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MAPPING ECOSYSTEMS ALONG NEVADA HIGHWAYS AND THE DEVELOPMENT OF SPECIFICATIONS FOR VEGETATION REMEDIATION

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INTRODUCTION

This project was designed to inventory the major plant communities and general soil classification units along the various highways across the state, and to recommend The best procedures and management practices for vegetation remediation based on the appropriate ecosystems and soil types.

The vegetation mapping has been accomplished using year 2000 Landsat 7 Thematic Mapper satellite data and image processing techniques. These data are presented by Nevada counties (Table 1). Soil polygon data from the Natural Resources Conservation Service are placed on the vegetation maps using GIS procedures. The goal is to be able to quickly examine the soil characteristics associated with each polygon and its associated vegetation type. Presently the soil characteristics must be examined by going to the hard copies of the soil surveys referred to in Table 2. This information, along with information from the literature, appropriate seed and revegetation companies and the experience of the investigators, has been used to prepare specifications for the re-vegetation of disturbed areas.

Table 1. Nevada Counties

Churchill (church_s, church_v)	Humboldt (humbo_s,humbo_v)	Pershing (persh_s,persh_v)
Clark (clark_s, clark_v)	Lander (lande_s,lande_v)	Storey (store_s,store_v)
Douglas (dougl_s,dougl_v)	Lincoln (linco_s,linco_v)	Washoe (washo_s,washo_v)
Elko (elko_s,elko_v)	Lyon (lyon_s,lyon_v)	White Pine (white_s,white_v)
Carson City (carso_s,carso_v)	Mineral (miner_s,miner_v)	
Eureka (eurek_s,eurek_v)	Nye (nye_s,nye_v)	

A number of considerations go into the development of specifications for the re-vegetation of disturbed areas. Among these are species selection/species mixtures; seeding procedures; irrigation; fertilization, and erosion control. To determine the most appropriate and successful species for use on any highway rights-of-way, emphasis has been given to indigenous, long-lived plants, including perennial grasses, herbs, and shrubs. Preference was also given to species that can be established with little or no maintenance by the Nevada Department of Transportation (NDOT) over the long term and can create defensible space for wildfire along the highway corridors. Species selected for remediation purposes have been evaluated for drought tolerance, minimum annual rainfall needs, salt and alkali tolerance, seedling vigor, growth habit, suitable soil groups, seeding rates, PLS (Pure Live Seed), availability, and general costs of native seed sources. Some possible seeding procedures include drilling or broadcast dispersal, placing container-grown nursery stock onto the areas of concern, mycorrhizal inoculums, site preparation such as mulching or hydro-mulching or other means of dust control, and supplemental irrigation to facilitate initial establishment. Specifically, drip systems or a sprinkler system could be used for initial establishment of plant species. For example, a portable 1 to 2 acre drip system could be developed and moved from site to site as areas are revegetated. It can be assumed that most sites will be deficient in nitrogen but will have more than adequate amounts of potassium. Some sites may also be deficient in phosphorous. These problems may require certain soil amendments to assure revegetation success. Additive nutrient selection is based on the nutrient deficiencies of a site and the ability of a plant to utilize the additional nutrients.

Vegetation maps and Natural Resources Conservation Service (NRCS) soils data will help in determining the best vegetation for remediation purposes. A five-mile buffer along each highway was clipped to Landsat 7 Thematic Mapper Images of Nevada

(Figure 1). These maps are provided for each county. They provide a first-cut analysis of the general kinds of dominant plant communities found along the highways in Nevada. Fieldwork was acquired by driving all highways with frequent stops, primarily at mile markers, to document the dominant vegetation. These data are being used to develop the vegetation classifications. Soil polygons from the NRCS SSURGO data will be overlaid on each set of images to provide additional information upon which to base the specifications for revegetation. In addition, we have started to record the location of invasive and noxious weeds, as well as vegetation types known to offer a high fire hazard. This must be an ongoing process because the vegetation continues to change. The clipped Landsat 7 TM images were classified to create vegetation maps with dominant vegetation types. Classification was based on various image-processing classifications that we have used in the past and on our field sampling. An example of a classification north of Wells, Nevada is shown below. In Figure 1, the vegetation map is overlaid onto a hill shade derived Digital Elevation Model (DEM). Figure 2 is an overall vegetation map along Nevada highways with 13 general classes.

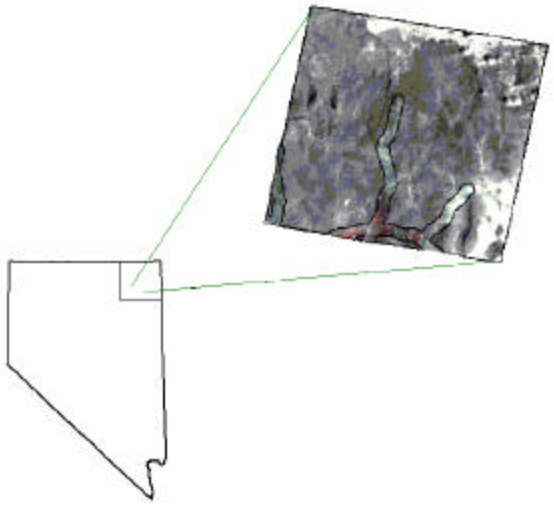

Figure 1. A example of the Landsat TM Image mapping. In this case the map is overlaid on a shade derived Digital Elevation Model.

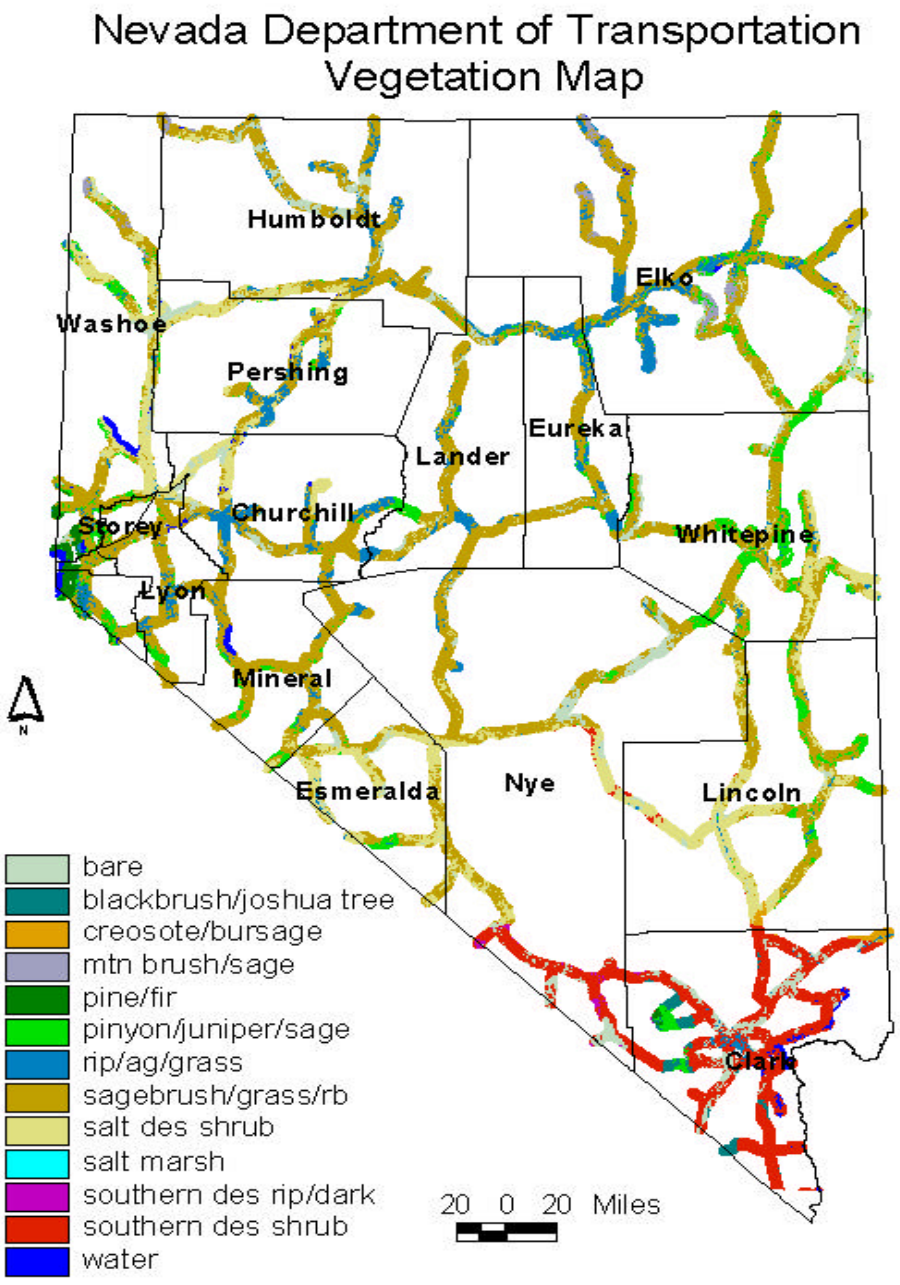

Figure 2. Nevada roadside vegetation map derived from Landsat TM data.

Figure 2 is a map of the entire state highway system. These maps have been prepared for each county and include a five-mile swath with the highway right-of-way in the center.

Vegetation and Soil Maps

Vegetation maps are included with this report. The maps have been prepared for each Nevada County. Landsat 7 TM scenes were originally mapped using image-processing software. Then the data was displayed by county in Arc Cover files for use in ARCInfo or Arcview. An example of this is found in Figure 3. Table 1 lists the counties and how the map data will be placed on the accompanying CDs. Both the vegetation and soil maps have been prepared by county. The soil polygons represent soil associations that are keyed to specific soil surveys. Table 2 is a list of the soil surveys for Nevada that can be referenced for soils information. There are 39 soil surveys within the state of Nevada representing a wide variety of soil classifications. The NRCS has developed and made available online the SURRGO soil survey data which will eventually be keyed more closely to the various polygons. Presently the polygon, soil association data must

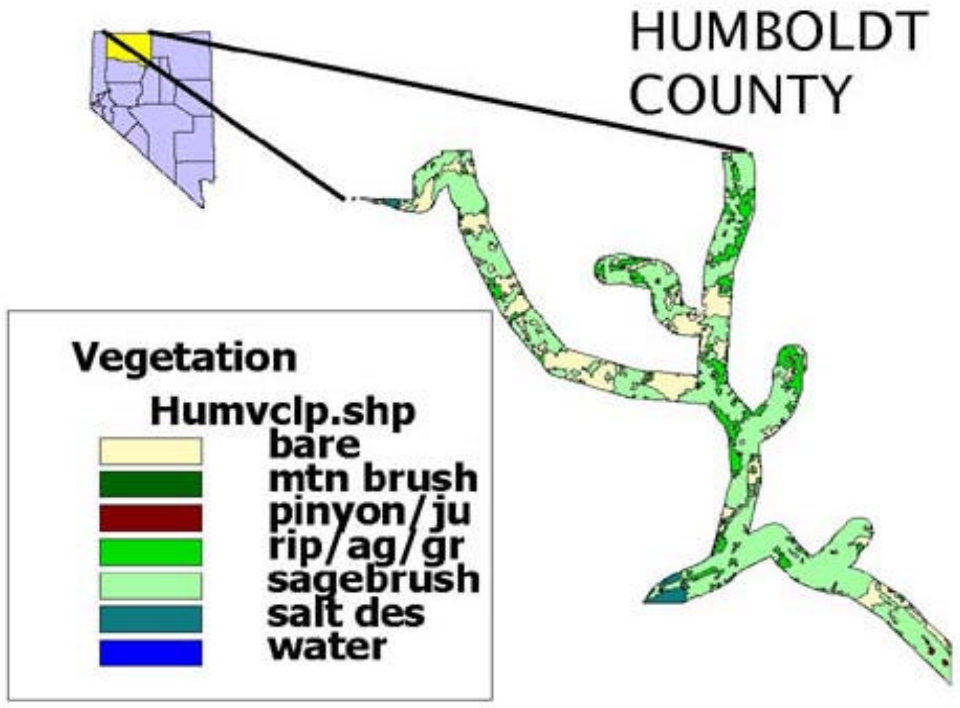

Figure 3. An example of one of the county vegetation maps, Humboldt County, showing the various vegetation classes.

be accessed by using the hard copies of the soil surveys. One can determine the soil series involved in the soil polygon representing a soil association and then reference can be made specifically to the soil series descriptions and other pertinent information to determine exactly what kinds of soil are found in an area of interest. These areas of

interest would be where a highway crosses a soil polygon and the manager or remediation specialist wishes to know the various soil characteristics that might be encountered at that site. Figure 4 shows an example of the soil data and the information necessary to refer to the specific soil surveys.

