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TO: Division Guideline Folder

FROM: Staff Hydrologists

RE: Position Paper on Design Storm Event Criteria Relative to Design and Approval of Temporary Diversions for Miscellaneous Flows

SUMMARY

The design event criteria set forth in Rules R645-301-742.320 and R645-301-742.330 needs clarification to ensure consistent application of the rules in our reviews. Specifically, it was decided to develop a position paper for use as a working guideline in the preparation of permit applications by the Operators and for our reviews. The issue is the application of Rule R645-301-742.333 which specifies design event criteria for diversions of miscellaneous flows. The rule allows the use of a 2 yr. - 6 hr. precipitation event in the design of temporary diversions.

The Division's concern is that the design of diversions using the 2 year event criteria of R645-301-742.333 for operational diversions will result in diversion failures. In underground mining, operational diversions will typically be installed, maintained and relied upon during the entire life of mine. Failure of these diversions could jeopardize pond performance and safety, increase sediment loading to the pond, and potentially cause off-site increases in sediment loads. It is felt that the approval of such designs is actually a disservice to the Operator in terms of increased enforcement liability, diversion maintenance costs, and protection of the hydrologic balance.

The R645 rules define temporary diversions as those that are not approved by the Division to remain after reclamation as part of the approved postmining land use. For an underground coal mine, these diversions could be in place for 20 - 30 years during the life of the operational facilities. The guideline provides permitting direction that will recommend the use of 10 year - 6 hour design events for those long term operational diversions. Diversions that have a short design life (on the order of months) will be allowed to be designed using the 2 yr. - 6 hr. event.

Guideline
Diversion Design Event Criteria

I. STATEMENT OF RULES

The applicable rules are presented as an attachment to this paper for reference to aid in the discussion and development of the working guideline (Attachment C). In summary, the current R645 rules and the Federal CFR rules are essentially identical with regard to the use of 2 year return period events for the design of temporary diversions of miscellaneous flows. The "old" UMC rules clarified the use of the 2 year event with the following language: "However, temporary diversions designed to divert runoff from sediment ponds must be designed and constructed to pass safely the peak runoff from a 10-year, 24 hour precipitation event." In other words, the intent of the rule was to ensure that all flows diverted away from a sediment pond were controlled by diversions able to pass flows consistent with the pond design (10 year, 24 hour event). The R645 rules did not specifically retain this language, but rules providing for consistent, prudent, standard engineering practice would still incorporate this philosophy.

Current Rules (R645-301, ET. SEQ.):

732.300. Diversions. All diversions will be constructed and maintained to comply with the requirements of R645-301-742.100 and R645-301-742.300.

742.300. Diversions.

742.314. The Division may specify additional design criteria for diversions to meet the requirements of R645-301-742.300.

742.330. Diversion of Miscellaneous Flows.

742.331. Miscellaneous flows, which consist of all flows except for perennial and intermittent streams, may be diverted away from disturbed areas if required or approved by the Division. Miscellaneous flows will include ground-water discharges and ephemeral streams.

742.333. The requirements of R645-301-742.312.2 will be met when the temporary and permanent diversions for miscellaneous flows are designed so that the combination of channel, bank and floodplain configuration is adequate to

pass safely the peak runoff of a 2-year, 6-hour precipitation event for a temporary diversion and a 10-year, 6-hour precipitation event for a permanent diversion.

FEDERAL RULES

Sec. 817.43 Diversions.

(2) The diversion and its appurtenant structures shall be designed, located, constructed, and maintained to--

(i) Be stable;

(ii) Provide protection against flooding and resultant damage to life and property;

(iii) Prevent, to the extent possible using the best technology currently available, additional contributions of suspended solids to streamflow outside the permit area; and

(iv) Comply with all applicable local, State, and Federal laws and regulations.

(4) The regulatory authority may specify additional design criteria for diversions to meet the requirements of this Section.

(c) Diversion of miscellaneous flows. (1) Miscellaneous flows, which consist of all flows except for perennial and intermittent streams, may be diverted away from disturbed areas if required or approved by the regulatory authority. Miscellaneous flows shall include ground-water discharges and ephemeral streams.

(2) The design, location, construction, maintenance, and removal of diversions of miscellaneous flows shall meet all of the performance standards set forth in Paragraph (a) of this Section.

(3) The requirements of Paragraph (a)(2)(ii) of this Section shall be met when the temporary and permanent diversions for miscellaneous flows are designed so that the combination of channel, bank and flood-plain configuration is adequate to pass safely the peak runoff of a 2-year, 6-hour precipitation event for a temporary diversion and a 10-year, 6-hour precipitation event for a permanent diversion.

