Appendix E. Wetland Functional Assessment Model

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E.1 Selection of the Model

Various models for wetlands functional assessments exist nationwide, yet most are region-specific and, thus, cannot be prudently adapted for use in wetlands of the Great Basin. Other methods of assessment, such as the habitat evaluation procedure (HEP) and hydrogeomorphic (HGM) assessment, are appropriate for use in the region but have other limitations. A HEP provides general information on relative presence of habitat that meets specified criteria by using inferential models to calculate basic habitat functions; however, it does not rely on empirical data to assess those functions. It is most useful for assessing total acreage of available habitat (converted to habitat units) prior to and after mitigation actions, not for parsing wetland habitat by quality of function. HGM assessment method (Brinson 1993; Brinson et al. 1995) utilizes chemical, physical, and biological processes to assess wetland functions, measure wetland ecological condition, and establish compensation ratios for mitigation-based projects. However, HGM models developed for use in Utah are generally in their preliminary stages and require considerable time upfront to assess reference conditions.

So far, there are three Utah models known to be potentially appropriate for a wetlands functional assessment of the SAMP area:

1. UDOT Wetlands Functional Assessment Method (UDOT Model; latest draft 2005 [Johnson 2005]);
2. Functional Assessment Model for Slope – Spring and Seep Fed Wetlands of the Great Basin (Hill Air Force Base Model; Jones et al. 2003); and
3. Functional assessment of Great Salt Lake Ecosystem Slope and Depressional Wetlands (Great Salt Lake [GSL] Model; latest draft 2005 [Keate 2005]).

The ACOE has favored the GSL Model for use in several projects around Great Salt Lake—not only the Shorelands SAMP, but also the Legacy Parkway project, the Tooele SAMP, and the Mountain View Corridor project.

E.2 The GSL Model: Capabilities and Limitations

The GSL Model initially developed in 2001 was designed to assess function of wetlands on a site-by-site basis. In 2005, it was adapted to assess wetland function and determine environmental consequences for large planning projects such as SAMPs (Tooele County, Salt Lake County), the environmental impact statement for the Legacy Parkway, and recently, identifying the least environmentally damaging practicable alternative (LEDPA) along the Mountain View Corridor. Using the GSL Model in a functional assessment approach to these large-scale planning projects has provided a consistent, scientifically defensible method for understanding existing wetland functions and ranking their functional capacities, determining future development-related impacts to wetlands, and developing adequate compensatory mitigation for development (Keate 2005).

The mathematical GSL Model utilizes algebraic formulas to calculate a score of 0 to 1 for six indices of wetlands functional capacities. For any given wetland, these six Functional Capacity Indices (FCIs):

- reflect the level of disturbance or degradation to the wetland's hydrology (by extrapolating interception and conveyance of groundwater and surface water [FCI_{hydro}, $FCI_{inhydro}$]);
- reflect the level of disturbance or degradation to a wetland's ability to improve water quality (by extrapolating the removal of dissolved elements and compounds and its capacity for particulate retention [$FCI_{dissolved}$, $FCI_{particulates}$]); or

- estimate the wetland's potential as wildlife habitat by assessing vegetation structure (as habitat support) and modeling habitat connectivity ($FCI_{habitat}$, $FCI_{connectivity}$).

All but $FCI_{habitat}$, which uses vegetation data collected from the project area, rely on national averages of runoff and loading indices as related to various land uses (Nnadi 1997). Assigning appropriate numeric values to land use types as well as hydrologic modifications and non-native plant infestations depends on both GIS interpretation and field reconnaissance. Depending on the project objectives, any combination of the GSL Model's most applicable FCIs can be used. In the case of the Cutler Reservoir / Bear River TMDL, all but $FCI_{connectivity}$ were used.

E.3 Land Use Classification via Geographic Information Systems (GIS)

Land use, a major component of the GSL Model wetland functional assessment, is considered a surrogate for human impacts on, or impairment of, wetland functions. Using a water-use file from Utah's Automated Geographic Reference Center (AGRC), ground-truthing, and verification with land owners, land uses were classified, compiled into a GIS land-use layer, and applied to the assessment areas. The GSL Model lists 23 different land use types, from roads and industrial areas to golf courses and cropland (Keate 2001; Appendix A). Six of the 23 listed land uses were found to occur within the assessment areas.