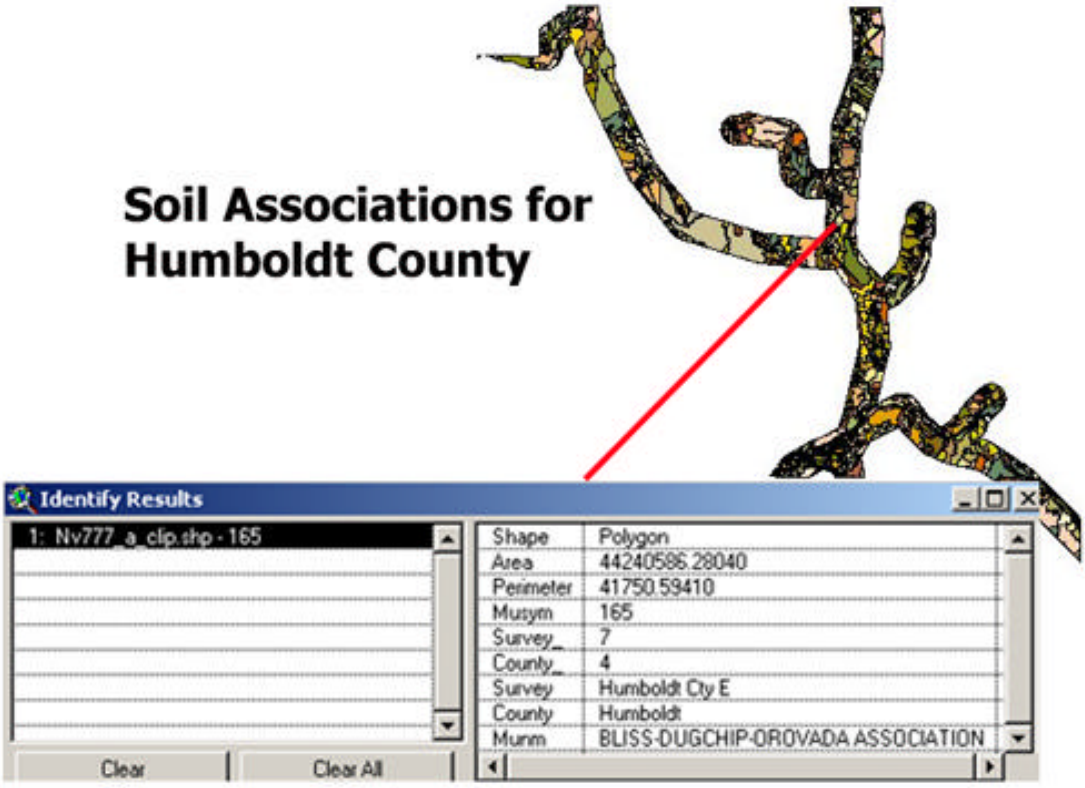

Figure 4. An example of a county roadside soil map with the attributes that will be presented for each polygon. Polygon area and perimeter is recorded in square meters. Musym = map symbol number, Survey = soil survey number and name, County = county number and name, Munm = map unit name (this may be either an association or soil series).

TABLE 2. Nevada soil surveys that were referred to in developing the vegetation maps along the highways.

Big Smoky Valley area Nye County
Carson County
Churchill County and parts of Lyon County
Diamond Valley area and parts of Elko and Eureka
Douglas County
Duck Valley Reservation NV ID
Elko Central
Elko County Northeast
Elko County Northwest
Elko County Southeast
Esmeralda County
Eureka County
Humboldt County East
Humboldt County West
Lake Tahoe
Lander County North
Lander County South
Las Vegas
Lincoln County South
Lyon County
Mineral County Hawthorne Ammunition Plant
Mineral County
Nye County Northeast
Nye County Northwest
Nye County Southeast
Nye County Smoky Valley Area
Nye County Southwest
Parts of Churchill/Washoe Counties
Parts of Whitepine/Eureka/Elko Counties/Diamond Valley
Pershing County East
Pershing County West
Storey County
Tahoe Basin
Tooele Area UT/NV
Tuscarora Mtns area NV
Virgin River Area NV/AZ Clark county Mohave
Washoe County Central
Washoe County North
Washoe County South

The vegetation and soil maps are on the CDs included with this report and will be placed on the NDOT Web site. Each vegetation and soil map is saved in a folder named by county. The vegetation maps were saved as ARC Grid files, using the first five letters of the county with an underscore "v" to denote vegetation. For instance, "humb_v" represents the vegetation map for Humboldt county. Due to the nature of the GRID format, each vegetation map is initially displayed without the vegetation classes. The file "vegclass.dbf" needs to be imported as a table and linked to the vegetation map using the "value" field. The "final.avl" contains the colors for each vegetation class that can be loaded into the legend editor in Arc View. The grid for the entire state is saved in a folder called "Nevada_state" Metadata is included, called "final.met" and "final.html."

Once the vegclass.dbf file is linked to the county grids, each soil polygon contains information on the vegetation type, revegetation specifications, and species that compose each vegetation class. Many of the classes contain a number of different specifications due to the generality of the vegetation types. For instance, southern desert shrub is composed of many different plant species, which were classified to other vegetation classes. For example, southern desert shrub can be linked to specifications numbered 1a and 1b, the Mohave specifications listed in the "Categories for Specifications Along Nevada Highways." Table 3 lists the vegetation classes (types) along with the corresponding re-vegetation specifications (re_veg_specs). Species 1 – 9 list some of the associated species with each vegetation class.

Table 3. Revegetation classes used in the NDOT vegetation maps linked to the revegetation specifications described in the report. The value number serves as a reference allowing vegetation class names to be joined to the vegetation map in its grid format.

veg-class	value	Re_veg Specs	species1	species2	species3	species4
southern desert shrub	1	1a, 1b	creosote bush	Joshua tree	geological features	
blackbrush/jJoshua tree	2	1b	blackbrush	creosote bush		
bare areas	3	2	playa	urban areas	snow	cloud
rip/ag/grass	4	3c, 4a, 8	riparian	agriculture	golf	urban areas
pinyon/juniper/sagebrush	7	4b, 5b, 6,	sagebrush	mtn brush	bitterbrush	
pine/fir	9	7	pine	fir	agriculture	
creosote/bursage	12	1a	creosote	bursage		
salt desert shrub	13	3a, 3b, 3c	southern desert shrub	sagebrush	indian rice grass	playa
sagebrush/grass	15	4a, 4b	sagebrush	rabbitbrush	some agriculture	grass
water	16	2, 5, 8	salt desert shrub	sagebrush	southern des shrub	
southern des rip/dark geol	19	1a, 1b, 1c	southern desert shrub	geological features		
mtn brush/sagebrush	21	4a, 4b, 6	ephedra	bitterbrush	chokecherry	sagebrush
salt marsh	25	2	salt marsh	salt marsh		

veg-class	**value**	**Re_veg Specs**	**species5**	**species6**	**species7**	**species8**
southern des shrub	1	1a, 1b				
blackbrush/joshua tree	2	1b				
bare	3	2	cheat grass (Brte)			
rip/ag/grass	4	3c, 4a, 8	grasses	aspen	wet meadow	pinyon/juniper
pinyon/juniper/sagebrush	7	4b, 5b, 6,				
pine/fir	9	7				
creosote/bursage	12	1a				
salt des shrub	13	3a, 3b, 3c				
sagebrush/grass/frb	15	4a, 4b	low sagebrush	salt desert shrub		
water	16	2, 5, 8				
southern des rip/dark geol	19	1a, 1b, 1c				
mtn brush/sage	21	4a, 4b, 6				
salt marsh	25	2				

The soil polygons are the digital soil polygons created by the NRCS. They contain information on the map unit symbol (Musym) and county. The soil polygons were clipped to the road buffer (Figure 4), which includes a five-mile swath along the roads. They can be overlaid with the vegetation maps to identify the dominant vegetation type and soil information for vegetation remediation. When the soil polygon is specified, information on the county, the soil survey, the specific soil numbers, and the soil associations are displayed. Once the map unit symbol and county are identified, the user can refer to the hard copy for extensive information concerning the soils including physical and chemical characteristics. These data are necessary for creating a favorable soil environment for the seed and container-grown plant species used in re-vegetation efforts.

REVEGETATION SPECIFICATIONS

Throughout the state there are numerous environments and their associated ecosystems. Each of these sites is different enough that specifications for revegetation will be different for each situation. Below we have listed the principle types that we have considered as part of this report. We believe that almost every site along every highway can be considered by using one of these specification write-ups. As one considers the vegetation around the state there are numerous potential classifications for the natural vegetation. The soils have been described throughout the state by the Soil Surveys accomplished by the Natural Resources Conservation Service. Below we have listed a classification that may not fit every plant ecologist's dream classification but does fit the needs of remediation of sites associated with the highways throughout the state of Nevada. It must also be remembered that every site may have significant differences in soil and vegetation characteristics and therefore would require a careful one-time evaluation to specify the best management practices and revegetation protocols for that

particular site. Identification of the dominant species associated with these various sites is distinct to the botanist/plant ecologist but not necessarily to the layman. We have included some photographs and descriptions of the dominant species to assist the user of this report in determining exactly what kind of vegetation is found on a site in order to determine the appropriate protocol for successful revegetation. In addition we have given locations of areas along highways identified by mile markers that have the specified kind of vegetation.

For each site, the species lists are provisional. The actual selection of species is dependent upon 1) seed costs; 2) seed availability; and 3) design suggestions from the landscape architects. The write–ups by category include sections on site analysis, species selection, soil/site preparation and revegetation procedures. Apart from species selection, a number of other factors must be taken into consideration. These include supplemental irrigation to aid in establishment, fertilization, use of mulches to protect new seedings and reduction of erosion from both water and wind. Wind erosion may be a problem on certain sites. Wind can remove the smaller clay particles and organic matter from the soil while coarser materials are left behind. The continued loss of fine particles reduces soil quality. In shallow soils and soils with a hardpan layer, wind erosion also results in decreased root zone depth and water-holding capacity. Soils that are prone to wind erosions may require further treatment to prevent wind erosion and the associated dust hazards. If vegetation can be established, this problem is more or less solved. The years 1999 and 2000 fires resulted in the removal of vegetation along broad expanses of highway and led to dust clouds that obscured traffic and caused a number of accidents.

Climate

The climate of Nevada is characterized by both cold desert or Great Basin environments and Mojave Desert environments. Mojave desert sites are found in the lower elevations of the southern part of the state. The Great Basin has basically an oceanic climate with winters wet and summers dry. In the north precipitation amounts vary from less than 4 inches annually to almost 25 inches at the highest elevations in the Sierra Nevada. Higher precipitation amounts are found generally in the more than 114 separate distinct mountain ranges found in Nevada spreading across the Great Basin (Maclean). The rain shadow of the Sierra Nevada gives considerable dryness to the valleys and mountain ranges just to the east of the Sierra Nevada. In Reno, for example, the long-term annual precipitation is 7.8 inches, and eastward it is as low as 4 inches or 5 inches. The precipitation in the southern low elevations portions of the state is very low near 2 inches or 3 inches but certainly with no consistency. Precipitation in he Mojave Desert averages 2 inches to 3 inches but can exceed 18 inches to 20 inches in the mountainous regions associated with Mt. Charleston.

Temperatures also fluctuate a great deal. It is not uncommon to have, in the summertime, a 50-degree temperature fluctuation. In summers the temperatures in many of the northern valleys can exceed 100 degrees Fahrenheit for several days. Temperatures below zero degrees Fahrenheit may be recorded in the winter. In the south daily temperatures of 100 degrees Fahrenheit are common over several months. Frost-

free days vary from about 90 days in the north to more than 200 in the south, although it is possible for a killing frost to occur in the north during any month. In the south this is less a problem but is offset by the desert characteristics of these sites.

The overall climate suggests that most of the sites along highways in the state are very droughty deserts and require methods and species adapted to these climatic conditions. With specifications below, an attempt has been made to meet these harsh requirements.

Revegetation Practices

Seeding Windows. A seeding window represents a time when the amount of soil moisture and temperatures, both nighttime and daytime, are most conducive to establishment. Factors that contribute to the determination of the seeding window may vary among the various ecosystems discussed here. Some factors generally hold true:

?? Seeding prior to a period of adequate moisture for seed germination.

?? Seeding prior to an extended period of adequate moisture for early seedling growth and establishment.

?? Seeding when soil temperatures are adequate for seed germination and seedling growth.

?? Seeding prior to a period that could meet the stratification (a common requirement of many native species for breaking of seed dormancy is a cold stratification or cold treatment) requirements of the species (Hansen, et al 1991).

Soil Treatments. In almost every case of remediation, some soil treatment is necessary. These include plowing, disking, harrowing, furrowing, hydroseeding, applying mulches and using tackifiers to firmly anchor the mulches to the site, fertilization, and in some cases, supplemental irrigation. As a part of the prescriptions prepared for this report, we have covered many of the potential techniques for accomplishing this in different ecosystems because it is important to provide safe seed sites and good locations for the placement of container-grown materials onto the disturbed sites.

Container-Grown Material. These can be either in the form of bare-rootstock, balled and burlap, or container-grown plants. Shrubs in particular can be grown in containers and out planted by hand if the areas are small enough. Hand planting must be carefully accomplished. For example, bare-rootstock should be placed in the hole so the root crown will be right at the soil surface. The plant should be crimped in tightly. Where possible when planting bare-root stock, build a cone in the bottom of the hole and arrange the roots over the cone and backfill. Balled and burlap, and container stock should be planted in a hole at lease twice as wide as the root ball and only as deep. Back fill with soil amended with an organic mulch. Soak each plant thoroughly after planting.

Mature transplants must be ordered with a reasonable "lead time" to assure their availability at the appropriate seeding window. In many cases greenhouse-grown plants must be hardened to withstand the temperature extremes that might be encountered when the plants are set out. So storage, including healing-in and hardening, is very important and must be considered to help achieve successful revegetation with container-grown materials. The soil around these mature plants should be placed so that the top of the root plug is ½ inch to 1 inch below the ground surface.