II. LEGISLATIVE HISTORY AND RULE INTENT

In the preamble to SMCRA, diversion design event criteria is not discussed specifically. The preamble discussion centers around the fact that the hydrologic balance regulations are:

> "structured on the premise that the applicant for a permit will research and understand the hydrologic balance in the mine plan and adjacent areas prior to mining, as well as understand the potential impacts of mining on

> that balance, so that operations are planned and conducted to minimize disturbances to the hydrologic balance both on-site and off-site." 44 CFR 14902 March 13, 1979

According to 48 CFR 43956, Federal Register, September 26, 1983, a discussion on diversions was presented. A complete copy of this section is attached. Diversions are specified in Sections 816.43(a) - 816.43(a) and 817.43(c) - 817.43(c).

> "Paragraph 816.43(a)(2) and 817.43(a)(2) requires that the design, location, construction, maintenance, and use of the diversion and its appurtenant structures will ensure stability; provide protection against flooding and resultant damage to life and property; prevent additional contributions of suspended solids to streamflow outside the permit area; . . ".

The key words here are design, stability, and protection against flooding.

General Requirements

Section 816.43(a)(3) and 817.43(a)(3) provides authority to the regulatory authority (RA) to "specify additional design criteria for diversions." Diversion as discussed in this context continues to reflect diversions as a means of diverting un-regulated water away from a regulated mine site. Specifically, the discussion mentions pre-existing flows, undisturbed flows, and flows from mines abandoned prior to May 3, 1978.

Diversion of Perennial and Intermittent Streams

Section 816.43(b) and 817.43(b) covers diversions of perennial and intermittent streams. This refers to stream channel diversions in the mine area. Designs for these segments reflect channel configurations similar to those existing above and below the channel in question and do not affect the design of diversions for disturbed areas.

Diversions of Miscellaneous Flows

Section 816.43(c) and 817.43(c) governs diversions of miscellaneous flows. Disturbed area diversions would fall under this category. A discussion in the June 25, 1982, Federal Register indicates that an operator is required to design diversions to prevent flooding to life and property. This proposed rule states:

> "Proposed rule 816.41(f)(2)(iii) and 817.41(f)(2)(iii) would also provide the operator flexibility in meeting the flooding, life and property damage requirements of proposed rule 816.41(f)(i)(B) and 817.41(f)(i)(B). This flexibility is available under the condition that the operator voluntarily choose to design temporary and permanent diversions to handle the 2-year, 24-hour and the 10-year, 24-hour events for temporary and permanent diversions, respectively. OSM anticipates that this will encourage sound engineering practices while reducing the cost of designing and constructing diversions by allowing local needs to govern their size."

This discussion shows that the intent of the law in 1982, was to provide design criteria to reduce flooding; damage to life and property; to reduce additional contributions of suspended solids to streamflow outside the permit area; and to protect the hydrologic balance in and adjacent to the permit area. The rules that were promulgated reflect the 2-year, 6-hour event and not the originally proposed 2-year 24-hour event.

The final rules provide the RA with sufficient authority to address environmental concerns with respect to miscellaneous flows without necessitating the listing of limitations as previously was the case. It also provides the RA authority to specify design criteria specific to a particular regional climate and topography and expected diversion design life.

III. TECHNICAL DISCUSSION

a) Probability Theory and Utah Diversions

The objective of this section is to present the basis of probability theory used in risk analysis for the selection of an appropriate design event return period. A summary of example design events typical to Utah operations is presented.

The selection of an event to be used for the design of a given structure incorporates three concepts: 1) life of the structure (design life), 2) level of acceptable risk, and 3) recurrence interval for the event. Given any two of these values allows calculation of the third. Most often the return period is the unknown to be determined. This will be the focus of this discussion. Implicit in the risk level selection are economic factors (i.e. costs to repair and mitigate environmental damage/loss of life, costs to replace structure, costs associated with loss of use of structure). Once the design life of the structure and the level of risk are determined, the recurrence interval of the design event can be calculated. The formulas for this calculation are

founded in basic probability theory unrelated to hydrologic factors. The formula for the calculation of the recurrence interval with design life and risk level given is as follows:

$$Tr = \frac{1}{1-(1-J)^{1/n}}$$

where: Tr = average recurrence period for event with;
J = probability of occurrence
n = design life in years

It is important to remember the correct interpretation of the recurrence interval. The recurrence interval of an event is the average period within which a given event will be equaled or exceeded. The selection of an acceptable risk level incorporates many factors including potential loss of life, downstream values, replacement costs, and regulatory issues. The Division will approve the use of design events less than the 10 year event for temporary or short term structures (usually access roads, construction staging areas, etc.)

