Appendix B

Application of WEPP-Mine to Western Alkaline Coal Mines: Simulating Impoundments

Shuhui Dun, William J. Elliot, James R. Frankenberger, Joan Wu, Dennis C. Flanagan

The ultimate goal of developing WEPP-Mine was to provide an easy-to-use, cost-effective, and reliable computer simulation package for evaluating site-specific sediment control and reclamation plans in surface coal mine operations in the western US. The impoundment component in WEPP-Mine was developed for the assessment of Best Management Practices (BMPs) that involves small hydraulic structures, such as sediment pond and silt fence, for erosion and sediment control.

In total, we developed nine templates for nine different types of commonly used hydraulic structures for erosion and sediment control and customized the template inputs to the dry climatic conditions of the western US (see the section of Impoundment inputs for WEPP simulations). These templates are (1) culvert, (2) drop spillway with circular riser and barrel, (3) drop spillway with rectangular riser and circular barrel, (4) emergency spillway, (5) filter fence, (6) perforated riser, (7) rock-fill check dam, (8) straw bales, and (9) 2'-diameter culvert for forest roads, all within or connected to a sediment pond. They are used as default impoundment settings in WEPP-Mine.

While both may be implemented at the watershed outlet, sediment ponds with drop spillway and emergency spillway are categorized, in WEPP-Mine, as large hydraulic structures, and those with culvert, perforated riser, and rock-filled check dam as small structures with no permanent pool. Impoundments formed behind a filter fence or straw bales are primarily structures for use at the foot of individual hillslopes.

“Add/Change Impoundment” appears in the list of the model setup functions after the study watershed is built and watershed summary is reviewed (see Appendix A). A sediment pond can be placed at the end of a channel segment or the foot of a hillslope (Fig. 1). Clicking the “Submit” button in the “Change Impoundment” window will complete the selection (Fig. 2). A user can also bring in the “View and Edit Impoundment Inputs” window by clicking the “View Impoundment Parameters” button (Fig. 3).

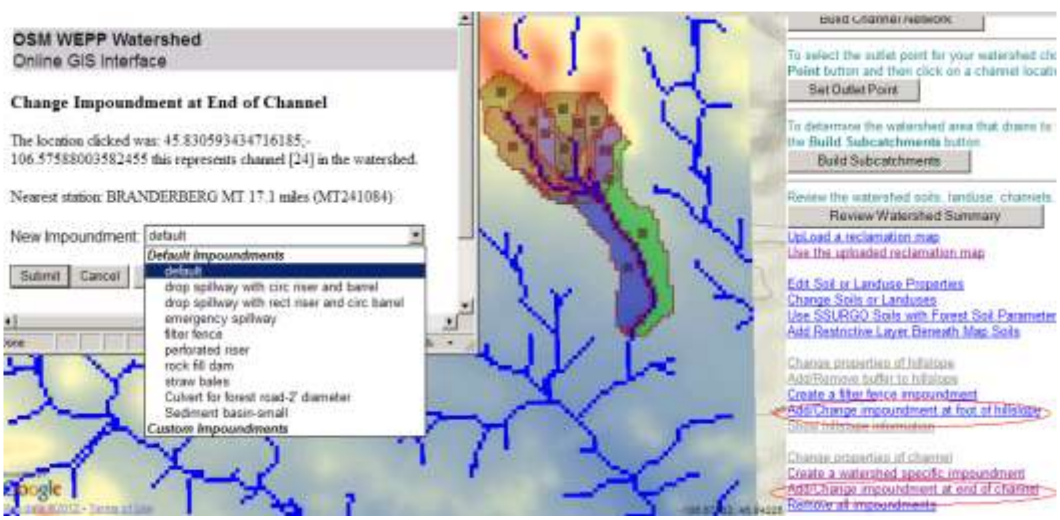

Fig. 1. Adding a hydraulic structure at the end of a channel segment or the foot of a hillslope