Each land use type was assigned a coefficient[1] derived from a composite of studies conducted throughout the U.S. (Nnadi 1997), and these coefficients were used to calculate 11 of 12 model variables[2] associated with the 6 FCIs (Keate 2001). High-value coefficients (those close to 1) are associated with land uses that have relatively little impact on wetland function, such as rotational grazing. Low-value coefficients (those at or close to 0) correspond to land uses that have a relatively large impact on wetland function, such as high-intensity commercial development. Table 2.1 provides a sample of some of the coefficients used to calculate the variables, and the complete table of coefficients is listed in Appendix A.

Table E.1. Sample Land Use Types and Associated Coefficients

	GSL Model Coefficients			
Land Use	**Runoff**	**Loading**	**Suspended Solids**	**Wildlife Habitat**
Dirt Road	0.71	0.92	0.97	0.30
High-intensity Commercial	0.13	0.00	0.00	0.00
Heavy Grazing	0.76	0.87	0.98	0.10
Multi-family Residential	0.38	0.69	0.16	0.10

Source: Keate 2001.

E.4 Functional Capacity Indices (FCIs) used in the Cutler Reservoir wetland assessment.

The FCIs of the GSL Model represent in mathematical terms the ability of a wetland to perform a specific wetland function. The five FCIs and their component variables (see Appendix B.1), as defined in the GSL Model (Keate 2001), are detailed here.

[1] For the unlisted "prior field crop" land use, the coefficient for "rotational grazing," a comparable land use, was used.
[2] The variables are related to runoff, pollutant loading, and suspended solid filtration both within and adjacent to the wetland.

1. FCI_{hydro}

   FCI_{hydro} measures a wetland's capacity for intercepting groundwater and surface water outside the wetland, as affected by land use and hydrologic modification:

   $$FCI_{hydro} = \sqrt{(V_{mod} \times V_{runoff})}$$

   where V_{mod} is a categorical scale that relates to how land use modifications have affected surface water hydrology in the area of the wetland.

   where V_{runoff} is the average amount of overland flow or surface runoff reaching the wetland. Quantity and timing of water delivery is affected by soil permeability as related to land uses adjacent to the wetland.

2. $FCI_{inhydro}$

   $FCI_{inhydro}$ measures the internal water flow as related to vegetative structure (as a measure of roughness and flow dissipation) as well as effects on soil permeability and vegetation type by land use within the wetland:

   $$FCI_{inhydro} = (V_{vegstruct} + V_{runoffin}) \div 2$$

   where $V_{vegstruct}$ is a measure of surface roughness associated with the quality and cover of wetland vegetation.

   where $V_{runoffin}$ measures the impact of land use on soil permeability and water infiltration and flow within the wetland.

3. $FCI_{dissolved}$

   $FCI_{dissolved}$ measures a wetland's capacity to remove dissolved elements or compounds through biotic, physical, and chemical processes:

   $$FCI_{dissolved} = (V_{diswetuse} + V_{disload}) \div 2$$

   where $V_{diswetuse}$ refers to the load of dissolved solids associated with land use within the wetland.

   where $V_{disload}$ measures the amount of dissolved solids associated with land uses adjacent to the wetland.

4. $FCI_{particulates}$

   $FCI_{particulates}$ measures the deposition and detention of inorganic and organic particulates due primarily to physical processes:

   $$FCI_{particulates} = (V_{susload} + V_{suswetuse} + V_{mod}) \div 3$$

   where $V_{susload}$ is total suspended solids (TSS), or particulate matter, associated with adjacent land uses and transported to surface waters of the wetland.

   where $V_{suswetuse}$ is TSS, or particulate matter, associated with sources from land uses within the wetland.

   where V_{mod} is a categorical scale that relates to how land use modifications have affected surface water hydrology in the area of the wetland.

5. $FCI_{habitat}$

$FCI_{habitat}$ is a measure of composition and characteristics of the living plant biomass as associated with human disturbances related to various land uses:

$$FCI_{habitat} = (V_{habwetuse} + V_{adjhab} + V_{vegstruct}) \div 3$$

where $V_{habwetuse}$ is a measure of habitat support of land uses within the wetland.

where V_{adjhab} is a measure of habitat support by adjacent land uses for wildlife utilization.

see function 2, $FCI_{inhydro}$, for $V_{vegstruct}$.

