

**APPENDIX L**

**SURVEY AND OTHER PROTOCOLS**

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**Attachment L-1**

**Reserved**

## **Attachment L-2**

### **Indiana Bat Habitat Assessment Protocols**

## **Appendix L-2**

### **Indiana Bat Habitat Assessment Protocols**

These protocols are currently being prepared and will be included in this MSHCP when available from the Service.

DRAFT

**Attachment L-3**

**Determination of Potential Winter Habitat  
for  
Indiana Bats**

## **Appendix L-3**

### **Indiana Bat Winter Habitat Assessment Protocols**

NiSource personnel or its consultants will determine whether potentially-suitable winter habitat exists within the project area by conducting “Winter Habitat Assessments” as described below. The results of these assessments will be recorded and documented in NiSource’s annual compliance report. Results will be valid for two years and can be completed anytime of year. The Winter Habitat Assessment Protocols are:

- i. Examine identified potential winter habitat for the following characteristics:
  1. The openings should be at least one foot in diameter or larger.
  2. The passage should continue beyond the dark zone and not have an obvious end within 40 feet of entrance (Note: This may not be verifiable by surveyor due to safety concerns).
  3. Entrances that are flooded or prone to flooding (i.e., debris on ceiling), collapsed, or otherwise inaccessible to bats will be excluded.
  4. Openings that have occurred recently (i.e., within the past 12 months) due to creation or subsidence will be excluded. However, a written description and photographs of the opening must be included in the pre-survey report.

## **Appendix L-4**

### **Indiana Bat Survey Protocols**

The current “Indiana Bat Mist Netting Guidelines” provided in Appendix 5 of the 2007 Indiana Bat draft Revised Recovery Plan or future versions of superseding Service-approved guidelines will be applied.



## **Attachment L-5**

### **Service Guidelines for Bog Turtle Surveys April 2006**

# GUIDELINES FOR BOG TURTLE SURVEYS<sup>1</sup>

(revised April 2006)

## RATIONALE

A bog turtle survey (when conducted according to these guidelines) is an attempt to determine presence or probable absence of the species; it does not provide sufficient data to determine population size or structure. Following these guidelines will standardize survey procedures. It will help maximize the potential for detection of bog turtles at previously undocumented sites at a minimum acceptable level of effort. Although the detection of bog turtles confirms their presence, failure to detect them does not absolutely confirm their absence (likewise, bog turtles do not occur in all appropriate habitats and many seemingly suitable sites are devoid of the species). Surveys as extensive as outlined below are usually sufficient to detect bog turtles; however, there have been instances in which additional effort was necessary to detect bog turtles, especially when habitat was less than optimum, survey conditions were less than ideal, or turtle densities were low.

## PRIOR TO CONDUCTING ANY SURVEYS

If a project is proposed to occur in a county of known bog turtle occurrence (see attachment 1), contact the U.S. Fish and Wildlife Service (Service) and/or the appropriate State wildlife agency (see attachment 2). They will determine whether or not any known bog turtle sites occur in or near the project area, and will determine the need for surveys.

- < If a wetland in or near the project area is *known* to support bog turtles, measures must be taken to avoid impacts to the species. The Service and State wildlife agency will work with federal, state and local regulatory agencies, permit applicants, and project proponents to ensure that adverse effects to bog turtles are avoided or minimized.
- < If wetlands in or adjacent to the project area are *not* known bog turtle habitat, conduct a bog turtle habitat survey (Phase 1 survey) if:
  1. The wetland(s) have an emergent and/or scrub-shrub wetland component, or are forested with suitable soils and hydrology (see below), *and*
  2. Direct and indirect adverse effects to the wetland(s) cannot be avoided.

See *Bog Turtle Conservation Zones*<sup>2</sup> for guidance regarding activities that may affect bog turtles and their habitat. In addition, consult with the Fish and Wildlife Service and/or appropriate State wildlife agency to definitively determine whether or not a Phase 1 survey will be necessary.

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<sup>1</sup> These guidelines are a modification of those found in the final “Bog Turtle (*Clemmys muhlenbergii*), Northern Population, Recovery Plan” (dated May 15, 2001). Several minor revisions were made to facilitate survey efforts and increase searcher effectiveness. As additional information becomes available regarding survey techniques and effectiveness, these survey guidelines may be updated and revised. Contact the Fish and Wildlife Service or one of the state agencies listed in Attachment 1 for the most recent version of these guidelines.

<sup>2</sup> See Appendix A of the “Bog Turtle (*Clemmys muhlenbergii*), Northern Population, Recovery Plan” (dated May 15, 2001).

## **BOG TURTLE HABITAT SURVEY (= Phase 1 survey)**

The purpose of this survey is to determine whether or not the wetland(s) are *potential* bog turtle habitat. These surveys are performed by a recognized, qualified bog turtle surveyor (contact the Service or the appropriate State wildlife agency to receive a list of recognized, qualified bog turtle surveyors). The following conditions and information apply to habitat surveys.

< Surveys can be performed any month of the year (except when significant snow and/or ice cover is present). This flexibility in conducting Phase 1 surveys allows efforts during the Phase 2 survey window to be spent on wetlands most likely to support bog turtles (*i.e.*, those that meet the criteria below).

< Potential bog turtle habitat is recognized by three criteria (*not all of which may occur in the same portion of a particular wetland*):

1. **Suitable hydrology.** Bog turtle wetlands are typically spring-fed with shallow surface water or saturated soils present year-round, although in summer the wet area(s) may be restricted to near spring head(s). Typically these wetlands are interspersed with dry and wet pockets. There is often subsurface flow. In addition, shallow rivulets (less than 4 inches deep) or pseudo-rivulets are often present.
2. **Suitable soils.** Usually a bottom substrate of permanently saturated organic or mineral soils. These are often soft, mucky-like soils (this does not refer to a technical soil type); you will usually sink to your ankles (3-5 inches) or deeper in muck, although in degraded wetlands or summers of dry years this may be limited to areas near spring heads or drainage ditches. In some portions of the species' range, the soft substrate consists of scattered pockets of peat instead of muck.
3. **Suitable vegetation.** Dominant vegetation of low grasses and sedges (in emergent wetlands), often with a scrub-shrub wetland component. Common emergent vegetation includes, but is not limited to: tussock sedge (*Carex stricta*), soft rush (*Juncus effusus*), rice cut grass (*Leersia oryzoides*), sensitive fern (*Onoclea sensibilis*), tearthumbs (*Polygonum* spp.), jewelweeds (*Impatiens* spp.), arrowheads (*Sagittaria* spp.), skunk cabbage (*Symplocarpus foetidus*), panic grasses (*Panicum* spp.), other sedges (*Carex* spp.), spike rushes (*Eleocharis* spp.), grass-of-Parnassus (*Parnassia glauca*), shrubby cinquefoil (*Dasiphora fruticosa*), sweet-flag (*Acorus calamus*), and in disturbed sites, reed canary grass (*Phalaris arundinacea*) or purple loosestrife (*Lythrum salicaria*). Common scrub-shrub species include alder (*Alnus* spp.), red maple (*Acer rubrum*), willow (*Salix* spp.), tamarack (*Larix laricina*), and in disturbed sites, multiflora rose (*Rosa multiflora*). Some forested wetland habitats are suitable given hydrology, soils and/or historic land use. These forested wetlands include red maple, tamarack, and cedar swamps.

**Suitable hydrology and soils are the critical criteria (*i.e.*, the primary determinants of potentially suitable habitat).**

< Suitable hydrology, soils and vegetation are necessary to provide the critical wintering sites (soft muck, peat, burrows, root systems of woody vegetation) and nesting habitats (open

areas with tussocky or hummocky vegetation) for this species. It is very important to note, however, that one or more of these criteria may be absent from portions of a wetland or wetland complex supporting bog turtles. Absence of one or more criteria does not preclude bog turtle use of these areas to meet important life functions, including foraging, shelter and dispersal.

- < If these criteria (suitable soils, vegetation and hydrology) are present in the *wetland*, then the *wetland* is considered to be potential bog turtle habitat, regardless of whether or not that portion of the wetland occurring within the project boundaries contains all three criteria. If the *wetland* is determined to be potential habitat and the project will directly or indirectly impact *any portion* of the wetland (see *Bog Turtle Conservation Zones*), then either:
  - < Completely avoid all direct and indirect effects to the wetland, in consultation with the Service and appropriate State wildlife agency, OR
  - < Conduct a Phase 2 survey to determine the presence of bog turtles.
- < The Service and appropriate State wildlife agency (see list) should be sent a copy of survey results for review and comment including: a USGS topographic map indicating location of site; project design map, including location of wetlands and stream and delineation of wetland type (PEM, PSS, PFO, POW) and “designated survey areas”<sup>3</sup>; color photographs of the site; surveyor's name; date of visit; opinion on potential/not potential habitat; a description of the hydrology, soils, and vegetation. A phase 1 report template and field form are available from the States and Service.

### **BOG TURTLE SURVEY (= Phase 2 survey)**

If the wetland(s) are identified as potential bog turtle habitat (see Phase 1 survey), and direct and indirect adverse effects cannot be avoided, conduct a bog turtle survey in accordance with the specifications below. Note that this is *not* a survey to estimate population size or structure; a long-term mark/recapture study would be required for that.

Prior to conducting the survey, contact the appropriate State agency (see attached list) to determine whether or not a scientific collector's permit valid for the location and period of the survey will be required.