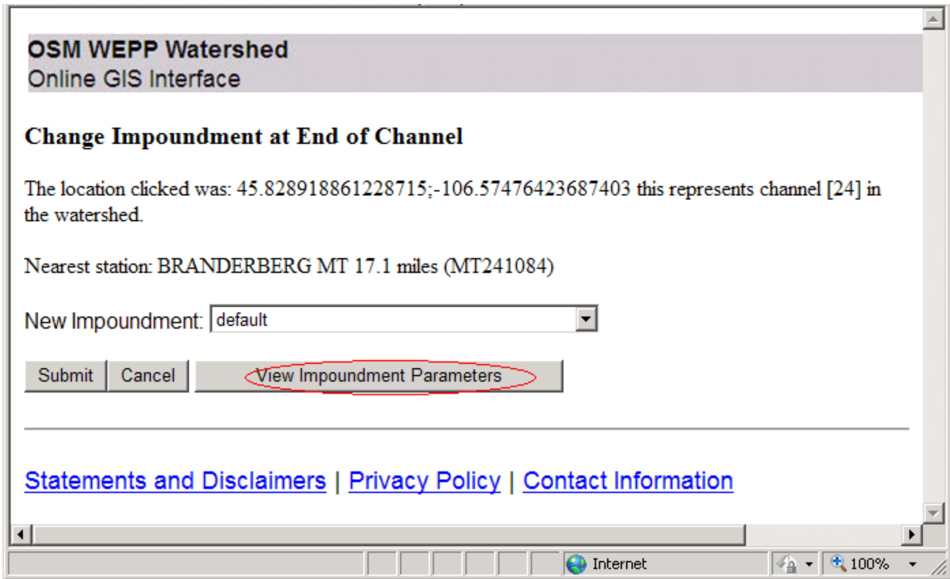

Fig. 2. The “Change Impoundment” window

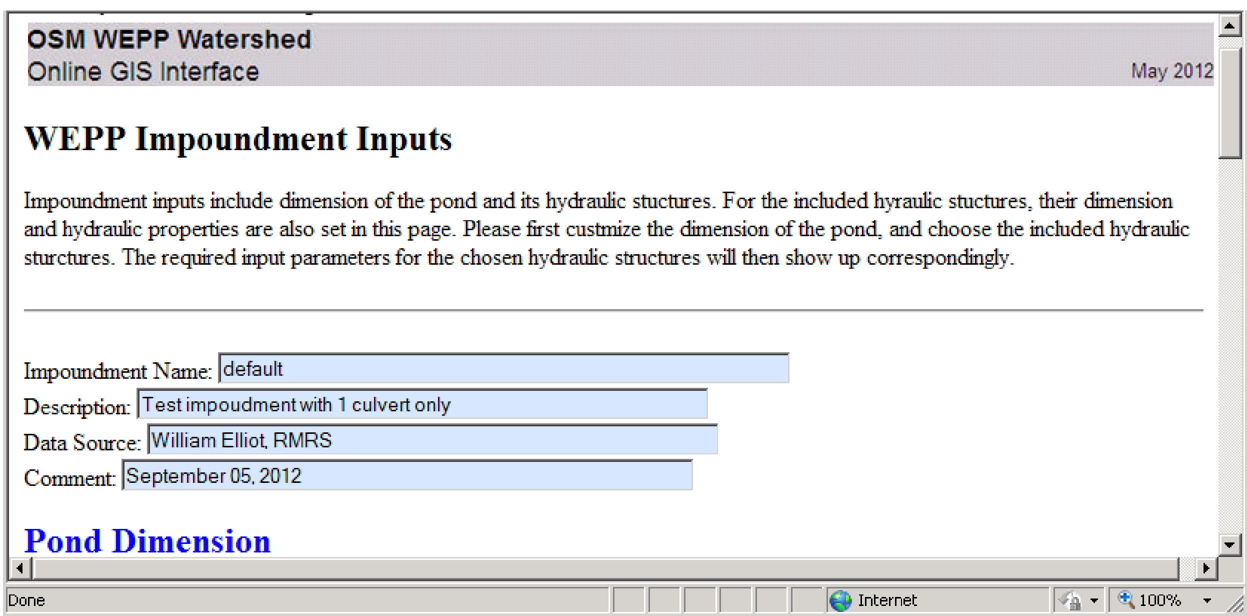

Fig. 3. The “View and Edit Impoundment Inputs” window

WEPP Impoundment inputs include a description line, sediment pond dimensions, other impoundment characteristics (e.g., stage at which overtopping would occur) and the hydraulic parameters and configuration of the selected hydraulic structures(Figs. 3, 4, and 5). The changes can be saved to define a user-specified pond by clicking the “Save Impoundment Parameters” button at the bottom of the “View and Edit Impoundment Inputs” window (Fig. 5). A site-specific pond can also be created using the function of “Create a watershed specific impoundment” or “Create a filter fence impoundment” from the model setup function list (Fig. 1).

Pond Dimension

Stage-Area-Length Relationship

Point	Stage (m)	Area (m^2)	Length (m)
0	0	47	12
1	0.1	54	13.3
2	0.2	61	14.6
3	0.3	69	15.9
4	0.4	77	17.2
5	0.5	86	18.5
6	0.6	95	19.8
7	0.7	104	21.1
8	0.8	113	22.4
9	0.9	123	23.7
10	1	133	25

Fig. 4.

Specification of sediment pond dimensions

General Impoundment Characteristics

Stage at which the overtop flag goes off (m): 1

Stage at which the full of sediment flag goes off (m): 0.25

Stage at the beginning of the simulation (m): 0

Initial time step (hr): 0.1

Infiltration rate (m/d): 0.024

Number of particle size subclass divisions: 2

Fig. 5. General Impoundment Characteristics

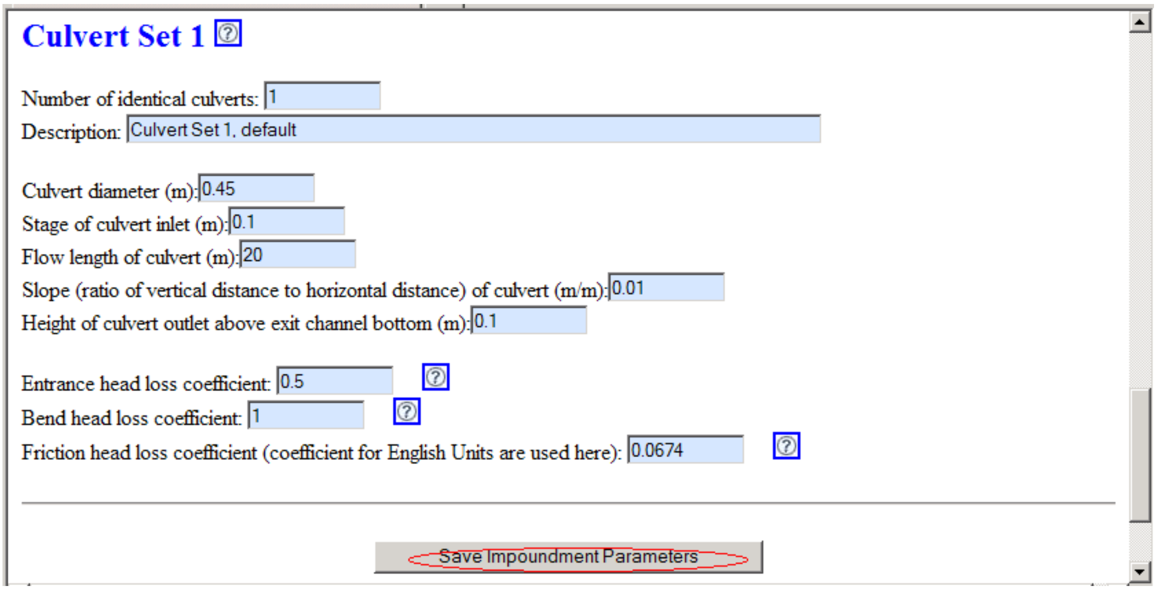

Fig. 5. Configuration and hydraulic parameters of a selected structure

The window for specifying a site-specific sediment pond is similar to the "View and Edit Impoundment Inputs" window used for viewing the existing impoundment files. To ease the procedure for defining a sediment pond that is substantially different from those described with the existing impoundment files, we provided functions for re-setting sediment pond dimensions and choosing hydraulic structures within the sediment pond on the "Impoundment Inputs" page (Figs. 6 and 7). Help information is provided about the specific terms used in WEPP impoundment inputs. Clicking on the question marks following a specific term would bring the help window with definitions, explanations, data ranges suggested, and cautions.

