imagery unlike the linear, white flow like patterns typical of Saline Lowlands. Saline Lowlands and Blowout/Solonetzic Order may be juxtaposed in some areas and can grade from one to another often in locations where recent saline flow typical of Saline Lowlands cuts across a Blowout/Solonetzic Order.

- Saline Lowlands is often associated with Overflow in low landscape positions where Overflow deposits are laid down at the base of shedding slopes as fluvial fans or aprons. Saline Lowlands may be evident on these Overflow features as linear flow lines or white saline deposits

- Represents lands receiving more than normal soil moisture, where salt or alkali accumulations, or both, are apparent and salt tolerant plants occur most over the area.

24. Gravel – Gr

- See distinction from Shallow to Gravel and Overflow in the Description for Shallow to Gravel, and for the purpose of GVI classification, reliance on soil survey information is important for identifying the Gravel site type.

- Dominated by gravels or cobbles (more than 50% coarse fragments). Covered by a sandy or loamy mantle less than 20 cm thick with some gravel content.

- Active lotic or riparian zones with gravels at or near the surface will be classified as some lotic site type (LtcC, LtcD, LtcS and/or LtcH) and not with SwG or Gr site types.

25. Badlands/Bedrock – BdL

- Badlands/Bedrock typically occurs on moderate to steep coulee or valley sides; also on eroded bedrock plains. This site type often occurs in association with Thin Breaks, Limy and Overflow.

- Nearly barren or barren lands, with significant exposures of soft rock, hard rock, or surficial geologic material. Includes steep valley walls

Anthropogenic Site Types

Anthropogenic site types are those that are human-made or modified, including crop, pasture, industrial sites, and settlements. These site types take precedence over Native/natural and Water primary classes with the exception that small Water or Native/Natural site type occurrences can be complexed with Anthropogenic site types provided each of these smalls site types make up at least 5% of the area in a polygon.

There are eight anthropogenic site types. If they are located in a riparian area then a riparian modifier must be applied along with any other modifiers that may be required to describe that particular site type. More information regarding the various modifiers applicable to the anthropogenic site types can be found in section 4.3.2 beginning on page 42 of these specifications. Crop and pasture categories include areas characterized by herbaceous vegetation that has been planted or is intensively managed for the production of food, feed, or fibre. Herbaceous vegetation accounts for the majority of the cover. The presence of visible salinity will be indicated with a salinity modifier. If the crop and/or pasture are located in a riparian area, this should be indicated with a riparian modifier. An agricultural site type can have both Salinity and Riparian modifiers.

Table 7. Site-Types (Anthropogenic Site Types)

Primary Class	Land Class	Land Sub-Class	Site Type	Short Code	ID
Anthropogenic	Agricultural	Crop	Crop (Irrigated)	CI	25
			Crop (Non-Irrigated)	CN	26
		Tame Pasture	Tame Pasture or Hay (Irrigated)	PI	27
			Tame Pasture or Hay (Non-Irrigated)	PN	28
	Industrial	Not Applicable	Pits	Pit	29
			Developed	Dev	30
	Settled	Not Applicable	Urban	Ur	31
			Rural	Ru	32

Agricultural Land Class

The site types that belong to the Agricultural land class are divided into irrigated and non-irrigated variants. Irrigation can appear in the form of centre pivots, wheel moves, or gravity irrigation. Gravity systems will have a series of dikes and distribution canals, and these can occur in both cropland and pasture fields. The dikes and canals are largely built on the contour, and it may even be possible to see standing water in low-lying areas or in the canals. Gravity systems can also include trickle irrigation, which usually has a series of parallel distribution pipes or hoses, and the crops are in rows (i.e. market garden vegetables or berry crops).

Occasionally, an old non-native hayfield or pasture (formerly seeded with, for example, Crested Wheatgrass) reverts to a Native upland site type. This field generally exhibits a less uniform pattern of tones indicating encroachment of native plant species along with patches of shrubs, which indicates a long period since cultivation and hay cutting. Sometimes hay is taken off native grassland in which case it may be difficult to separate Pasture Non-irrigated from Native upland Site Types. If there were assurance (i.e. through field checking or local knowledge) that the area is native grasslands where hay is being cut then a Native/Natural GVI site type would be the correct interpretation. As well, linear patterns resembling cultivation or mowing / swathing on Pasture Non-irrigated could be brush control or land spreading of drilling waste on native/natural pasture

26. Crop (Irrigated) – CI

- Irrigation is the replacement or supplementation of rainfall with water from another source in order to grow crops. Types of irrigation include; ditch/furrow, terracing, overhead /sprinkler, centre pivot, lateral move (side roll, wheel line), and drip, or trickle.

- Cropland includes row crops, small grains, oilseeds, sod, and fallow.
- Row Crops include potatoes, sugar beets, corn, and vegetables.
- Small Grains include wheat, barley, oats, triticale, and mixed grains.
- Oilseeds include canola and flax.
- Pulses and specialty crops include peas, lentils, fababeans, and others.
- Tree/shrub farms or nurseries
- Fallow describes areas used for the production of crops that do not exhibit visible vegetation as the result of being cultivated.

27. Crop (Non-Irrigated) – CN

- Non-irrigated agricultural land relies only on direct rainfall for crop growth and the process is referred to as rain-fed or dry-land farming.
- Cropland includes small grains, oilseeds, fallow, and occasionally row crops.
- Small Grains include wheat, barley, oats, triticale, and mixed grains.
- Oilseeds include canola and flax.
- Pulses and specialty crops include peas, lentils, fababeans, and others.
- Fallow describes areas used for the production of crops that do not exhibit visible vegetation as the result of being cultivated.
- Row Crops include potatoes, sugar beets, corn, and vegetables, but are seldom grown without irrigation
- Tree/shrub farms or nurseries

28. Tame Pasture (Irrigated) – PI

- Tame Pasture or hay represents areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops. Irrigation is the replacement or supplementation of rainfall with water from another source in order to grow crops. Types of irrigation include; ditch/furrow, terracing, overhead /sprinkler, centre pivot, lateral move (side roll, wheel line), and drip, or trickle.

29. Tame Pasture (Non-Irrigated) – PN

- Tame Pasture or hay represents areas of grasses, legumes or grass-legume mixtures planted for livestock grazing or hay crops. Non-irrigated agricultural land relies only on direct rainfall for crop growth and the process is referred to as rain-fed or dry-land farming. Some criteria for distinguishing grain fields (Cultivated) from hay crops (Pasture) are:

i) Grain matures later than hay and as a result is cut or harvested later in the season;

ii) Fields of cereal crops usually have more homogeneous and managed appearances than pastures or haylands.

iii) Hayland when cut will show active growth shortly after (reddish tones) on colour infrared imagery while cereal crop when cut leaves behind stubble which is dead standing vegetation with no evidence of regrowth unless the harvesting left behind a large residue of cereal crop or weed seeds resulting in active sprouting in the same growing season. Growth of hay tends to be splotchy compared to cereal crops, which is more extensive and continuous.

Industrial Land Class

30. Pits – Pit

- Pits represent locations where vegetative cover and overburden are removed to create a significant non-natural landscape expression in order to extract surficial deposits [Anderson et al 1976. This category includes both active and inactive operations. Unused pits or quarries that have been flooded are classified as a Lentic Open Water site type with a modifier set to Dugout.

- A modifier is mandatory for the Pits site type to describe the type of pit (Table 17, page 48). Reclaimed pits that no longer have a distinct excavation will be classified as a different site type, for example, Agricultural site types or Native/Natural site types if reverted to Native. If a pit that is not filled with water (i.e. not a LenW/Dugout) is located in a riparian area, this should be indicated with a riparian modifier (Section 4.3.2).

31. Developed – Dev

- The Developed site type represents man-made developments that are very difficult to return to crop, pasture, hay, or native/natural conditions. Developed site types do not include Urban or Rural developments (site types #31 and #32). This site type includes both active and inactive operations. Modifiers for Developed site types are mandatory, and are listed in the site-type modifier section (Section 4.3.2).

Settled Land Class

32. Urban – Ur

- Urban or built-up lands include areas where much of the land is covered by structures (Anderson et al. 1976) and the population density is high. The Urban site type includes cities, towns, summer villages, townsites, hamlets, cottage development, strip developments, cemeteries, and shopping centres. Urban does not include acreages or country residential areas, which are represented as Rural.

- Upland, wetland and agricultural site types that occur within Urban areas will be mapped separately. If Agricultural, Native/Natural upland and wetland site types

within an Urban area are much less than the minimum areas they can be included as part of a complex of site types provided each of these cover 5% or more of the polygon. These will include native landscapes such as natural parks, and areas with hay production (either Pasture Irrigated or Pasture Non-irrigated) surrounded by urban infrastructure.

- The riparian modifier must be used to describe urban or built-up lands that are located in riparian areas. See the definition on page 48.

- Non-native parks and other human-modified landscapes such as golf courses, schoolyards and campgrounds will be mapped out as Urban – Green Space using the GS modifier. A distribution pattern is not used for the GS modifier. Shelterbelts or tree (Linear – Point) occurrences will not be delineated in urban areas.

- Transportation facilities and corridors and all Lotic site types (Lotic River, Lotic Deciduous, Lotic Coniferous, Lotic Shrub, Lotic Herbaceous) will be mapped continuously (will not terminate at the urban perimeter) through Urban areas.

33. Rural – Ru

- The Rural site type represents areas with persons living in sparsely populated lands lying outside urban areas, or areas being used by a relatively small number of people on a temporary basis where the native vegetation surface cover has been removed or severely altered by human activity. Rural residential areas include country residential developments (acreages), farmsteads, golf courses, parks and campgrounds in rural areas.

- The riparian modifier must be used to describe Rural site types located in a riparian areas (Section 4.3.2).

- Rural green-space areas (that are non-native) such as community parks, campgrounds, golf courses, and schoolyards will be mapped and described using the rural site type and the green-space modifier. A distribution pattern is not required for the green-space modifier. If agricultural, native/natural upland, and wetland site types within a rural area are much less than the minimum mapping units, they can be included as additional sites as part of a larger polygon provided each of these cover more than 5% of the polygon.