The Phase 2 survey will focus on the areas of the wetland that meet the soils, hydrology and vegetation criteria, as defined under the Phase 1 survey guidelines. Those areas that meet the criteria are referred to as “designated survey areas” for Phase 2 and Phase 3 survey purposes.

1. Surveys should only be performed during the period from April 15-June 15. For the Lake Plain Recovery Unit (see Recovery Plan), surveys should only be performed during the period from May 1 to June 30. This coincides with the period of greatest annual turtle activity (spring emergence and breeding) and before vegetation gets too dense to accurately survey. While turtles may be found outside of these dates, a result of no turtles would be

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<sup>3</sup> “Designated survey areas” are those areas of the wetland that meet the soils, hydrology and vegetation criteria for potential bog turtle habitat. These areas may occur within the emergent, scrub-shrub or forested parts of the wetland.

considered inconclusive. Surveys beyond June also have a higher likelihood of disruption or destruction of nests or newly hatched young.

2. Ambient air temperature at the surface in the shade should be  $\geq 55^{\circ}$  F.
3. Surveys should be done during the day, at least one hour after sunrise and no later than one hour before sunset.
4. Surveys may be done when it is sunny or cloudy. In addition, surveys may be conducted during and after light rain, provided air temperatures are  $\geq 65^{\circ}$  F.
5. At least one surveyor must be a recognized qualified bog turtle surveyor<sup>4</sup>, and the others should have some previous experience successfully conducting bog turtle surveys or herpetological surveys in wetlands. To maintain survey effort consistency and increase the probability of encountering turtles, the same surveyors should be used for each wetland.
6. A minimum of four (4) surveys per wetland site are needed to adequately assess the site for presence of bog turtles. At least two of these surveys must be performed in May. From April 15 to April 30, surveys should be separated by six or more days. From May 1 to June 15, surveys should be separated by three or more days. The shorter period between surveys during May and June is needed to ensure that surveys are carried out during the optimum window of time (*i.e.*, before wetland vegetation becomes too thick).

Note that bog turtles are more likely to be encountered by spreading the surveys out over a longer period. For example, erroneous survey results could be obtained if surveys were conducted on four successive days in late April due to possible late spring emergence, or during periods of extreme weather because turtles may be buried in mud and difficult to find.

Because this is solely a presence/absence survey, survey efforts at a particular wetland may cease once a bog turtle has been found.

7. Survey time should be at least four (4) to six (6) person-hours per acre of designated survey area per visit. Additional survey time may be warranted in wetlands that are difficult to survey or that have high quality potential habitat. The designated survey area includes all areas of the wetland where soft, mucky-like soils are present, regardless of vegetative cover type. This includes emergent, scrub-shrub, and forested areas of the wetland.

If the cover is too thick to effectively survey using Phase 2 survey techniques alone (*e.g.*, dominated by multiflora rose, reed canary grass, *Phragmites*), contact the Service and State wildlife agency for guidance on Phase 3 survey techniques (trapping) to supplement the Phase 2 effort. In addition, Phase 3 (trapping) surveys may also be warranted if the site is in

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<sup>4</sup> Searching for bog turtles and recognizing their habitat is a skill that can take many months or years of field work to develop. This level of expertise is necessary when conducting searches in order to ensure that surveys are effective and turtles are not harmed during the survey (*e.g.*, by stepping on nests). Many individuals that have been recognized as qualified to conduct bog turtle surveys obtained their experience through graduate degree research or employment by a state wildlife agency. Others have spent many years actively surveying for bog turtles as amateur herpetologists or consultants.

the Lake Plain-Prairie Peninsula Recovery Unit. Check with the Service or State wildlife agency for further guidance.

8. Walk quietly through the wetland. Bog turtles will bask on herbaceous vegetation and bare ground, or be half-buried in shallow water or rivulets. Walking noisily through the wetland will often cause the turtles to submerge before they can be observed. Be sure to search areas where turtles may not be visible, including under mats of dead vegetation, shallow pools, underground springs, open mud areas, vole runways and under tussocks. Do not step on the tops of tussocks or hummocks because turtle nests, eggs and nesting microhabitat may be destroyed. Both random opportunistic searching and transect surveys should be used at each wetland.

The following survey sequence is recommended to optimize detection of bog turtles:

- Semi-rapid walk through the designated survey area using visual encounter techniques.
  - If no bog turtles are found during visual survey, while walking through site identify highest quality habitat patches. Within these highest quality patches, begin looking under live and dead vegetation using muddling and probing techniques.
  - If still no bog turtles are found, the rest of the designated survey area should be surveyed using visual encounter surveys, muddling and probing techniques.
9. Photo-documentation of each bog turtle located will be required; a macro lens is highly recommended. The photos should be in color and of sufficient detail and clarity to identify the bog turtle to species and individual. Therefore, photographs of the carapace, plastron, and face/neck markings should be taken of each individual turtle. Do not harass the turtle in an attempt to get photos of the face/neck markings; if gently placed on the ground, most turtles will slowly extend their necks if not harassed. If shell notching is conducted, do the photo-documentation after the notching is done.
  10. The following information should be collected for each bog turtle: sex, carapace length-straight line and maximum length, carapace width, weight, and details about scars/injuries. Maximum plastron length information should also be collected to differentiate juveniles from adults as well as to obtain additional information on recruitment, growth, and demography.
  11. Each bog turtle should be marked (*e.g.*, notched, PIT tagged) in a manner consistent with the requirements of the appropriate State agency and/or Service. Contact the appropriate State wildlife agency prior to conducting the survey to determine what type of marking system, if any, should be used.
  12. All bog turtles must be returned to the point of capture as soon as possible on the same day as capture. They should only be held long enough to identify, measure, weigh, and photograph them, during which time their exposure to high temperatures must be avoided. No bog turtles may be removed from the wetland without permission from the Service and appropriate State agency.

13. The Fish and Wildlife Service and appropriate State agency should be sent a copy of survey results for review and concurrence, including the following: dates of site visits; time spent per designated survey area per wetland per visit; names of surveyors; a site map including wetlands and delineations of designated survey areas; a table indicating the size of each wetland, the designated survey area within each wetland, and the survey effort per visit; a description of the wetlands within the project area (*e.g.*, acreage, vegetation, soils, hydrology); an explanation of which wetlands or portions of wetlands were or were not surveyed, and why; survey methodology; weather per visit at beginning and end of survey (air temperature, wind, and precipitation); presence or absence of bog turtles, including number of turtles found and date, and information and measurements specified in item 10 above; and other reptile and amphibian species found and date.

### **ADDITIONAL SURVEYS / STUDIES**

Proper implementation of the Phase 2 survey protocol is usually adequate to determine species presence or probable absence, especially in small wetlands lacking invasive plant species.

Additional surveys, however, may be necessary to determine whether or not bog turtles are using a particular wetland, especially if the Phase 2 survey results are negative but the quality and quantity of habitat are good and in a watershed of known occurrence. In this case, additional surveys (Phase 2 and/or Phase 3 (trapping) surveys), possibly extending into the following field season, may be recommended by the Service or appropriate State agency.

If bog turtles are documented to occur at a site, additional surveys/studies may be necessary to characterize the population (*e.g.*, number, density, population structure, recruitment), identify nesting and hibernating areas, and/or identify and assess adverse impacts to the species and its habitat, particularly if project activities are proposed to occur in, or within 300 feet of, wetlands occupied by the species.

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**CONTACT AGENCIES - BY STATE***(April 2006)*

STATE	FISH AND WILDLIFE SERVICE	STATE AGENCY
Connecticut	U.S. Fish and Wildlife Service New England Field Office 22 Bridge Street, Unit #1 Concord, NH 03301	Department of Environmental Protection Env. & Geographic Information Center 79 Elm Street, Store Floor, Hartford, CT 06106 <i>(info about presence of bog turtles in or near a project area)</i>  Department of Environmental Protection Wildlife Division, Sixth Floor 79 Elm Street, Store Floor, Hartford, CT 06106 <i>(to get a Scientific Collectors Permit or determine what type of marking system to use)</i>
Delaware	U.S. Fish and Wildlife Service Chesapeake Bay Field Office 177 Admiral Cochrane Drive Annapolis, MD 21401	Nongame & Endangered Species Program Delaware Division of Fish and Wildlife 4876 Hay Point Landing Road Smyrna, DE 19977
Maryland	U.S. Fish and Wildlife Service Chesapeake Bay Field Office 177 Admiral Cochrane Drive Annapolis, MD 21401	Maryland Department of Natural Resources Wildlife & Heritage Division PO Box 68, Main Street Wye Mills, MD 21679
Massachusetts	U.S. Fish and Wildlife Service New England Field Office 22 Bridge Street, Unit #1 Concord, NH 03301	Division of Fisheries and Wildlife Dept. Fisheries, Wildlife and Env Law Enforcement Rt. 135 Westboro, MA 01581
New Jersey	U.S. Fish and Wildlife Service New Jersey Field Office 927 North Main Street, Bldg. D-1 Pleasantville, NJ 08232	New Jersey Division of Fish and Wildlife Endangered and Nongame Species Program 143 Van Syckels Road Hampton, NJ 08827
New York	U.S. Fish and Wildlife Service 3817 Luker Road Cortland, NY 13045	New York Natural Heritage Program 625 Broadway, 5th Floor Albany, NY 12233-4757 Phone: (518) 402-8935 <i>(info about presence of bog turtles in or near a project area)</i>  NYS Department of Environmental Conservation Division of Fish, Wildlife, and Marine Resources Special Licenses Unit 600 Broadway, 5th Floor Albany, NY 12233-4752 <i>(for endangered species permit applications)</i>
Pennsylvania	U.S. Fish and Wildlife Service Pennsylvania Field Office 315 South Allen Street, Suite 322 State College, PA 16801	Natural Diversity Section Pennsylvania Fish and Boat Commission 450 Robinson Lane Bellefonte, PA 16823