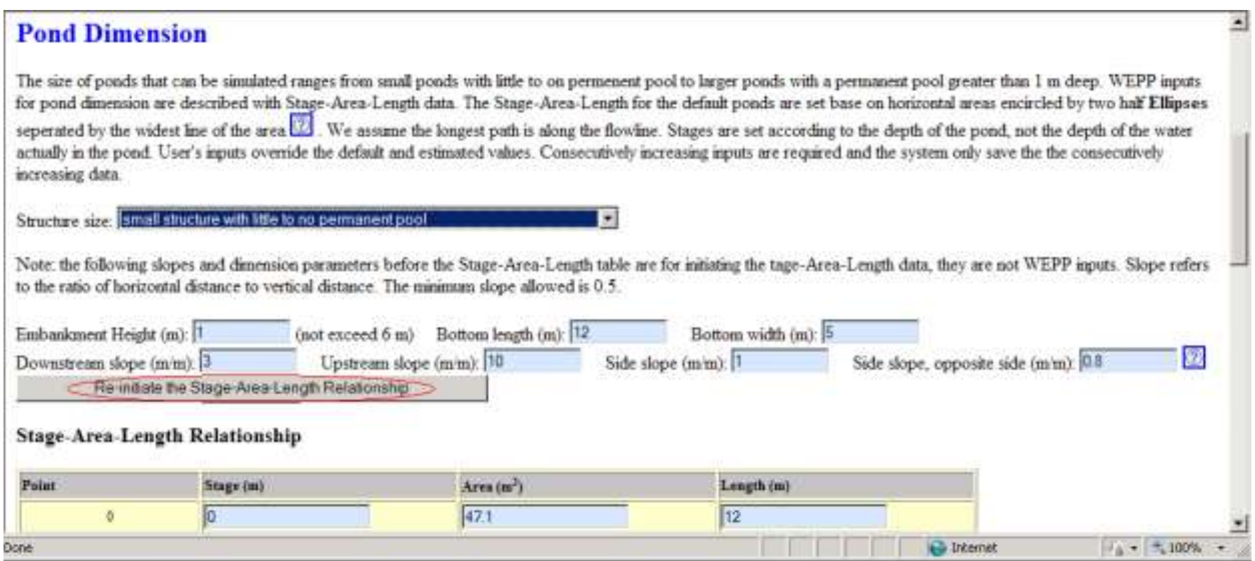

Fig. 6. Specifying the size of a sediment pond

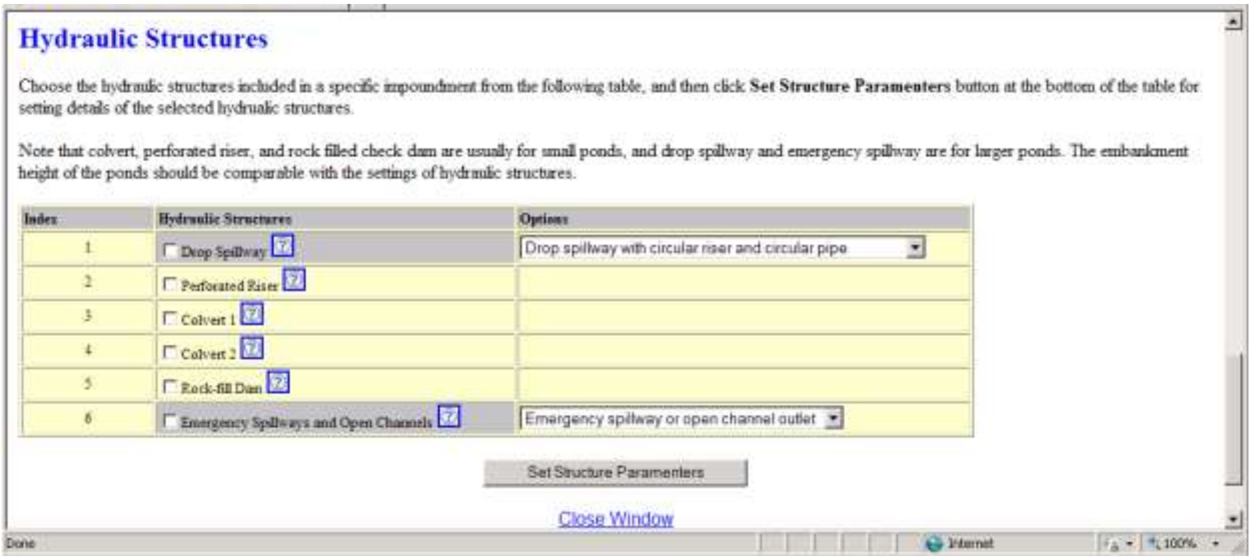

Fig. 7. Selecting a hydraulic structure

To create a new sediment pond file for WEPP simulation, first choose “Structure size” in the “View and Edit Impoundment Inputs” window to create an impoundment (Fig. 6) from its two options, small structure with no permanent pool and large structure with a permanent pool more than 1 m deep. The default embankment height is 3 m for a large structure and 1 m for a small structure.

In WEPP-Mine, the pond dimensions are described with the Stage-Area-Length relation, Which is defined by the horizontal areas composed of two different half-ellipses connected at a common axis (Fig. 8). We assume the longest path is along the flowline. The Stage-Area-Length relation can be re-defined using the pond configuration parameters above the Stage-Area-Length table and by clicking the “Re-initiate the Stage-Area-Length Relationship” button (Fig. 6). User inputs in the Stage-Area-Length relation table will override the default or estimated values from the pond configuration parameters. Only increasing values of stage, area, and length are accepted and saved in the system without causing errors.

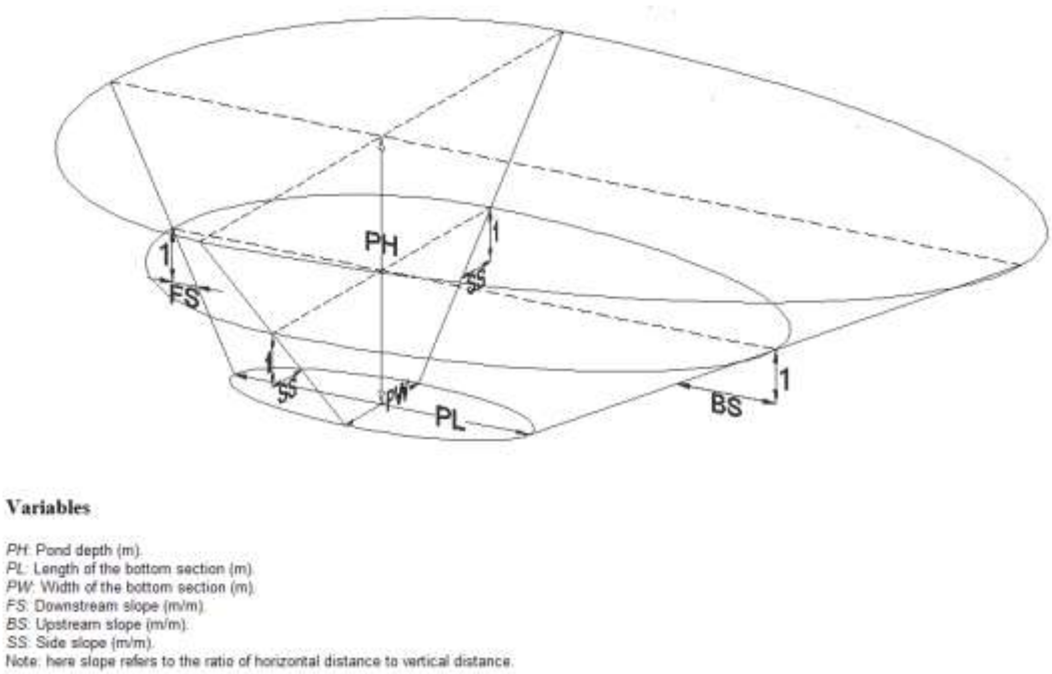

Fig. 8. Geometric shape of a default sediment pond

A combination of hydraulic structures in a sediment pond may be used and simulated by WEPP-Mine. Of all the hydraulic structures that WEPP simulates except culvert, only one of each can be included in an impoundment; either one or two culverts may be used for each impoundment. Fig. 7 illustrates the options for choosing hydraulic structures within a sediment pond and for setting the configuration and hydraulic parameters of the selected hydraulic structures by clicking the "Set Structure Parameters" button near the bottom of the window. Note the embankment height of the sediment pond should be compatible with the settings of the selected hydraulic structures.

A user can also go back to the window to re-select hydraulic structures by clicking the "Reselect Hydraulic Structure" button (Fig. 9). User inputs will override the default values. To resume the default values of the selected hydraulic structures, click the button at the bottom of the window (see Fig. 10, for example).