- Rural is an appropriate call for "ghost towns" which may consist of old abandoned residences, and occasionally abandoned commercial buildings. It can also represent hamlets in the last stages of existence, where only a few buildings are inhabited.

4.3.2. Site-Type Modifiers

Site-type modifiers are used to classify the site beyond the scope of the site type alone. They provide supplementary information related to specific site types. There are 27 different values available for use in the site-type modifier fields. The ID values range from #0 to #27, inclusive, and there is no site-type modifier #14. To be clear, as stated in the section overview, every site record must have the three modifier attributes set to some allowable value, potentially including zero – "Not Applicable", which is the default in most cases.

Guidance for the selection of modifier values is provided in the tables below. These tables give the allowable values for the site-type modifiers for any given site type and the field that must be used for that modifier value (i.e. whether a modifier value goes in the *Modifier 1*, *Modifier2*, *or Modifier 3* attribute field). Additional information regarding the various modifier values is provided, when required, to give further context to their use. At this time, the *Modifier 3* field is not used and shall always be set to zero – "Not Applicable". This is subject to change in the future as the purpose of this field is to accommodate evolving uses of the GVI. As the *Modifier 3* field is not presently used at all, it has not been expressly mentioned that it shall be zero – "Not Applicable" in the tables below on a per-site-type basis.

Newly introduced in the 2009/2010 collection year of the GVI programme are new modifiers to accommodate the notation of the presence of beaver ponds and of the appropriate wetland class of the site according to the Canadian Wetland Classification System [Warner et al., 1997]. The tables below list the available modifiers for these site types and give a brief description of each. Note that Fens are separated in the GVI into rich and poor fens. Naturally, data captured prior to the 2009/2010 collection year will lack these modifier values in some situations, but the accommodation is there for future updates.

Modifiers for Site Type 1: Lentic Temporary

Table 8. Modifiers (Site Type 1: Lentic Temporary)

ID	Code	Modifier	Field	Description
0	N/A	Not Applicable	Modifier 1, Modifier 2, Modifier 3	For the modifier 1 field, there are no modifier values applicable to this site type.

Modifiers for Site Type 2: Lentic Seasonal

Table 9: Modifiers (Site Type 2: Lentic Seasonal)

ID	Code	Modifier	Field	Description
0	N/A	Not Applicable	Modifier 1, Modifier 3	For the modifier 1 field, there are no modifier values applicable to this site type. For the Modifier 2 field, the marsh modifier should always be used.
27	M	Marsh	Modifier 2	All LenS get this modifier. Wet-meadow vegetation present; periodically or permanently flooded; absence of trees; emergent vegetation; usually of high nutrient content

Modifiers for Site Type 3: Lentic Alkali

Table 10. Modifiers (Site Type 3: Lentic Alkali)

ID	Code	Modifier	Field	Description
0	N/A	Not Applicable	Modifier 1, Modifier 2, Modifier 3	For the modifier 1 field, there are no modifier values applicable to this site type.

Modifiers for Site Type 4: Lentic Semi-Permanent to Permanent

Table 11: Modifiers (Site Type 4: Lentic Semi-Permanent to Permanent)

ID	Code	Modifier	Field	Description
0	N/A	Not Applicable	Modifier 1, Modifier 3	This is used when there is no applicable modifier value that should otherwise be applied. A modifier must be used in the Modifier 2 field.
22	BP	Beaver Pond	Modifier 1	A wetland that was created or influenced by dams built by beavers
23	B	Bog	Modifier 2	Dense layer of peat; acidic; low nutrient content; water table at or near the surface; usually covered with sphagnum mosses, shrubs and sedges; trees possibly present
24	FR	Fen – Rich	Modifier 2	Covered with peat; water table at or near the surface; higher nutrient content than bogs; vegetation usually characterized by sedges and grasses; trees and shrubs may or may not be present; sedges and brown mosses
25	FP	Fen – Poor	Modifier 2	Covered with peat; water table at or near the surface; higher nutrient content than bogs; vegetation usually characterized by sedges and grasses; trees and shrubs may or may not be present; extremely low in dissolved minerals with sphagnum mosses and ericaceous shrubs
26	Sw	Swamp	Modifier 2	Stagnant or slow-flowing pool; high nutrient content; usually covered with trees or shrubbery
27	M	Marsh	Modifier 2	Periodically or permanently flooded; absence of trees; emergent vegetation; usually high nutrient content

Modifiers for Site Type 5: Lentic Open Water

The descriptions for the native/ natural lake, dugout, and reservoir site-type modifiers used in the table below are taken from the Base-Features Hydro Update Specifications, Version 1.5, dated April 16, 2007.

Table 12: Modifiers (Site Type 5: Lentic Open Water)

ID	Code	Modifier	Field	Description
0	N/A	Not Applicable	Modifier 2, Modifier 3	For the Modifier 2 field, there are no modifier values applicable to this site type. Some other value is required in the Modifier 1 field
15	N	Native/ Natural Lake	Modifier 1	Represents variably sized natural depressions with open water often having an irregular curvilinear shoreline
16	D	Dugout	Modifier 1	Represents small artificial depressions, typically rectangular, constructed to catch run-off, streamflow, or a high water table typically used by livestock. There is no minimum area-size for capture. The dugout modifier is also used to describe abandoned Pits that have filled with water over time.
17	Res	Reservoir	Modifier 1	Represents a variably-sized, often elongated body of water created by excavation or man-made damning of a river or stream channel or gully. Some reservoirs may have dugouts in them.
22	BP	Beaver Pond	Modifier 1	A wetland that was created or influenced by dams built by beavers

Modifiers for Site Types 6 – 10: Lotic Wetlands

Table 13: Modifiers (Site Types 6 – 10: Lotic Wetlands)

ID	Code	Modifier	Field	Description
0	N/A	Not Applicable	Modifier 1, Modifier 2, Modifier 3	There are no modifier values applicable to these site types

Modifiers for Site Types 11 – 18 & 20 – 24: Native/Natural Uplands

Table 14: Modifiers (Site Types 11 – 18 & 20 – 24: Native/Natural Uplands, Excluding Choppy Sandhills)

ID	Code	Modifier	Field	Description
0	N/A	Not Applicable	Modifier 1, Modifier 2, Modifier 3	There are no modifier values applicable to these site types

Modifiers for Site Type 19: Choppy Sandhills

Table 15. Modifiers (Site Type 19: Choppy Sandhills)

ID	Code	Modifier	Field	Description
0	N/A	Not Applicable	Modifier 1, Modifier 2, Modifier 3	For the Modifier 2 field, there are no modifier values applicable to this site type. For the Modifier 1 field, this is used when there is no applicable modifier value that should otherwise be applied
18	A	Active Erosion	Modifier 1	Wind blown exposed mineral soil indicating active erosion processes are present

Modifiers for Site Types 25 – 28: Agricultural Areas

Table 16. Modifiers (Site Types 25 – 28: Agricultural Areas)

ID	Code	Modifier	Field	Description
0	N/A	Not Applicable	Modifier 1, Modifier 2, Modifier 3	For the Modifier 2 field, there are no modifier values applicable to this site type. For the Modifier 1 field, this is used when there is no applicable modifier value that should otherwise be applied.
19	Sn	Salinity	Modifier 1	Used given evidence of soil salinity, such as atypical plant growth. See below for a detailed definition
21	R	Riparian	Modifier 2	Used when an anthropogenic site type is totally or partially located in a riparian area Or A drainage that has been farmed through

Salinity Modifier Definition

Salinity is used as a modifier for agricultural site types only (Crop Non-irrigated, Crop Irrigated, Pasture or Hay Non-Irrigated, Pasture or Hay Irrigated) that have evidence of soil salinity (i.e. salt deposits and/or atypical plant growth). Saline agricultural lands are subject to an elevated water table, promoting groundwater discharge. It is not to be used if there are other signs of soil degradation, such as cultivation in hardpan areas, and wind or water erosion.

If saline areas greater than 5 hectares in size occur within agricultural areas, they will be delineated as separate polygons and the modifier SN plus the Distribution Pattern Class Number as indicated in Table 4 will be applied. This provides a spatial representation of salinity within agricultural lands.

Often salinity in agricultural land shows as atypical vegetation growth compared to the surrounding field. This can be represented by a lush growth of halophytes or salt-tolerant plants (red coloured on colour infrared) to more commonly, irregular patches of colour representing sparse/stunted vegetation. Salinity does not manifest on "bare ground" unless there are salt deposits and/or evidence of seepage (i.e. drainage). It is important to rely on soil survey information and salinity mapping products specific to municipalities for the identification of salinity. Salinity in cropland should not be confused with Solonetzic soils in cropland. Both may be characterized by bare patches and mottled crop growth, but salinity in cropland will have a brighter red coloration on colour infrared imagery, due to the high water table and active discharge and the presence of halophytic vegetation.

Riparian Modifier Definition

In GVI, riparian is not limited to channels and floodplains in a lotic zone. Riparian areas are also found in Agricultural site types 25 – 28; Crop Irrigated/Non-irrigated, Pasture Irrigated/Non-irrigated. In these site types the riparian modifier is used when fields have obvious native/natural drainages or channels that have been farmed through and do not have native vegetation any more. The drainages are still visible because of higher moisture conditions.