**BOG TURTLE COUNTIES OF OCCURRENCE OR LIKELY OCCURRENCE<sup>1</sup>**  
*(April 2006)*

STATE	COUNTY	
Connecticut	Fairfield	Litchfield
Delaware	New Castle	
Maryland	Baltimore Carroll	Cecil Harford
Massachusetts	Berkshire	
New Jersey	Burlington Gloucester Hunterdon Middlesex Monmouth Morris	Ocean Salem Somerset Sussex Union Warren
New York	Albany Columbia Dutchess Genesee Orange Oswego Putnam	Seneca Sullivan Ulster Wayne Westchester
Pennsylvania	Adams Berks Bucks Chester Cumberland Delaware Franklin	Lancaster Lebanon Lehigh Monroe Montgomery Northampton Schuylkill York

<sup>1</sup> *This list is valid for one year from the date indicated. It may, however, be revised more frequently if new counties of occurrence are documented. Updates to this list are available from the Service upon request.*

## **Attachment L-6**

### **Bog Turtle Pre-construction Survey Protocol**

## APPENDIX L-6

### NiSource HCP Bog Turtle Pre-Construction Survey Protocol (revised April 1, 2009)

The purpose of a pre-construction survey is to find bog turtles within a proposed work area and move them to a safer location before work begins. Because bog turtles are small, cryptic and shy, it is not likely that all bog turtles will be found within a search area, unless the search area is relatively small and is thoroughly searched. Pre-construction surveys will be most effective in non-mucky<sup>1</sup> areas of the wetland, since turtles cannot escape into firm soils. However, they may still evade surveyors by hiding under dense wetland vegetation or by moving back into areas that have already been searched. While pre-construction surveys are not always effective in avoiding take, they are considering a viable option to reduce take, especially in non-mucky portions of the wetland or in small, isolated mucky areas<sup>2</sup>.

Pre-construction surveys will be done by qualified bog turtle surveyors. Lists of qualified surveyors are available from the Fish and Wildlife Service Field Office in the State in which the survey is proposed.

Pre-construction surveys will be done between April 15 and September 15, which approximates the bog turtle active season. Surveys are likely to be most effective between April 15 and May 30, when bog turtles are quite active and wetland vegetation is not as dense as it is later in the growing season.

#### Survey Methods

1. Clearly mark the full extent of the proposed disturbance area<sup>3</sup>.
2. Where wetland vegetation is dense and difficult to search, consider cutting wetland vegetation to a height of approximately 6-8 inches using a mower or weed-eater and raking away this vegetation.
3. Thoroughly search the proposed disturbance area. Visual pre-construction surveys will take anywhere from several hours to a few days, depending upon the size of the area to be searched.
4. If a bog turtle is found in the proposed disturbance area, collect and record appropriate turtle data in accordance with Service and State requirements. Hold the turtle in an appropriate container with 1-2 inches of water in a safe, shaded location on-site until the pre-construction survey is complete for that day.

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<sup>1</sup> "Non-mucky" refers to soils that only be probed (e.g., with a blunt tool handle) to a depth of less than 3 inches.

<sup>2</sup> "Mucky" refers to soft, saturated soils that can be probed (e.g., with a blunt tool handle) to a depth of at least 3 inches. In this case, it does NOT refer to a specific wetland soil type(s) or classification.

<sup>3</sup> The disturbance area includes all areas that will be affected by any type of construction or heavy equipment use, including, but not limited to, temporary roads, staging areas, construction areas, temporary fill or stockpiling areas, areas where timber mats will be placed, etc.

5. Immediately following the first pre-construction survey (*i.e.*, the same day), install silt fencing to isolate the work area from the remainder of the wetland (see AMM # ). The purpose of this fencing is two-fold – to keep bog turtles from entering the disturbance area, and to keep sediment from entering the undisturbed portion of the wetland.
6. Once silt fencing has been installed, release any bog turtles that were found during the pre-construction survey into appropriate habitat in the same wetland, outside the fenced area.
7. Before beginning any work activities within the fenced area, conduct a second pre-construction survey within the next 1-2 days and move any bog turtles to wetland habitat outside the fenced area.
8. If 2500 ft<sup>2</sup> (*e.g.*, 50 x 50 ft) or more of the proposed disturbance area is “mucky”, conduct at least 10 days of trapping in the fenced area using a trapping density of at least 20 traps/acre to locate bog turtles and remove them from the disturbance area. Trapping will be done by Service-approved surveyors with appropriate permits and authorizations.
9. Once the second pre-construction survey is complete (#7) and the trapping survey is complete (#8), work activity within the fenced area may begin.
10. If the silt fencing is breached during the bog turtle active season (between April 15 and September 15), immediately repair the breach and conduct another pre-construction survey within the fenced area before resuming any work.
11. Within 30 days, provide the Service and appropriate State wildlife agency with copies of all field forms and data sheets documenting bog turtle captures.

**Attachment L-7**

**Bog Turtle Recovery Plan - Appendix A April 18, 2001**

## APPENDIX A

### BOG TURTLE CONSERVATION ZONES

(revised April 18, 2001)

Projects in and adjacent to bog turtle habitat can cause habitat destruction, degradation, and fragmentation. Of critical importance is evaluating the potential direct and indirect effects of activities that occur in or are proposed for upland areas adjacent to bog turtle habitat. Even if the wetland impacts from an activity are avoided (i.e., the activity does not result in encroachment into the wetland), activities in adjacent upland areas can seriously compromise wetland habitat quality, fragment travel corridors, and alter wetland hydrology, thereby adversely affecting bog turtles.

The following bog turtle conservation zones have been designated with the intent of protecting and recovering known bog turtle populations within the northern range of this species. The conservation suggestions for each zone are meant to guide the evaluation of activities that may affect high-potential bog turtle habitat, potential travel corridors, and adjacent upland habitat that may serve to buffer bog turtles from indirect effects. *Nevertheless, it is important to recognize that consultations and project reviews will continue to be conducted on a case-by-case basis, taking into account site- and project-specific characteristics.*

#### *Zone 1*

This zone includes the wetland and visible spring seeps occupied by bog turtles. Bog turtles rely upon different portions of the wetland at different times of year to fulfill various needs; therefore, this zone includes the entire wetland (the delineation of which will be scientifically based), not just those portions that have been identified as, or appear to be, optimal for nesting, basking or hibernating. In this zone, bog turtles and their habitat are most vulnerable to disturbance, therefore, the greatest degree of protection is necessary.

Within this zone, the following activities are likely to result in habitat destruction or degradation and should be avoided. These activities (not in priority order) include:

- ▶ development (e.g., roads, sewer lines, utility lines, storm water or sedimentation basins, residences, driveways, parking lots, and other structures)
- ▶ wetland draining, ditching, tiling, filling, excavation, stream diversion and construction of impoundments
- ▶ heavy grazing
- ▶ herbicide, pesticide or fertilizer application<sup>1</sup>
- ▶ mowing or cutting of vegetation<sup>1</sup>
- ▶ mining
- ▶ delineation of lot lines (e.g., for development, even if the proposed building or structure will not be in the wetland)

Some activities within this zone may be compatible with bog turtle conservation but warrant careful evaluation on a case-by-case basis:

- light to moderate grazing
- non-motorized recreational use (e.g., biking, hunting, fishing)

### Zone 2

The boundary of this zone extends *at least 300 feet* from the edge of Zone 1 and includes upland areas adjacent to Zone 1. Activities in this zone could indirectly destroy or degrade wetland habitat over the short or long-term, thereby adversely affecting bog turtles. In addition, activities in this zone have the potential to cut off travel corridors between wetlands occupied or likely to be occupied by bog turtles, thereby isolating or dividing populations and increasing the risk of turtles being killed while attempting to disperse. Some of the indirect effects to wetlands resulting from activities in the adjacent uplands include: changes in hydrology (e.g., from roads, detention basins, irrigation, increases in impervious surfaces, sand and gravel mining); degradation of water quality (e.g., due to herbicides, pesticides, oil and salt from various sources including roads, agricultural fields, parking lots and residential developments); acceleration of succession (e.g., from fertilizer runoff); and introduction of exotic plants (e.g., due to soil disturbance and roads). This zone acts as a filter and buffer, preventing or minimizing the effects of land-use activities on bog turtles and their habitat. This zone is also likely to include at least a portion of the groundwater recharge/supply area for the wetland.

Activities that should be avoided in this zone due to their potential for adverse effects to bog turtles and their habitat include:

- development (e.g., roads, sewer lines, utility lines, storm water or sedimentation basins, residences, driveways, parking lots, and other structures)
- mining
- herbicide application<sup>1</sup>
- pesticide or fertilizer application
- farming (with the exception of light to moderate grazing - see below)
- certain types of stream-bank stabilization techniques (e.g., rip-rapping)
- delineation of lot lines (e.g., for development, even if the proposed building or structure will not be in the wetland)

Careful evaluation of proposed activities on a case-by-case basis will reveal the manner in which, and degree to which activities in this zone would affect bog turtles and their habitat. Assuming impacts within Zone 1 have been avoided, evaluation of proposed activities within Zone 2 will often require an assessment of anticipated impacts on wetland hydrology, water quality, and habitat continuity.

