SEDIMENTATION POND DESIGN[1]

by

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Abstract. Surface Mining Control and Reclamation Act of 1977 (SMCRA) requires that all surface drainage from the permit area shall be passed through a sedimentation pond. The pond design is required to provide adequate sediment storage volume and to contain the design event of 10-year, 24-hour precipitation. Also, the pond is required to provide adequate detention time for the incoming sediment to settle to enable the effluent to meet the state and federal limitations, and to provide a dewatering device to maintain the required capacity.

A perforated riser pipe at the inlet of principal spillways is an economic and effective means for the Iowa ponds to comply with the required performance standards. In case the pond is too small to contain the design event, Sedimot II and Sedcad computer models have been widely used to demonstrate that the effluent would meet the required limitations for settleable solids.

The mining industry has to comply with both the design standards and the performance standards, the former to get a permit and to start the mining operations, and the latter to continue mining operations without incurring the avoidable enforcement actions. SMCRA helps the environment, although coal mining, especially in mid-west, contributes only a small fraction of the total sediment loss to the streams as compared to the agriculture, deforestation and urbanization.

Key words: Iowa, NPDES, Perforated riser, Sedcad, Sedimot II, Settleable solids.

Introduction

The sedimentation pond design requirements and methodology for each component of the pond are discussed with the applicable rules. The Iowa designs are analyzed relevant to the rules. In conclusion, the whole perspective is viewed for the procedures and significance.

Design Requirements

The design of a sedimentation pond broadly consists of two criteria: first, the pond should have a capacity to contain adequate sediment inflow and the 10-year, 24-hour precipitation event; and second, the principal and emergency spillways combined

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should pass the runoff resulting from the 25-year, 6-hour precipitation event.

Rule Requirements
Surface Mining Control and Reclamation Act of 1977 (SMCRA) requires in 30 CFR 816.46(b)(2) that all surface drainage from the disturbed area shall be passed through a sedimentation pond before leaving the permit area. The subrule 780.25(b) dictates that the sedimentation ponds shall be designed in compliance with the requirements of the rule 816.46, the design standards are delineated in the subrule 816.46(c). The subrule 816.46(b)(4) dictates that the ponds shall be designed in accordance with the rule 816.49 which deals with the impoundments. Thus, the sedimentation pond designs have to comply with both 816.46(c) and 816.49.

MSHA Standards
30 CFR 77.216(a) delineates the standards: If a structure can impound water, sediment or slurry to an elevation of five feet or more above the upstream toe and can have a storage volume of 20 acre-feet or more, OR if it can impound water, sediment or slurry to an elevation of 20 feet or more above the upstream toe of the structure, it meets the MSHA standards. In case an emergency spillway is provided, a dam can impound water to the spillway crest.

MSHA standards are important because if a dam meets the standards, then the spillways have to be designed to pass a 100-year, 6-hour precipitation event; also, the criteria for slope stability and foundation are more rigorous beside the inspection and maintenance criteria.

Pond Capacity
The storage capacity of the pond behind the dam embankment should be adequate for the combined sediment storage and the design event runoff flowing from the watershed into the pond.

Pond Capacity = sediment storage volume + design runoff volume

Sediment Storage. The universal soil loss equation (USLE) is generally used to estimate the sediment storage capacity. It may be noted here that USLE gives the rate of erosion, and not the rate of deposition, of soil particles in tons per acre per year for the given values of the rainfall event, length and grade of the slope, land cover, and erosion control practice. All the eroded soil from a watershed does not reach the pond, some gets deposited in the drainage channels. Modified universal soil loss equation (MUSLE) accounts for the deposition, and therefore, it gives closer estimate than USLE. A general estimate of 0.1 acre-feet per acre of the disturbed area is a fair estimate for sediment storage capacity.

Runoff. The design event runoff volume results from the 10-year, 24-hour storm event. USDA Soil Conservation Service (SCS) method of runoff curve number is the most popular method to estimate the runoff. The required pond capacity is provided to the crest of the emergency spillway.