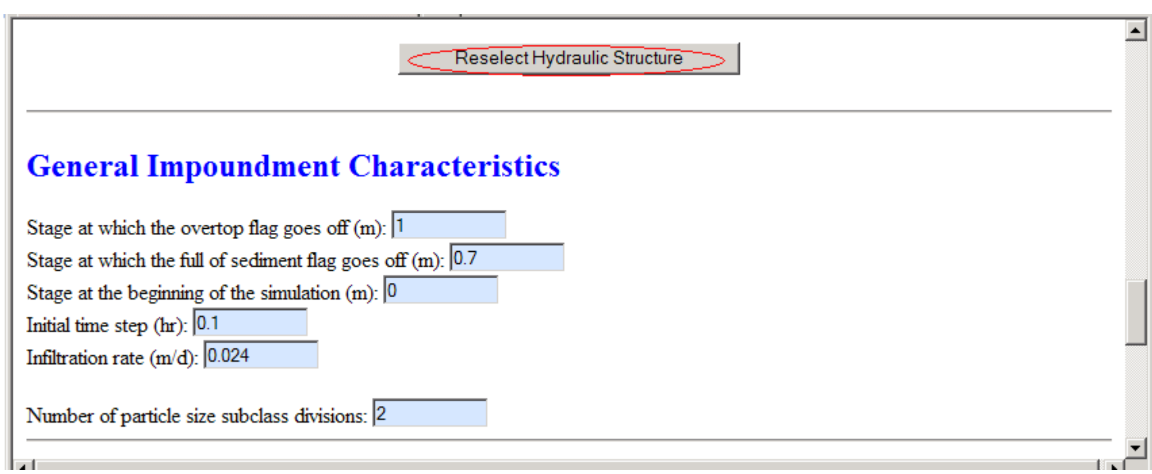

Fig. 9. Function for reselecting hydraulic structures

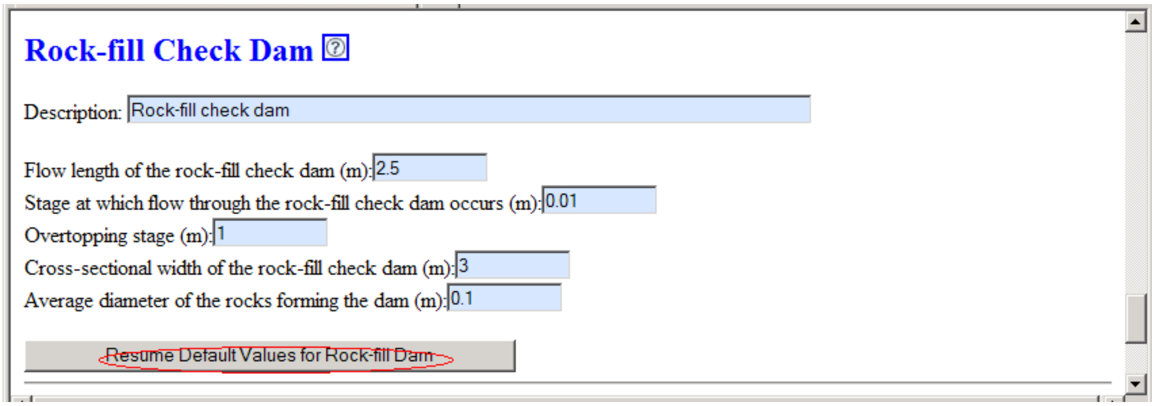

Fig. 10. Option of resuming default values of a selected hydraulic structure

To create new input files for a filter fence and straw bales, choose the "Create a filter fence impoundment" function. Click the "Set Structure Parameters" button in the "View and Edit Filter Fence" window (Fig. 11) to set the configuration and hydraulic parameters of the filter fence. The "View and Edit Impoundment Inputs" window for defining a filter fence is similar to the one for defining other impoundments except that default pond dimensions for a filter fence and straw bales is calculated for rectangular horizontal areas enclosed by the filter fence and the hillslope (Fig. 12).