Activities that are likely to be compatible with bog turtle conservation but that should be evaluated on a case-by-case basis within this zone include:

- ▶ light to moderate grazing
- ▶ non-motorized recreational use (e.g., hiking, hunting, fishing)
- ▶ mowing or cutting of vegetation

### Zone 3

This zone includes upland, wetland, and riparian areas extending either to the geomorphic edge of the drainage basin or at least one-half mile beyond the boundary of Zone 2. Despite the distance from Zone 1, activities in these areas have the potential to adversely affect bog turtles and their habitat. This particularly applies to activities affecting wetlands or streams connected to or contiguous with Zone 1, because these areas may support undocumented occurrences of bog turtles and/or provide travel corridors. In addition, some activities (e.g., roads, groundwater withdrawal, water/stream diversions, mining, impoundments, dams, “pump-and-treat” activities) far beyond Zone 1 have the potential to alter the hydrology of bog turtle habitat, therefore, another purpose of Zone 3 is to protect the ground and surface water recharge zones for bog turtle wetlands. Where the integrity of Zone 2 has been compromised (e.g., through increases in impervious surfaces, heavy grazing, channelization of stormwater runoff), there is also a higher risk of activities in Zone 3 altering the water chemistry of bog turtle wetlands (e.g., via nutrient loading, sedimentation, and contaminants).

Activities occurring in this zone should be carefully assessed in consultation with the Fish and Wildlife Service and/or appropriate State wildlife agency to determine their potential for adverse effects to bog turtles and their habitat. Prior to conducting activities that may directly or indirectly affect wetlands, bog turtles and/or bog turtle habitat surveys should be conducted in accordance with accepted survey guidelines.

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<sup>1</sup> Except when conducted as part of a bog turtle habitat management plan approved by the Fish and Wildlife Service or State wildlife agency



## **Attachment L-8**

### **Karst Monitoring Protocols**

## KARST FEATURE MONITORING PROTOCOLS

The purpose of this section is to establish a standard set of monitoring protocols for karst features occurring within the range of the Madison Cave Isopod (MCI) encompassed by the NiSource Gas Transmission Pipeline Right of Way (ROW) and adjacent areas. The intent of these protocols is to minimize impact to the habitat of the MCI, by preventing the intrusion of unfiltered surface water, contaminants, and sediment into the phreatic aquifer via transport through open surface conduits located in the epikarst stratum.

### **I. Definitions**

1. **Karst Specialist** – A Certified Professional Geologist engaged in the practice of engineering geology (or) a Virginia Registered Professional Engineer engaged in the practice of Geotechnical Engineering, with a minimum of 5 years experience in karst geology and remediation. Practice experience shall be verified by a statement of qualifications (e.g. resume, CV, project experience, etc.).
2. **Cave** – A natural hole in the ground, large enough for human entry is probably the most useful definition. This covers the enormous variety of caves that do occur, but eliminates the many artificial tunnels and galleries incorrectly named caves. The size criterion is arbitrary and subjective, but practical, as it eliminates narrow openings irrelevant to explorers but very significant hydrologically, that may be better referred to as *proto-caves*, *sub-conduits* or *fissures*. A cave may be a single, short length of accessible passage, or an extensive and complex network of tunnels as long as hundreds of kilometers.
3. **Doline; Sinkhole** – A basin- or funnel-shaped hollow or depression in limestone, ranging in diameter from a few meters up to a kilometer and in depth from a few to several hundred meters. Some dolines are gentle grassy hollows or depressions; others are rocky cliff-bounded basins. A distinction may be made by direct solution of the limestone surface zone, (solution dolines), and those formed by collapse over a cave, (collapse dolines), but it is generally not possible to establish the origin of individual examples. Generally referred to as a "sinkhole" in the United States, the term doline is more widely accepted by the international geology community.
4. **Throat** – An opening within a sinkhole leading into the subsurface, too small to qualify as a cave and often called a *proto-cave*, *sub-conduit* or *fissure*. Throats may be "open" (i.e. air-filled or water-filled), or "closed/clogged" (filled with debris including but not limited to: loose-soil; gravel; rock; dead-fall wood or brush; trash).
5. **Parapet** – The outer edge or perimeter of a doline (sinkhole).

6. **Ponor** – 1. Hole or opening in the bottom or side of a depression where a surface stream or lake flows either partially or completely underground into the karst groundwater system. 2. Hole in the bottom or side of a doline through which water passes to or from an underground channel. Also known as a swallow hole.
7. **Solution Cavity** – A natural cavity or depression formed by the dissolution of soluble bedrock, typically not large enough to allow the entry of a human being and therefore not classified as a cave.
8. **Breccia** - Angular fragments of rock commonly, but not inevitably, cemented by finer-grained materials including silica, iron minerals, and calcite to form a new rock. Many fault planes are marked by zones of broken rock, either loose or re-cemented, forming a fault breccia.
9. **Non-Karst Closed Depression** – A natural or non-natural topographic depression that is not formed by karst processes and is not floored by bedrock. Examples include (but are limited to) construction-related soil subsidence, silage pits, farm ponds, scour pools, animal wallows, large animal burrows, and pits created by removal of tree stumps.

## **II. Inspection Protocols**

**Pre-Construction Inspection** – Prior to the commencement of any earth disturbance activity, the area of the pipeline that will be affected by the planned activities shall be inspected by the karst specialist (KS) as follows:

- a. The KS will walk the entire section of the pipeline ROW in the designated work area, and note any suspect karst features including sinkholes, caves, areas of soil subsidence or closed depressions.
- b. The locations of any observed features shall be noted on site drawings and flagged for surveying and/or recorded using sub-meter accuracy GPS instrumentation.
- c. The KS will issue a report summarizing the findings of the inspection, with specific reference to the potential impact of any observed features to the MCI habitat. Findings shall include an inventory of feature type(s), drainages, potential impact to the feature by the planned activities, and recommendations to limit impacts if they are expected.
- d. Features that are considered to have potential impact to the MCI habitat are: caves, sinkholes with throats, ponors, open solution cavities, abandoned wells, and sinking streams. (Note – If a sinkhole throat is filled, the type of fill, i.e. rock, soil, flood debris, etc. shall be described in detail).
- e. Features that are not considered to have an impact to the MCI habitat are: soil-bottomed (stable) sinkholes (i.e. no evidence of recent soil raveling or tension cracks along the parapet), karst springs, or non-karst closed depressions.

- f. The pre-construction inspection will have a “shelf-life” of 1 year from the day of the inspection. If work does not commence within 1 year, a new inspection must be completed prior to any earth disturbing activities.
- g. The pre-construction inspection report shall be delivered to NiSource and the USFWS no later than 1-month after the completion of field survey.

**Monitoring of Pre-Identified Features During Construction** – Features identified during the pre-construction inspection shall be monitored as follows:

- a. If an identified feature with potential impact to the MCI habitat falls within the area designated for earth disturbing activities, the feature will be documented by field location and with photographs, and then assessed for pre-construction remediation by the NiSource Engineering staff with input and guidance to be provided by the KS.
- b. If a feature that has potential impact to the MCI falls within the ROW but is not intercepted by the work, that feature shall be monitored during the work by NiSource staff for any changes such as:
  - 1. soil subsidence
  - 2. rock collapse
  - 3. sedimentation
  - 4. increased surface water infiltration
  - 5. flooding
  - 6. cloggingOr any other changes in morphology or function that might indicate potential impact to the epikarst stratum caused by the work.
- c. All features, whether remediated or left in an undisturbed natural state, shall be monitored by NiSource staff for any changes in appearance, drainage, siltation, etc. at 1 year, 2 years, and 5 year intervals after the completion of the earth disturbing activities. If any changes are observed, NiSource staff will report the condition to the KS, who will provide consult on potential impacts to the MCI habitat and remedial actions, accordingly.

**Monitoring of Features that are intercepted during Construction** – Features that are intercepted during construction shall be monitored as follows:

Level 1 Inspection of Features intercepted during construction – If any feature is intercepted during work activities including drilling, blasting, and excavation or trenching, the NiSource staff will conduct an initial assessment of the feature to determine if further inspection (Level 2) by the KS will be required. Suspect features shall include:

1. Bedrock enclosed conduits or voids;
2. Solution pockets that extend beyond visual examination range (and therefore may be open);
3. Areas of soft soils;
4. Soil voids;
5. Highly fractured bedrock;
6. Areas of breccia enclosed within the surrounding bedrock.

Level 2 Inspection of Features intercepted during construction – If any of the aforementioned features are observed during the Level 1 inspection, work will stop within a 100-foot radius of the feature, and then the KS will conduct a Level 2 Inspection as follows:

- a. The KS will examine the feature and determine if it has potential impact to the MCI habitat based on potential connectivity with the phreatic aquifer via the epikarst stratum. The choice of characterization methods shall be determined by the KS, and shall include any combination of (but not be limited to):
  1. visual assessment;
  2. electrical resistivity survey;
  3. track drill probes;
  4. infiltration testing;
  5. or other techniques utilized to facilitate subsurface characterization of karst features.
- b. If the feature is determined to have potential impact to the MCI habitat, the KS will advise the NiSource Engineering staff regarding appropriate remedial actions.
- c. If the feature is determined to not have potential impact to the MCI habitat, work will resume as planned.
- d. All features that are intercepted during construction and subsequently remediated shall be located by the NiSource engineering staff surveyors exclusively, and monitored by NiSource staff for any changes in appearance, drainage, siltation, etc. at 1 year, 2 years, and 5 year intervals after the completion of the earth disturbing activities. If any changes are observed, the KS will provide consult on potential impact to the MCI habitat and remedial actions, if necessary.
- e. All Level 2 inspections, findings and remedial activity shall be summarized in a report by the KS, to be delivered to NiSource and the USFWS after the completion of the field work.