Modifiers for Site Type 29: Industrial Pits

Table 17. Modifiers (Site Type 29: Pits)

ID	Code	Modifier	Field	Description
0	N/A	Not Applicable	Modifier 2, Modifier 3 ONLY	For the Modifier 2 field, there may not be an otherwise applicable value. Some other value is required in the Modifier 1 field
1	Co	Coal	Modifier 1	Open-pit coal mine either active or inactive; includes any tailings and stockpiles
2	Sa	Sand	Modifier 1	Sand aggregate excavation; eolian or glaciofluvial fine to coarse sand deposits according to soil survey information
3	Gr	Gravel	Modifier 1	Gravel aggregate excavation; glaciofluvial, fluvial or till gravely deposits according to soil survey information; crushers often found near or in excavation
4	Cy	Clay	Modifier 1	Pottery or industrial clay excavation; fine lacustrine or glaciolacustrine clayey sediments according to soil survey information
5	Q	Quarries	Modifier 1	Hard rock, such as sandstone and limestone, for buildings and industrial use
6	U	Unknown	Modifier 1	Anything that does not fall into the above categories or cannot be identified
21	Rip	Riparian	Modifier 2	If wholly or partly located in a riparian area then the riparian modifier must be used in the Modifier 2 field in addition to the one of the above site-type modifiers used in the Modifier 1 field

Riparian Modifier Definition

The use of the riparian modifier in the GVI is to extend the classification of anthropogenic site types that occur within lotic zones and are not inherently of a riparian nature. The following definition of riparian areas is used in the GVI [Fitch et al., 2001]

"Riparian areas are transitional: they exist between the aquatic part (the river or stream) and the surrounding terrestrial (or upland) area. Common to all riparian areas are the following features:

- a combined presence and abundance of water, either on the surface or close to the surface;
- vegetation that responds to, requires and survives well in abundant water; and

- soils that are often modified by abundant water (as in high water tables), stream processes (like sediment deposition) and lush, productive and diverse vegetation.

Riparian areas are part of a larger, continuous landscape that grades from wet to dry. Sometimes it will not be easy to determine precisely where a riparian area begins and ends. However, rivers, streams, drainages and springs all have riparian areas adjacent to them. There will most often be a defined channel that continuously or seasonally carries flowing water and a floodplain where high flows will periodically escape the channel."

PLEASE NOTE:

Some published definitions of "riparian" include areas adjacent to wetlands or standing water bodies. In the GVI, the Riparian modifier is limited to channels and floodplains in lotic zones.

Modifiers for Site Type 30: Developed

Table 18. Site-Type Modifiers (Site Type 30: Developed)

ID	Code	Modifier	Field	Description
0	N/A	Not Applicable	Modifier 2 and Modifier 3	For the Modifier 2 field, there may not be an otherwise applicable value. Some other value is required in the Modifier 1 field
7	CFO	Confined feeding operations	Modifier 1	Large-scale feedlot, dairy, piggery, or poultry operation. Typical features include extensive corrals, feeders, large industrial size buildings. This should not be used for farms with only a few corrals that should be classified as Rural.
8	Tr	Transportation and utility facilities and corridors	Modifier 1	Four-lane highways, rail yards, service yards. Also paved highways or gravel roads including ditches, railways, utility corridors (i.e. pipeline or transmission lines) which separately or in combination exceed 50 metres in width. Airports active or inactive (paved runways, tarmac, terminals and associated facilities), including grassy areas and grassy air strips; includes wind-farms and associated infrastructure and access. This site type includes disturbed / engineered terrain such as road shoulders, medians, ditches, and embankments adjacent to qualifying features named above.
9	Ag	Agricultural research or processing	Modifier 1	Buildings or infrastructure and adjacent experimental vegetation plots and animal enclosures; food processing facilities; ancillary information may be checked to confirm these facilities. This site type is not to be confused with large farming operations with extensive farm buildings, numerous residences, corrals large garden plots, typical of Hutterite colonies in southern Alberta which could be classified Rural and/or Developed (Confined Feeding Operation).
10	IP	Industrial processing	Modifier 1	Buildings and infrastructure, including yards. Common industries include sawmills, manufacturing
11	Lg	Lagoons	Modifier 1	Artificial water storage or sewage treatment; are usually large square or rectangular man-made water bodies. Does not include Dugouts for domestic livestock watering or Reservoirs which represent water impounded behind a man-made dam.

ID	Code	Modifier	Field	Description
12	OG	Oil or gas facilities	Modifier 1	Batteries, compressors, well site complexes, refineries, and local access roads. Such features that appear **reclaimed** or effectively **reverted** to Native/Natural by virtue of native species (e.g. shrub) encroachment (even though they may show signs of former use like old fence-lines) are to be called an appropriate Native/Natural or Agricultural site type.
13	Mi	Mining facilities	Modifier 1	Buildings or infrastructure adjacent to an excavation/pit or underground mine
6	U	Unknown	Modifier 1	Anything that does not fall into the above categories or cannot be identified
21	Rip	Riparian	Modifier 2	If wholly or partly located in a riparian area then the riparian modifier must be used in the Modifier 2 field in addition to the one of the above site-type modifiers used in the Modifier 1 field

Modifiers for Site Types 31 – 32: Settled Areas

Table 19: Site-Type Modifiers (Site Types 31 – 32: Settled Areas)

ID	Code	Modifier	Field	Description
0	N/A	Not Applicable	Modifier 1, Modifier 2, Modifier 3	For the Modifier 1 or the Modifier 2 field, there may not be an otherwise applicable value.
20	GS	Green Space	Modifier 1	Represents non-native parks and human-modified landscapes like golf courses, schoolyards, and campgrounds
21	Rip	Riparian	Modifier 2	If a rural or urban site is wholly or partly located in a riparian area then the riparian modifier must be used in the Modifier 2 field

Green-Space Modifier Definition

In Urban areas, non-native parks and other human-modified landscapes such as golf courses, schoolyards and campgrounds will be mapped out as Urban – Green Space using the GS modifier. In addition, Urban units having some dominance or lesser proportion of these smaller-sized features would qualify for a GS modifier. A distribution pattern is not used for the GS modifier, as this modifier is not meant to provide a spatial or percent cover measure.

Rural green space areas (non-native areas) such as community parks, campgrounds, golf courses, and schoolyards, will be mapped and described using the Rural site type and the GS modifier. In addition, Rural units having some dominance or lesser proportion of these smaller-sized features would qualify for a GS modifier. A distribution pattern is not used for the GS modifier, as this modifier is not meant to provide a spatial or percent cover measure.

Summary of Allowable Modifier Values

Below are three tables summarizing the allowable site-type modifier values for any given site type or range of site types, one for each of the three modifier attribute fields. Although the information provided below is redundant to that in the tables above, it may be more usefully formatted depending on your requirements.

Table 20. Summary of Allowable Values (Modifier 1)

Site Types	Allowable Values - *Modifier 1* Field
1	0 (N/A)
2	0 (N/A)
3	0 (N/A)
4	0 (N/A), 22 (BP)
5	15 (N), 16 (D), 17 (Res), 22 (BP)
6 – 18	0 (N/A)
19	0 (N/A), 18 (A)
20 - 24	0 (N/A)
25 - 28	0 (N/A), 19 (SN)
29	1 (Co), 2 (Sa), 3 (Gr) , 4 (Cy), 5 (Q), 6 (U)
30	6 (U), 7 (CFO), 8 (Tr), 9 (Ag), 10 (IP), 11 (Lg), 12 (OG), 13 (Mi)
31 - 32	0 (N/A), 20 (GS)

Table 21. Summary of Allowable Values (Modifier 2)

Site Types	Allowable ID Values - *Modifier 2* Field
1	0 (N/A)
2	27 (M)
3	0 (N/A)
4	23 (B), 24 (FR), 25 (FP), 26 (Sw), 27 (M)
5 - 24	0 (N/A)
25 - 32	0 (N/A), 21 (Rip)

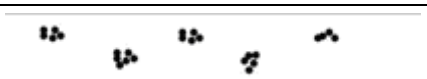
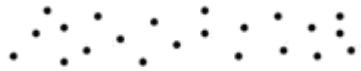
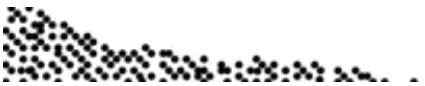
Table 22. Summary of Allowable Values (Modifier 3)

Site Types	Allowable ID Values - *Modifier 3* Field
1 - 32	0 (N/A)

4.3.3. Distribution Patterns

In the GVI, pre-defined distribution patterns are used to describe the arrangement or spatial patterns of landscape features. Below, Table 23 lists the various distribution patterns with descriptions and example diagrams. All site types have a distribution pattern describing their distribution within the polygon. Only two modifiers – Salinity and Active Erosion make use of distribution patterns. Additionally, distribution patterns are used to describe the arrangement of vegetation within a site. At this time, a distribution pattern is not required for herbaceous plant cover.

Table 23. Distribution Patterns

ID	Description	Approximate Area Coverage[9]	Example
0	Not Applicable (Modifiers and vegetation only)	0	
1	Rare	1% to 5%	
2	A few sporadic occurrences	1% to 5%	
3	A single patch	1% to 10%	
4	A single patch plus a few sporadic occurrences	1% to 10%	
5	Several sporadic occurrences	5% to 10%	
6	A single patch plus several sporadic occurrences	5% to 10%	
7	A few patches	10% to 30%	
8	A few patches plus several sporadic occurrences	10% to 30%	
9	Several well-spaced patches	10% to 30%	
10	Continuous, uniform, well-spaced occurrences	10% to 30%	
11	Continuous occurrences with a few gaps	30% to 65%	
12	Continuous dense occurrences	30% to 65%	
13	Continuous occurrences with a distinct curvilinear edge in the polygon; may have a few outliers	10% to 65%	
14	Applies to the majority of the polygon or site (Site-types and modifiers only)	≥65%	

[9] Percent-of-polygon values are captured to the nearest 5% and modifier coverage is not expected to be estimated any better either.

Depending on the attribute to be populated, the available distribution patterns will vary. The use of distribution patterns can be catagorized as follows:

- In general, distributions 0 to 13 apply to vegetation, distributions 1 to 14 apply to site types, distributions 1 – 14 apply to the site type modifiers that permit distribution patterns (details to follow), and distribution 0 applies to the other modifiers or when there is no modifier.