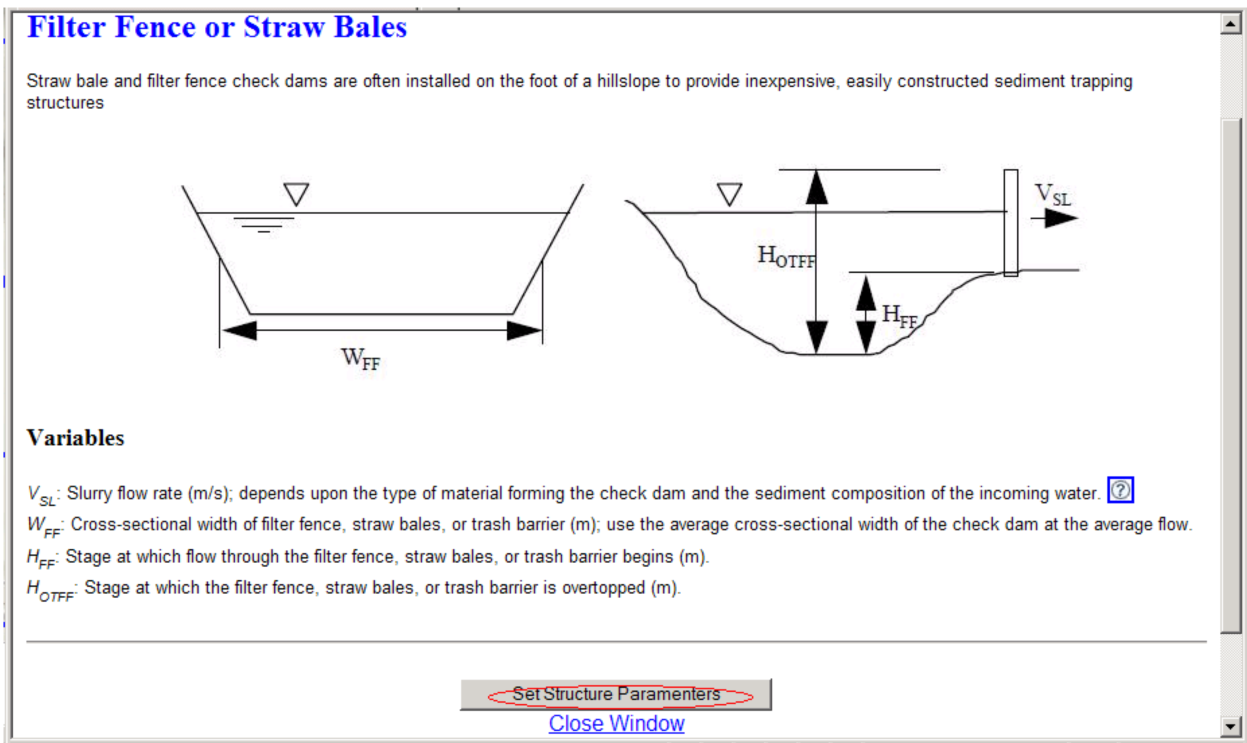

Fig. 11. Window for specifying a new filter fence

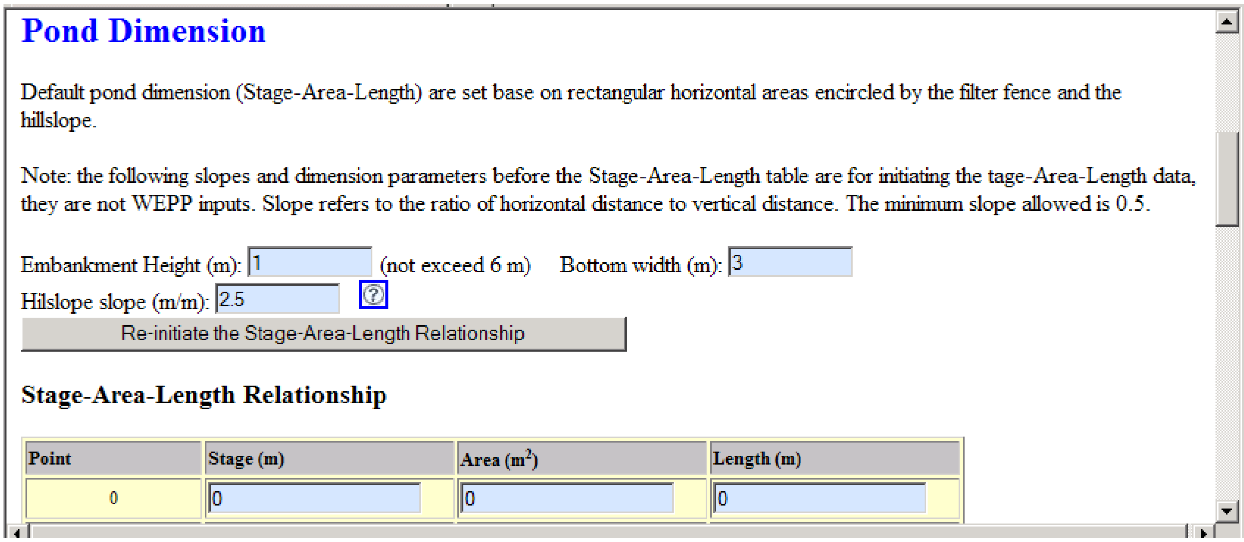

Fig. 12. Default dimensions of a sediment pond formed by a filter fence or straw bales

To test the default impoundment settings in WEPP-Mine, we chose three small nested watersheds (areas of 10-, 20-, and 50 ha, respectively) upstream the “demo” watershed in Area A, Big Sky Mine. Watershed-only WEPP simulations for 30 years were conducted using the default WEPP inputs for watershed without an impoundment and with impoundment at the watershed outlet, respectively.

WEPP inputs for landuse and soils were determined from individual cells. Climatic inputs were generated using CLIGEN (v5.2) based on the long-term climate statistics for Branderberg, MT, the nearest weather station to the study watersheds included in the WEPP database, further adjusted for distance and elevation using PRISM (Fig. 13). The long-term average annual precipitation was 370 mm and average daily maximum and minimum temperatures were 15.34 °C and −0.23 °C, respectively (Table 1).

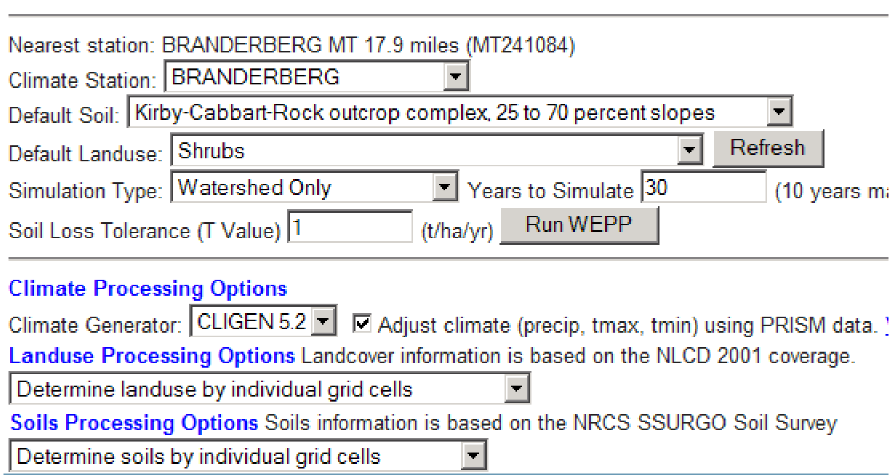

Fig. 13. WEPP simulation settings

Table 1. Climate statistics used in CLIGEN in generating daily climatic inputs for WEPP-Mine simulation

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Tot.	Avg.
Precp (mm)	15.3	11.3	22.4	33.3	66	64.1	34.3	26.8	33	34.1	16.5	12.5	370	
Max Temp (°C)	0.93	4.53	9.2	14.97	20.44	25.68	30.2	29.85	23.5	15.91	6.84	2.08		15.34
Min Temp (°C)	–12.98	–9.81	–5.22	–0.38	4.89	9.59	12.26	11.57	5.65	–0.02	–6.51	–11.79		–0.23

The selected nested watersheds discharge to the same stream in Area A, Big Sky Mine (Figs. 14–16). Summaries of landuse and soils for each watershed are presented in the section of Landuse and soils inputs for WEPP simulations. The dominant landuse for all three watersheds is grassland. The dominant soil for both the 10- and 20-ha watersheds is the Kirby-Cabbart-Rock outcrop complex with slope steepness ranging 25–70 percent. For the lower section of the 50-ha watershed, the predominant soil is the Yamac-Busby complex, with 8–15 percent of slope steepness.

By default, the impoundments with small hydraulic structures, i.e. culvert, perforated riser, and rock-fill check dam, with no permanent pool, have an embankment height of 1 m and a volume of 90 m^3. The impoundments with larger hydraulic structures, i.e. drop spillway and emergency spillway and open channel with a permanent pool more than 1 m deep, have an embankment height of 3 m and a volume of 2045 m^3. The impoundments formed behind a filter fence or straw bales at the foot of the hillslopes have an embankment height of 1 m and 0.5 m, respectively, with a volume of 5 m^3 per meter silt fence width. Parameters for the default impoundments in WEPP-Mine are presented in the section of Impoundment inputs for WEPP simulations.

WEPP-simulated runoff and sediment yield for each scenario were extracted from the summary of the simulation results and presented in Tables 2–4. The larger hydraulic structures, i.e. drop-spillway and emergency-spillway, may be inefficientfor the 10-ha watershed with a sediment delivery ratio smaller than 10%, but they appear the most efficient for the 20-ha watershed. Small hydraulic structures yielded similar sediment trapping efficiency for the 10- and 20-ha watersheds, but became overtopped in the 50-ha watershed.

Watershed summary and WEPP simulation results

(1) Watershed around 10 ha

Area (ha): 9 (cells: 100)
Number of Representative Hillslopes: 3
Number of Channels: 1
Number of Impoundments: 1
Outlet Location: −106.5914, 45.8386
Minimum Source Channel Length (m): 60
Critical Source Area (ha): 4