**Monitoring of Features that form during Construction** – Features that form during construction shall be monitored as follows:

Level 1 Inspection of Features that form during construction – If any feature forms during work activities including hydro-testing, drilling, blasting, and excavation or trenching, the NiSource staff will conduct an initial assessment of the feature to determine if further inspection (Level 2) by the KS will be required. Suspect features shall include:

1. Sinkholes;
2. Soil subsidence areas;
3. Rock collapses.

This shall apply to any of the above features that may form either within the work area, whether located along the proposed disturbance section or anywhere within the covered lands within a 100-yard radius the work area.

Level 2 Inspection of Features that form during construction – If any of the aforementioned features are observed during the Level 1 inspection, work will stop in the area of the feature, and then the KS will conduct a Level 2 Inspection as follows:

- a. The KS will examine the feature and determine if it has potential impact to the MCI habitat based on potential hydraulic connectivity with the phreatic aquifer via the epikarst stratum.
- b. The choice of characterization methods shall be determined by the KS, and shall include any combination of (but not be limited to):
  1. visual assessment;
  2. electrical resistivity survey;
  3. track drill probes;
  4. infiltration testing;
  5. or other techniques utilized to perform subsurface characterization of karst features.
- c. If the feature is determined to have potential impact to the MCI habitat, the KS will consult with the NiSource Engineering staff regarding appropriate remedial actions.
- d. If the feature is determined to not have potential impact to the MCI habitat, work will commence as planned.
- e. All features that form during construction, whether remediated or left in an undisturbed natural state, shall be located on the site plans by the NiSource engineering staff surveyors, and shall be monitored by NiSource staff for any changes in appearance, drainage, siltation, etc. at 1 year, 2 years, and 5 year intervals after the completion of the earth disturbing activities. If any changes are observed, the KS will provide consult on potential impact to the MCI habitat and remedial actions, if necessary. This

monitoring shall be carried out on all features that form during work activities, regardless of whether they have a potential impact to the MCI habitat or not.<sup>1</sup>

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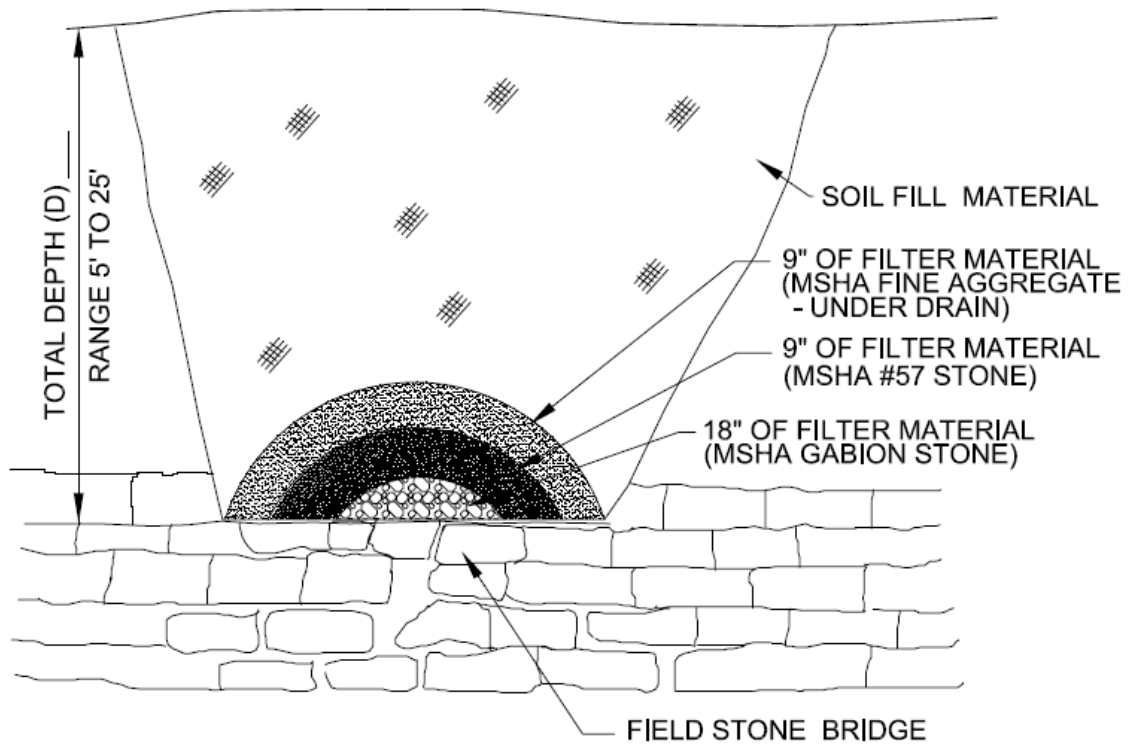
<sup>1</sup>The monitoring of any feature that forms during work is critical, in that there may be no opening to the subsurface (i.e. open throat) when it first forms, but subsequently an opening may appear that will require remedial actions.

## **Attachment L-9**

### **Figure 6.2.3.3\_2 Sinkhole Mitigation Procedures**



MARYLAND STANDARDS FOR AGRICULTURAL BMPs  
 DETAIL 725-A - SINKHOLE TREATMENT



NOTE:  
 A NONWOVEN GEOTEXTILE MEETING MSHA CLASS SE  
 MAY BE SUBSTITUTED FOR THE MSHA #57 STONE  
 AND MSHA FINE AGGREGATE.

## SINKHOLE TREATMENT

( DRAINAGE AREA LESS THAN 5 ACRES)

725-A-INV FILTER.DWG

NTS

U.S. DEPARTMENT OF AGRICULTURE  
 NATURAL RESOURCES CONSERVATION SERVICE  
 MARYLAND

725-A-INV FILTER.DWG  
 6/03

MARYLAND DEPARTMENT OF AGRICULTURE  
 MARYLAND SOIL CONSERVATION DISTRICTS

Figure 6.2.3.3-2 Sinkhole Mitigation Procedures

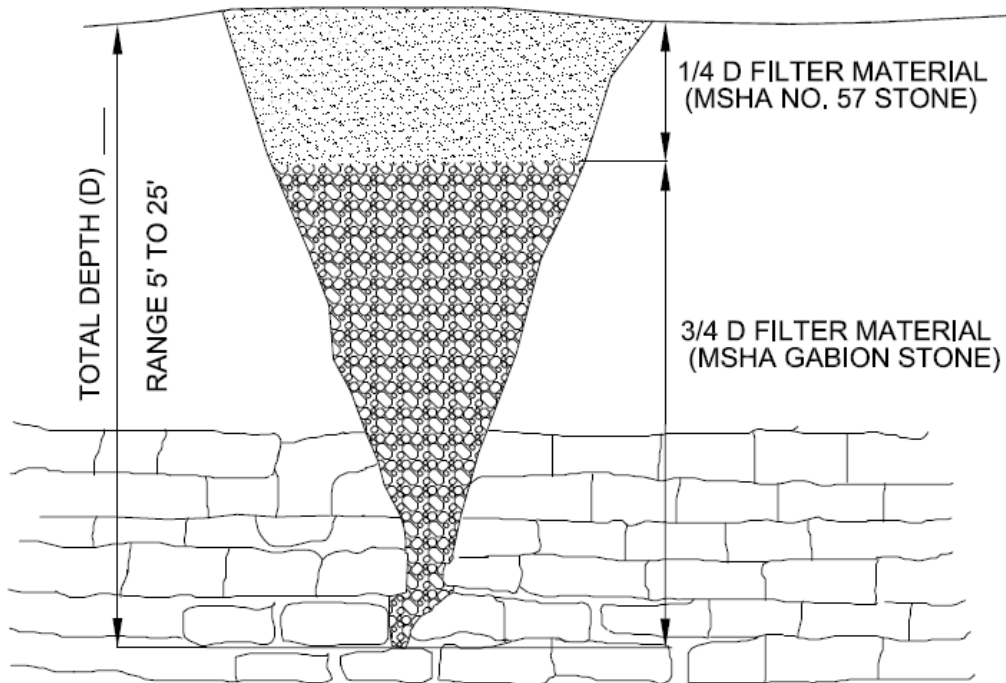
## **Attachment L-10**

### **Figure 6.2.3.3\_3 Sinkhole Mitigation Procedures**

## **Attachment L-11**

### **Figure 6.2.3.3\_4 Sinkhole Mitigation Procedures**

MARYLAND STANDARDS FOR AGRICULTURAL BMPS  
DETAIL 725-B - SINKHOLE TREATMENT



## SINKHOLE TREATMENT

( DRAINAGE AREA 5-15 ACRES)