Drill Seeding. Drill seeding is the preferred method of seed planting since the seed is placed in the ground. This gives more protection and seed-to-soil contact. Less seed is necessary for germination and production of a good stand of grass. Where slopes are level to a run/rise of no greater than 4-to-1 it is possible to use tractor-drawn drills to place seed on disturbed sites. Drilling should be done on the contour. In many cases it is useful to use a site preparation technique prior to drilling. These include ripping (chiseling), disking, and harrowing. A number of different drills are available, and it is necessary to follow the manufacture's procedures when determining seeding rates. The rangeland drill or specific modifications of it are often the most effective machines for reclamation drill seeding if the soil is rocky or contains other large debris (Hansen *et al* 1991).

Broadcast Seeding. Broadcast seeding is generally required on slopes steeper than 4-to-1, on extremely rocky sites, or on remote or inaccessible sites, where seed is small in size, and in areas where the appearance of drill rows is undesirable. Broadcasting still requires soil preparation in order to provide a good seed bed. This can often be done by raking, chaining, harrowing or cultipacking (Brillion seeder) (www.brillionfarmeq.com.). Broadcasting normally requires higher seeding rates and results in less efficient use of the seed. It is difficult to calibrate seeding rates precisely. Safe seed sites must be provided and seeds must be covered for protection prior to germination.

The fall seeding windows for Nevada conditions are Oct. 1 – Jan. 1 for southern Nevada and Aug. 15 – to Nov. 15 for the northern part of the State. Fall seeding is usually best for southern Nevada conditions. Spring seeding, primarily done in northern Nevada, is recommended from March 1 - May 15. Spring seeding results are often poor because seeding is not done until after the soil moisture buildup has been lost. In many cases fall seeding is superior in northern Nevada. Many of the species prescribed for northern Nevada may pregerminate in the fall and lie dormant during most of the winter. This is followed by rapid growth when temperatures warm up and soil moisture is readily available in the spring.

Ecosystem Categories for Revegetation Specifications Along Nevada Highways

These categories have been selected because they are a compromise between a purely ecological classification and consideration of the important kinds of vegetation and soils that must be evaluated separately relative to the potential and procedures for successful re-vegetation. The categories are somewhat biased toward valley bottom vegetation since most of the highways are found crossing or continuing along the valleys.

1. Mojave Desert

    a) Creosote Bush (*Larrea tridentata*)/Bursage (*Ambrosia dumosa*).
    b) Black Brush (*Coleogyne ramossissima*). Each of these may have overstories of Joshua Trees (*Yucca brevifolia*).
    c) Desert Riparian/Mesquite (*Prosopsis juliflora*) Bottoms.

2. Salt Marsh Zone/Wetland. These areas are found along the edges of playas throughout the state and some highways traverse the playas directly. Many are wet much of the year and usually high in salt.

3. Salt Desert Shrub

    a) Black Greasewood Sites (*Sarcobatus vermiculatus*). This type is also found along the playa edges.
    b) Shadscale (*Atriplex confertifolia*)
    c) Bailey's Greasewood (*Sarcobatus baileyi*)/Indian Ricegrass (*Acnatherum hymenoides*). These latter two types have been combined in the specification write-up since their environments and species composition are similar.

4. Sagebrush Sites
    a) Lowest Elevation Sites with big sagebrush either Wyoming Big Sagebrush (*Artemisia tridentata wyomingensis*) or Basin Big Sagebrush (*Artemisia tridentata tridentate*).
    b) Mountain Big Sagebrush (*Artemisia tridentata vaseyana*)

5. Pinyon/Juniper Woodland. – These sites are dominated primarily by the single needle pinyon (*Pinus monophylla*) and the Utah Juniper (*Juniperus osteosperma*).

6. Mountain Brush. - Sites found along highways as they cross some of the mountain ranges in the state. Some important dominant species include Curleaf Mountain Mahogany (*Cercocarpus ledifolius*), Service Berry (*Amelanchier pallida*), Choke Cherry (*Prunus melanocarpa*), Snowberry (*Symphoricarpos orbiculatus*) and associated sagebrush taxa and a number of grasses and forbs. Also in the eastern Sierra the chaparral vegetation consists of several species

primarily Buckbrush (*Ceanothus velutinus*), Squaw carpet (*Ceanothus prostratus*), greenleaf manzanita (*Arctostaphylos patula*) and white thorn.

7. Forested Areas. – This would include yellow pine (Pinus jeffreyi) and lodgepole pine (Pinus contorta murrayana) in route to Lake Tahoe (Highway 431, Highway 28, Kingsbury Grade and portions of Highway 50; also the upper portions of the highway up to Mt.Charleston, the Kyle Canyon and Lee Canyon highways; the lower reaches would be Mojave desert).

8. Mountain Stream Crossings with Gallery Forests. - This is primarily poplar (mostly Black Cottonwood (*Populous fremontii*) with some willows (*Salix* sp.) and other streamside woody and herbaceous vegetation.

Reclamation Plans

For disturbed sites, or more particularly for sites that are to be disturbed as part of any construction project, it is useful to prepare a reclamation plan. The ecosystem specifications described below are examples of information that should go into a reclamation plan. Planning is often done during the preparation of an environmental assessment. A plan is designed to provide the initial guidance in identifying responsibilities, scheduling, and describing major needs for developing a specific project. Site-specific reclamation procedures must be defined and described as part of the plan. The components of such a plan include such things as site analysis, species selection, soil/site preparation and revegetation procedures. As described for the various Nevada ecosystems, these procedures are essentially described but will require review and revision for each site-specific area.

Ecosystem Specifications

MOJAVE DESERT – CREOSOTE BUSH/BURSAGE SITES

Site Analysis

These are desert sites with plants adapted to very hot dry conditions. The soils are variable but are often quite rocky and gravelly. Many of the soils are underlain by a silica or calcium carbonate hardpan that restricts rooting depth. The plants are sparse. Perennial grasses are few and annuals and woody plants are common. Precipitation

averages 3 inches or less over much of the range. The elevations are generally low, below 2500 feet.

Shrubs	lbs.seed/acre
1. Creosote bush – *Larrea tridentata*	2.0
2. Bur sage – *Ambrosia dumosa*	2.0
3. Cattle spinach – *Atriplex polycarpa*	2.0
4. Purple sage – *Salvia dorii*	1.0
5. Blader cenna – *Cassia armata*	0.5
6. Brittle bush – *Encelia farinosa*	1.0
7. Fremont dalea – *Psorothamnus fremontii*	0.5
8. Wolfberry – *Lycium andersonii*	0.5
9. Whitethorn acacia – *Acacia constricta*	0.5
10. Utah century plant – *Agave utahensis*	0.25
Grasses	
1. Big galleta – *Hilaria rigida*	1.0
2. Desert needlegrass – *Achnatherum speciosum*	1.0
3. Red brome – *Bromus rubens*	0.25
4. Six-weeks gramma – *Bouteloa barbata*	0.5
5. Ring muhly – *Muhlenbergia torreyi*	0.5
Forbs	
1. Desert marigold – *Baileya multiradiata*	1.0
2. California poppy – *Eschscholtzia californica*	1.0
3. Desert globe mallow – *Sphaeralcea ambigua*	1.0
4. Desert sunflower – *Viquiera deltoidea*	0.5
5. Desert lupin – *Lupinus sparciflorus*	0.5
	Total 17.5 lbs/acre

Site and Soil Preparation

Anything that adds organic matter to these harsh revegetation sites would be beneficial. In most cases fertilizer treatments would not be useful. Supplemental irrigation for establishment would be the most useful and would likely require the hauling of water. The presence of a hardpan and salts near the surface might require an amendment to control or ameliorate pH. This could be in the form of horticultural grade sulfur or calcium carbonate, which is usually less, water-soluble. The amount would have to be carefully regulated to avoid incurring any undue toxicity. On some sites deep ripping might help to loosen up a hardpan and improve seeding success.

Revegetation Procedures

In some cases we would recommend the placement of topsoil on disturbed sites in the Latr/Amdu vegetation. The soil should be roughened to provide safe seed sites. The seed can be broadcast or applied as a water-based slurry using a hydro-seeding method. Mature plant transplants may be appropriate in some cases. On most Mojave sites, some type of a mulch should be used. A number of mulch materials can be used and because of the high frequency of winds it would be necessary to tackify the mulch to the soil surface using one of several procedures.

MOJAVE DESERT - BLACKBRUSH SITES (*Coleogyne ramossissima*)

Site Analysis

Blackbrush is found at some of the higher elevations in the Mojave Desert, usually above 3000 feet. The dominant plant is black-brush, but an understory of Desert Needle grass (*Achnatherum speciosa*) may also be present. Other plants associated with this species are the Joshua tree (*Yucca brevifolia*) and Spanish bayonet (*Yucca baccata*). Soils are often gravelly, and slopes vary from nearly 0 degrees to 30 degrees. As part of the Mojave Desert these sites are mostly dry, and rainfall is usually no more than 4 or 5 inches. Little effort has gone into revegetation efforts on blackbrush sites.

Species Selection

Shrubs	lbs. seed/acre
1. Blackbrush – *Coleogyne ramosissima*	1.5
2. Brittlebush – *Encelia pharinosa*	1.5
3. Purple sage – *Salvia dorrii*	1.5
4. Three leaf sumac – *Rhus trilobata*	1.0
5. Cliffrose – *Cowania mexicana*	1.5
6. Apache's plume – *Fallugia paradoxa*	1.0
7. Wolfberry – *Lycium andersonii*	1.0
8. Squaw apple – *Peraphyllum ramosissimum*	1.0l
Grasses	
1. Desert needle grass – *Achnatherum speciosum*	1.5

2. Desert ricegrass – *Achnatherum hymenoides* 1.5
3. Galleta grass – *Hilaria jamesii* 1.0
4. Sand dropseed – *Sporobolus cryptandus* 1.0

Forbs

1. California poppy – *Eschscholtzia californica* 1.0
2. Desert globe mallow – *Spharalcea ambigua* 0.5
3. Palmer's penstemon – *Penstemon palmeri* 0.5
4. Sand verbena – *Abronia villosa* 0.5
5. Arizona lupine – *Lupinus arizonica* 0.5
6. Prickly poppy – *Argemone munita* 0.5
7. Beeplant (rocky mountain) – *Clemone serrulate* 1.0
8. Mohave aster – *Aster mohavensis* 0.5

Total 20.5 lbs./acre

Site Preparation

Slopes most likely would not require contouring unless there is a steep cut. These droughty sites may require supplemental irrigation for establishment via three sprinkler irrigations. Irrigation most likely would need to be applied after initial seeding for one season. Fertilizers such as an NPK fertilizer (16-16-16), would help for seeding success. Approximately 200 pounds/acre should be applied.

Revegetation specifications

Container-grown species will be difficult to obtain. Shrub seed should be drilled in with a small drill on flat to moderate slopes. The soil should be roughened before and after to create favorable seed sites for grass and forb seeds. Mulches, such as a straw mulch, would help with initial establishment and reduce dust hazards. Mulches should be tackified with light colored netting. Hydromulching may be an option, depending upon costs and the area is susceptible to high dust hazard.

MOJAVE DESERT – DESERT RIPARIAN SITES

Site Analysis

These sites are found at the lowest elevation in the hot desert, which in Nevada translates to Mojave Desert. Soils may vary and can be quite saline with a high pH

and salt accumulation at the surface. The surface soil horizons are mostly silty, but the lower horizons can have poor physical properties with clays and poor drainage. There may be stagnant water or no water in these drainages during parts of the year. A few have year-round streams, e.g. the Muddy River as it goes under Interstate 15.

Species Selection

Shrubs	lbs. seed/acre
1. Goodding willow – *Salix goodingii*	1.0
2. Cat claw acacia – *Acacia gregi*	1.0
3. Four wing saltbush – *Atriplex canescens*	1.0
4. Cheese bush – *Hymeoclea salsola*	1.0
5. White bursage – *Ambrosia dumosa*	1.0
6. Desert saltbush – *Atriplex polycarpa*	1.5
7. Desert broom – *Baccharis sarothroides*	1.5
8. Wash willow – *Chilopsis linearis*	1.0
Grasses	
1. Sand dropseed – *Sporobolus cryptandrus*	1.0
2. Giant Bermuda grasses – *Cynodon dactylon*	1.0
3. Tall fescue – *Festuca arundinacea*	1.0
4. Alkali sacaton – *Sporobolus airoides*	1.0
Forbs	
1. Desert marigold – *Baileyi multiradiata*	1.0
2. California poppy – *Eschscholtzia californica*	1.0
3. Globe mallow – *Spheralcea coccine*)	1.0
4. Sand verbena – *Abronia villosa*	1.0
	Total 17.0 lbs/acre

Soil and Site Preparation

These bottomland sites have a variety of soils as mentioned above. Some washes may be very rocky and thus preclude much in the way of site preparation. Some of the deeper soils may be silty at the surface and prone to wind erosion. A soil stabilizer, such as hydromulch or a matting material, can be applied to reduce a potential dust problem. The soils also may be low in organic matter and may require some fertilization. These sites likely would be able to utilize a nitrogen application (possibly 1 pound of N/1,000 square feet). Prior to seeding contouring may be required if slopes are steeper than 40 percent. If a high pH soil is found, then it will be necessary to add 400 pounds of horticultural grade sulfur.

Revegetation Procedures

Shallow slopes may lend themselves to the use of a drill. Steeper slopes should be seeded by broadcasting and mulching. Soils must be roughened in order to provide safe seed sites. This can be done using a disk if machinery can be used. On smaller areas hand-raking will suffice. Shrubs and even ramets of grasses may do best if container-grown and then planted on the contour of the site. Both container-grown and broadcast areas must be mulched and then tackified.