E.5 Calculation of Variables

V_{MOD}

V_{mod} is a categorical measure of the disruption of groundwater and surface water hydrology within a wetland and its adjacent, 300-foot perimeter (2,000-foot buffer used for $FCI_{habitat}$ and $FCI_{connectivity}$).

To calculate V_{mod}, identify all man-made disturbances (e.g., roads, berms, and ditches) that alter hydrology either by drying or storing water. Assign each modification a coefficient based on severity:

- 0.00 = 1, Extreme (e.g., four lane paved highway, ditches more than 3 feet deep)
- 0.50 = 2, Moderate (e.g., two-lane paved road, ditches 1-3 feet deep)
- 0.75 = 3, Slight (e.g., near-grade roads, ditches less than 1 foot deep)
- 1.00 = 4, None

Multiply the percentage of the wetland impacted by each modification by its coefficient. Sum them for a composite score (see example):

Example Calculation:
65% of wetland is unmodified (65% × 1.00 = 0.65)
20% of wetland is slightly modified (20% × 0.75 = 0.15)
15% of wetland is extremely modified (15% × 0.00 = 0.00)
$V_{mod} = 0.65 + 0.15 + 0.00 = 0.80$

$V_{VEGSTRUCT}$ (2001)

$V_{vegstruct}$ is one measure of surface roughness. It is an indicator of vegetation structure as a function of native and non-native species, based on wetland type or subclass.

The $V_{vegstruct}$ variable used for the Shorelands SAMP and other projects described in this document is the sum of the native species score and the score for herbaceous cover, divided by 2 (Keate 2001). Vegetation cover is determined at six inches above ground surface. The native species score is determined by dividing the number of individuals of the 5 dominant, native species by 5. If there are less than 5 dominant species, the total number of species is used as the divisor (e.g., if there are only 4 dominant, native species, the total number of individuals of those species is divided by 4).

Herbaceous cover scores are calculated by subclass, and scores are based upon relative level of salinity (see example below):

Table E.2 Example of herbaceous cover scores

	Conductivity	Actual Cover	Score
Slope Wetland Subclasses	< 8dS	≥ 0.83	1
	< 8dS	< 0.83	(2.87 × cover) - 1.40
	> 8dS	≤ 0.71	1
	> 8dS	> 0.71	3.46 × cover
Depressional Wetland Subclasses	< 8dS	≥ 0.82	1
	< 8dS	< 0.82	(0.43 × cover) + 0.39
	8dS – 16dS	≥ 0.76	1
	8dS – 16dS	< 0.76	(0.39 × cover) + 0.37
	> 16 dS	≤ 0.61	1
	> 16 dS	> 0.61	2.98 - (3.28 × cover)

Example Calculation:
Total number of dominant species = 5
Total number of native dominant species = 2
Native Species Score = 2 ÷ 5 = 0.40

For a depressional wetland with a salinity of 10 dS and an actual cover of 0.65:
Modified Herbaceous Cover Score = (0.39 × cover) + 0.37 = (0.39 × 0.65) + 0.37 = 0.62

$V_{vegstruct}$ = (Native Species Score + Modified Herbaceous Cover Score) ÷ 2
$V_{vegstruct}$ = (0.40 + 0.62) ÷ 2 = 0.51

$V_{VEGSTRUCT}$ (2005)

The revised $V_{vegstruct}$ variable is the sum of the native species score and the Similarity Index, divided by 2 (Keate 2005). To calculate the native species score for this variable, divide the number of native species that are dominant by the total number of dominant species (native and non-native), identifying no more then five. If there are fewer than five dominant plant species, use that number in the denominator (see example):

Example Calculation:
Total number of dominant species = 4
Total number of native dominant species = 3

Native Species Score = 3 ÷ 4 = 0.75

Determining the Similarity Index requires the use of wetland subclass profiles developed as part of this assessment and that contain data on reference standard conditions (e.g., plant species, work in progress, N. Keate 2005). To calculate the Similarity Index, divide the total number of total plant species in the wetland being assessed into the number of those species that occur in the reference standard for the type of wetland in which you are working (see example):

Example Calculation:

Total number of plant species in wetland = 5

Number of these species found in the reference standard for this wetland type = 3

Similarity Index = 3 ÷ 5 = 0.6

Having the native species score and the Similarity Index, you can calculate $V_{vegstruct}$:

$V_{vegstruct}$ = (Native Species Score + Similarity Index) ÷ 2

$V_{vegstruct} = (0.75 + 0.6) \div 2 = 0.68$

V_{RUNOFF}

V_{runoff} is the average amount of overland flow reaching the wetland. It is affected by land use surrounding the wetland that reduces soil permeability and alters the quantity and timing of water delivery to the wetland. V_{runoff} coefficients were calculated from one Florida study and tabulated in a working paper by Nnadi (1997).