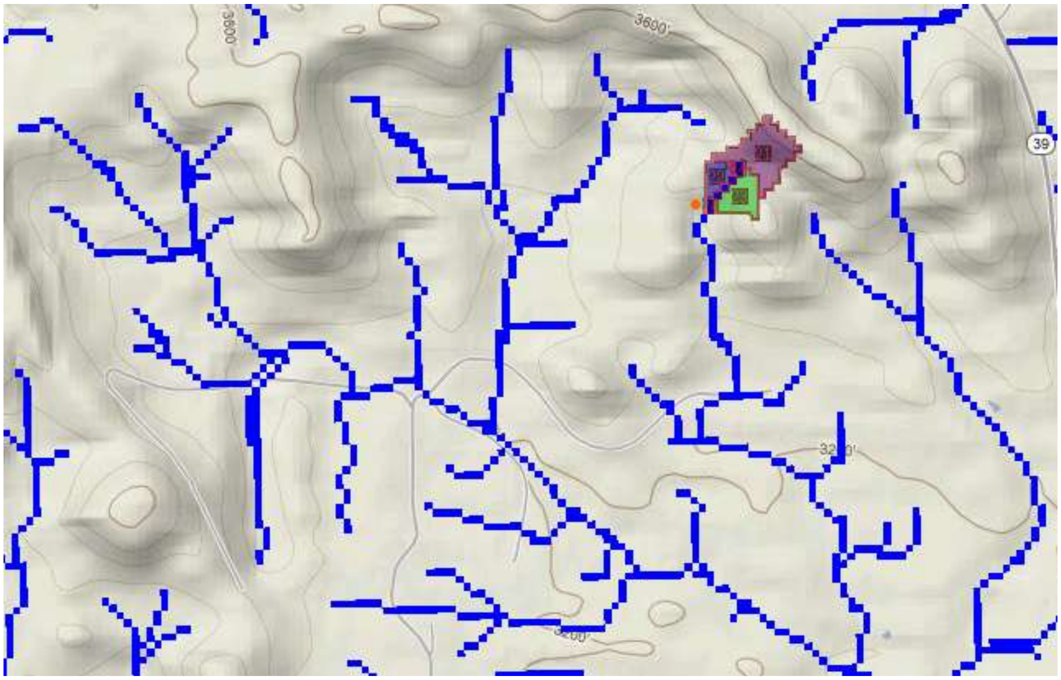

Fig. 14 The small watershed

Table 2. Simulated runoff and sediment yield from the small watershed

Impoundments	**Sediment**				**Runoff Discharge**	
	Yield		**Delivery Ratio**		**m^3/yr**	**mm/yr**
	ton/yr	**t/ha/yr**				
No impoundment	0.8	0.10	1.017	1.00	48.4	5.76
Default impoundment with one culvert	0.5	0.06	0.551	0.54	47.3	5.63
Drop spillway with circ riser and barrel	0.1	0.01	0.070	0.07	16.1	1.92
Drop spillway with rect riser and circ barrel	0.0	0.00	0.058	0.06	15.9	1.89
Emergency spillway	0.0	0.00	0.006	0.01	6.1	0.73
Filter fence	0.5	0.06	0.638	0.63	48.4	5.76
Perforated riser	0.6	0.07	0.727	0.71	48.3	5.75
Rock fill dam	0.4	0.05	0.456	0.45	48.1	5.73
Straw bales	0.4	0.05	0.519	0.51	48.4	5.76
Culvert for forest road-2' diameter	0.4	0.05	0.471	0.46	47.6	5.67
Sediment basin-small	0.4	0.05	0.475	0.47	48.3	5.75

(2) Watershed around 20 ha

Area (ha): 23.9 (cells: 266, Fig. 3)
Number of Representative Hillslopes: 3
Number of Channels: 1
Number of Impoundments: 1
Outlet Location: −106.5916, 45.8358
Reference Point: 0
Minimum Source Channel Length (m): 60
Critical Source Area (ha): 4

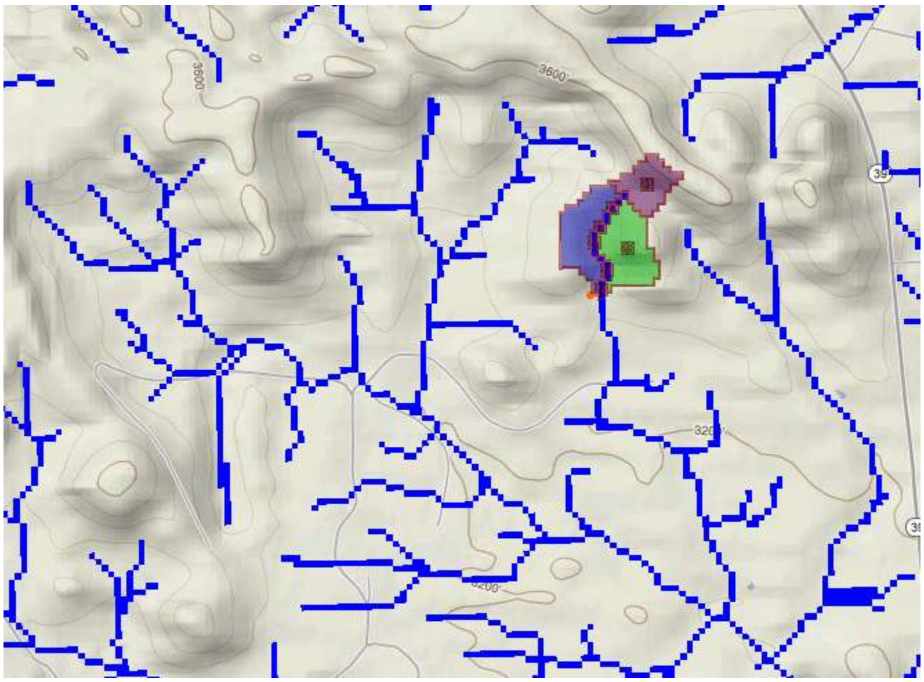

Fig. 15. The medium watershed

Table 3. Simulated runoff and sediment yield from the medium watershed

Impoundments	**Sediment**				**Runoff Discharge**	
	Yield		**Delivery Ratio**			
	ton/yr	**t/ha/yr**			**m^3/yr**	**mm/yr**
No impoundment	5.2	0.23	0.977	1.00	158.6	7.08
Default impoundment with one culvert	3.9	0.17	0.718	0.73	156.5	6.99
Drop spillway with circ riser and barrel	1.6	0.07	0.299	0.31	119.0	5.31
Drop spillway with rect riser and circ barrel	2.0	0.09	0.369	0.38	118.9	5.31
Emergency spillway	1.0	0.04	0.193	0.20	96.3	4.30
Filter fence	2.7	0.12	0.512	0.52	158.6	7.08
Perforated riser	4.7	0.21	0.871	0.89	158.5	7.08
Rock fill dam	2.8	0.13	0.523	0.54	158.4	7.07
Straw bales	2.7	0.12	0.512	0.52	158.6	7.08
Culvert for forest road-2' diameter	3.1	0.14	0.574	0.59	156.8	7.00
Sediment basin-small	3.4	0.15	0.630	0.64	158.5	7.08

(3) Watershed around 50 ha
Area (ha): 58.1 (cells: 645)
Number of Representative Hillslopes: 12
Number of Channels: 5
Number of Impoundments: 0
Outlet Location: −106.5915, 45.8318
Reference Point: 0
Minimum Source Channel Length (m): 60
Critical Source Area (ha): 4