725-B - INV FILTER.DWG

NTS

U.S. DEPARTMENT OF AGRICULTURE  
NATURAL RESOURCES CONSERVATION SERVICE  
MARYLAND

725-B-INV FILTER.DWG  
6/03

MARYLAND DEPARTMENT OF AGRICULTURE  
MARYLAND SOIL CONSERVATION DISTRICTS

Figure 6.2.3.3-3 Sinkhole Mitigation Procedures

DATE  
REVISED

DATE  
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REVISED

DATE  
REVISED

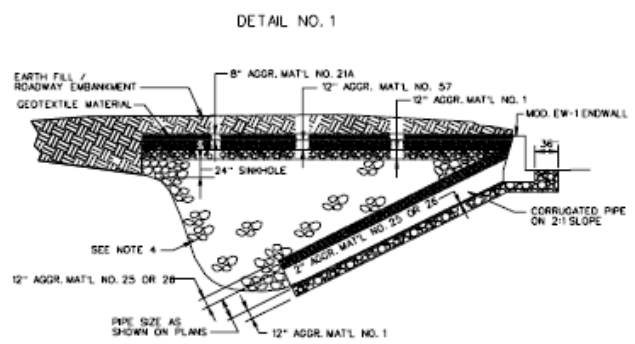
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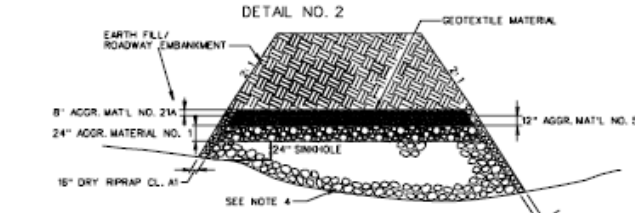
DATE  
REVISED

DESIGN FEATURES RELATING TO CONSTRUCTION OR TO REGULATION AND CONTROL OF TRAFFIC MAY BE SUBJECT TO CHANGE AS DEEMED NECESSARY BY THE DEPARTMENT

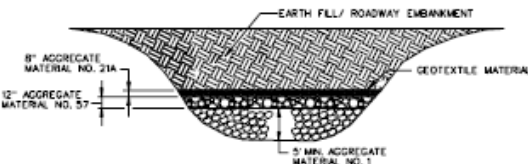
NO.	DATE	BY	CHKD.	APP.	REVISION



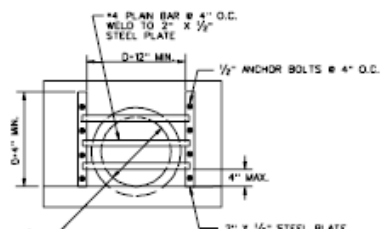
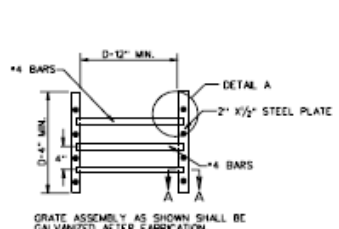
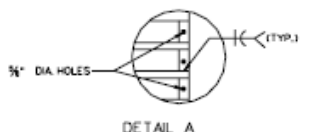
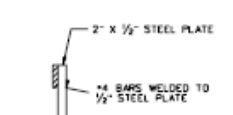
REMOVE ALL FOREIGN MATTER INCLUDING TRASH, REFUSE OR OTHER WASTE MATERIALS. EXCAVATE THE BOTTOM OF THE SINK TO ROCK. EXCAVATE THE SIDES BACKWARD AND TOWARD 10% OF FILL SLOPE TO AN ANGLE OF REFUSE OF 2:1 (2:1 SLOPE) FROM THE BOTTOM PLANE OF THE SINK. INSTALL A PIPE OF SUFFICIENT LENGTH TO INSURE POSITIVE DRAINAGE INTO THE SINK AT THE 10% OF FILL SLOPE. BED THE PIPE WITH 12" OF AGGREGATE MATERIAL NO. 1 OVERLAPPED BY 2" OF AGGREGATE MATERIAL NO. 25 OR 26 FOR A LEVELING COURSE. PLACE 12" AGGREGATE MATERIAL NO. 25 OR 26 ALONG THE SIDES AND TOP OF THE PIPE FOR PROTECTION AGAINST THE BACKFILL. BACKFILL WITH DRY RP RAP CLASS #1 TO A HEIGHT OF 24" ABOVE ORIGINAL GROUND AS SHOWN. CAP WITH 12" AGGREGATE MATERIAL NO. 1, 12" AGGREGATE NO. 57 AND 8" AGGREGATE MATERIAL NO. 21A. OVERLAY AGGREGATE MATERIAL WITH GEOTEXTILE MATERIAL AND BACKFILL WITH EARTH FILL AS NEEDED.



REMOVE ALL FOREIGN MATTER INCLUDING ALL VEGETATION, TRASH, REFUSE OR OTHER WASTE MATERIALS. EXCAVATE ALL UNSTABLE SOILS FROM THE SIDES AND BOTTOM OF THE SINK. BACKFILL WITH DRY RP RAP CLASS #1 TO A HEIGHT OF 24" ABOVE THE SURFACE DRAINAGE LINE. CAP WITH 24" AGGREGATE MATERIAL NO. 1, 12" AGGREGATE MATERIAL NO. 57 AND 8" AGGREGATE MATERIAL NO. 21A. A HEAVY VIBRATOR SHALL BE USED TO STABILIZE THE RP RAP AND THE AGGREGATE MATERIAL. AS EACH COURSE IS PLACED, PLACE A LAYER OF GEOTEXTILE MATERIAL ABOVE THE AGGREGATE MATERIAL COURSE. EARTH FILL IS TO BE PLACED ABOVE THE GEOTEXTILE FABRIC AS NEEDED. OVERLAY EXPOSED RP RAP WITH AGGREGATE FILL SLOPES WITH 10" DRY RIPRAP CLASS #1.



TREATMENT SHALL INCLUDE CLEARING AND DRIBBLING, STRIPPING TOPSOIL AND REMOVING EXCESS ORGANIC MATERIAL. ALL FOREIGN MATTER INCLUDING TRASH, WHITE GOODS AND OTHER REFUSE OR WASTE MATERIALS SHALL BE REMOVED. STRIPPED SINKHOLE SHALL BE BACKFILLED WITH A MINIMUM OF 5" DEPTH OF NO. 1 AGGREGATE OVERLAP WITH 12" OF NO. 57 AGGREGATE AND 8" OF AGGREGATE MATERIAL NO. 21A. AGGREGATE SHALL BE OVERLAP WITH A GEOTEXTILE MATERIAL.



FOR USE ON STANDARD EW-1

- GENERAL NOTES
1. PRIOR TO ANY SINKHOLE EXCAVATION THE CONTRACTOR SHALL CONTACT THE DISTRICT MATERIALS ENGINEER.
  2. EACH SINKHOLE SHOULD BE TREATED ON AN INDIVIDUAL, SITE SPECIFIC BASIS DEPENDING ON THE CONDITIONS IN THE AREA.
  3. CONSECUTIVE LAYERS OF AGGREGATE SHALL BE PLACED IN SUCH A MANNER AS TO PREVENT FUTURE MIGRATION OF SMALLER STONES INTO LARGER STONES.
  4. WHEN THE DEPTH OF A SINKHOLE OR A DEPRESSION IS LESS THAN 10', AGGREGATE MATERIAL NO. 1 SHALL BE USED FOR BACKFILL IN LIEU OF DRY RP RAP. THE AGGREGATE MATERIAL NO. 1 SHALL EXTEND TO A HEIGHT OF 24" ABOVE THE SURFACE DRAINAGE LINE. THE AGGREGATE MATERIAL NO. 1 SHALL BE CAPPED WITH NO. 57 AGGREGATE, NO. 21A AGGREGATE, AND GEOTEXTILE MATERIAL AS NOTED ON THE APPLICABLE DETAIL.
  5. EXCAVATION NECESSARY FOR PLACEMENT OF THE SINKHOLE FILL SHALL BE MEASURED AND PAID FOR AS REGULAR EXCAVATION IN ACCORDANCE WITH THE SECTION 205 OF THE SPECIFICATIONS. ALL OTHER MATERIAL SHALL CONFORM TO AND BE MEASURED AND PAID FOR IN ACCORDANCE WITH THE APPLICABLE SECTIONS.
  6. GEOTEXTILE MATERIAL SHALL CONFORM TO SECTION 245.03(B) OF THE SPECIFICATIONS.
  7. BASIS OF PAYMENT FOR SPECIAL DESIGN GRATE WILL BE MEASURED AND PAID FOR AT THE CONTRACT UNIT PRICE PER EACH. THIS PRICE SHALL INCLUDE ALL COST FOR FURNISHING THE FABRICATED GRATE AND ITS INSTALLATION. ALL HARDWARE, EQUIPMENT, LABOR, TOOLS, GALVANIZING AND INCIDENTALS NECESSARY TO COMPLETE THE WORK SHALL BE INCLUDED IN THE UNIT PRICE PER EACH COST.

NEW 11/02  
SPECIAL DESIGN SECTION  
DRAWING NO. 2344

DATE	BY	CHKD.	APP.