SALT MARSH ZONE SITES

Site Analysis

These sites are found near the edges of playas throughout Nevada with a number of highways crossing them. The osmotic potential is very high and most species, except those native to the area, are difficult to establish and maintain. The terrain is generally flat because of the location. In addition to being very saline, soils often have a high clay content constituting a restrictive layer relative to root growth. The soil structure in the clay horizon is usually columnar and prismatic with a high sodium content. Water often ponds on these sites in the spring. During much of the year, however, they can be very droughty. These sites may also be in close proximity to wetlands associated with the playas, although the wetlands constitute a different set of requirements.

Species Selection

The number of native species adapted to these sites is somewhat limited. Only a few species are highly adapted to these sites because of the requirement for high salt tolerance.

Shrubs	lbs.seed/acre
1. Rubber rabbitbrush – *Chrysothamnus naseosus*	2.0
2. Russian olive – *Eleagnus angustifolia*	1.0
3. Silver buffalo berry – *Shepherdia argentea*	2.0

4. Fourwing saltbush – *Atriplex canescens*	2.0
5. Pickle weed – *Allenrolfia* sp.	1.0
6. Soap weed – *Sueada torreayana*	1.0
Grasses	
1. Salt grass – *Disticlis spicata*	1.5
2. Alkali sacaton – *Sporobolus airoides*	2.5
3. Common reed – *Arundo donax*	1.0
Forbs	
1. Almu aster – *Aster pauciflorus*	1.5
2. Globe mallow – *Sphaeralcea ambigua*	1.5
3. Alkali mallow – *Sida hederacea*	1.0
	Total 18.0 lbs./acre

Soil/Site Preparation

The high salinity may require the use of soil amendments. High-sodium soils may require the addition of gypsum during establishment of these highly salt-tolerant species. On difficult sites as much as 4,000 pounds per acre might be applied. On some sites it may be important to apply a tackifier to reduce wind erosion. There are a number of products available and the prices vary considerably.

Revegetation Procedures

These sites are generally quite flat and would allow a drill to be used. For some species container-grown material might be recommended. Spring seeding would be recommended, but might present an access problem because ponding of these clay soils. Late fall seeding might be used if a mulch is tackified onto the soil to protect the seed during the winter. The least expensive method would be using certified-clean straw. The potential for weed infestations is always a possibility.

SALT DESERT SHRUB – Shadscale and Bailey's Greasewood Sites

Site Analysis

These sites are adjacent to many miles of highways in northern and central Nevada. This vegetation primarily follows the valley bottoms and usually accompanies many miles of relatively straight highways. The soils vary but can be neutral to somewhat strongly saline. They are generally saline to strongly saline over much of this vegetation type. Many of the soils are fairly sodic. The surface soils are often restrictive to good water penetration. Some of the soils are quite sandy, especially on sites supporting Bailey's greasewood. Many of the soils may have restrictive layers in the form of silica or calcium carbonate duripans.

The floristics of this vegetation is quite simple. Only a few shrubby species are found associated with the shadscale and Bailey's greasewood. Some other common shrubs that might be present include green rabbitbrush, bud sage, whitesage (in some valleys), and spiny hopsage. Forbs are particularly wanting. They often consist of weeds such as mustards and halogeton, and annual grasses, such as cheatgrass. One important native forb is globe mallow. Perennial grasses include saltgrass, indian ricegrass and squirreltail.

Species Selection

Shrubs	lbs. seed/acre
1. Shadscale – *Atriplex confertifolia*	2.0
2. Fourwing saltbush – *Atriplex canescens*	2.0
3. Spiny hopsage – *Grayia spinosa*	1.0
4. Gardner saltbush – *Atriplex gardneri*	0.5
5. Prostrate summer cypress – *Kochia prostrat*a	2.0
Grasses	
1. Saltgrass – *Distichillis spicatum*	2.0
2. Squirreltail – *Elymus elymoides*	0.5
3. Creeping wildrye – *Elymus tricoides*	1.0
4. Galleta grass – *Hilaria jamesii*	0.5

5.	Indian ricegrass – *achnatherum hymenoides*	2.0
6.	Siberian wheatgrass – *Agropyron sibericum*	1.0
7.	Alkali sacaton – *Sporobolus airoides*	1.0

Forbs

1.	Globe mallow – *Spheralcea coccine*	1.0
2.	Yellow sweet clover – *Melilotis officinalis*	2.0
3.	Evening primrose* – *Oenothera* spp.	0.5
		Total 20.0 lbs./acre

In developing appropriate seed mixes, the cost of some of the less common seed may be prohibitive. This must, of course, be taken into consideration as the seed mixture is formulated and the total costs for the seed mixture is determined. In our mixtures we have, in some cases, used lower seeding rates because some of these less available seeds would be much more costly. However, their potential importance on these landscapes suggests that they be included in the mixtures.

Site/Soil Preparation

Because these sites are often very droughty, we would recommend the use of some kind of mulch. For establishment supplemental irrigation would be very helpful, but water often is not available. In some cases, where you wish to obtain new vegetation with a high success rate, it might then be feasible to provide water for one or more supplemental irrigations by hauling water to the site. Often when seeding in shadscale/Bailey's greasewood sites, the remediation specialist must be prepared to seed the entire area perhaps two years in a row particularly if no supplemental irrigation is used.

These sites often would be relatively low in many nutrients, particularly nitrogen, and would require a fertilizer of some sort, possibly applied with the supplemental irrigation. Since the seed sources might be devoid of mychorrizal fungi then an inoculum can be prescribed.

Revegetation Procedures

These sites may vary from rocky to loamy soils. If the site has few rocks, it might lend itself to seeding with a drill. Also, unless the berms are quite steep the terrain in this type of vegetation is generally flat and could be drilled with a rangeland drill or some other drill used for tough seeding.

SALT DESERT SHRUB - BLACK GREASEWOOD SITES

Site Analysis

These sites are found in valley bottoms and usually have alkaline and saline soils with heavy clay horizons. Sometimes they are impounded with water. The total number of species is generally low, and for many months the sites are very droughty. The dominant species is black greasewood (*Sarcobatus vermiculatus*) with only a few other species. Occasionally you will find mustard weeds (*Descurania* sp.), salt grass (*Distichlis spicata*), squirreltail grass (*Elymus elymoides*), and globe mallow. These soils hold onto soil moisture tenaciously because of the heavy clay horizons. The salinity or alkalinity may impact the kinds of species that can be seeded there.

Species Selection

Even though there are few native adapted species, attempts will be made to select common species found on such sites or species that have similar characteristics and requirements. Woody species (shrubs), grasses and forbs will be included in the specified mixtures. The species listed below are recommended for mixtures to be used on these sites.

Shrubs	lbs.seed/acre
1. Quail bush – *Atriplex lentiformi*	1.0
2. Rubber rabbitbrush – *Chrysothamnus naseousus*	2.0
3. Greasewood – *Sarcobatus vermiculatus*	2.0
4. Kochia – *Kochia prostrata*	2.0
5. Fourwing saltbush – *Atriplex canescens*	2.0

Grasses	
1. Alkali sacaton – *Sporobolus airoides*	1.0
2. Tall wheatgrass – *Agropyron elongatum*	2.0
3. Great Basin wildrye – *Leymus cenereus*	2.0
4. Salt grass – *Distichlis spicata*	1.0
5. Squirreltail – *Elymus elymoides*	0.5

Forbs

1. Desert globe mallow – *Spaeralcea ambigua*	1.0
2. Yellow sweet clover – *Melilotus officinalis*	1.0
3. White evening primrose – *Oenothera pallida*	1.0
	Total 18.5 lbs./acre

Site and Soil Preparation

Importing topsoil may be necessary for initial establishment of these species. Screened soil from nearby material pits or the soil used for the road platform, 1/8 inch or less, would be suitable for topsoil. It is also suggested to apply 250 pounds/acre of horticulture sulfur to reduce the soil pH, making the site more conducive to establishment of the seed mixture. It might be possible to break up these heavy clays with a large chisel or other implement behind a tractor. It might be feasible to provide supplemental irrigation by sprinkling to assist in establishment. This, however, would be somewhat costly unless a water source was near by. It might be possible to bring water in by tanker-truck on a one-time basis. Also a nitrogen fertilizer, such as ammonium sulfate can be applied.

Revegetation Procedures

These areas tend to be relatively flat, and thus a drill might be used to place the mixture into the soil. However, the roadside berms might be too steep for this. In addition to the mixture of seeds, it might be very helpful to acquire some container-grown material of four wing saltbush and rubber rabbitbrush. Container-grown plants would require hand labor to place them in the relatively small areas to be revegetated. In order to reduce competition among the seeded species, it would be appropriate to place the container-grown plants apart from the seeded areas. In some cases different mixtures might be used to develop a pattern with grasses and forbs apart from areas seeded heavily with shrubs.

SAGEBRUSH SITES – LOWEST ELEVATION SITES WITH BIG SAGEBRUSH
Wyoming big sagebrush (Artemisia *tridentata var. wyomingensis),* basin big sagebrush (*Artemisia tridentata tridentate)* and black sagebrush *(Artemisia nova.*

Site Analysis

The site is dominated by big sagebrush with a number of perennial grasses. Big sagebrush soils are often deep and relatively dark although they usually have little organic matter. The precipitation at the site is approximately 12 inches annually in the form of snow in winter and early spring. The goal of revegetation on disturbed sites will be to compete with noxious weeds, control erosion, and be fire resistance and aesthetically pleasing. In addition, it should not unduly attract wildlife We have listed a preliminary set of procedures or specifications that could be used on such a site.

Species Selection

Shrubs	lbs.seed/acre
1. Big sagebrush – *Artemisia tridentata*	1.0
2. Antelope bitterbrush – *Purshia tridentata*	1.0
3. Desert peach – *Prunus andersonii*	1.0
4. Green ephedra – *Ephedra viridis*	1.0
5. Green rabbitbrush – *Chrysothamnus viscidiflorus*	1.0
6. Four-wing saltbush – *Atriplex canescens*	1.0
7. Skunkbush sumac – *Rhus trilobata*	1.0
8. Winterfat – *Krascheninnikovia lanata*	1.0
Grasses	
1. Blue bunch wheat grass – *Pseudoroegneria spicata*	1.0
2. Basin wildrye – *Leymus cinereus*	1.0
3. Sandberg bluegrass – *Poa secunda*	0.5
4. Big bluegrass – *Poa ampla*	1.0
5. Indian ricegrass – *Achnatherum hymenoides*	1.0
6. Desert needlegrass – *Achnatherum speciosum*	1.0
7. Creeping wildrye – *Leymus triticoides*	1.0
8. Great Basin wildrye – *Leymus cinereus*	1.0

Forbs

1. Yellow sweet clover – *Melilotus officinalis*	0.5
2. Small burnet – *Sanguisorba minor*	0.5
3. Prairie flax – *Linum lewisii*	0.5
4. Palmer's penstemon – *Penstemon palmeri*	0.5
5. Evening primrose – *Oenothera tanecetifolia*	0.5
6. Scarlet gilia – *Ipomopsis aggregat*	0.5
7. Goldenrod – *Solidago spectabilis*	0.5
8. Globe mallow – *Sphaeralcea coccinea*	0.5
9. Firemaker penstemon – *Penstemon eatonii*	0.5
10. Lupine – *Lupinus spp.*	0.5
11. Vetch – *Vicia sp.*	0.5
12. Alfalfa – *Medicago sativa*	0.5
	Total 21.5 lbs. seed/acre

Site/Soil Preparation

Site preparation may require contour development and/or terracing on steep slopes. The appropriate amounts of soil amendments such as fertilizer and mycorrhizal inoculums may be added to the soil. The combination of fertilizer with a drip irrigation system could be used to assure plant establishment. Additional soil preparation such as disking may be required.

Revegetation Procedures

On steeper sites, the slopes should be shaped to no steeper than 3-to-1. Possibly replace topsoil. The container-grown shrubs should be placed on terraced slopes. Drill at 0.57 pounds/1000 square feet. Broadcast a mixture of forb/grass/shrub seed. Placement and arrangement of seed and container-grown shrubs should be decided with the landscape architect. Apply a portable, one-acre to two-acre drip system to assure establishment of container-grown shrubs. Determine the appropriate number of emitters to irrigate a specific density of shrubs. If the site dictates, possibly add an appropriate fertilizer and mycorrhizal inoculums. A mulch applied to support seeding success should be stabilized with netting or tackifier. Mulch with 68.9 pounds/1000 square feet of straw material that is tacked to the ground with jute netting.

UPPER ELEVATION BIG SAGEBRUSH SITES (Primarily *Artemisia tridentata* var. *vaseyana*) and Low sagebrush (*Artemisia arbuscula* and *A. longiloba*)

Site Analysis

These sites have higher rainfall and often deeper soils, higher in organic matter. However, the growing season is often short. The soils will be variable. Precipitation amounts can vary from 10 inches to 20 inches, and the winters can be cold and long. Snow cover is variable but can be deep during some winters. As a general rule-of-thumb the transition between the low-elevation sagebrush sites and the mountain big sagebrush sites is at about 5800 feet. The vegetation is dominated with mountain big sagebrush (*Artemisia tridentata vaseyana*) except as one crosses over the ridges or passes. Here if a sagebrush taxa is dominant, it usually will be a low sagebrush such as *Artemisia arbuscula* and will have very shallow soils with heavy clay subsoil at about 8 inches to 10 inches. The big sagebrush sites will have a wider variety of perennial grasses and annual and perennial forbs than found in the lower elevation sagebrush sites.

Species Selection

An ideal mix of species should include a combination of a couple species of grass, shrubs, and forbs. It should be emphasized that all of these species do not need to be included in the species selection for vegetation remediation. The number of seeds per pound should be considered in the density of application since, their numbers vary widely. For instance, tall fescue has approximately 225,000 seeds per pounds, while bentgrass has a density of 6 million seeds per pound.