Fig. 16 The large watershed

Table 4. Simulated runoff and sediment yield from the large watershed

Impoundments	**Sediment**				**Runoff Discharge**	
	Yield		**Delivery Ratio**		$\mathbf{m^3/yr}$	**mm/yr**
	ton/yr	**t/ha/yr**				
No impoundment	2.7	0.05	0.375	1.00	331.6	6.14
Default impoundment with one culvert	2.7	0.05	0.371	0.99	328.5	6.08
Drop spillway with circ riser and barrel	2.1	0.04	0.288	0.77	281.2	5.21
Drop spillway with rect riser and circ barrel	2.1	0.04	0.288	0.77	280.5	5.19
Emergency spillway	1.7	0.03	0.236	0.63	254.8	4.72
Filter fence	2.7	0.05	0.367	0.98	331.5	6.14
Perforated riser	2.7	0.05	0.370	0.99	331.5	6.14
Rock fill dam	2.7	0.05	0.365	0.97	330.7	6.12
Straw bales	2.7	0.05	0.364	0.97	331.6	6.14
Culvert for forest road-2' diameter	2.7	0.05	0.369	0.98	328.6	6.09
Sediment basin-small	2.7	0.05	0.371	0.99	331.3	6.14

Landuse and soils inputs for WEPP simulations

(1) The 10-ha watershed

Landuse Summary

The watershed contains the following landuse as detemined by the USGS National Land Cover Database 2001 - http://www.mrlc.gov/nlcd.php

ID	Name	WEPP File	Number of Cells	Area(ha)	Percent Watershed
31	Barren Land	Good grass.rot	5	0.45	5.0
42	Evergreen Forest	Mature forest.rot	5	0.45	5.0
52	Shrub/Scrub	Shrubs.rot	33	2.97	32.7
71	Grasslands/Herbaceous	Good grass.rot	58	5.22	57.4

Soils Summary

The watershed contains the following soils as determined by the NRCS Soil Survey. The data is requested directly from the NRCS soils database. Information on the NRCS Soils Data structure and how it can be accessed are found at: http://sdmdataaccess.nrcs.usda.gov/

MuKey	Soil Name	Number of Cells	Area(ha)	Percent Watershed
347929	Kirby-Cabbart-Rock outcrop complex, 25 to 70 percent slopes	85	7.65	84.2
348038	Yamac-Busby complex, 8 to 15 percent slopes	7	0.63	6.9

(2) The 20-ha watershed

Landuse Summary

The watershed contains the following landuse as detemined by the USGS National Land Cover Database 2001 - http://www.mrlc.gov/nlcd.php

ID	Name	WEPP File	Number of Cells	Area(ha)	Percent Watershed
31	Barren Land	Good grass.rot	14	1.26	5.4
42	Evergreen Forest	Mature forest.rot	5	0.45	1.9
52	Shrub/Scrub	Shrubs.rot	54	4.86	20.7
71	Grasslands/Herbaceous	Good grass.rot	188	16.92	72.0

Soils Summary

The watershed contains the following soils as determined by the NRCS Soil Survey. The data is requested directly from the NRCS soils database. Information on the NRCS Soils Data structure and how it can be accessed are found at: http://sdmdataaccess.nrcs.usda.gov/

MuKey	Soil Name	Number of Cells	Area(ha)	Percent Watershed
347929	Kirby-Cabbart-Rock outcrop complex, 25 to 70 percent slopes	190	17.1	72.8
348038	Yamac-Busby complex, 8 to 15 percent slopes	61	5.49	23.4
348042	Birney, moist-Armells-Cabbart complex, 25 to 70 percent slopes	9	0.81	3.4

(3) The 50-ha watershed

Landuse Summary

The watershed contains the following landuse as detemined by the USGS National Land Cover Database 2001 - http://www.mrlc.gov/nlcd.php

ID	Name	WEPP File	Number of Cells	Area(ha)	Percent Watershed
31	Barren Land	Good grass.rot	14	1.26	2.2
42	Evergreen Forest	Mature forest.rot	5	0.45	0.8
52	Shrub/Scrub	Shrubs.rot	93	8.37	14.4
71	Grasslands/Herbaceous	Good grass.rot	533	47.97	82.3
82	Cultivated Crops	GeoWEPP/corn,soybean-fall mulch till.rot	3	0.27	0.5

Soils Summary

The watershed contains the following soils as determined by the NRCS Soil Survey. The data is requested directly from the NRCS soils database. Information on the NRCS Soils Data structure and how it can be accessed are found at: http://sdmdataaccess.nrcs.usda.gov/

MuKey	Soil Name	Number of Cells	Area(ha)	Percent Watershed
347929	Kirby-Cabbart-Rock outcrop complex, 25 to 70 percent slopes	269	24.21	41.5
347986	Birney channery loam, 15 to 25 percent slopes	31	2.79	4.8
348038	Yamac-Busby complex, 8 to 15 percent slopes	170	15.3	26.2
348042	Birney, moist-Armells-Cabbart complex, 25 to 70 percent slopes	9	0.81	1.4

Impoundment inputs for WEPP simulations

(1) Default impoundment with one culvert

```
99.1
1
Test impoudment with 1 culvert only
William Elliot, RMRS
September 05, 2012
0       # Drop Spillway
1 1     # Culvert 1
default
0.1600 0.4500 0.1000 20.0000 0.0100 0.1000
0.5000 1.0000 0.0674 0.519 0.64 0.0289 0.9
0 0     # Culvert 2
0       # Rockfill Checkdam
0       # Emergency Spillway
0       # Filter Fence
0       # Perforated Riser
1.0000 0.2500 0.0000 0.1000 0.024000
1 2
10       # Number of stage-area-length points
0.0000 47.0000 12.0000
0.1000 0.2000 0.3000 0.4000 0.5000 0.6000 0.7000 0.8000 0.9000 1.0000
54.0000 61.0000 69.0000 77.0000 86.0000 95.0000 104.0000 113.0000 123.0000 133.0000
13.3000 14.6000 15.9000 17.2000 18.5000 19.8000 21.1000 22.4000 23.7000 25.0000
```

(2) Drop spillway with circular riser and barrel

```
99.1
1
farm pond with drop spillway
William Elliot, RMRS
September 05, 2012
1       # Drop Spillway
drop spillway with circ riser and barrel
0.9000 2.0000 3.2000 0.6000
0.6000 2.0000 20.0000 0.0100 0.1000
0.5000 1.0000 0.0459
0 0     # Culvert 1
0 0     # Culvert 2
0       # Rockfill Checkdam
0       # Emergency Spillway
0       # Filter Fence
0       # Perforated Riser
3.0000 1.7000 2.0000 0.1000 0.024000
2 2
10       # Number of stage-area-length points
0.0000 47.0000 12.0000
0.3000 0.6000 0.9000 1.2000 1.5000 1.8000 2.1000 2.4000 2.7000 3.0000
69.0000 95.0000 123.0000 155.0000 190.0000 229.0000 271.0000 316.0000 365.0000 416.0000
15.9000 19.8000 23.7000 27.6000 31.5000 35.4000 39.3000 43.2000 47.1000 51.0000
```

(3) Drop spillway with rectangular riser and circular barrel

```
99.1
1
farm pond with drop spillway
William Elliot, RMRS
September 05, 2012
2       # Drop Spillway
drop spillway with rect riser and circ barrel
0.4000 0.4000 2.0000 3.2000 0.6000
0.3000 2.0000 20.0000 0.0100 0.1000
0.5000 1.0000 0.1160
0 0     # Culvert 1
0 0     # Culvert 2
0       # Rockfill Checkdam
0       # Emergency Spillway
0       # Filter Fence
0       # Perforated Riser
3.0000 1.7000 2.0000 0.1000 0.024000
2 2
10       # Number of stage-area-length points
0.0000 47.0000 12.0000
0.3000 0.6000 0.9000 1.2000 1.5000 1.8000 2.1000 2.4000 2.7000 3.0000
69.0000 95.0000 123.0000 155.0000 190.0000 229.0000 271.0000 316.0000 365.0000 416.0000
15.9000 19.8000 23.7000 27.6000 31.5000 35.4000 39.3000 43.2000 47.1000 51.0000
```