To calculate V_{runoff}, identify all land uses within a 300-foot perimeter of the wetland and determine the percentage of the total area that each use occupies. Multiply each percentage by its land use coefficient (see Appendix A). Sum them for a composite score (see example):

Example Calculation:

50% of perimeter is rotational grazing (50% × 0.96 = 0.48)

34% of perimeter is field crop (34% × 0.95 = 0.32)

16% of perimeter is light-intensity commercial development (16% × 0.19 = 0.03)

$V_{runoff} = 0.48 + 0.32 + 0.03 = 0.83$

$V_{RUNOFFIN}$

$V_{runoffin}$ measures the impact of land use within the wetland via surface roughness (as related to plant structure) and water infiltration and flow over wetland soils. $V_{runoffin}$ coefficients were calculated from one Florida study represented by a tabulation of multiple studies throughout the U.S. by Nnadi (1997).

To calculate $V_{runoffin}$, identify all land uses within the wetland and determine the percentage of the total area that each use occupies. Multiply each percentage by its land use coefficient (see Appendix A). Sum them for a composite score (see example):

Example Calculation:

62% of wetland is waterfowl management area (62% × 0.86 = 0.53)

21% of wetland is rotational grazing (21% × 0.96 = 0.20)

17% of wetland is dirt road (17% × 0.71 = 0.12)

$V_{runoffin}$ = 0.53 + 0.20 + 0.12 = 0.85

$V_{DISLOAD}$

$V_{disload}$ is a measure of the loading of the wetland with elements and compounds from land use from adjacent lands within a 300-foot perimeter. $V_{disload}$ coefficients were calculated from studies conducted throughout the U.S. and tabulated in a working paper by Nnadi (1997).

To calculate $V_{disload}$, identify all land uses within the 300-foot perimeter and determine the percentage of the total area that each use occupies. Multiply each percentage by its land use coefficient (see Appendix A). Sum them for a composite score (see example):

Example Calculation:

68% of perimeter is waterfowl management area (68% × 0.86 = 0.58)

21% of perimeter is rotational grazing (21% × 0.96 = 0.20)

11% of perimeter is sewage treatment lagoon (11% × 0.61 = 0.07)

$V_{disload}$ = 0.58 + 0.20 + 0.07 = 0.85

$V_{DISWETUSE}$

$V_{diswetuse}$ is a measure of the loading of the wetland with elements and compounds from land use within the wetland. $V_{diswetuse}$ coefficients were calculated from studies conducted throughout the U.S. and tabulated in a working paper by Nnadi (1997).

To calculate $V_{diswetuse}$, identify all land uses within the wetland and determine the percentage of the total area that each use occupies. Multiply each percentage by its land use coefficient (see Appendix A). Sum them for a composite score (see example):

Example Calculation:

54% of wetland is heavy grazing (54% × 0.87 = 0.47)

36% of wetland is forested (36% × 1.00 = 0.36)

10% of wetland is high traffic highway (10% × 0.43 = 0.04)

$V_{diswetuse}$ = 0.47 + 0.36 + 0.04 = 0.87

$V_{SUSLOAD}$

$V_{susload}$ is a measure of the relative volume of total suspended solids (TSS) carried into a wetland surface water from the surrounding landscape. $V_{susload}$ coefficients were calculated from studies conducted throughout the U.S. and tabulated in a working paper by Nnadi (1997).

To calculate $V_{susload}$, identify all land uses within the 2,000-foot perimeter and determine the percentage of the total area that each use occupies. Multiply each percentage by its land use coefficient (see Appendix A). Sum them for a composite score (see example):

Example Calculation:

74% of perimeter is low-density rural development (74% × 0.98 = 0.73)

16% of perimeter is surface solid waste (16% × 0.61 = 0.10)

10% of perimeter is dirt road (10% × 0.97 = 0.10)

$V_{susload}$ = 0.73 + 0.10 + 0.10 = 0.93

$V_{SUSWETUSE}$

$V_{suswetuse}$ is a measure of the relative volume of TSS carried into the wetland surface water from land uses within the wetland. $V_{suswetuse}$ coefficients were calculated from studies conducted throughout the U.S. and tabulated in a working paper by Nnadi (1997).