Grasses

	lbs. seed/acre
1. Bluebunch wheatgrass or beardless bluebunch wheatgrass – *Agropyron spicatum*	1.0
2. Idaho fescue – *Festuca idahoensis*	1.0
3. Big/Sherman bluegrass – *Poa ampla*	0.5
4. Smooth or mountain brome – *Bromus inermis/ Bromus marginatus*	1.0
5. Pubescen wheatgrass – *Agropyron trichophorum*	1.0
6. Creeping or Russian wildrye – *Leymus triticoides/ Leymus junceus*	1.0
7. Thurber's Needlegrass – *Achnathermum thurberianum*	1.0

Forbs

1.	Palmer's penstemon/Firecracher penstemon – *Penstemon palmerii/Penstemon eatonii*	2.0
2.	Woolypod vetch – *Vicia dasycarpa*	0.5
3.	Indian paintbrush – *Castilleya spp.*	0.5
4.	Lupine -*Lupinus spp.*	1.0
5.	Blue flax -*Linium lewisii*	1.0
6.	Prickly poppy -*Argemone munita*	0.5
7.	Sunflower -*Helianthus annuus*	0.5

Shrubs

1.	Mormon tea, (green) – *Ephedra viridis*	1.0
2.	Douglas rabbit brush – *Chrysothamnus viscidiflorus*	1.0
3.	Mountain big sagebrush – *Artemisia tridentate*	1.0
4.	Bitterbrush – *Purshia tridentate*	1.0
5.	Purple sage – *Salvia dorii*	1.0
	Total	17.5 lbs./acre

Site and Soil Preparation

These sites may lend themselves well to the storage and replacement of topsoil. These soils, when not too rocky, can lend themselves to machine drilling, possibly proceeded by disking, to create a more favorable seedbed for initial establishment. Normally, they would not require fertilization, but this should be determined by soil tests taken at the site. The addition of organic matter would be beneficial for plant establishment. Often it may be necessary to assure establishment with the addition of nitrogen fertilizers, as determined by the soil samples.

Revegetation Procedures

Where feasible, the best procedure would be disking and drilling. In some cases, container-grown species spaced approximately 3-feet apart may be used in conjunction with drilling. Different shrub container species should be alternated at 3-foot spacing for purposes of landscape and aesthetic variety. Planting should occur in either the spring or fall. Planting from containers in the summer would require supplemental irrigation for the first season. Forbs and grasses should be drilled at a density of 20 pounds/acre. Mulches are important on these sites to assure establishment of drilled seed. Straw and other light-colored mulches will reduce the soil temperature during the summer months. An application rate of 2000-3000 pounds/acre of mulch is recommended to reduce erosion and cover seed (R-4 reclamation guide, p. 25). Mulches can be applied by hand on 3-to-1 or greater slopes. Steeper slopes will require a mechanical application of mulch.

PINYON/JUNIPER WOODLAND SITES

Site Analysis

Identify the naturally occurring vegetation as a possible means for assisting with species selection. Examine the vegetation maps and the soil polygons to further determine the natural vegetation. Examine the soils data to determine the natural physical and chemical conditions. This will lead to an analysis of the potential need for certain soil amendments, supplemental irrigation, and mulching to assure success. Examine the physical characteristics of the site such as precipitation, temperature, slope, aspect, and elevation. In some cases it may be necessary to examine the chemical and physical characteristics of the material to be revegetated.

Species Selection

Species selection for pinyon/juniper woodland sites will include species commonly found in the woodland. We will include primarily native species and a mixture of shrubs, grasses, and forbs. Among the forbs, we will include at least one leguminous species for possible nitrogen fixation. The species listed below are recommended for the mixture.

Shrubs	lbs. seeds/acre
1. Black sagebrush – *Artemisia nova*	1.0
2. Mountain big sagebush – *Artemisia tridentata* ***varvaseyan****a*	2.0
3. Green rabbitbrush - *Chrysothamnus nauseosa*	2.0
4. Mormon tea - *Ephedra viridis*	1.0
5. Summercypress - *Kochia prostata*	2.0
6. Skunkbush sumac – *Rhus trilobata*	1.0

Grasses	
1. Bluebunch wheatgrass – *Pseudoroegneria spicata*	1.0
2. Sandberg's bluegrass – *Poa sandbergii*	0.5
3. Smooth brome – *Bromus inermis*	1.0
4. Crested wheatgrass – *Agropyron cristatum*	2.0
5. Siberian wheatgrass – *Agropyron fragile*	2.0
6. Giant wild rye – Leymus glaucus	1.0

Forbs

1.	Palmer's penstemon – *Penstemon palmeri*	1.0
2.	Prarie flax – *Linium lewisii*	1.0
3.	Small burnet – *Sanguisorba minor*	1.0
4.	Lupine – *Lupinus spp.*	1.0
5.	Indian paintbrush – *Castilleya spp.*	1.0
6.	Sticky purple geranium – *Geranium viscosissimum*	1.0
	Total	21.5 lbs./acre

Site and Soil Preparation

For most pinyon/juniper sites we would not recommend supplemental irrigation. However, we would recommend that a fertilizer be applied. If the topsoil has been removed, the site analysis would likely lead to the appropriate recommendation for a fertilizer. Since many of these soils have sufficient phosphorous and potassium, we would recommend a formulation of 16-20-0 ammonium phosphate applied at 40 pound/acre. If the material is a homogenous mixture of various materials, a higher nitrogen fertilizer might be recommended. Also in this case a mycorrhizal inoculum would be recommended. Slopes over 3-to-1 would require terracing to help retain soil moisture and provide safe sites for seed. In some cases this would require hand labor.

Revegetation Procedures

For small areas, less than an acre, it would be feasible to hand-seed using a cyclone spreader. This would be followed by the application of mulch. We would recommend the spreading of straw by hand on the terraces and tacking the straw by spreading soil by hand or placing a jute netting over the mulched areas. In some cases we would recommend that a number of container-grown specimens be planted on the site to improve establishment and provide instantaneous landscaping and aesthetics. The container-grown material can be planted in concert with other species of shrubs and the suggested grasses and forbs. To reduce competition between the woody and herbaceous species, we would recommend planting shrubs separate from areas where grasses and forbs are seeded.

MOUNTAIN BRUSH SITES

Site Analysis

These sites are at higher elevations, mostly above 6,000 feet, as the highways cross mountain passes. The typical mountain brush vegetation supports some of the following dominant species: bitterbrush, mountain mahogany, snowberry, serviceberry, mountain big sagebrush, currant, gooseberry, elderberry and chokecherry. Soils are often higher in organic matter and may or may not be rocky. The soil chemistry normally would be neutral to slightly acid but not alkaline. Litter accumulation could be high. Often the road cuts are deep and steep. There may be a cut on one side and a fill on the other side. The cuts and fills can remove topsoil and/or cover it up. The organic matter would often be higher than most of the desert sites and similar to forested areas. The higher organic matter generally provides a greater abundance of nutrients.

Species Selection

Availability and costs will dictate what seed combination to use. We recommend 19 pounds/acre to 20 pounds/acre of a combination of seed from the species list below. Not all of these species should be used, but a combination of these is suggested.

Shrubs	lbs. seeds /acre
1. Serviceberry – *Amelanchier alnifolia*	1.0
2. Mountain big sagebrush – *Artemisia tridentata*	0.5
3. Chokecherry – *Prunus virginiana*	1.0
4. Cliffrose – *Cowania stransburiana*(southern passes)	1.0
5. Gambel's oak – *Quercus gambellii* (Eastern & S.eastern NV)	2.0
6. Common snowberry – *Symphoricarpus albus*	1.0
7. Three leaf sumac – *Rhus trilobata*	1.0
8. Rubber rabbitbrush – *Chrysothamnus nauseosus*	0.5

Grasses

1.	Bluebunch wheatgrass – *Pseudoroegneria spicata*	1.0
2.	Big bluegrass – *Poa ampla*	1.5
3.	Smooth brome – *Bromus inermis*	1.0
4.	Mountain brome – *Bromus marginatus*	1.5
5.	Idaho fescue – *Poa festuca*	0.5
6.	Perennial rye grass – *Lolium perennee*	1.0
7.	Tall wheatgrass – *Agropyron longatum*	1.0
8.	Great Basin wildrye – *Leymus cinereus*	1.0

Forbs

1.	Palmer's penstemon – *Penstemon palmeri*	1.0
2.	Scarlet gilia – *Ipomopsis aggregata*	1.0
3.	Indian paint brush – *Castilleya* spp.	1.0
4.	Lupine – *Lupinus* spp.	1.0
5.	Wild geranium -*Geranium viscosissimum*	1.0
		Total 21.5bs.seed/acre

Site and Soil Preparation

If slopes are steeper than 3-to-1, we recommend some terracing – either by hand or with a backhoe. Supplemental irrigation may not be necessary for these sites due to higher elevations correlated with more rainfall. Suggested fertilizer would require a formulation of 16-20-0 (16% nitrogen,20% phosphorous, and 0% potassium) applied at 40 pounds/acre. If seeding is done in the early fall or spring, we would not recommend supplemental irrigation. If the material is a homogenous mixture of various soils, possibly a higher nitrogen fertilizer would be recommended. However, this could be determined by site-specific soil tests. Mycorrhizal inoculums would most likely not be needed at these sites due to the high organic matter in these soils.

Revegetation procedures

On many of these sites, we would recommend container-grown shrubs of two or three species placed randomly across the disturbed landscapes to provide plant cover in a reasonable amount of time. Furthermore, container-grown species are conducive to successful establishment as many of these species require some sort of seed stratification for germination and are limited by short growing seasons. Seeding of grasses, forbs, and shrubs (not container-grown) along with mulch and tackifier, should precede the placement of the container-grown shrub species. We recommend the spreading of straw on terraces using a tackifier. Container grown shrub species should be planted in the spring to access more soil moisture.

FORESTED SITES: Forested areas are found primarily in western Nevada, in and around Lake Tahoe, and on a few sites in the spring range in southern Nevada.

Site Analysis

Forest sites and their soils are quite variable. They generally have a neutral to slightly acid reaction and may vary in depth. These sites are usually above 5,500 feet in elevation and are found on every aspect. In the Tahoe area many of the soils are granitic and have poor moisture holding capacity. Often the soils are quite stony, which would preclude revegetation practices involving machinery. Roadside areas can be quite steep requiring contouring or other practices. In the Tahoe Basin winter salting has negatively impacted many of the trees and other vegetation. Some roadside vegetation at higher elevations has been impacted by snow blowing equipment used to clear the highways. The widening, cutting, and filling involved in resurfacing the highways has also had a significant impact on roadside vegetation. The growing seasons are short and snowpack will influence remediation.

Species Selection

Trees and Shrubs. Normally we would not recommend trees close to the highway because of the problems mentioned above and safety concerns they pose by reducing visibility under some circumstances. Therefore our species lists include primarily native shrubs, grasses and forbs.

Shrubs	lbs. seed/acre
1. Snowbush – *Ceanothus velutinus*	1.0
2. Huckleberry oak – *Quercus vaccinifolia*	1.0
3. Serviceberry – *Amelanchier alnifolia*	1.0
4. Chokecherry – *Prunus melanocarpa*	1.0
5. Whitethorn – *Ceanothus integerrimus*	
6. Mountain mahoghany – *Cercocarpus ledifolius*	1.0
7. Manzanita – *Arctostaphylos patula*	
8. Squaw carpet – *Ceanothus prostrates*	
9. Mountain big sagebrush – *Artemisia tridentata vaseyana**	1.0
10. Bitterbrush – *Purshia tridentata**	

*Sagebrush and bitterbrush might be used at slightly lower, drier sites. Bitterbrush has been shown to be well adapted to very dry sites with low nutrients along road cuts. It should be noted, that many of these species do not establish well from seed, and it may be necessary on many sites to purchase and plant container-grown material.

Cost will readily dictate the quantity of species to be used in roadside revegetation procedures. Generally, we recommend planting one shrub species per square yard to allow shrub species to grow without competing against one another. The landscape architect could also suggest spacing for aesthetics and safety purposes.

Grasses

1.	California brome – *Bromus marginatus*	1.0
2.	Smooth brome – *Bromus inermis*	1.0
3.	Tall fescue – *Festuca arundinacea*	2.0
4.	Western wheatgrass – *Agropyron smithii*	1.0
5.	Pubescent wheatgrass – *Agropyron trichorophum*	2.0
6.	Sherman big bluegrass – *Poa ampla*	2.0

Forbs

1.	Mules ear – *Wyethia mollis*	0.5
2.	Palmers penstemon – *Penstemon palmeri*	0.5
3.	Mountain lupine – *Lupinus alpestris*	0.5
4.	Columbine – *Aquilegia formosa*	0.5
5.	California bluebess – *Phacelia campanularia*	0.5
		Total 17.5 lbs.seed/acre

Several seed companies provide flower seed mixture for different kinds of habitats. For example, Flagstaff Native Plant and Seed (see appendix 2) has a mixture of flowers adapted to Pinus ponderosa sites that includes eight or ten species and is sold by the ounce. Such mixtures may be appropriate for broadcasting and covering with mulch on many of our forested and mountain sites. On these sites container-grown shrubs would be quite appropriate and so the amount of seed versus seedlings would vary. Approximately 10 pounds to 11 pounds/acre is suggested for broadcast seeding of grasses and forbs. This will be supplemented with grasses planted as ramets.