(4) Emergency spillway

```
99.1
1
Test impoudment with emergency spillway
William Elliot, RMRS
September 05, 2012
0       # Drop Spillway
0 0     # Culvert 1
0 0     # Culvert 2
0       # Rockfill Checkdam
1       # Emergency Spillway
emergency spillway
3.0000 3.0000 0.1000 2.5000 2.9000
0.1400 12.2000 0.0200 3.0000 0.2500
0       # Filter Fence
0       # Perforated Riser
2.7000 2.2000 0.0000 0.1000 0.024000
2 2
10       # Number of stage-area-length points
0.0000 47.0000 12.0000
0.3000 0.6000 0.9000 1.2000 1.5000 1.8000 2.1000 2.4000 2.7000 3.0000
69.0000 95.0000 123.0000 155.0000 190.0000 229.0000 271.0000 316.0000 365.0000 416.0000
15.9000 19.8000 23.7000 27.6000 31.5000 35.4000 39.3000 43.2000 47.1000 51.0000
```

(5) Filter fence

```
99.1
1
Test impoudment with filter fence
William Elliot, RMRS
September 05, 2012
0       # Drop Spillway
0 0     # Culvert 1
0 0     # Culvert 2
0       # Rockfill Checkdam
0       # Emergency Spillway
1       # Filter Fence
filter fence
0.0200 3.0000 0.0100 1.0000
0       # Perforated Riser
1.0000 0.6000 0.0000 0.0100 0.024000
1 2
9        # Number of stage-area-length points
0.0000 0.0100 0.1000
0.1000 0.2000 0.3000 0.4000 0.5000 0.6000 0.7000 0.8000 0.9000
0.5000 1.5000 2.4000 3.8000 4.9000 6.5900 9.0600 10.7900 13.8000
1.0000 2.0000 3.0000 4.0000 5.0000 6.0000 7.0000 8.0000 9.0000
```

(6) Perforated riser

```
99.1
1
Terrace with perforated riser
William Elliot, RMRS
September 05, 2012
0       # Drop Spillway
0 0     # Culvert 1
0 0     # Culvert 2
0       # Rockfill Checkdam
0       # Emergency Spillway
0       # Filter Fence
1       # Perforated Riser
perforated riser
0.7500 0.2500 0.5000 0.0000 0.2000 0.0200 0.1000
1.2000 20.0000 0.0200 0.2000
 0.6530 3.2000 0.6000 0.6110
1.0000 1.0000 0.2000 0
1.0000 0.5000 0.0000 0.1000 0.024000
1 2
10       # Number of stage-area-length points
0.0000 47.0000 12.0000
0.1000 0.2000 0.3000 0.4000 0.5000 0.6000 0.7000 0.8000 0.9000 1.0000
54.0000 61.0000 69.0000 77.0000 86.0000 95.0000 104.0000 113.0000 123.0000 133.0000
13.3000 14.6000 15.9000 17.2000 18.5000 19.8000 21.1000 22.4000 23.7000 25.0000
```

(7) Rock-fill check dam

```
99.1
1
Test impoudment with rock fill outlet
William Elliot, RMRS
September 05, 2012
0       # Drop Spillway
0 0     # Culvert 1
0 0     # Culvert 2
1       # Rockfill Checkdam
rock fill dam
2.5000 0.0100 1.0000 3.0000 0.1000
0       # Emergency Spillway
0       # Filter Fence
0       # Perforated Riser
1.0000 0.7000 0.0000 0.1000 0.024000
1 1
10       # Number of stage-area-length points
0.0000 47.0000 12.0000
0.1000 0.2000 0.3000 0.4000 0.5000 0.6000 0.7000 0.8000 0.9000 1.0000
54.0000 61.0000 69.0000 77.0000 86.0000 95.0000 104.0000 113.0000 123.0000 133.0000
13.3000 14.6000 15.9000 17.2000 18.5000 19.8000 21.1000 22.4000 23.7000 25.0000
```

(8) Straw bales

```
99.1
1
Test impoudment with straw bales or trash barrier
William Elliot, RMRS
September 05, 2012
0       # Drop Spillway
0 0     # Culvert 1
0 0     # Culvert 2
0       # Rockfill Checkdam
0       # Emergency Spillway
2       # Filter Fence
straw bales
0.0040 3.0000 0.0100 1.0000
0       # Perforated Riser
0.5000 0.2000 0.0000 0.0100 0.024000
1 2
9        # Number of stage-area-length points
0.0000 0.0100 0.1000
0.1000 0.2000 0.3000 0.4000 0.5000 0.6000 0.7000 0.8000 0.9000
0.5000 1.5000 2.4000 3.8000 4.9000 6.5900 9.0600 10.7900 13.8000
1.0000 2.0000 3.0000 4.0000 5.0000 6.0000 7.0000 8.0000 9.0000
```

(9) Culvert for forest road-2' diameter

```
99.1
1
Test impoudment with 1 culvert only
William Elliot, RMRS
September 05, 2012
0       # Drop Spillway
1 1     # Culvert 1
Culvert for forest road-2' diameter
0.2800 0.6000 0.1000 13.7000 0.0200 0.1000
0.5000 1.0000 0.0459 0.519 0.64 0.0289 0.9
0 0     # Culvert 2
0       # Rockfill Checkdam
0       # Emergency Spillway
0       # Filter Fence
0       # Perforated Riser
1.2000 0.3000 0.0000 0.0100 0.024000
1 2
10       # Number of stage-area-length points
0.0000 47.0000 12.0000
0.1000 0.2000 0.3000 0.4000 0.5000 0.6000 0.7000 0.8000 0.9000 1.0000
54.0000 61.0000 69.0000 77.0000 86.0000 95.0000 104.0000 113.0000 123.0000 133.0000
13.3000 14.6000 15.9000 17.2000 18.5000 19.8000 21.1000 22.4000 23.7000 25.0000
```

(10) Small sediment basin

```
99.1
1
Test impoudment with 1 culvert only
William Elliot, RMRS
September 05, 2012
0       # Drop Spillway
1 1     # Culvert 1
Sediment basin-small
0.3000 0.6000 0.0000 13.7000 0.0200 0.0000
0.5000 1.0000 0.0621 0.519 0.64 0.0289 0.9
0 0     # Culvert 2
0       # Rockfill Checkdam
0       # Emergency Spillway
0       # Filter Fence
0       # Perforated Riser
1.0000 0.3000 0.0000 0.0100 0.024000
1 2
10       # Number of stage-area-length points
0.0000 47.0000 12.0000
0.1000 0.2000 0.3000 0.4000 0.5000 0.6000 0.7000 0.8000 0.9000 1.0000
54.0000 61.0000 69.0000 77.0000 86.0000 95.0000 104.0000 113.0000 123.0000 133.0000
13.3000 14.6000 15.9000 17.2000 18.5000 19.8000 21.1000 22.4000 23.7000 25.0000
```