- The distribution of the lands comprised of a particular site type relative to the full spatial extent of the *Landscape Polygon*. The is used in the *Site-Type Distribution* attribute fields. Distribution pattern 1 to 14 apply in this respect. If a landscape polygon contains only one site type, or if the site type makes up 65% or more of the landscape polygon then it is classified as distribution type 14.

- The distribution of the lands to which the *Site-Type Modifier* applies relative to the extent of the entire *Site* (not the *Landscape Polygon*). This is used in the *Modifier 1/2/3 Distribution* attribute fields. Distribution pattern 1 to 14 apply in this respect, but only for the "Active Erosion" and "Salinity" modifiers. Distribution pattern 0 applies for all other modifiers or when there is no modifier for the *Site* (see below for details).

- The distribution of all all trees, shrubs or grass/herbaceous relative to the extent of the entire site on which they grow (not the *Landscape Polygon*). This is used in the *Tree/Shrub Distribution Pattern* attribute fields. If trees and/or shrubs are present in a polygon their abundance and spatial pattern will be described by selecting the most appropriate distribution pattern. Distribution pattern 0 to 13 apply in this respect.

Below are three tables summarizing the allowable site-type modifier distribution values for any given site type or range of site types, one for each of the three modifier attribute fields.

Table 24. Summary of Allowable Values (Modifier 1 Distribution)

Modifier 1	Allowable Values - *Modifier 1 Distribution* Field
0 - 17	0
18 - 19	1 - 14
20	0
22	0

Table 25. Summary of Allowable Values (Modifier 2 Distribution)

Modifier 2	Allowable Values - *Modifier 2 Distribution* Field
0	0
21	0
23 - 27	0

Table 26. Summary of Allowable Values (Modifier 3 Distribution)

Modifier 3	Allowable Values - *Modifier 3 Distribution* Field
0	0

4.3.4. Percent-Cover of Trees, Shrubs, Grass or Herbaceous, Non-Vegetated, and Water

These values represent the percentage of the ground covered by each of the five cover types, namely:

- Trees
- Shrubs
- Grass or Herbaceous
- Non-Vegetated
- Water

The use of these fields applies only to native/natural and water site types (i.e. site types 1 – 24). These values are determined by projecting all cover types present into a single plane so that the total is 100% for a given site type, that is, for sites with a native/natural or water site type; the sum of these five cover-type percentages, including zeros, must equal 100%. Additionally, for anthropogenic site types (i.e. site types 25 – 32) these fields should be set to 0%. Values are recorded to the nearest 1%. Trees or shrubs covering less than 1% will be mapped as points or lines (section 4.5). Below, Figure 3 depicts some examples of how various cover-percentage values would appear. Areas where the *Percent Cover* would differ by more than 20% if delineated separately, must be delineated as such, respecting the minimum-mapping units.

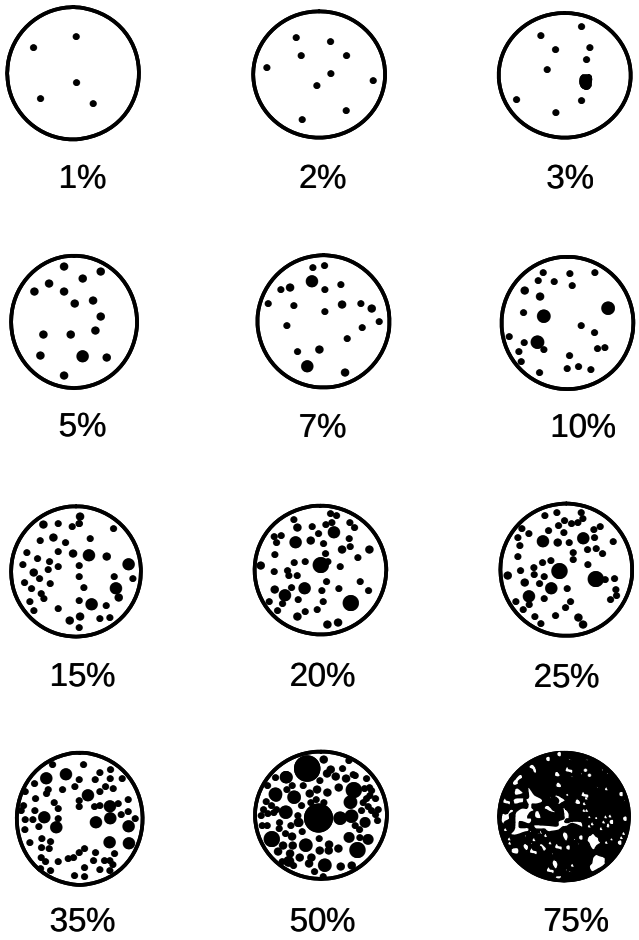


Figure 3: Visual Depictions of Percent-Cover Values

4.3.5. Percent of Polygon

The percentage of the area of a polygon that is represented by any given site type must be between 5% and 100%, depending on the number of site types in the polygon. The sum of these values for all site types in the same polygon must equal 100%. This is a requirement to pass validation.

Where important site type or visible vegetation differences (usually surface cover) do not represent 5% of the polygon area or cannot be mapped according to minimum polygon size criteria (Table 36), they may be captured by isolating a portion of (subdividing) a larger polygon in order to concentrate these features to comprise at least 5% of a new polygon. This new polygon must meet minimum size requirements and attributed based on differences including the minor site type or surface cover. In qualitative terms, the more highly-contrasting the site type or surface cover (e.g. potentially a more significant local vegetation community, or a significant land-use difference), the threshold is finer or smaller for subdivision of a larger original GVI polygon. For example, a difference of 5% in contrasting site types or associated surface cover provides justification for polygon subdivision if the adjacent (original) polygon does not have that site type or if the associated surface cover is 0%.

Table 27. Summary of Allowable Values (Percent of Polygon)

Number of Site Types	Percent of Polygon	
	Maximum	Minimum
1 (Minimum required)	100%	100%
2	95%	5%
3	90%	5%
4 (Maximum allowed)	85%	5%

4.3.6. Tree and/or Shrub Height Classes

There are five overlapping classes for tree height, and five overlapping classes for shrub height. It defaults to zero – "Not Applicable". If two or more height classes occur in the same polygon then use the dominant (greater percent cover) height class. If both species are co-dominant, then record the highest of the two height classes. The tables below list the five height classes for the trees and the five height classes for the shrubs.

Table 28. Tree Height Classes

ID	Height (metres)	Classification	Code	Examples
0	None	Not Applicable	N/A	No Trees Present
1	3 – 6	Very Short	VS	Wind-stunted Aspen
2	5 - 10	Short	S	Much of the Aspen in the Northern Fescue
3	8 – 15	Medium	M	Most cottonwood stands
4	14 – 20	High	H	Aspen or Spruce on north-facing slopes in the Northern Fescue
5	> 20	Very	VH	Generally for community types outside of the Grassland Natural Region

Table 29. Shrub Height Classes

ID	Height (metres)	Classification	Code	Examples
0	None	Not Applicable	N/A	No Shrubs Present
1	0.1 – 0.3	Very Low	VL	Horizontal Juniper or Decimetre-high Silver Sagebrush
2	0.25 – 0.75	Low	L	Buckbrush and Rose in northern Foothills Fescue and Northern Fescue
3	0.5 – 1.5	Moderate	M	Shrubby Cinquefoil in the Foothills Fescue; Silver Sagebrush on apron deposits in river valleys
4	1 - 3	Moderate to High	MH	Sandbar willow; chokecherry
5	> 3	High	H	Thorny Buffaloberry; Beaked Willow

4.3.7. Crown Closure

We are no longer asking interpreters to estimate tree or shrub crown closure. This field has not been removed from the schema, so will be populated with the same value that is used when describing percent (%) tree or shrub cover. Footnotes 1 and 2 found in Table 2 (p.24) are no longer valid.

4.4. VEGETATION TABLE

This sub-section contains information describing each of the values that can be entered for each of the required attributes present in the *Vegetation* table. It should be noted that many attribute values in the *Vegetation* table are dependant on the value chosen for the vegetation *Class*. The *Class* identifies the record as being one of "Tree", "Shrub", or "Grass or Herbaceous". As the species available for use in the *Species* field vary depending on the *Class*, the *Class* should be selected prior to populating the other attributes. It should be noted that only tree species are expected to be captured at this time (i.e. no shrubs or herbaceous). Additionally, only two species should be captured if more than one exists on the site. Although it is perfectly acceptable to have additional species entered, the contractor is only expected to collect a maximum of two.

The facility to capture shrub and herbaceous species information is built into the GVI data model for future use. At this time, because the requirements on contractors do not include the capture of shrub and herbaceous species, a user of the data should not assume that shrub or herbaceous species are absent based on a lack of vegetation records in that regard. Instead, the user should base this decision on the percent-cover attribute fields for trees, shrubs, and herbaceous; and only in native/natural site types. Below, Table 30 summarizes the attribute fields that are to be populated manually and those that are prohibited.

Table 30. Attributes Requiring Data Entry (Vegetation Table)

Attribute Field	Manual Data Entry Required	Input or Modification Prohibited
Created-By User		✓
Created-On Date		✓
Updated-By User		✓
Updated-On Date		✓
Vegetation Class	✓	
Species	✓	
Percent of Vegetation Class	✓	
Site GUID[10]	✓	
Source ID		✓

4.4.1. Vegetation Class

With the consolidation of the three vegetation-related data tables used in the old GVI data model into one data table used in the new GVI data model, a new attribute was introduced to identify records as being one of "Tree", "Shrub", or "Grass or Herbaceous" as mentioned above. Selecting the correct class is critical in identifying the vegetation present, but also in the sense that when populating the *Species* field, only species that develop into trees are allowed when the *Class* is "Tree", species that develop into shrubs are allowed when the *Class* is "Shrub", and only grass/herbaceous species allowed when the *Class* is "Grass or Herbaceous".

[10] The Site GUID is the foreign key that relates the Vegetation record to the Site record to which it belongs. The GUID matches the Global ID of the corresponding Site record, is utilized by the relationship class, and should not be manually edited other than to create or modify a relationship.