Site/Soil Preparation

Steep slopes will require contouring or furrowing. A mulch would be recommended, and straw would probably be the best mulch. It might be possible to obtain some local materials, such as mulch made from pine needles or pine cones. In addition wood chips and ground-up Christmas trees might be available to use as mulch material. The mulches would have to be tackified with jute netting or some other product. We would not recommend hydroseeding because of mixed reviews of success. A slow release nitrogen fertilizer might be appropriate at about ½ pound/thousand square feet. This might not be appropriate along stream environment zones because of potential lake and stream pollution.

Revegetation Procedures

Container-grown material would have to be hand planted. Container-grown grasses, such as ramets, could be used in conjunction with the broadcasted grass and wildflower seed for initial establishment. A mixture of wildflowers and grasses could be broadcasted in the interspaces between the container-grown shrub species at some spacing determined by the landscape architect. Mulch should be used to initially establish the container-grown species. Mulch may be applied after the broadcast seeding to protect the seed from wildlife and dehydration.

STREAM CROSSING SITES WITH GALLERY FORESTS OF POPLARS WITH WILLOW AND OTHER STREAMSIDE WOODY AND HERBACEOUS VEGETATION

Site Analysis

Unlike uplands areas, natural and human induced stream meander and channel downcutting result in continuous changes for these vegetation types. This vegetation is often associated with hydric soils. Riparian soils are often the result of streams, seeps, and springs and may not be dependent upon local precipitation. Soils tend to be more organic due to the long history of dense vegetation in these areas. These areas are not elevation dependent but rather dependent upon the presence of streams or riparian areas. Examples include the Humboldt, Truckee, Carson, Walker, Salmon, and the Muddy River drainages. Erosion and periodic flooding are some of the main challenges for the revegetation of these areas. Noxious weeds such as tall white top shown in the lower portion of the photo above often become a problem in these riparian areas.

Species Selection

Trees and Shrubs	lbs. seed/acre
1. Fremont cottonwood – *Populus fremontii*	0.0*
2. Mountain alder – *Alnus tenuifolia*	2.0
3. White alder – *Alnus incana*	2.0
4. Dogwood – *Cornus stolonifera*	1.0
5. Spirea – *Spirea densiflora*	1.0
6. Blue elderberry – *Sambucus coerulea*	1.0
7. Willow – *Salix boothii* (5700’ – 9000’)	0.0

8.	Pacific willow – *Salix lasiandra* (5000'-7800')	0.0
9.	Water willow or Seep willow – *Baccharis glutinosa (Mohave stream areas)*	1.0
10.	Virgin's bower – *Clematis ligusticifolia*	1.0

Grasses

1.	Streambank wheatgrass – *Agropyron riparium*	1.0
2.	Fowl bluegrass – *Poa palustris*	1.0
3.	Nebraska sedge – *Carex nebraskensis*	1.0
4.	Baltic rush – *Juncus Baltic*	1.0
5.	Meadow barley – *Hordeum brachyantherum*	1.0

Forbs

1.	Nettleleaf giant hyssop – *Agastache urticifolia*	1.0
2.	California false hellebore – *Veratrum californicum*	0.5
3.	Small bluebells – *Mertensia longiflora* .	0.5
4.	Sticky purple geranium - *Geranium viscosissimum*	1.0
5.	Columbian monkshood – *Aconitum columbianum*	1.0
6.	Mule's ear – *Wyethia mollis*	1.0
	Total	19.0 lbs.seed/acre

*Often these species are grown only from cuttings or container-grown plants. Usually seed is not available for poplars and willows.

Site and Soil Preparation

Generally these areas tend to be in moist sites, so adding organic matter to the existing soils may not be required. However, if fill soil is being used, the addition of organic matter is necessary. Irrigation for initial establishment may not be necessary for these soil types due to the prevalence of a high water table. The addition of nutrients will encourage faster establishment of plants. Topsoil should be stockpiled and reapplied after grading of these sites. Special care should be taken to minimize disturbing the existing plants in riparian zones. Soil samples should be taken at the site and compared to the undisturbed adjacent sites before amendments are applied.

Re-vegetation Procedures

In some cases, placement of topsoil on disturbed sites prior to seeding would be beneficial for seed germination. The application of amendments and fertilizers should be based on the results of the soil testing. Many of the shrubby plants, such as willow, for

example can be planted as unrooted cuttings to a depth of 6 inches. This is more practical and cost-effective than using container-grown stock. Seeds should be broadcast at the recommended rate for each species, raked lightly and mulched with a light application of composted bark. Evaluating the success of riparian revegetation efforts may be coordinated with other agencies such as the Bureau of Land Management and the Forest Service, who are actively monitoring these areas. Proper functioning condition (PFC) is one quick and qualitative method to assess stream health and vegetation.

Special attention should be given to areas where roads intersect with streams. Bridges and culverts have traditionally been inadequate at handling 150-year flood events. This results in massive sediment transport downstream, incising channels, and flooding of road surfaces. Planning for large culverts and bridge crossings that will not impede the flow of water during these events is essential in maintaining riparian health and road safety. The structural engineer should consult with a hydrologist on this issue.

SPECIFIC EXAMPLE SPECIFICATIONS

In this section we have taken three specific sites and described specifications that might be followed in order to improve the aesthetics, dust control and other problems on these sites.

Example #1. A sagebrush/grass site in Elko County

REVEGETATION OF A SAGEBRUSH/ GRASS SITE NEAR WELLS, NEVADA

Site Analysis

-The predominate vegetation on this site is big sagebrush and a variety of perennial grasses.

-The soils are fairly high in organic matter and the topsoil can be shallow with heavy clay subsoil.

-The precipitation varies from 10 inches to 20 inches, and much of it comes in the form of snow.

-Revegetation is usually successful, even though the growing season is short. Slopes of more then 3-to-1 are common.

Suggested Reclamation Steps

Step 1: Site Preparation

Shape site to slopes no steeper than 3-to-1.

Additional soil preparation such as disking may be required.

Step 2: Application of Soil amendments

Possibly replace topsoil. Possibly add an appropriate NPK (nitrogen, phosphorous, potassium) fertilizer and mycorrhizal inoculums.

Step 3: Seed Application

Use a drill and seed apply at a rate of 0.57 lbs/1000 sq. ft.

Step 4: Mulching

Apply mulch at a rate of 68.9 lbs/1000 sq. ft of straw material that is tacked to the ground with jute netting.

The Proposed Species Mixture

- Blue bunch wheatgrass – *Pseudoroegneria spicata*
- Basin wildrye – *Leymus cinereus*
- Sandberg bluegrass – *Poa secunda*
- Yellow sweet clover – *Melilotus officinalis*
- Small burnet – *Sanguisorba minor*
- Prairie flax – *Linum lewisii*
- Big sagebrush – *Artemisia tridentata*
- Rubber rabbitbrush – *Chrysothamnus nauseosus*

Example #2 **Robb Drive Interchange**

REVEGETATION PROTOCOL FOR ROBB DRIVE INTERCHANGE ON INTERSTATE 80

Site Analysis

-There are very steep slopes.

-The soils have several layers of chalk or diatomaceous earth.

-Portions of topsoil have been removed.

-Deficient soil development will require tests for additions of mycorrhizal inoculums and fertilizers.

-The site is subject to frequent, high winds.

-It is a relatively droughty site.

-The site has considerable weedy volunteer vegetation.

-There is considerable litter along fences.

-There is a narrow steep soil/earth divider between the on and off ramps.

-The cost of placing aesthetic vegetation on this site is likely to be expensive.

Suggested Reclamation Steps

Step 1: Site Preparation

Contour development and/or terracing on steep slopes.

Step 2: Application of Soil Amendments

Determine and apply appropriate amounts of fertilizer and mycorrhizal inoculums.

Combine fertilizers with drip irrigation systems to ensure plant establishment.

Step 3: Supplemental Irrigation

Apply a portable, 1-to-2 acre drip system to ensure development of container-grown shrubs.

Determine the appropriate number of emitters needed to irrigate a specific density of shrubs.

Step 4: Seeding/Planting of Native Plants

Cold-desert native shrubs will out-compete the existing undesirable weedy vegetation.

Place container-grown shrubs on terraced slopes.

Broadcast a mixture of forb/grass/shrub seed.

Step 5: Mulching

Stabilize mulch applied to support seeding success with netting, soil or another tackifier.

Step 6: Species Selection

Place mixture of native species listed below on the terraces.

Placement and arrangement of seed and container grown shrubs should be decided upon with the landscape architect.

Native Shrub Species

- Antelope bitterbrush – *Purshia tridentata*
- Desert peach – *Prunus andersonii*
- Green ephedra – *Ephedra viridis*
- Green rabbitbrush – *Chrysothamnus viscidiflorus*
- Big sagebrush – *Artemisia tridentata*
- Four-wing saltbush – *Atriplex canescens*
- Skunkbush sumac – *Rhus trilobata*

Native Grass Species

- Big bluegrass – *Poa ampla*
- Sandberg's bluegrass – *Poa secunda*
- Indian ricegrass – *Achnatherum hymenoides*
- Desert needlegrass – *Achnatherum speciosum*
- Creeping wildrye – *Leymus triticoides*
- Great Basin wildrye – *Leymus cinereus*

Native Forb Species

- Palmer's penstemon – Penstemon palmeri
- Evening primrose – *Oenothera tanecetifolia*
- Scarlet gilia – *Ipomopsis aggregata*
- Goldenrod – *Solidago spectabilis*
- Globemallow – *Sphaeralcea coccinea*
- Firemaker penstemon – *Penstemon eatonii*
- Lupine – *Lupinus spp.*
- Vetch – *Vicia spp.*
- Yellow sweet clover – *Melilotus officinalis*
- Alfalfa – *Medicago sativa*

Example #3. Interchange of off Interstate 15 to the Valley of Fire, east of Las Vegas

REVEGETATION PROTOCOL FOR THE VALLEY OF FIRE INTERCHANGE EAST OF LAS VEGAS.

Site Analysis

-This is a Mojave Desert site with extremely low rainfall.

-The soils are rocky and most have a hardpan cemented with calcium carbonate or silica. Much of the topsoil has been removed.

-The soil should be analyzed before planting to determine which supplements should be added to assist in revegetation.

-We would recommend that native desert species be planted on this site, possibly merged with a cobble ground cover in a pleasing pattern.

-This site is wind prone, which presents a potential dust hazard that can be ameliorated with vegetation and rock cover.

-This site receives heavy traffic because it is along a major highway, and more importantly, an exit to one of Nevada's premier recreation destinations.

Suggested Reclamation Steps

Step 1**:** Site Preparation
Rip the surface soil in preparation for planting.

Step 2: Application of Soil Amendments
Determine and apply appropriate fertilizers.

Step 3: Supplemental Irrigation
Install a 1- to-2 acre portable drip system to ensure establishment of container-grown plants. Determine the appropriate number of emitters needed to irrigate a specific number of shrubs on this site. Water could come from several potential sources, for example, a cooperative plan with the casino located at the site, drilling of a well, or hauling water. Irrigation on these sites would not be continuing, but would only be done to ensure establishment.

Step 4: Seeding/Planting of Native Plants
The excellent plant cover in the wash to the north cannot be repeated on the interchange but suggests some of the species that might be selected.

Step 5:Mulching

A mulch should be applied to provide cover for the new seedlings on the site. A tackifier, such as jute netting, or a spray-on mulch should be used to improve the chances for successful revegetation. This will also help reduce the dust hazard.

Step 6: Species Selection

Here we have listed a number of species that can be used on this site. This site probably would lend itself to drill seeding but broadcast seeding would be difficult. It is likely that container-grown native shrubs and one or two native grasses and forbs might be useful on this site.

Native Shrubs Species*

Creosote Bush – Larrea tridentata
Bur sage – Ambrosia dumosa
Cattle Spinach – Atriplex polycarp
Purple sage – Salvia dorii
Blader Cenna – Cassia armata
Brittle bush – Encelia farinosa
Fremont dalea – Psorothamnus fremontii
Wolfberry – Lycium andersonii
Whitethorn acacia – Acacia constricta

Native Grass Species

Big Galleta – Hilaria rigida
Desert needlegrass – Achnatherum speciosum
Red brome – Bromus rubens
Six-weeks gramma – Bouteloa barbata
Ring muhly – Muhlenbergia torreyi

Native Forb Species

Desert marigold – Baileya multiradiata
Desert globe mallow – Sphaeralcea ambigua
Desert sunflower – Viquiera deltoidea
Desert Lupine – Lupinus sparciflorus

*Container-grown shrubs should be planted in relatively deep containers, at least 8 inches to 10 inches. The native grasses and forbs can be transplanted as either ramets or seedlings if they can be made available. Supplemental irrigation to ensure establishment would be required if a mixture of seed is to be placed on this site.

ADDENDUM

DUST CONTROL

Soil productivity is affected by wind erosion in various ways. Areas of erosion and deposition on disturbed sites require more costly and less efficient soil management practices. Wind removes the smaller clay particles and organic matter from the soil while coarser materials are left behind. The continued loss of fine particles reduces soil quality. In shallow soils and soils with a hardpan layer, wind erosion also results in decreased root zone depth and water-holding capacity. Such changes may occur slowly and go unnoticed for many years. Bare soil can lead to dust that may be detrimental to safe driving and so must be considered. Many of the procedures discussed above will lead to good dust control. An number of emergency control methods are available to reduce damage from wind-induced soil erosion that already has started or is anticipated:

- ?? tillage to produce ridges and clods;
- ?? addition of a mulch;
- ?? application of livestock manure;
- ?? irrigation to increase soil moisture;
- ?? temporary, artificial wind barriers;
- ?? soil additives or spray-on adhesives.