To illustrate the concept of this evaluation, the following table presents return periods for projects with design lives of 2 years and 15 years for different risk levels:

Chance of Failure

Design Life:	30 percent	50 percent
2 years	7 year event	2 year event
15 years	43 year event	23 year event

The design life of the structure has a large role in the design event selection. A temporary structure, such as a culvert in an ephemeral channel for an exploration road to be used for a period less than a year, will have a relatively low recurrence interval for a given risk level when compared to more long term structures used for life of mine. A surface mine with temporary diversions constructed and reclaimed at relatively frequent intervals will utilize less stringent design events than those for most underground mine operations where structures are more long-term for the operational areas. These factors should all be considered when selecting the design event. **The Division cautions operators against simply selecting the minimum design events specified in the regulations, those events may not meet the long term needs of the project or provide adequate protection of the project investment and downstream values.**

b) Sensitivity Analysis of Different Design Event Criteria and Peak Flows

Precipitation data used in the runoff calculations for this paper were obtained from Estimated Return Periods For Short Duration Precipitation in Utah (DOGM files). The Clear Creek gaging station was chosen because it is an upland site and its proximity to a coal mine. Also of concern was a site subject to precipitation events that would significantly exceed the initial abstraction of the assumed watershed(s). Storm recurrence intervals, durations and the associated precipitation are:

Precipitation Event	Total Precipitation From Event
2 year 6 hour	1.04 inches
10 year 6 hour	1.55 inches
25 year 6 hour	1.88 inches
100 year 6 hour	2.29 inches

In order to perform runoff calculations, it was necessary to assume certain watershed characteristics. The following values were chosen as a best estimate of an "average" disturbed and undisturbed watershed encountered by coal mines in Utah. The time of concentration is not an assumed value, but rather, a value calculated from all the other parameters. Time of concentration is a constant for all calculations, so it is included here. Watershed characteristics are:

Disturbed Watershed Characteristics
Hydraulic Length = 500 feet
Curve Number (CN) = 88
Slope (S) = 4% = 2.3°
Area (A) = 5 acres
Manning's "*n*" = .03
Time of Concentration (T_c) = .1155 hours

Undisturbed Watershed Characteristics
Hydraulic Length = 1200 feet
Curve Number (CN) = 75
Slope (S) = 45% = 24°
Area (A) = 30 acres
Manning's "*n*" = .03
Time of Concentration (T_c) = .1061 hours

Given the precipitation data and watershed characteristics listed above, runoff calculations using the Division's Peak Flow program (Hawkins, et. al) yielded the following values for the disturbed watershed:

Disturbed Watershed Peak Flows				
Recurrence Interval Duration	2 year 6 hour	10 year 6 hour	25 year 6 hour	100 year 6 hour
Runoff Depth	0.2763 in.	0.6178 in.	0.8695 in.	1.2036 in.
Initial Abstraction	0.2727 in.	0.2727 in.	0.2727 in.	0.2727 in.
Peak Flow Time To Peak	1.23 cfs 2.53 hrs	2.86 cfs 2.53 hrs	4.04 cfs 2.51 hrs	5.57 cfs 2.51 hrs

while the undisturbed watershed values are:

Undisturbed Watershed Peak Flows				
Recurrence Interval Duration	2 year 6 hour	10 year 6 hour	25 year 6 hour	100 year 6 hour
Runoff Depth	0.0376 in.	0.1850 in.	0.3238 in.	0.5316 in.
Initial Abstraction	0.6667 in.	0.6667 in.	0.6667 in.	0.6667 in.
Peak Flow Time To Peak	0.47 cfs 6.01 hrs	3.53 cfs 2.55 hrs	7.76 cfs 2.53 hrs	13.95 cfs 2.53 hrs

c) Impact of Different Design Event Flows on Channel Size.

Using the peak flow values generated, typical diversions to handle the design event are designed. For disturbed diversions, it was assumed that the bottom width would be one (1) foot; left and right side slopes would be 2:1; Manning's "*n*" equal to 0.03; and a channel slope of 0.04. Using the Open Channel Flow Module (Haestad Methods), it was the possible to solve for the minimum channel depth. The table below does not contain any considerations for freeboard. Minimum channel depths are:

Minimum Channel Depth for Disturbed Area Diversions				
Recurrence Interval Duration	2 year 6 hour	10 year 6 hour	25 year 6 hour	100 year 6 hour
Peak Flow To Pass	1.23 cfs	2.86 cfs	4.04 cfs	5.57 cfs
Channel Depth	0.26 feet	0.40 feet	0.47 feet	0.55 feet

For undisturbed diversions, it was assumed that the bottom width would be 1.5 feet; left and right side slopes would be 2:1; Manning's "*n*" equal to 0.03; and a channel slope of 0.04. The channel slope value was chosen because it was assumed that the undisturbed diversion would be along the perimeter of the disturbed area and as such would have the same channel slope as disturbed diversions. Using the Open Channel Flow Module (Haestad Methods), it was then possible to solve for the minimum channel depth. The table below does not contain any considerations for freeboard. Minimum channel depths are:

Minimum Channel Depth for Undisturbed Area Diversions				
Recurrence Interval Duration	2 year 6 hour	10 year 6 hour	25 year 6 hour	100 year 6 hour
Peak Flow To Pass	0.47 cfs	3.53 cfs	7.76 cfs	13.95 cfs
Channel Depth	0.12 feet	0.38 feet	0.57 feet	0.77 feet

Graphs (Attachment B) illustrate peak flows versus event recurrence interval for disturbed and undisturbed watersheds as well as minimum channel depth versus event recurrence interval for disturbed and undisturbed watersheds. **These graphs demonstrate that diversions of disturbed and undisturbed miscellaneous flows based on the 10 year 6 hour event are not significantly larger than those based on the 2 year 6 hour event.** For both design events, the channel depth is less than 0.5 feet. While these values are based on

calculations using assumed watersheds and assumed channel specifications, the results indicate that, on average, channel design based on the 10 year 6 hour precipitation event is not appreciably larger than that of the 2 year 6 hour event. In addition, implementing such design would not be significantly more cost intensive.

Summaries from the Peak program and the Open Channel Flow Module are found in Attachment B.

IV. SUMMARY OF WESTERN STATES COAL REGULATORY PROGRAM DIVERSION DESIGN REQUIREMENTS

Many states use "the last line of defense" philosophy when sizing ditches, so that if a failure occurs, the minimum design criteria is the 10yr.-24hr. storm event for the most downstream disturbed area diversion. While the Division does not require this design criteria, it is recommended that operators consider the design philosophy for incorporation into their respective drainage plans. The following table summarizes design practices currently in use in the western region:

State	Temporary	Permanent	Exemptions
Arizona	10yr-6hr	Ephemeral 10yr-6hr Intermittent & Perennial 100yr-6hr	
Colorado	10yr-24hr	100yr-24hr	2yr-24 temp. + 10yr-24hr perm. *
Montana	10yr-24hr	100yr-24hr	2yr-24hr roadside ditches
New Mexico	Overland Flow: 2yr-24hr Last Line Of Defense: 10yr-24hr	Ephemeral 10yr-24-hr Intermittent & Perennial 100yr-24hr	
Utah	10yr-6hr	Ephemeral 10yr.-6hr. Intermittent & Perennial 100yr-6hr	2yr-6hr temp. (in place only months) *
Wyoming	Intermittent & perennial: < 3 yrs.: **10yr-6hr** 3-10 yrs.: **25yr-6hr** 11-20yrs.: **50yr-6hr** > 20 yrs.: **100yr-6hr** Ephemeral: **2yr-6hr**	100yr-6hr	Based on Probability of Failure

* not desired alternatives but allowed under special circumstances.

Proposed Utah Criteria

	Temporary	Permanent	Exemptions
Utah	Short-term Ditch (<6 mos.): 2yr.-6hr. Disturbed Area Diversions: 10yr.-6hr.	Ephemeral Intermittent Perennial 1) Meet Upstream Downstream Predisturbance Profile and Cross-section 2) 100yr.-6hr.*	* A 10yr.-6hr Criteria For Permanent Ephemeral Ditches is Acceptable After Meeting Condition 1

V. CONCLUSIONS AND PERMITTING GUIDANCE

The Division's permitting guidance on the use of the 2 yr.- 6 hr. precipitation event criteria for the design of miscellaneous flows remains unchanged from past practice. Procedurally, the permitting process remains consistent and the intent of this guideline is to formalize current and past permitting practices. The Division is not disallowing the use of this rule, the 2 yr. criteria does have merit and intent for specific cases. In practice, those cases where the Division will approve diversions for miscellaneous flows designed for the 2 yr. - 6 hr. event will be for diversions to be constructed and removed in a short time period. This time period will typically be on the order of several months to a year maximum. Examples would include an access road culvert for construction of a substation, a drainage plan for a staging area for construction, or drainage control for exploration projects. It must be emphasized that this is a guideline, individual reviewers have full authority to approve diversions designed using the 2 yr. event criteria based upon site conditions, the diversion design life and intended use, downstream values, and level of protection warranted.

Designs for diversions of miscellaneous flows that are integral to the operational drainage plan for the life of the surface facilities should be based upon the 10 yr. - 6 hr. precipitation event. Prudent engineering would dictate that diversions to sediment ponds would be based upon the 10 yr. - 24 hr. event to ensure consistency with the pond design criteria. The adopted rules do not mandate this design criteria (10 yr. - 24 hr.), however, the Division should encourage and explain the benefits and merits of this criteria to applicants when given the opportunity.

When approving a short term diversion based upon the 2 yr. - 6 hr. event, reviewers should ensure that the MRP reflects a commitment to remove the diversion within a specific