Short-circuiting. The configuration of the principal and emergency spillways should be selected in a manner that enough time is allowed for the incoming flow to settle the suspended solids before these can pass through the spillways to minimize short-circuiting.

Detention Time. The pond is required to provide adequate detention time for the incoming sediment to settle down to meet the state and federal effluent limitations delineated as 0.5 milliliter per liter of settleable solids in the National Pollutant Discharge Elimination System (NPDES). The settling velocity for the representative soil for the worst scenario in the watershed can be determined in a laboratory. The required minimum detention time can be extrapolated from the lab results for settling velocity. A period of 24 hours is considered a fair estimate of the desired detention time.

Computer model. The settleable solids in the effluent are expected to be within NPDES limits if the pond capacity is adequate to contain the design volumes of sediment and runoff, short-circuiting is minimized, and adequate detention time is provided. Yet, the operator is responsible if the effluent is observed to violate the NPDES limit. In case the dam is not large enough to contain the design event runoff or the required detention time is not feasible, the applicant has to demonstrate that the effluent limits of NPDES would still be met; Sedimot II and Sedcad computer models of the University of Kentucky have been widely used for the purpose.

Dewatering. A dewatering device is required to maintain the adequate pond capacity for the runoff resulting from the next precipitation event. Care is required to ensure that the effluent does not exceed the NPDES limit. The dewatering time should not be less than the detention time. The principal spillway pipe, generally, serves the purpose.

Spillways. The principal and emergency spillways combined are required to safely pass the design event runoff discharge resulting from a 25-year or 100-year, 6-hour precipitation depending on the size of the pond with reference to the MSHA criteria. The principal spillway is designed from the detention time criterion. The emergency spillway is designed for the remaining flood after considering the discharge from the principal spillway, computed by reservoir routing. The slope of the emergency spillway channel should have an appropriate lining to allow the non-erosive velocity for the design discharge.

Iowa Designs

USDA SCS Standards

Iowa designs follow the USDA SCS Practice Standard 378 to estimate pond capacity using the runoff curve number method, for sizing the dam embankments for width, inslope and outslope The size of principal spillway pipe is checked for detention time and dewatering. SCS criteria are used for emergency spillway designs for widths and side slopes, and also for the permissible velocities in the exit channels.

Conservative Designs

Most of the Iowa designs are over-designed, and therefore, are conservative. In some cases where the ponds do not have adequate capacity, Sedimot II computer model was used to demonstrate that the effluent will meet the NPDES limit for settleable solids. Three factors which make the Iowa designs conservative are discussed here:

Disturbed area. The entire area of the watershed to be disturbed in the lifetime of the permit is considered as disturbed for computing the weighted runoff curve number. In reality, the entire area is not disturbed at any time because of the contemporaneous reclamation requirement. Drainage from a portion of the watershed is intercepted in the pits between the watershed boundary and the pond, and it does not reach the pond. Thus, the pond can handle runoff more than the design value.

Runoff. The reservoir routing is not done. The entire runoff is considered for the design of the emergency spillway. A portion of the design runoff will flow out from the principal spillway. Thus, the design values of the pond capacity, and the crest elevation and width of the emergency spillway are conservative.

Perforated riser. A perforated riser pipe at the inlet of principal spillways is an economic and effective means for the ponds to comply with the required performance standards for detention time. Also, it facilitates the reservoir to drain, maintaining the required pond capacity. The SCS Engineering Field Manual provides the formula for the discharge through the riser openings as follows:

$$Q = 0.078*n*d*h^{1.5} \qquad (1)$$

where, n is number of perforations per foot height,
d is diameter of the perforations, and
h is the height of the riser.

Conclusion

The applicant has to comply with the design standards to get a permit and to start the mining operations. The operator has to comply with the performance standards to continue mining operations without incurring the avoidable expenses for enforcement actions. Iowa designs are conservative. SMCRA helps the environment, although coal mining contributes only a fraction of the total sediment loss to the streams as compared to the agriculture, deforestation and urbanization.

Literature Cited

USDI 30 CFR
USDA SCS PS 378