Choice of method, or combination of methods, depends on severity of erosion and the relationship to planned remediation procedures that have been prescribed for a site.

MONITORING

Since remediation efforts are somewhat costly, we would recommend that monitoring be done to assess the success and failure of these efforts. This can be done either on an ad hoc basis or by using a more objective methodology to appraise success and/or failure over time. We would strongly recommend that an objective and scientifically based monitoring protocol be adopted to examine revegetated sites for several years after the treatment to assess the success and/or failure of the efforts. A number of excellent monitoring procedures are available. As a minimum we would suggest a series of belt transects where the seeded and volunteer species are counted one, two and five years after the treatment. Each belt should be about 15 meters or 50 feet in length and 1 meter or 3 feet wide. The number of transects would depend upon the size of the disturbed/seeded area. Small areas may require only two or three transects while larger areas may require several more to provide a good statistically valid sample.

Within each belt, a plant density count should be accomplished, counting the number of individual plants per unit area. Density should be determined for both seeded

and volunteer species. The purpose for looking at the density of the volunteer native species is to have some idea of the level of competition with the seeded species. For some superabundant species, i.e., cheatgrass, it would be necessary to use a subsample to obtain a reliable but feasible density count. Plant vigor should also be measured. Vigor can be determined in several ways, e.g. measuring the height of grass culms, leader length in seeded shrubs, and the height and number of leaves of both grasses and forbs. For grasses, a simple count of the number of seed heads signifying reproductive culms would be appropriate. These determinations should be done for all species but especially for seeded species. This can be accomplished in several ways such as by counting the number of seed heads, measuring the height of the plant, and counting the number of new tillers for the perennial grasses. In many cases, a mixture will be used to revegetate and it would be valuable to know which of these species established best and exhibited the greatest vigor on a particular site.

NOXIOUS AND INVASIVE WEEDS

Table 4 is a list of noxious weeds that have been designated by the Nevada State Department of Agriculture. There are a few other species that can be classified as invasive weeds. These might include cheatgrass (*Bromus tectorum*) and halogeton (*Halogeton glomeratus*) in the north and red brome (*Bromus rubens*) and Mediterranean Grass (*Schismus barbatus*) in the south. In some areas species of mustard (*Descurainia spp*. and *Sysimbrium spp.*) are invasive and can contribute to fire hazard. Our assessment of these weeds along Nevada highways in summarized in Table 5 where we have listed those species that we encountered and the location of populations found along Nevada highways. It would be important for those involved in remediation to have a working knowledge of these plant species and be able to identify them in the field. We have examined the records of the State Department of Agriculture. They have documented the location of a number of weeds at specific points along the highways. We have these records and they are available in the offices of the State of Nevada Department of Agriculture, Division of Plant Industry.

Table 4 Nevada's noxious weeds listed by common name and scientific name as of 4/02

(alphabetical by common name)

Common Name	Scientific Name
African Rue	*Peganum harmala*
Austrian fieldcress	*Rorippa austriaca*
Austrian peaweed	*Sphaerophysa salsula / Swainsona salsula*
Black henbane	*Hyoscyamus niger*
Camelthorn	*Alhagi camelorum*
Common crupina	*Crupina vulgaris*
Dyer's woad	*Isatis tinctoria*
Eurasian water-milfoil	*Myriophyllum spicatum*
Goats rue	*Galega officinalis*
Hemlock: (a) Poison (b) Water	*Conium maculatum* *Cicuta maculata*
Horse-nettle: (a) Carolina (b) White	*Solanum carolinense* *Solanum elaeagnifolium*
Houndstongue	*Cynoglossum officinale*
Hydrilla	*Hydrilla verticillata*
Klamath weed	*Hypericum perforatum*
Knapweed: (a) Diffuse (b) Russian (c) Spotted (d) Squarrose	*Centaurea diffusa* *Acroptilon repens* *Centaurea maculosa* *Centaurea virgata Lam. Var. squarrose*
Leafy spurge	*Euphorbia esula*
Mayweed chamomile	*Anthemis cotula*
Mediterranean sage	*Salvia aethiopis*
Medusahead	*Taeniatherum caput-medusae*
Perennial pepperweed	*Lepidium latifolium*
Puncturevine	*Tribulus terrestris*
Purple loosestrife	*Lythrum salicaria, L. virgatum & cultivars*
Rush skeletonweed	*Chondrilla juncea*
Saltcedar (tamarisk)	*Tamarix ramosissima*
Sorghum species, perennial, Including, but not limited to: (a) Johnson grass; (b) Sorghum alum; and (c) Perennial sweet sudan	
Sulfur cinquefoil	*Potentilla recta*
Thistle: (a) Canada (b) Musk (c) Scotch (d) Sow (e) Iberian star (f) Purple star (g) Yellow star	*Cirsium arvense* *Carduus nutans* *Onopordum acanthium* *Sonchus arvensis* *Centaurea iberica* *Centaurea calcitrapa* *Centaurea solstitialis*

Toadflax, Dalmatian	*Linaria dalmatica*
Toadflax, yellow	*Linaria vulgaris*
Whitetop or hoary cress	*Cardaria draba*

(alphabetical by scientific name)

Scientific Name	**Common Name**
Acroptilon repens	Knapweed: (b) Russian
Alhagi camelorum	Camelthorn
Anthemis cotula	Mayweed chamomile
Cardaria draba	Whitetop or hoary cress
Carduus nutans	Thistle: (b) Musk
Centaurea calcitrapa	Thistle: (f) Purple star
Centaurea diffusa	Knapweed: (a) Diffuse
Centaurea iberica	Thistle: (e) Iberian star
Centaurea maculosa	Knapweed: (c) Spotted
Centaurea solstitialis	Thistle: (g) Yellow star
Centaurea virgata Lam. Var. squarrose	Knapweed: (d) Squarrose
Chondrilla juncea	Rush skeletonweed
Cicuta maculata	Hemlock: (b) Water
Cirsium arvense	Thistle: (a) Canada
Conium maculatum	Hemlock: (a) Poison
Crupina vulgaris	Common crupina
Cynoglossum officinale	Houndstongue
Euphorbia esula	Leafy spurge
Galega officinalis	Goats rue
Hydrilla verticillata	Hydrilla
Hyoscyamus niger	Black henbane
Hypericum perforatum	Klamath weed
Isatis tinctoria	Dyer's woad
Lepidium latifolium	Perennial pepperweed
Linaria dalmatica	Toadflax, Dalmatian
Linaria vulgaris	Toadflax, yellow
Lythrum salicaria, L. virgatum & cultivars	Purple loosestrife
Myriophyllum spicatum	Eurasian water-milfoil
Onopordum acanthium	Thistle: (c) Scotch
Peganum harmala	African Rue
Potentilla recta	Sulfur cinquefoil
Rorippa austriaca	Austrian fieldcress
Salvia aethiopis	Mediterranean sage
Solanum carolinense	Horse-nettle: (a) Carolina
Solanum elaeagnifolium	Horse-nettle: (b) White
Sonchus arvensis	Thistle: (d) Sow
Sorghum species, perennial, Including, but not limited to: (a) Johnson grass (b) Sorghum alum (c) Perennial sweet sudan	

Sphaerophysa salsula / Swainsona salsula	Austrian peaweed
Taeniatherum caput-medusae	Medusahead
Tamarix ramosissima	Saltcedar (tamarisk)
Tribulus terrestris	Puncturevine

Attempts were made to record noxious and invasive weeds at mile markers visited along Nevada Highways as a part of this project. They are summarized as to location by Highway number and mile-marker and further summarized by numbers of occurrences along each highway (Table 5). This data is by no means complete and requires further inventory and monitoring. We also are aware of a number of other species as listed in this report that were not seen at the mile-markers that we visited.

Table 5. Selected noxious and invasive weeds summarized by highway and for the entire state. US = U.S. Highways, SR = State Routes, IR = Interstate Highways

Total # Statewide

Amaranthus spp. (Pigweed)	BRTE (Cheatgrass)	CHNA (Grey Rabbitbrush)	CHVI (Green Rabbitbrush)	Circium spp. (Thistle)	DEPI (Tansy Mustard)	GUSA (Snakeweed)	Grindellia spp. (Gumweed)	HAGL (Halogeton)	LELA (Whitetop)	Salsola spp.	SCBA	Tamarix spp.
40	277	398	80	3	63	1	19	83	13	168	6	29

Total # Per Highway Designation

Route	System	Amaranthus spp. (Pigweed)	BRTE (Cheatgrass)	CHNA (Grey Rabbitbrush)	CHVI (Green Rabbitbrush)	Circium spp. (Thistle)	DEPI (Tansy Mustard)	GUSA (Snakeweed)	Grindellia spp. (Gumweed)	HAGL (Halogeton)	LELA (Whitetop)	Salsola spp.	SCBA	Tamarix spp.
95A	US	1	1	3						1		4		
93A	US			4						3		1		
50A	US	1		1								1		
892	SR	1		16						3		1		
860	SR													1
844	SR		1	2						1		1		
839	SR		11	5										
824	SR			2										
823	SR	2		1					1			3		
789	SR	1	8	3	1		3			2	1	3		
774	SR									1		2		
773	SR									3				
767	SR				3									
766	SR		2	7						1		1		
757	SR		1		1				1					
756	SR	1			1									

Route	System	Amaranthus spp. (Pigweed)	BRTE (Cheatgrass)	CHNA (Grey Rabbitbrush)	CHVI (Green Rabbitbrush)	Circium spp. (Thistle)	DEPI (Tansy Mustard)	GUSA (Snakeweed)	Grindellia spp. (Gumweed)	HAGL (Halogeton)	LELA (Whitetop)	Salsola spp.	SCBA	Tamarix spp.
490	SR		1	2								1		
487	SR		2	1						1		1		
447	SR		3	5			2					4		
446	SR		2	6								1		
445	SR			13								1		
429	SR	2	1	2								2		
427	SR										1			
400	SR		10	4			3					2		
399	SR		7	3			1			1		1		
397	SR	1										4		1
395	IR		3	2	5				1			1		
379	IR		3	1						5	1	1		
377	SR			4						1				
376	SR	6	5	9			1			7		4		1
374	SR									1				
361	SR	1	18	8						2		4		
360	SR		1	1								3		
359	SR	1	2	8	2							2		
341	SR			6					1			1		
338	SR	1	1	5								2		
306	SR		11	4			2			3	1	6		
294	SR		1				3				1	4		
293	SR		8	14			2		1		1	3		
292	SR			1								1		
290	SR		5	6			5				1	5		
278	SR		12	36			1					4		
267	SR									3		2		
266	SR			6			1		1	2		3		
265	SR									2				1
264	SR	1			3					2		5		
233	SR	2		4						1		1		

Route	System	Amaranthus spp. (Pigweed)	BRTE (Cheatgrass)	CHNA (Grey Rabbitbrush)	CHVI (Green Rabbitbrush)	Circium spp. (Thistle)	DEPI (Tansy Mustard)	GUSA (Snakeweed)	Grindellia spp. (Gumweed)	HAGL (Halogeton)	LELA (Whitetop)	Salsola spp.	SCBA	Tamarix spp.
232	**SR**		**1**											
231	**SR**	**2**			**2**									
230	**SR**	**1**	**1**	**3**	**1**				**1**			**1**		
229	**SR**		**2**		**9**		**1**		**1**			**4**		
228	**SR**			**9**										
227	**SR**		**1**		**6**									
226	**SR**	**2**			**6**							**1**		
225	**SR**	**1**	**6**	**10**	**5**				**4**			**4**		
208	**SR**			**2**	**3**						**1**	**7**		
207	**SR**		**1**	**1**										
206	**SR**		**1**		**4**									
170	**SR**													**3**
169	**SR**													**1**
168	**SR**											**2**		**3**
164	**SR**							**1**				**1**		
163	**SR**												**2**	
162	**SR**												**1**	**2**
140	**SR**		**7**	**4**								**4**		
121	**SR**		**5**	**2**								**4**		
116	**SR**											**3**		
95	**US**	**2**	**31**	**37**			**23**			**6**	**2**	**12**	**1**	**9**
93	**US**		**1**	**19**	**1**				**2**	**3**		**1**		**1**
88	**SR**				**1**				**1**					
80	**IR**	**2**	**61**	**40**	**26**		**12**		**3**	**5**	**1**	**18**		
50	**US**	**4**	**29**	**60**			**1**		**1**	**3**	**1**	**9**		**5**
15	**IR**		**1**			**2**						**1**	**2**	
6	**US**	**4**	**9**	**16**		**1**	**2**			**20**	**1**	**10**		**1**

Table 5 is a summary of our determination of selected noxious and invasive weeds along Nevada highways. Cheatgrass is the most prevalent. As mentioned before, the number of different species encountered relative to the list found in Table 4 is rather low but, of course, we did examine every location along the many highways. For example, the total number of occurrences of cheatgrass was 277. On the other hand, we found only one occurrence of snake weed. Snake weed (*Gutierrezia sarothrae*) is a native shrub species, but under certain circumstances such as heavy grazing or soil disturbance, it can become an important weed. From this data we can get a general idea of the distribution of some of these species around the state as they are recorded by highway number. Of the other species encountered we can note that rabbitbrush, also a native species, often becomes an important species found in the rights-of-way along with Russian thistle (*Salola spp*.). Russian thistle was found at 168 mile markers while grey rabbitbrush and green rabbitbrush were found at 398 and 80 mile markers, respectively. These species are often the first species to move onto disturbed areas. Another important weed species was halogeton, and it was found at 83 mile markers. This species is found throughout northern Nevada, but fortunately it is not a very competitive species and therefore can be controlled rather easily. It is found only on disturbed sites. It was noted that as the elevation and annual precipitation increased going east on Interstate 80 the dominance of cheat grass in previously seeded areas decreased and crested wheatgrass increased. This illustrates the need to match plant species use for revegetation with soils and plant communities for specific sites. Other weeds encountered with some frequency were mustard, tall white top, tamarisk, pigweed and gumweed. The distribution of tall whitetop around the state is deemed critical and much effort is being directed toward determining its spread and occurrence.