Table 31: Vegetation Classes

Vegetation Class Description	Class ID
Tree	1
Shrub	2
Grass or Herbaceous	3

4.4.2. Species

The species of vegetation should be identified if possible, and selected from the appropriate species list. As with the other attribute values, the list is included as a domain in the GVI geodatabase. To date, only tree species are required for initial mapping by contractors. Below, Table 32 lists the tree genera and/or species along with the corresponding numeric IDs that are available for use in the GVI for vegetation records with a *Class* of "Tree". The full species list includes shrub and herbaceous species and has several thousand items. For a full listing, contact the GVI programme manager or the GVI data custodian who can provide the most up-to-date species list with the associated identifier numbers for each[11].

The purpose of the presence of the shrub and herbaceous species is so that they can be added later as part of more detailed field verified surveys for sub-areas of GVI.

[11] Current contact information for the GVI Programme Manager and for the GVI Data Custodian can be found in the GVI metadata.

Table 32: Tree Species List

Genus/Species & Common Name	Species ID
Abies balsamea (Balsam Fir)	1
Abies balsamea x lasiocarpa (Balsam X Subalpine Fir)	2
Abies lasiocarpa (Subalpine Fir)	3
Abies spp (Unspecified Fir)	3487
Acer negundo (Manitoba Maple)	4
Acer spp (Unspecified Maple)	3483
Betula neoalaskana (Alaska Birch)	5
Betula papyrifera (White Birch)	6
Betula spp (Unspecified Birch)	3485
Elaeagnus angustifolia (Russian Olive)	3498
Hippophae rhamnoides (Sea Buckthorn)	3499
Larix laricina (Tamarack)	7
Larix lyallii (Subalpine Larch)	8
Larix occidentalis (Western Larch)	9
Larix spp (Unspecified Larch)	3482
Picea engelmannii (Engelmann Spruce)	11
Picea engelmannii x glauca (Engelmann X White Spruce)	10
Picea glauca (White Spruce)	12
Picea mariana (Black Spruce)	13
Picea spp (Unspecified Spruce)	3481
Pinus albicaulis (Whitebark Pine)	14
Pinus banksiana (Jack Pine)	15
Pinus contorta (Lodgepole Pine)	17
Pinus contorta x banksiana (Lodgepole X Jack Pine)	16
Pinus flexilis (Limber Pine)	18
Pinus monticola (Western White Pine)	19

Genus/Species & Common Name	Species ID
Pinus spp (Unspecified Pine)	3479
Populus angustifolia (Narrow-Leaf Cottonwood)	21
Populus balsamifera (Balsam Poplar)	22
Populus deltoides (Plains Cottonwood)	23
Populus spp (Unspecified Poplar/Aspen/Cottenwood)	3480
Populus tremuloides (Aspen)	24
Populus x acuminata (Lance-Leaf Cottonwood)	20
Pseudotsuga menziesii (Douglas-Fir)	25
Pseudotsuga spp (Unspecified Douglas Fir)	3484
Sorbus aucuparia (European Mountain-Ash)	26
Thuja plicata (Western Red Cedar)	27
Tsuga heterophylla (Western Hemlock)	28
Tsuga spp (Unspecified Hemlock)	3486

4.4.3. Species Percentage of Vegetation Class

The percentage value entered will be indicative of the percent-cover of the previously indicated species relative to the total percent-cover of all the species of the same *Class* for the same site type. For example, consider the following scenario:

1. A *Site* record is created for a polygon with site type 11 - "Subirrigated"

    - The mapper sees that there are both Lodgepole Pine and Spruce trees present, but is unsure of the species of the Spruce. Additionally, it is evident that there are twice as many spruce trees as pine trees and that some rose bushes are present, making up approximately one quarter of the vegetation cover on the site[12].

2. A *Vegetation* record is added to the *Site*, and the *Class* is set to "Tree"

    - The species is set to 17 (i.e. "Pinus Contorta (Lodgepole Pine)")

    - The *Percent of Class* is set to 33 (i.e. 33%)

[12] Shrubs are not required for capture but are included in this example to demonstrate the use of the *Percent of Class* attribute field.

3. Another *Vegetation* record is added to the site, and the *Vegetation Class* is set to "Tree"

    - The species is set to 3481 (i.e. "Picea spp (Unspecified Spruce)")
    - The *Percent of Class* is set to 67 (i.e. 67%)

4. Another *Vegetation* record is added to the site, and the *Vegetation Class* is set to "Shrub".

    - The species is set to 3493 (i.e. "Rosa spp (Unspecified Rose)")
    - The *Percent of Class* is set to 100 (i.e. 100%)

4.5. LINEAR AND POINT VEGETATION FEATURES

This sub-section contains information describing each of the values that can be entered for each of the required attributes present in the *Linear Vegetation* and *Point Vegetation* feature classes. As these fields are identical between the two feature classes, they are described only once as the information applies to both. For information about the use of these feature classes, see section 3.5 on page 19. Below, Table 33 and Table 34 summarize the attribute fields that are to be populated manually and those that are prohibited.

Table 33. Attributes Requiring Data Entry (Linear Vegetation)

Attribute Field	Manual Data Entry Required	Input or Modification Prohibited
Source ID		✓
Created-By User		✓
Created-On Date		✓
Updated-By User		✓
Updated-On Date		✓
Photo Date		✓
10-TM Length		✓
Tree Height Class	✓	
Shrub Height Class	✓	
Percent Coniferous Trees	✓	
Percent Deciduous Trees	✓	
Percent Shrubs	✓	
Attribution Status[13]		✓

[13] This field is populated automatically when the data is validated using the GVI Validation Tools for the new GVI 5.3 Schema. In general it should not be changed manually as it will be overwritten by the GVI Validation Tools.

Table 34. Attributes Requiring Data Entry (Point Vegetation)

Attribute Field	Manual Data Entry Required	Input or Modification Prohibited
Source ID		✓
Created-By User		✓
Created-On Date		✓
Updated-By User		✓
Updated-On Date		✓
Photo Date		✓
Tree Height Class	✓	
Shrub Height Class	✓	
Percent Coniferous Trees	✓	
Percent Deciduous Trees	✓	
Percent Shrubs	✓	
Attribution Status[14]		✓

4.5.1. Rules for Use of Linear Vegetation

Linear vegetation represents linear occurrences of trees or shrubs that make-up less than 1% of tree or shrub cover of a site type. This feature type is typically limited to shelterbelts and trees or shrubs occurring in agricultural fields, rural farmyards, and adjacent to linear rights-of-way in anthropogenic landscapes.

- Linear feature in native/natural landscapes will also be captured if they make up less than 1% of the surface cover of a native/natural site type.

[14] This field is populated automatically when the data is validated using the GVI Validation Tools. In general it should not be changed manually. Like all other attributes, it should never be changed manually for existing data.

- Linear vegetation can be native or anthropogenic.
- Linear features will not be identified in urban areas.
- There are five overlapping classes each for tree and/or shrub height in Table 28 and Table 29
- Shelterbelts may have discontinuous tree or shrub cover. If the shelterbelt has a break of 20 meters or more, then at least two linear features must be identified.
- Parallel or adjacent linear features separated by less than 20 meters will be represented by a single line down the middle.
- Where there are multiple parallel lines of trees and/or shrubs additional lines should be captured to help display the full breadth of these parallel lines rather than only one line down the middle. In addition, the mapper must capture more than one line where there are parallel arrangements of distinctly different percent-covers of trees and shrubs different covers of coniferous and deciduous trees.
- Parallel or adjacent linear features separated by 20 meters or greater must be represented as unique lines.
- In some instances, trees and shrubs can be captured as irregular non-linear or zigzag lines provided these lines represent features with consistent tree types (Conifers and/or Deciduous), consistent tree heights, and consistent shrub heights.

4.5.2. Rules for Use of Point Vegetation

Point vegetation represent individual or patch occurrences of trees or shrubs that are smaller than 5 hectares and that make up less than 1% of the total surface cover per site type for a GVI polygon. Also, do not both attribute tree and/or shrub covers as part of a site in a polygon and capture these same trees and/or shrubs as point features. This is considered double counting so either include as part of the attribution or a point feature but not both.

- Point vegetation can be native or anthropogenic trees and shrubs.
- Point vegetation will not be identified in urban areas.
- There are five overlapping classes each for tree and/or shrub height in Table 28 and Table 29
- Trees or shrub patches with 1 percent or more surface cover must be represented in the attribution for site type that trees and/or shrubs occurs on in a GVI polygon, rather than as a point.

4.5.3. Vegetation Height Classes

The vegetation height classes used in the *Sites* table are identical to those used in the *Linear Vegetation* and *Point Vegetation* feature classes. Refer to section 4.3.6 on page 59 for details.

4.5.4. Percent Coniferous Trees

This should be a value between 0 and 100 (i.e. 0% and 100%). This indicated the relative portion of the vegetation feature represented by the point or line that is made up of coniferous trees. Please note that the sum of *Percent Coniferous Trees, Percent Deciduous Trees,* and *Percent Shrubs* shall be 100 (i.e. 100%).

4.5.5. Percent Deciduous Trees

This should be a value between 0 and 100 (i.e. 0% and 100%). This indicated the relative portion of the vegetation feature represented by the point or line that is made up of deciduous trees. Please note that the sum of *Percent Coniferous Trees, Percent Deciduous Trees,* and *Percent Shrubs* shall be 100 (i.e. 100%).

4.5.6. Percent Shrubs

This should be a value between 0 and 100 (i.e. 0% and 100%). This indicated the relative portion of the vegetation feature represented by the point or line that is made up of shrubs. Please note that the sum of *Percent Coniferous Trees, Percent Deciduous Trees,* and *Percent Shrubs* shall be 100 (i.e. 100%).

5. TECHNICAL STANDARDS FOR CAPTURE OF GVI DATA

5.1. OVERVIEW

This section outlines the requirements on the contractor with regard to digitally delineating GVI data. In addition, the following information serves as a guide to assist users in understanding the level of precision associated with the GVI data in terms of the care and quality assurance principles employed during their production. The result is that the following information serves as a formalization of the quality assurance principles associated with the GVI collection programme, that for the most part, have always been in effect.