To calculate $V_{suswetuse}$, identify all land uses within the wetland and determine the percentage of the total area that each use occupies. Multiply each percentage by its land use coefficient (see Appendix A). Sum them for a composite score (see example):

Example Calculation:
35% of wetland is field crop (35% × 1.00 = 0.35)
33% of wetland is rotational grazing (33% × 0.98 = 0.32)
32% of wetland is range (32% × 1.00 = 0.32)
$V_{suswetuse} = 0.35 + 0.32 + 0.32 = 0.99$

V_{ADJHAB}

V_{adjhab} is a measure of the habitat support of the land within the 2,000-foot perimeter for wildlife utilization. V_{adjhab} coefficients were calculated from studies conducted throughout the U.S. and tabulated in a working paper by Nnadi (1997).

To calculate V_{adjhab}, identify all land uses within the 2,000-foot perimeter and determine the percentage of the total area that each use occupies. Multiply each percentage by its land use coefficient (see Appendix A). Sum them for a composite score (see example):

Example Calculation:
45% of perimeter is light-intensity commercial (45% × 0.10 = 0.05)
25% of perimeter is multi-family residential (25% × 0.10 = 0.03)
17% of perimeter is single-family residential (17% × 0.50 = 0.09)
13% of perimeter is dirt road (13% × 0.30 = 0.04)
$V_{adjhab} = 0.05 + 0.03 + 0.09 + 0.04 = 0.21$

$V_{HABWETUSE}$

$V_{habwetuse}$ is a measure of the habitat support of the land within the wetland for wildlife utilization. $V_{habwetuse}$ coefficients were calculated from studies conducted throughout the U.S. and tabulated in a working paper by Nnadi (1997).

To calculate $V_{habwetuse}$, identify all land uses within the wetland and determine the percentage of the total area that each use occupies. Multiply each percentage by its land use coefficient (see Appendix A). Sum them for a composite score (see example):

Example Calculation:
78% of wetland is waterfowl management area (78% × 0.85 = 0.66)
22% of wetland is golf course (22% × 0.30 = 0.07)
$V_{habwetuse} = 0.66 + 0.07 = 0.73$

E.6 Results of the Wetland functional Assessment Model

The following table presents the various FCI scores for each functional unit and the associated scores of each variable used in the calculation.

Table X.2

Function	FCI Score	Calculations
Benson Bridge		
FCI Hydro	.93	.99 (Vmod) * .88 (Vrunoff) ^ 1/2
FCI InHydro	.88	.90 (Vvegstruc) + .85 (Vrunoffin) /2
FCI Dissolved	.90	.91 (Vdiswetuse) + .90 (Vdisload) /2
FCI Particulates	.98	(.97 (Vvegstruc) + .97 (Vrunoffin) /2) + .99 (Vmod) / 2
FCI Habitat	.73	.45 (Vadjhab) + .84 (Vhabwetuse) + .90 (Vvegstruc) / 3
Swift Slough		
FCI Hydro	.95	.99 (Vmod) * .92 (Vrunoff) ^ 1/2
FCI InHydro	.85	.83 (Vvegstruc) + .87 (Vrunoffin) /2
FCI Dissolved	.92	.91 (Vdiswetuse) + .93 (Vdisload) /2
FCI Particulates	.99	(.99 (Vvegstruc) + .98 (Vrunoffin) /2) + .99 (Vmod) / 2
FCI Habitat	.70	.46 (Vadjhab) + .80 (Vhabwetuse) + .83 (Vvegstruc) / 3
Amalga Barrens		
FCI Hydro	.97	.99 (Vmod) * .95 (Vrunoff) ^ 1/2
FCI InHydro	.96	1.0 (Vvegstruc) + .91 (Vrunoffin) /2
FCI Dissolved	.95	.94 (Vdiswetuse) + .95 (Vdisload) /2
FCI Particulates	.99	(.99 (Vvegstruc) + .99 (Vrunoffin) /2) + .99 (Vmod) / 2
FCI Habitat	.75	.36 (Vadjhab) + .90 (Vhabwetuse) + 1.0 (Vvegstruc) / 3