GENERAL SOIL MANAGEMENT QUESTIONS

For each individual site there may be specific questions to be answered relative to soil chemical and physical problems. This might involve determinations of pH and salinity or adverse physical characteristics such as a heavy clay soil. Many Nevada soils have a neutral pH and do not present any kind of chemical problems. Others may require treatments of sulfur or other additives to ameliorate high pH. If a soil has a high electrical conductivity (EC) (Table 6) further treatment might be required. Of the categories specified in this report, we have described a typical EC and pH that would give further clues as to how the soil must be treated.

Table 6. pH and EC (electrical conductivity) soils data for selected sites along the Interstate 80 Corridor. Data obtained May 14, 16 and 17, 2002.

LOCATION	CLOSEST MILE MARKER	PH	EC
Salt marsh east of Fernley N. 39º55.237' W. 118º48.072'	MM 57	Sur* 8 Sub* 8	12.8
Lake playa east of Fernley N. 39º55.287' W. 118º44.072'	MM 80	Sur 8 Sub 8	49
Fallon turnoff US 95/I80 N. 39º56.414' W. 118º44.976'	MM 83	Sur 7.6 Sub 7.0	1.1
East of Rye Patch turnoff (5mi. E) N. 40º29.591' W. 118º16.938'	MM 131 (Cheatgrass burn)	Sur 8 Sub 8	.2
Reseeding 0.25 miles west of MM154 N. 40º43.252' W. 118º02.306	MM 154 Elevation. 4,312 feet	Sur 6.67 Sub 6.80	.12 .14
Pumpernickel Valley (west end) N. 40º53.652' W. 117º17.876	MM 206	Sur 7.6 Sub 9.2	10 4.3
East. of Battle Mountain (3x1 slope) N. 40º39.155' W. 116º45.504'	MM 243	Sur 7 Sub 7.3	.03 .02
West side of Carlin (Emigrant Pass) N. 40º39.017' W. 116º22.967'	MM 264 (0.13 miles. East) (slope)	Sur 6.6 Sub 7.1	.05 .06
Picture of fill	MM 264 (1/2mi E.) Crested Wheat and GBW Rye		
Terracing on east slope, west. of Carlin N. 40º43.101 W. 116º22.122	MM 280 (Cheatgrass)		
Terrace Picnic Area N. 40º37.849' W. 115º22.122'	Lamoille Canyon Elevation - 8,484 feet	Sur 6.5	.06
0.7mi N. of Thomas Canyon Campground N. 40º39.345' W. 115º25.182'	Lamoille Canyon Elevation - 7.415 (typical vegetation)		
Way to Spring Creek	0.7mile south. of new hospital - Elko		
Flowers	1mile of MM 271 west. bound I 80		

* Sur represents soil samples taken from the surface and Sub those samples taken from eight to ten inches deep.

WILDFIRE HAZARD

Wildfire is of considerable concern to all Nevadans. Unfortunately many sites along Nevada highways possess vegetation characteristics that have a high potential for wildfire ignition. In this report we are attempting to promote plants that do not constitute high fire hazard. Reference here must be made to the USDA Fire Effects Information System, which has useful information about most of the plants we have listed as possible revegetation species in this report. The FEIS can be accessed at the following Web site (http://www.fs.fed.us/database/feis/). Areas of high fire hazard have been identified on the vegetation maps. Those areas with the highest fire hazard are sites with pure stands of cheatgrass (*Bromus tectorum*), various sagebrush species with understories of cheatgrass, sites with other weeds such as mustards, and other areas where weeds have become commonplace along the rights-of-way. Cheatgrass is the most common fire species found along Nevada highways. These sites can generally be identified by examining the various vegetation polygons on the vegetation maps. Of course, under very dry conditions a wildfire can start anywhere. On especially high fire hazard sites, it may be wise to attempt to establish fire-resistant species along the highways. However, the cost of such endeavors might be prohibitive. It then becomes a situation where the users of the highway system must be informed about fire hazard. While the U. S. Forest Service and Bureau of Land Management are handling this, perhaps the NDOT could somehow add to the message, or work with them to help get the message out.

Selected References

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Houghton, John G. 1969. Characteristics of Rainfall in the Great Basin. Desert Research Institute. University and College System of Nevada. Reno, Nevada 206 pp.

Hogan, Michael. 1999. Objectives and Guidelines for Re-vegetation success Under the Tahoe Bond Act. Nevada Tahoe Bond Act Technical Advisory Committee. 13pp.

McLane, Alvin R. 1978. Silent Cordilleras, The Mountain Ranges of Nevada. Camp Nevada Monograph Number 4. 118pp.

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Appendices

Appendix #1 Species selection

The species listed in the general ecosystem specifications are those that we selected from advertised seed sources. These species are thought to be adapted to the ecosystems in question. Species selection is of paramount importance and requires several steps. The first step is to evaluate the environment where the revegetation effort is to take place. This would require examining the soil and climatic conditions, topography and microtopography, and competing vegetation which may or may not be native species. Then someone familiar with the natural vegetation would begin the selection process. This would require going to various seed companies and determining just what seed is available and what might best fit into a mixture, considering cost and the desirability to include a species in the mixture. Some western seed companies are listed in Appendix #2. Others are available. For each site there would be a number of species that would be appropriate and desirable. For the major ecosystems along Nevada highways we have listed some of the appropriate species. After the selection process is complete, purchase and delivery can be requested. The species finally selected will be a function of availability and cost. In some cases the cost will preclude the inclusion of a species in the mixture even though it may be desirable. Also the cost and availability of container-grown plants must be carefully considered.

Seeding rates will vary from site to site depending upon the soil, the species used, the price and availability of the selected seed. A reasonable rule of thumb would be to seed at a rate of 19 pounds to 20 pounds/acre of pure live seed. In one of the appendices we have included information on how to convert the acre seeding rates to the weight of seed per square foot or per square meter. In addition, it is important to calculate, based on seed germination percentages, the pounds of bulk seed required to yield one pound of pure live seed. This information is also included in Appendix #3.

Appendix #2 Sources of native seeds

We have listed here only a few of numerous seed companies with emphasis on those who provide seed adapted to Nevada conditions. There certainly may be others that could be used.

Applewood Seed Co., 5310 Vivian Street, Dept. D., Arvada, CO 80002, Phone (303) 431 7333, Fax (303) 467 7886, e-mail applewoodseed@worldnet.att.net.

Comstock Seed, 917 Highway 88, Gardnerville, NV, 89410, Phone: (775) 746-3681, Fax: (775) 746-1701, e-mail ed@comstockseed.com. Web site www.gardenwatchdog.com.

Granite Seed, 1697 West 2100 North, Lehi, UT 84043. Phone: (801) 768-4422 Fax: (801)-768-3967, e-mail info@graniteseed.com, Web site www.graniteseed.com.

Lawyer Nursery, Inc., 950 Highway 200 West, Phone (800) 551 9875, Fax (406) 826 5700, e-mail trees@lawyernursery.com, Web site www.lawyernursery.com.

Pacific Coast Seed, 6144-A Industrial Way, Livermore, CA 94550. Phone (925) 373 4417 Fax (925) 373 6855, e-mail pcseed@worldnet.net.

Plants of the Southwest On-Line, Aqua Fria Rt. 6. Box 11-A, Santa Fe, NM 87507. (800)-788-SEED (7333), Web-site www.plantsofthesouthwest.com.

Appendix #3 Bulk pure live seed requirements for seed with specified germination rates.

Percent Germination

% Purity	100	95	90	85	80	75	70	65	60	55	50	45	40
100	1.0	1.1	1.2	1.2	1.3	1.4	1.5	1.6	1.7	1.9	2.0	2.3	2.5
95	1.1	1.2	1.2	1.3	1.4	1.5	1.6	1.7	1.8	2.0	2.2	2.4	2.7
90	1.2	1.2	1.3	1.4	1.4	1.5	1.6	1.8	1.9	2.1	2.3	2.5	2.8
85	1.2	1.3	1.4	1.4	1.5	1.6	1.7	1.9	2.0	2.2	2.4	2.7	3.0
80	1.3	1.4	1.4	1.5	1.6	1.7	1.8	2.0	2.1	2.3	2.5	2.8	3.2
75	1.4	1.5	1.5	1.6	1.7	1.8	2.0	2.1	2.3	2.5	2.7	3.0	3.4
70	1.5	1.6	1.6	1.7	1.8	2.0	2.1	2.2	2.4	2.6	2.9	3.2	3.6
65	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.4	2.6	2.8	3.1	3.5	3.9
60	1.7	1.8	1.9	2.0	2.1	2.2	2.4	2.6	2.8	3.1	3.4	3.8	4.2
55	1.9	2.0	2.1	2.2	2.3	2.5	2.6	2.8	3.1	3.4	3.7	4.1	4.6
50	2.0	2.2	2.3	2.4	2.5	2.7	2.9	3.1	3.4	3.7	4.0	4.5	5.0
45	2.3	2.4	2.5	2.7	2.8	3.0	3.2	3.5	3.8	4.1	4.5	5.0	5.6
40	2.5	2.7	2.8	3.0	3.2	3.4	3.6	3.9	4.2	4.6	5.0	5.6	6.3
35	2.9	3.1	3.2	3.4	3.6	3.9	4.1	4.4	4.8	5.7	5.8	6.4	7.2
30	3.4	3.6	3.8	4.0	4.2	4.5	4.8	5.2	5.6	6.1	6.7	7.5	8.4
25	4.0	4.3	4.5	4.8	5.0	5.4	5.8	6.2	6.7	7.3	8.0	8.9	10.0
20	5.0	5.3	5.6	5.9	6.3	6.7	7.2	7.7	8.4	9.1	10.0	11.2	12.5
15	6.7	7.1	7.5	7.9	8.4	8.9	9.6	10.3	11.2	12.2	13.4	14.9	16.7
10	10.0	10.6	11.2	11.8	12.5	13.4	14.3	15.4	16.7	18.2	20.0	22.3	25.0

Prepared by Graig Plummer, Soil Conservation Service

Appendix #4 Soil Samples

The following soil sampling suggestions were included from the "Objectives and Guidelines for Revegetation Success Under the Tahoe Bond Act" by Michael Hogan. These methods are necessary to assess the soil properties vital to the success of the establishment and vigor of plant species used in remediation efforts.

Pre-project soil sampling

Soil samples must be taken from the project site and from an adjoining native or well-vegetated reference site, where possible, in order to establish nutrient needs and nutrient status.

? Soil samples must be taken by a qualified and trained individual using an approved method.

? Soil samples can be analyzed by a qualified soil lab using specific testing methodology. This methodology is that which was used by Claassen and Hogan (Caltrans Report RTA53X461) in collecting data referenced previously. Using this methodology, meaningful analysis can be accomplished. The analysis protocol has been developed for wildland soils analysis and is additional to any agronomic tests that may be required. These tests will be available from Plant and Soil Laboratories, Laurie Littleford, (408) 727-0330. Other labs may be able to perform these tests. Inquiries should be made to the Nevada Tahoe Bond Act TAC or the Tahoe Natural Resources, Conservation Service office (530) 541-1496.

? Soil samples must be analyzed by a soils laboratory using appropriate methods.

Appendix #5 Soil amendments, mulches and soil stabilizations materials including blankets and tackifiers.

This list in not complete but it does refer to many of the materials available on the market for soil stabilization and to facilitate revegetation.

Southwest Environment Services, Inc., 2400 E. Erwin, P.O. Box, Tyler, Texas 744710. Phone (903) 531-2211, Fax (903) 532-2312, e-mail dmarch@southwestenvironment.com, Web site www.southwestenvironment.com.

Quattro Environmental, Inc., 649 'I' Ave., Coronado, CA 92118. Phone (619) 522-0044, Fax (619) 522-0055, Web site www.kiwipower.com.

Terra Firma, Phone (800) 908-9222 or (505) 994-0846, Fax (505) 892-7702, Web site www.terra-firma-ind.com.

Nilex Corporation, 15171 E. Fremont Drive, Englewood, CO 80112. Phone (303) l766-2000, Fax (303) 766-1110, e-mail Denver@nilex.com, Web site www.nilexlcom/nilx_usa.html.

Western Sere, P.O. Box 10610, Casa Grande, AZ 85230. Phone in Phoenix (602) 268-8811, in Tucson: (520) 884-7111, or (888)-448-7373, e-mail email@westernsere.com, Web site www.westernsere.com

Aqua-Shed Echnologies, Inc., P.O. Box 505, 11304 Missouri St., South Houston, TX 77587. (800)-661-6646, Fax (713) 947-9885, e-mail fkramer@aqua-shed.com, Web site www.aqua-shed.com.

Golden Gate Products, P.O. Box 106, Davis, CA 95617. Phone & Fax (707) 678-6798, Web site www.goldengateproducts.com.

National Seed Pellet, LLC, P.O.Box 10136, Reno, Nevada 89510. Phone (775)324 1737, Fax (775) 324 5131. E-mail svonderheide@msm.com