SINKHOLE TREATMENT DETAILS

Figure 6.2.3.3-4 Sinkhole Mitigation Procedures

## **Attachment L-12**

### **Figure 6.2.3.3\_5 Sinkhole Mitigation Procedures**

NO. 1000

NO. 1000

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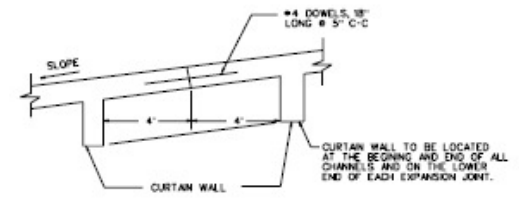
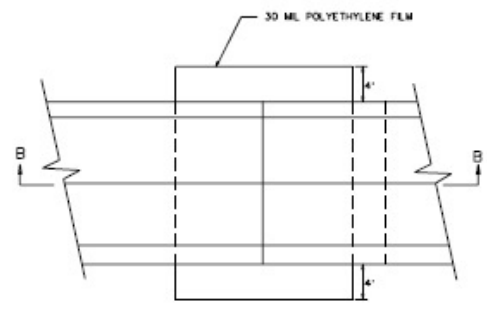
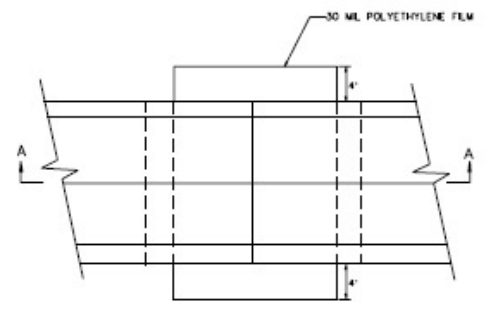
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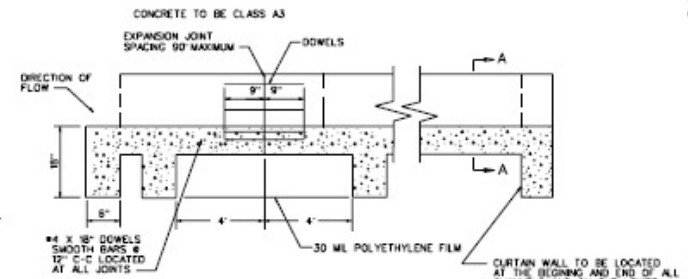
NO. 1000

NO. 1000

DESIGN FEATURES RELATIVE TO CONSTRUCTION OR TO REGULATION AND CONTROL OF TRAFFIC MAY BE SUBJECT TO CHANGE AS DEEMED NECESSARY BY THE DEPARTMENT.

SECTION A-A  
STANDARD PG-2A MODIFIED



STANDARD PG-5 MODIFIED

**BASIS OF PAYMENT**  
 STANDARD PG-2A MODIFIED AND PG-5A MODIFIED IS TO BE PAID FOR AT THE CONTRACT UNIT PRICE IN SQUARE YARDS. THE PRICE INCLUDES CLASS A3 CONCRETE, REINFORCING STEEL, 30 ML POLYETHYLENE FILM, COMPLETE IN-PLACE FURNISHING ALL MATERIALS, TOOLS, EQUIPMENT AND INCIDENTALS NECESSARY TO COMPLETE THE WORK.

NEW 11/02  
 SPECIAL DESIGN SECTION  
 DRAWING NO. 2945

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Figure 6.2.3.3-5 Sinkhole Mitigation Procedures

## **Attachment L-13**

### **WV Sinkhole Mitigation Guidance**



**West Virginia Department of Environmental Protection  
Division of Water and Waste Management  
Groundwater Protection Program**

**Sinkhole Mitigation Guidance**

**August 8, 2005**

**Purpose:**

These sinkhole mitigation designs serve to allow the filling of sinkholes while maintaining recharge to the aquifer, reducing potential contamination threats to groundwater, and eliminating safety hazards at sinkhole entries.

**General:**

Consideration should be given to the method used for removing contaminated materials from sinkholes and reducing or eliminating direct inflow of surface water into sinkholes. Land treatment methods that improve the filtration and infiltration of surface water before it enters the sinkhole should be used along with the mitigation of the sinkhole.

Before selecting a treatment option the following should be considered:

- Land use
- Existing and planned land treatment
- Sinkhole drainage area
- Dimensions of the sinkhole opening
- Safe outlet for diverted surface water
- Environmentally safe disposal of sinkhole “clean out” material
- Availability and quality of filter material
- Safety of equipment and operators and laborers during installation

Treatment selection should be based on the dimensions of the sinkhole drainage area and include direct sinkhole treatment with surface water control measures and filter strips. Whichever treatment option is chosen, it should avoid surface water ponding or the creation of high soil moisture conditions in excess of 72 hours.

Treatment designs apply to sinkholes with excavated depths of 5 to 25 feet and with drainage areas up to 15 acres. Excavations up to 5 feet are sufficient for most sinkholes. Sinkholes with excavation depths of greater than 25 feet or with uncontrolled drainage areas greater than 15 acres may require adjustments to the treatment measure(s) and/or surface water control measure(s). In these cases, geologic and engineering assistance must be obtained and a site-specific treatment design prepared.

#### **Treatment for Sinkholes with Drainage Areas Less than 5 Acres**

Treat the sinkhole using the mitigation design in Figure 1 of this guidance document. The treatment site should be inspected after periods of heavy precipitation because some material may run into adjacent sinkhole voids causing a surface depression. In this case, maintenance will include adding soil material at the surface. The existing land use or practice may continue over the treated sinkhole as long as the treatment is maintained.

#### **Treatment for Sinkholes with Drainage Areas of 5 Acres or More and Having a Safe Outlet**

The following additional treatment criteria are applicable to sinkholes with drainage areas of 5 acres or more where a safe outlet can be provided to divert surface water away from the sinkhole. A safe outlet is one that does not erode, divert surface water to another sinkhole or injection well, or cause flood damage to crops, property, buildings, or highways/roads.

Surface water control measures should be situated to reduce the internal drainage area around the sinkhole to less than 5 acres. The choice of surface water control measures is generally based on site-specific conditions.

#### **Treatment for Sinkholes with Drainage Areas of 5 to 15 acres and Having No Safe Outlet**

Treat the sinkhole using the mitigation design in Figure 2 of this guidance document. The site should be inspected after periods of heavy precipitation because some material may run into adjacent sinkhole voids causing a surface depression. In this case, maintenance will include adding soil material at the surface. The sinkhole should remain as unused land.

### **Vegetated Buffer Area**

A vegetated buffer area should be installed around the sinkhole to improve runoff water quality by filtration and adsorption of contaminants. The vegetated buffer area should be installed within the sinkhole drainage area and should begin at the treated sinkhole.

The minimum width (in feet) of the vegetated buffer area is determined by multiplying the sinkhole drainage area (in acres) by seven. This width should provide beneficial filtering for some distance outside the sinkhole because surface water runoff may be temporarily held before reaching the treated sinkhole.

Appropriate vegetation should be used for the buffer area. Use native vegetation as much as possible. **DO NOT** use noxious plants or weeds. It is recommended that a plant nursery be consulted for the appropriate vegetation.

### **Acceptable Materials**

Engineering fabric - must meet the applicable requirements of AASHTO M-288.

Aggregates – fine aggregates, gravel, or rock rip rap that conforms to the West Virginia Department of Highways, Standard Specifications for Roads and Bridges, Sections 702, 703, and 704.

### **Specifications**

Use the following guidance for installing a mitigation design for sinkholes and sinkhole areas with drainage areas of less than 5 acres:

1. Remove and properly dispose of materials dumped in and around the sinkhole in accordance with applicable federal, state, and local laws.
2. Excavate loose material from the sinkhole and try to expose the solution void(s) in the bottom. Enlarge the sinkhole, as necessary, to allow for installation of the filter material.

3. Select stone that is approximately 1.5 times larger than the solution void(s). Place the stone into the void(s) forming a competent bridge. Stone used for the bridge should have rock strength equal to, at least, moderately hard (*e.g.*, resistant to abrasion or cutting by a knife blade but can be easily dented or broken by light blows with a hammer). Shale or similar soft and non-durable rock is not acceptable.
4. Place a layer of filter material over the bridge to a minimum thickness of 24 inches. Approximately 35 percent of the material should be larger than the opening between the bridge and the void(s). There should be no discernable large openings around the bridge. The material should be either gabion stone, stone for rip rap, or stone for special rock fill that conforms to West Virginia Department of Highways, *Standard Specification Roads and Bridges*, Section 704.
5. Place a layer of smaller size filter material over the previous layer to a minimum thickness of 10 inches. The size of the material should be  $\frac{1}{4}$  to  $\frac{1}{2}$  the size of that used in the previous layer. The material should be No. 57 aggregate, which conforms to West Virginia Department of Highways, *Standard Specifications Roads and Bridges*, Sections 703.1.1, 703.1.2, 703.1.3, 704.1.4, and 703.2.1. Unacceptable filter material consists of pea gravel or slags (steel, electromagnetic, or power plant).
6. Place a layer of sand-sized filter material over the previous layer at to a minimum thickness of 10 inches. The sand must be compatible in size with the previous layer to prevent piping. The material should be fine aggregate that conforms to West Virginia Department of Highways, *Standard Specification Roads and Bridges*, Sections 702.1.1, 702.1.2, and 702.1.3.
7. Engineering fabric conforming to AASHTO M 288 may be substituted for the stone and sand filter materials discussed in 5 and 6.
8. Backfill over the top filter layer or engineering fabric with soil material to the surface. This should be mineral soil with at least 12 percent fines. Reuse soil material excavated from the sinkhole as much as possible and place any available topsoil over the backfill. Overfill by about 5 percent to allow for settling.