An exception is the information contained in section 5.8, Display Colour Calibration, which is completely new. This section outlines the responsibility of all contractors and correlators involved in the auditing process to ensure their computer monitors are colour calibrated to a reasonable standard gamma and colour temperature. This requirement is a new development intended to help address a lack of standardization with regard to softcopy photo-interpretation processes.

5.2. SPATIAL REFERENCE

For the purposes of GVI data collection or update, data will be distributed and must also be digitized and delivered back to ASRD in *NAD83 / Alberta 10-TM (Forest)*[15]. For the purpose of public distribution, GVI data are made available in *NAD83* geographic[16]. The reason for the difference is simply that GVI data are maintained in the 10-TM map projection, but for consistency and cross-jurisdictional compatibility, they are published in geographic coordinates. It is important to be aware that reprojection of the data is a form of modification[17], which along with all other unauthorized modifications, is prohibited for data that are to be part of a submission for a collection or update contract.

5.3. DELINEATION ACCURACY

Points or nodes and line segments making up polygons or polylines shall be within 5.0 metres of the "true location" of the clearly defined feature it represents in 95% of all tested locations for upland features and 2.0 metres for wetland features. To achieve this, a minimum scale, outlined below, is required for delineation of features for each of the wetland and upland feature types. The results will meet this standard given appropriate care and the assumption that delineation is always done as accurately as possible and without visual impairment within the acceptable display scale range. In theory, the data will then have a 2-D root-mean-square error of 2.0 metres and 0.8 metres or better, respectively, for each of the upland and wetland features when tested at a large number of clearly defined test locations, which yields the 95% confidence

[15] EPSG:3400, spatialreference.org
[16] EPSG:4269, spatialreference.org
[17] Reprojection "on-the-fly" does not change the data stored on disk, so it is not subject to this restriction.

intervals[18] of 5.0 metres and 2.0 metres, noted above. For the purpose of this discussion, "true location" is referring to the clearly defined Northing and Easting of the feature in question as derived from the native coordinate system inherent to the imagery provided as part of the collection/update contract. Resultantly, the measurements of error are indicative of the error in the GVI data relative to the aerial photography, and are not all-inclusive with respect to any error present in the imagery itself. Below, Table 35 summarizes the required scales for delineation along with the statistically expected error based on site type.

The purpose of this is to be confident in the spatial quality of the data based on the method of collection rather than a rigorous check against independent mapping data. Resultantly, the contractor does not need to confirm this accuracy level, but merely attest that these requirements for delineation were met.

5.4. DISPLAY SCALE

The drawing of polygons, polylines, and points should occur at a scale of 1:7700 or greater (i.e.: between 1:1 and 1:7700) for native/natural upland and anthropogenic site types and at a scale of 1:3000 or greater (i.e.: between 1:1 and 1:3000) for wetland site types[19]. Naturally, it is up to the user to interpret the imagery at whatever scale is necessary, but the actual drawing of the geometry must happen within this scale range to maintain the level of spatial detail and accuracy required.

Table 35. Minimum Scale and Expected Error by Site Type

Site Type	Minimum Scale for Delineation	Expected Error at 95% Confidence [20]
1-10 (Lentic and Lotic Wetland types)	1:3000	2 m
11-32 (Upland and Anthropogenic types)	1:7700	5 m

5.5. MINIMUM MAPPING UNIT

The minimum mapping unit, or the smallest allowable 2-D area, of GVI polygons depends on the dominant site type of the polygon being delineated. Below, Table 36 outlines the allowable areas for polygons based on site-type. There are exceptions, which are outlined following.

[18] Confidence interval is RMSE scaled by the inverse chi-square distribution coefficient with 5% significance and 2 degrees of freedom, i.e. 2.448

[19] This standard assumes a display pixel density of 96dpi (dots-per-inch), which is the default in Microsoft Windows. Values other than the default should be scaled inversely.

[20] Relative to the imagery

Table 36. Minimum Mapping Units by Site Type

Dominant Site Type	Minimum Area	Minimum Width
1-10 (Lentic and Lotic Wetland types)	1.00 ha suggested minimum; 0.80 ha absolute minimum	Suggested 10.00 m width; 5.00 m absolute minimum width
11-32 (Upland and Anthropogenic types)	5.00 ha suggested minimum; 3.00 ha absolute minimum	Suggested 50.00 m width; 30.00 absolute minimum width

The following exceptions apply to the above two rules:

- Dugouts will be captured regardless of their size (i.e. there is no minimum size other than what is possible to interpret). These features must be attributed as Lentic (Open Water) with the Dugout modifier, even if they are dry.

- If the situation arises where two common polygons can be bridged together, a minimum width of 30.00 metres (rather than 50.00 metres) will be accepted for upland site types and 5.00 metres (rather than 10.00 metres) for wetland site types.

- Islands in the Lotic (River) and Lentic (Open Water) site types may have a minimum area of 0.16 hectares. These features must be attributed as a Lotic or upland site type.

5.6. NODE SPACING

Node spacing should be, in general, no less than 5 metres for upland types or 2 metres for wetland types, and no greater than 500 metres for either type. In older versions of ESRI[21] software, re-projecting data caused significant error between nodes if the spacing was not small. In modern versions, this is no longer a problem and there is no need for excess node density. Operationally, this means setting the point streaming tolerance to 500 metres, and enabling streaming while digitizing. The intent is that the line-work must accurately represent a distinguishable feature edge within the desired tolerances but not have excess nodes created.

[21] ESRI: Environmental Science Research Institute – the company that produces the ArcGIS software suite.

Table 37. Node Spacing by Dominant Site Type

Dominant Site Type	Minimum Node Spacing	Maximum Node Spacing
1-10 (Lentic and Lotic Wetland types)	2.00 m	500.00 m
11-32 (Upland and Anthropogenic types)	5.00 m	500.00 m

5.7. TOPOLOGY

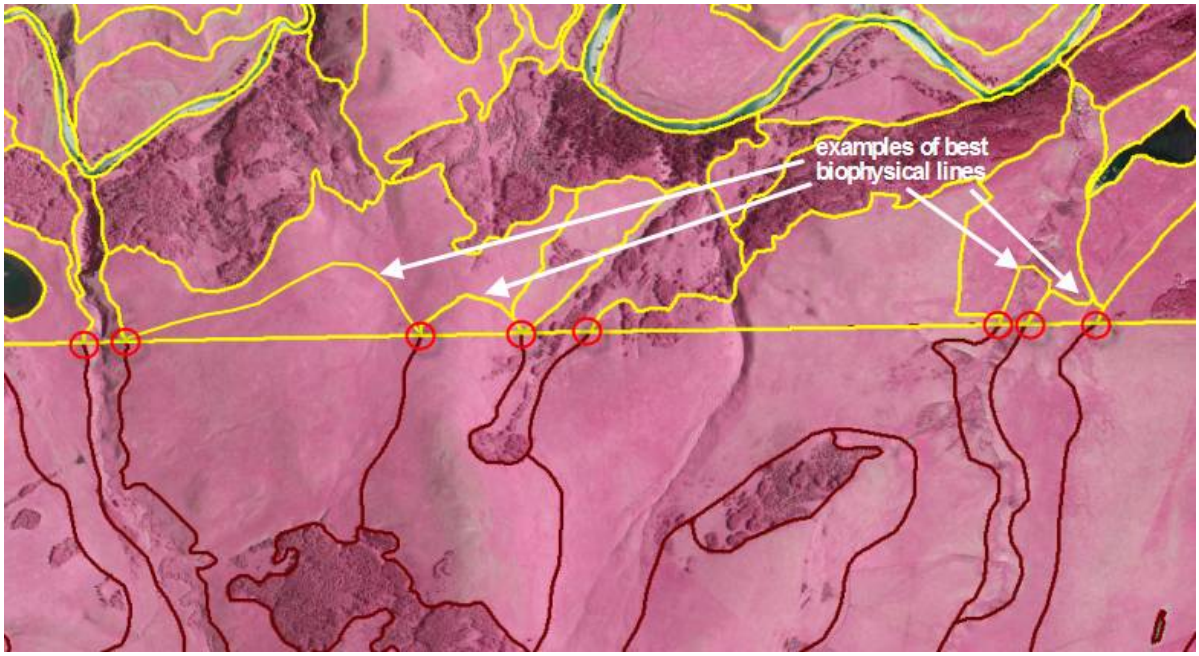
This section outlines some of the topological concerns with regard to collection of GVI data. GVI data must transition to existing GVI and AVI[22] data at the boundary between the two inventories. Additionally, GVI data utilize the Land-use Framework Hydrography Polygons ("Hydro-polygons") as a base. Finally, there are internal geometry rules for maintenance of data quality. More on each of these items follows.

5.7.1. Edge Matching with Existing GVI Data

GVI data exists for a large portion of southern Alberta. Where existing GVI data occurs adjacent to areas of new GVI capture, mappers are required to edge-tie along the boundary by snapping GVI polygon nodes to the corresponding existing GVI polygon nodes that represent the same unit. These existing GVI polygons will being snapped If a segment of the project area boundary happens to fall on a road or fence line that separates different site types, then snapping to existing polygon nodes may not be needed.

Below in Figure 4, the new GVI polygons have been snapped to the existing GVI polygons. The mapper must enter the same attribution for the new GVI polygon as is present in the corresponding existing GVI polygon provided the two polygons represent the same or very close to the same site types and corresponding attribution. If the attribution in the existing GVI polygon is not considered acceptable to be extended into the new polygon, then the mapper should truncate the polygon by adding a "best biophysical line". Below, Figure 4 shows examples of "best biophysical lines". The resultant small new polygon along the boundary should be attributed exactly the same as the corresponding existing GVI polygon. The remainder of the new polygon can then be attributed with values that are more accurate. Existing GVI polygons and attributes must not be changed.