9. Establish vegetation on the mitigated sinkhole and other disturbed areas of the site.

Use the following guidance for installing a mitigation design for sinkholes and sinkhole areas with drainage areas of 5 to 15 acres:

1. Remove and properly dispose of materials dumped in and around the sinkhole.
2. Excavate loose material from the sinkhole.
3. Place a layer of filter material into the sinkhole, allowing the stone to fill the void(s) below the bottom of excavated sinkhole. The size should be  $\frac{1}{4}$  to  $\frac{1}{2}$  the size of the void(s). This material can be WVDOH gabion stone, rip rap stone, or special rock fill stone.
4. Place a layer of the same size filter material to a thickness of about  $\frac{3}{4}$  TD (TD = total depth) above the sinkhole bottom.
5. Place a layer of smaller size filter material over the previous layer to a thickness of about  $\frac{1}{4}$  D. Bring this layer to surface level. The size should be  $\frac{1}{4}$  to  $\frac{1}{2}$  the size of the previous layer. The material should be No. 57 aggregate, which conforms to West Virginia Department of Highways, *Standard Specification Roads and Bridges*, Sections 703.1.1, 703.1.2, 703.1.3, 703.2.1, and 704.1.4. Unacceptable stone consists of pea gravel or slags (steel, electrometallurgical, or power plant).
6. Shale or similar soft and non-durable rock is not acceptable.
7. Establish vegetation on the mitigated sinkhole and disturbed areas of the site.

### **Engineering Fabric Requirements for Subsurface Drainage**

Engineering fabric used in the mitigation of sinkholes should meet the applicable requirements of AASTHO M 288, Section 7.2

## **Engineering Fabric Installation**

Proper construction and installation techniques are essential to ensure that the intended function of the engineering fabric is fulfilled.

When sewn seams are necessary, the seam strength must be equal to or greater than 90 percent of the specified grab strength, as measured in accordance with ASTM D 4632.

When sewn seams are used for the seaming of the engineering fabric, the thread must be high strength polypropylene, or polyester. Nylon thread is unacceptable.

For Sinkhole Mitigation Design A, place the engineering fabric loosely, with no wrinkles or folds, and with no void spaces between the fabric and the bridge. Overlap successive sheets of engineering fabric a minimum of 12 inches, with the upstream sheet overlapping the downstream sheet.

Prior to covering, the engineering fabric should be inspected to ensure that it has not been damaged (*e.g.* holes, tears, rips) during installation. An engineer or the engineer's designated representative should conduct the inspection. The designated representative should be a certified field inspector.

Damaged fabric must be repaired immediately. Cover the damaged area with an engineered fabric patch that overlaps to 12 inches beyond the damaged area.

Any damaged engineering fabric that cannot be repaired shall be replaced as directed by the engineer.

Place material over the engineering fabric in such a manner as to avoid stretching and subsequently tearing the fabric. Do not drop stone and soil placement from a height greater than one meter. Do not allow stone with a mass of more than 100 kg to roll down the slope of the sinkhole.

Grading the sinkhole slope is not permitted if the grading will result in the movement of the stone directly above the engineering fabric.

## **Operation and Maintenance**

The owner/operator is responsible for maintaining the mitigated sinkhole and sinkhole area. At a minimum, the following maintenance practices should be performed:

1. Mow grass and plantings as necessary to promote vigorous growth.
2. Inspect mitigation measures at least twice a year and after all major rain events. Repairs to the sinkhole mitigation measures should be made promptly were warranted.

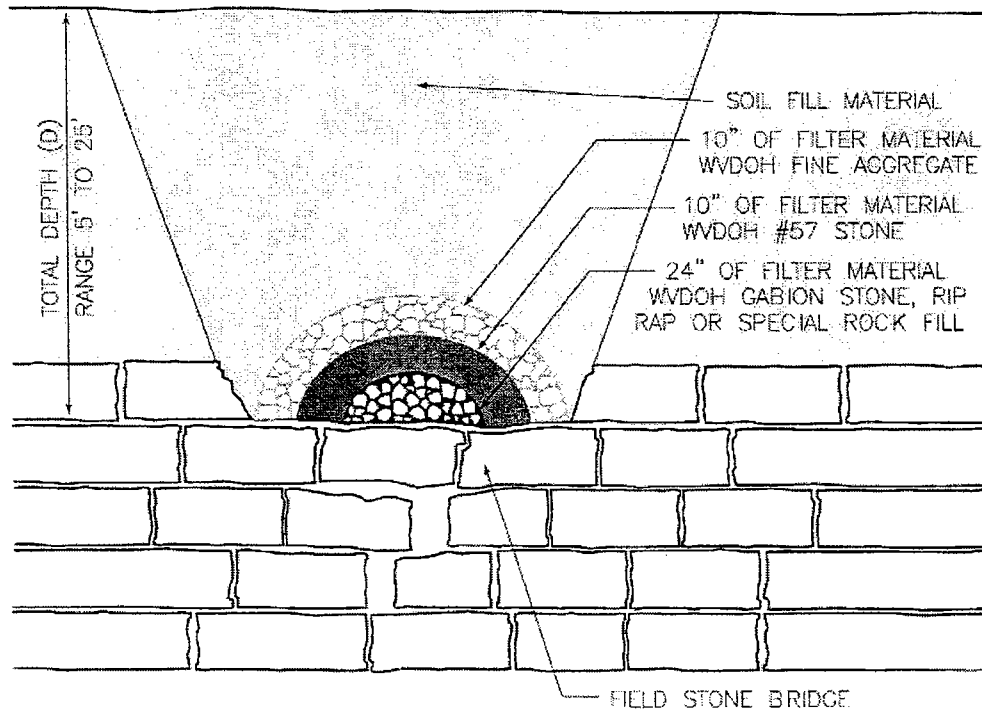
## **References:**

USDA Natural Resources Conservation Center, January 2004. *Maryland Conservation Practice Standard, Sinkhole and Sinkhole Area Treatment, Code 725.*

West Virginia Department of *Highways, Standard Specifications Roads and Bridges*, 2000, Section 702, "Fine Aggregates", Section 703, "Coarse Aggregates", Section 704, "Stone and Crushed Aggregate", Section 715, "Miscellaneous Materials".

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FIGURE 1



NOTE:  
A NONWOVEN GEOTEXTILE MEETING AASHTO M288,  
SECTIONS 7.1-7.2 MAY BE SUBSTITUTED FOR THE  
WVDOK #57 STONE AND WVDOK FINE AGGREGATE.

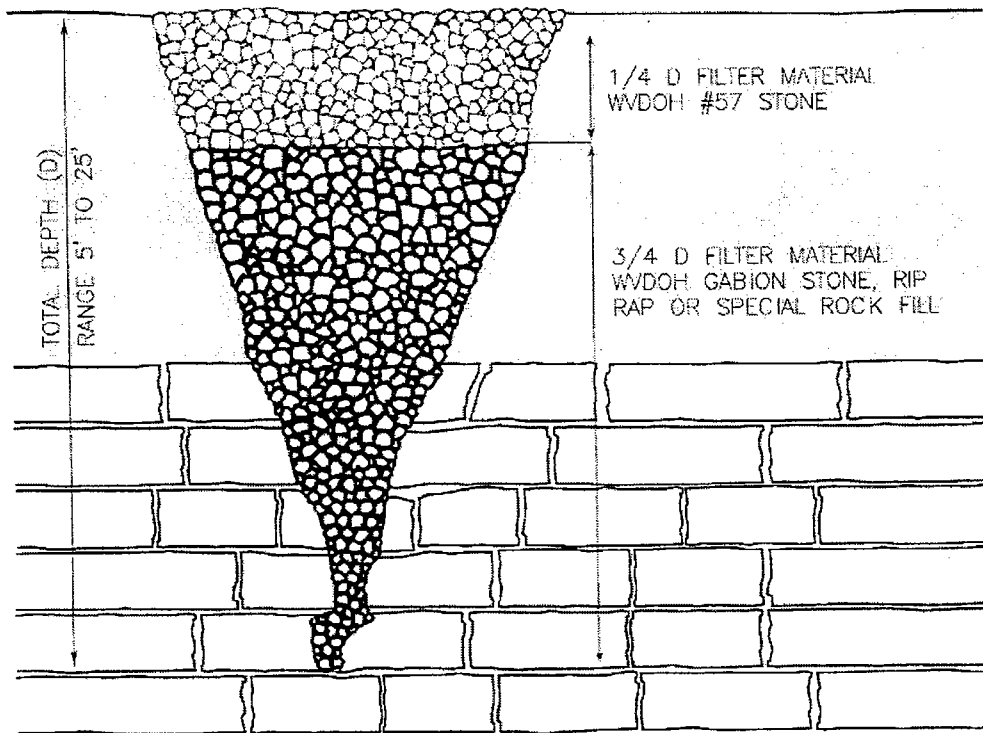
## SINKHOLE MITIGATION

(DRAINAGE AREA LESS THAN 5 ACRES)



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FIGURE 2



# SINKHOLE MITIGATION

(DRAINAGE AREA 5 TO 15 ACRES)

## **Attachment L-14**

### **Herbicide List for use in Madison Cave Isopod Habitat**

## **Appendix L-14**

### **Herbicide List for use in Madison Cave Isopod Habitat**

These protocols are currently being prepared and will be included in this MSHCP when available from the Service.

DRAFT