[22] AVI: Alberta Vegetation Inventory – A forestry-oriented vegetation inventory used primarily in the provinces "Green Area"



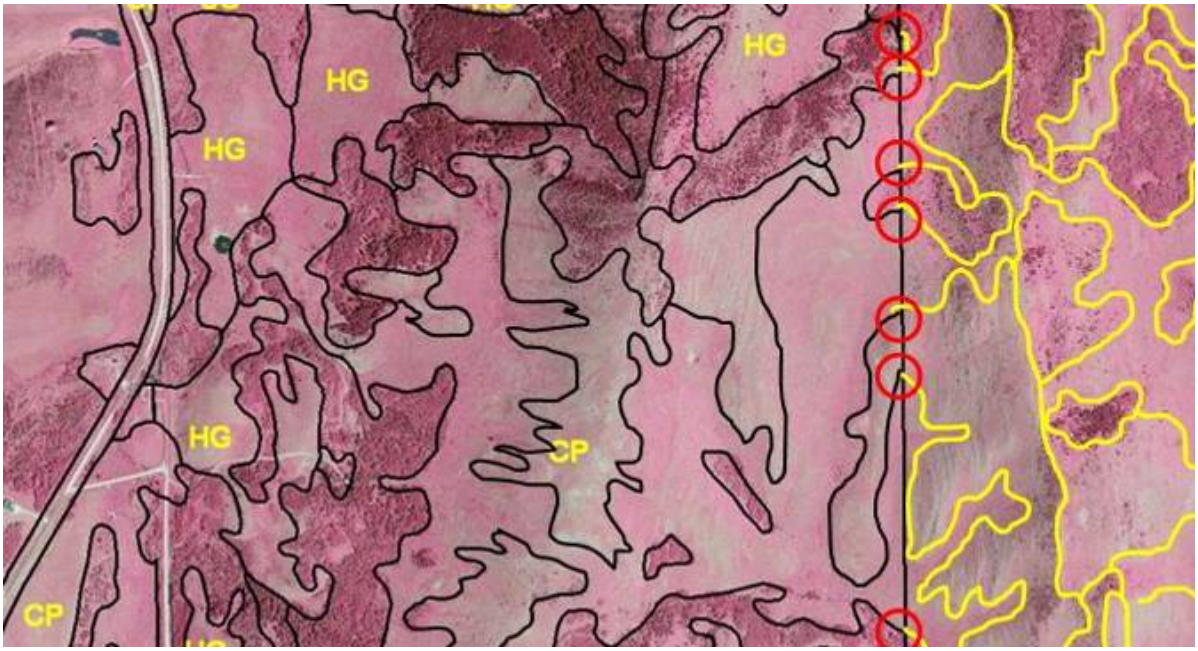
Legend:

- Yellow Polygons: New GVI
- Brown Polygons: Existing GVI
- White Arrows: "Best Biophysical Lines"

Figure 4: Examples of Proper Edge-Ties between New and Existing GVI and the Use of "Best Biophysical Lines"

5.7.2. Edge Matching with Existing AVI Data

The Alberta Vegetation Inventory (AVI) has been completed for the forested regions of the province. As the GVI moves west and north, the boundaries between the AVI and the GVI coincide. For townships were the GVI and the AVI are adjacent, the contractor is required to edge tie these two inventories along the boundary by snapping the GVI polygons lines to the corresponding AVI polygon lines. Below, Figure 5 depicts the GVI polygons (yellow) snapped to the AVI polygons (black).



Legend:

- Yellow Polygons: New GVI
- Black Polygons: Existing AVI

Figure 5. Transition between GVI and AVI Data

5.7.3. Internal Topology

The topology rules within the GVI dataset are for geometric integrity purposes; there are no contextual topology rules pertaining to allowable adjacency depending on attribution. The cluster tolerance of GVI data is 0.001 metre and the coordinate resolution is 0.0001 metre, both the default values in ArcGIS.

The following topology rules, as referred to in ArcGIS, are used in the GVI.

Applying to polygons:

- Must Not Overlap
- Must Not Have Gaps

Applying to polylines:

- Must not Overlap
- Must Not Intersect
- Must Not Have Pseudos (i.e. Pseudo-nodes)
- Must be Single Part
- Must Not Self-Overlap (i.e. cannot double-back on itself)
- Must Not Self-Intersect (i.e. cannot cross over itself)

5.8. DISPLAY COLOUR CALIBRATION

The combination of the monitor and video-card colour settings of all computers used for aerial photo interpretation, digital delineation, or auditing of data must be colour calibrated. At a minimum, the systems must be adjusted to display colour:

- With a white-point of 6500K, sRGB, or D65 (equivalents)
- With a confirmed gamma of 2.2 in each of the Red, Green, and Blue channels of the monitor.

The result is that both the apparent absolute luminosity of an image (i.e. aerial photo) and the apparent relative luminosity of each of the image channels (for colour imagery) are standardized in regards to the ability of the PC to correctly display the information it is instructed to display. In other words, two people looking at the same imagery on different computers will see close to the same thing if the displays are calibrated, but will see something randomly different if they are not.

Below, Figure 6 and Figure 7 demonstrate an extreme case of visual misrepresentation of colour due to a poorly calibrated display system. It is worth noting that despite monitor colour calibration, which is one of the steps in the process of depicting the image originally captured by a camera, other standards of digital colour

representation must be followed to achieve absolute colour uniformity and full dynamic range but are beyond the scope of this document. In addition to the directions provided below, it should be noted that image enhancements[23] would likely have to be made using the GIS or stereoscopic viewing software to bring the stereo-imagery to some "standard" appearance. Whatever is done should be communicated to the GVI Correlators so that any audit work done can be done using the same process.

Figure 6. Example Imagery before Colour Calibration

[23] Histogram equalization is recommended as the method of image enhancement that will maintain as much useful information as possible within the digital image data.

Figure 7. Example Imagery after Colour Calibration

To verify that your system is calibrated correctly:

2. Check the settings of your CRT or LCD computer monitor to verify that the colour gamut white-point is set to 6500K, sRGB, or D65 – in that order of preference.

    - The colour temperature is related to the mixture of wavelengths of the light emitted from the display (or any other light source). This is the setting (6500 kelvins) most closely resembling natural daylight on an overcast day and the standard for computer displays in the photography, graphics design, and print industries.

3. LCD displays do not display colour correctly when connected with analogue (i.e. VGA) cables. Use digital (i.e. DVI, HDMI, etc) cables and connectors when possible.

    - Proper gamma charts have alternating black and pure colour rows of pixels[24]. Due to the "rise-time" associated with the individual pixels of the display, some LCDs may give different results depending on the orientation of the calibration chart (especially with analogue cables). Because of this, it may be more difficult to calibrate such a display. CRT monitors do not have this problem, but are also more prone to massive degradation of luminous response over time resulting in poor display of colour without proper calibration.

4. Use a Red/Green/Blue + Grey gamma chart to determine the current gamma level of every display in question in each of the red, green, and blue channels. They should be between 2.15 and 2.25. Using the grey chart as a check, the resultant combined gamma should also be close to 2.2 and should be perfectly neutral in tone, rather

[24] Contact the GVI Programme Manager or the GVI Data Custodian for a good quality gamma chart.

than blue-ish, green-ish, or red-ish which indicate the individual channels are not properly set.

- The gamma is a non-linear function that maps input brightness values to match the output brightness values the display is capable of generating across the entire range. A value of 2.2 is the standard in the photography, graphics design, and print industries. Remember that two displays on the same computer may have very different gamma response, even if they are similar models.

5. Assuming the display in question requires calibration, there are two options:

   - **Software-based calibration:**

     This process involves manually adjusting gamma on each of the red, green, and blue channels using video-card driver controls or third party software. It is assumed that all soft-copy workstations used for GVI interpretation and auditing have a good quality video card from NVIDIA or ATI. The drivers for these video cards include gamma-altering capabilities in their respective settings menus. The results can be evaluated as previously mentioned using a good quality gamma chart. This process comes with no additional cost and only takes a few minutes. The result is less accurate than the hardware-based approach as it requires visual interpretation to make the adjustments. If comfortable with this approach and good care is taken, the results of this type of calibration should suffice.

   - **Hardware-based calibration:**

     This process involves purchasing a calibration device[25] (and accompanying software) to do the calibration for you. The device measures the actual light output of the display and custom calibrates it for you (or guides you on how to adjust it). The result is virtually perfect and the quality of the results is limited only by the quality of the hardware – both the monitor and the calibration tool. This more rigorous approach comes with some additional cost and is not required to achieve good [enough] results, but does reduce user error.

[25] At the time of publication of this document, the recommended calibration device and software is the *ColorEyes Display Pro* software with an *XRite DTP-94* or *Spyder-3* sensor available from Integrated Color Corp or various resellers.

APPENDIX A. DESCRIPTION OF LENTIC VEGETATION ZONES

Lentic types are classified according to the vegetation zones that are present (Figure 8, Table 38, below). Lentic vegetation zones include, in order from shallowest to deepest water: low-prairie, wet meadow, shallow-marsh, peripheral deep marsh, and permanent-open-water. Ephemeral ponds generally exhibit only the low-prairie zone, while the permanent-open-water zone is present only in Lentic Semi-permanent to Permanent or Lentic Open Water GVI site types.

Wetland classes are usually distinguished easily in the field. Occasionally, the deepest part of a pond or lake is occupied by a mixture of species characteristic of two different zones. In this case, the class designation is assigned based on which characteristic species group represents more than 50% of the vegetation growth in the deeper central area [Stewart et al., 1971].

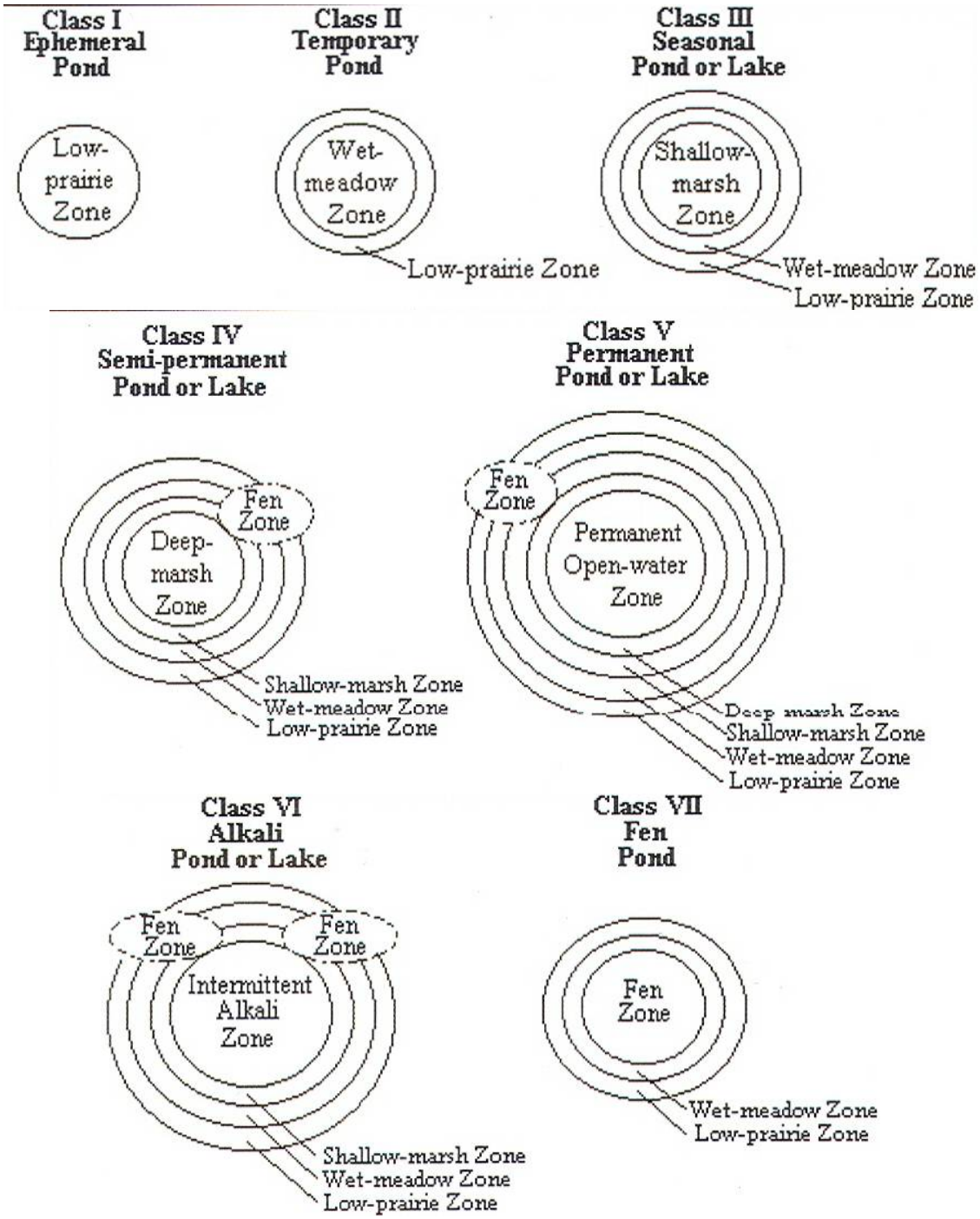


Figure 8. Spatial Relationships among Wetland Vegetation Zones [Stewart et al., 1971]

Low-prairie zone

The low-prairie zone is not truly a wetland, but it represents a transition to the wetland. It is characterized by ephemeral types, where ponding occurs for only a few days in the spring [Richardson and Vepraskas, 2001].

Wet-meadow zone

Wet-meadow plants occur as emergent species. The most numerous species are fine-textured grasses, rushes, and sedges of relatively low stature. Wet-meadow zones in the central areas of shallow pond basins are restricted to fresh or slightly brackish wetlands, while peripheral bands of wet-meadow zone frequently occur in deeper, more permanent ponds or lakes with salinity ranging from fresh to subsaline. Major differences in species composition within the normal emergent phase may be correlated with variations in salinity.

Shallow-marsh zone

Shallow-marsh vegetation dominates at the following locations:

- The central areas of Lentic Seasonal ponds, which normally maintain surface water for an extended period in spring and early summer but frequently, are dry during late summer and fall. Water is generally fresh, slightly brackish, or moderately brackish.

- In deeper, more permanent ponds and lakes, as a concentric band between wet-meadow and deep-marsh zones. Water is generally fresh to subsaline.

- In shallow alkali ponds and lakes, as a band between wet-meadow and intermittent-alkali-zones. Water is generally subsaline, in contrast to the greater salinity of the central open areas.

The shallow-marsh zone is represented by four wetland phases: a normal emergent phase that occurs regularly; an open-water phase, often with submerged aquatic plants, occurring during high water; and a natural drawdown emergent phase, occasionally preceded by a drawdown bare-soil phase that develops during periods of low precipitation. Typical dominant species in the normal emergent phase are grasses or herbaceous species that are intermediate in height in comparison with emergent plants in the normal emergent phase of wet-meadow and deep-marsh zones. More subtle differences within each phase may be represented as a continuum of overlapping species that is correlated with differences in salinity.

Deep-marsh zone

Deep-marsh vegetation dominates the central areas of pond basins that ordinarily maintain surface water throughout the spring and summer and frequently maintain surface water into fall and winter. Deep-marsh zones also occur as marginal bands that adjoin the deep permanent-open-water zones of permanent ponds and lakes. Deep-marsh zones are nearly always present in the deeper ponds and lakes in which salinity ranges from slightly brackish to subsaline. During high water, this zone may also be found locally in some of the deep fresh-water ponds.

The deep-marsh zone is normally represented by an emergent phase and an open-water phase. In permanent lakes, marginal bands of deep marsh are usually represented by the normal emergent phase in the outer, shallower portions, while the open-water phase is typical of the deeper portions that adjoin the permanent-open-water. Two other phases, a drawdown bare-soil (non-vegetated) phase, and a natural drawdown emergent phase, develop only during drought. In the deeper ponds, an alternation of the normal emergent phase and the open-water phase is common because of annual and seasonal changes in water depth.

Submerged or floating plants often occur throughout the deep-marsh zone. Certain species of these plants occur as subdominants in the normal emergent phase, while many other species are characteristic of the open-water phase. Dominant plant species in the normal emergent phase are in general coarser and taller than corresponding species in shallow-marsh zones. Species composition of plant associations differs noticeably in the three vegetation phases of deep marsh, and under different ranges of salinity within each phase.

Open-water zone

The permanent-open-water zone is represented only by the open-water phase. Water in this zone may be classified as slightly brackish, moderately brackish, brackish, or subsaline. Only two species of vascular plants are found in this zone. Western widgeon grass (*Ruppia occidentalis*) commonly occurs, and is occasionally associated with big-sheath pondweed (*Potamogeton vaginatus*). In some lakes the deeper portions of this zone are completely devoid or submerged vegetation. Because of stability of water levels and greater water depth, emergent plants do not develop in permanent-open-water zone. Toward shore this zone is frequently bordered by a band of open water representing the open-water phase of the deep-marsh zone. Although superficially similar in appearance, this shallow open-water band differs in species composition of submerged plants.

Intermittent-alkali zone

The intermittent-alkali zone is characterized by highly saline shallow water that frequently alternates with exposed glistening-white alkali salt flats. The principal salts represented are sulphates and chlorides of sodium and magnesium, which are termed alkali salts by common usage throughout the Great Plains. On windy days it is not unusual for great clouds of white alkali dust to form. Emergent plants do not develop in this zone, apparently because of the high salt content, but one submerged species, saltwater widgeon grass (*Ruppia maritima*), is frequently abundant whenever surface water is maintained for a few weeks during the summer.

Fen (alkaline bog) zone

The vegetation characteristic of the "fen (alkaline bog) zone" occasionally dominates the central areas of pond basins, but more frequently occurs as isolated pockets along the margins of typical ponds and lakes. Surface water is sometimes lacking in this zone, although the bottom soils are normally saturated by alkaline ground-water seepage. Most bottom soils in the deeper portions have the consistency of soft muck or ooze. In many cases, fen zones could be considered quagmires with floating or quaking surface mats of emergent vegetation. Springs are sometimes present, and these are usually on

raised mounds of wet organic material that are covered with mats of dense vegetation. Water in fen zones is slightly brackish. Pockets of fen zones adjoining the more typical basin wetlands are most frequent along the margins of brackish, subsaline, and saline ponds and lakes. In these situations, fen zones are often located on gently sloping terrain with a perceptible flow of ground water on or near the surface, extending from seepage inflow or spring sites to the ponded surface water below. Ordinarily, salinity increases as water moves down the slope, and this is reflected in changes in species composition of wetland plants. Typical fen species gradually merge until being replaced by species characteristic of salinity ranges in other zones. Vegetation of fens is represented by a normal emergent phase and open-water phase.

Table 38. Summary of GVI and S & K Lentic Types

Stewart and Kantrud (1971)		GVI
Lentic Type	**Vegetation Zones Present**	**Lentic Type**
Ephemeral	Low-prairie	Lentic Temporary (LenT)
Temporary	Low-prairie Wet-meadow	Lentic Temporary (LenT)
Seasonal	Low-prairie Wet-meadow Shallow marsh	Lentic Seasonal (LenS)
Alkali	Low-prairie Wet-meadow Shallow marsh Intermittent alkali or fen	Lentic Alkali (LenA)
Semi-permanent	Low-prairie Wet-meadow Shallow marsh Deep marsh	Lentic Semi-Permanent to Permanent (LenSP)
Permanent	Low-prairie Wet-meadow Shallow marsh Deep marsh	Lentic Semi-Permanent to Permanent (LenSP)
	Open-water	Lentic Open Water (LenW)

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