1985 Fact Sheet, Rationale, and Information for General NPDES Permit for Oil and Gas Operations in West Virginia

This is a transcription of pages from a corrected copy of the 1985 Fact Sheet for the General Water Pollution Control Permit that was sent out with a request for comments. I've chosen only those sections devoted to waste management and its rationale.

At that time pit waste was being legally discharged into streams and rivers or landsprayed. A year or two after this Fact Sheet was created, discharge into streams and rivers was discontinued because of the Clean Water Act. I didn't skip over those sections pertaining to stream discharge since they seemed relevant to the fact that the Permit was, at that time, a document in transition. Evaluation of operators' practice was a fundamental part of the creation of the Permit and the changes the Permit underwent in the 1980s were as much in response to those practices as they were a response to a suit against the state by industry and a growing awareness of the varieties of hazards pit waste constituted.

The Permit has not been changed since the late 1980s in spite of changes of practices in the industry and changes in awareness of the broad range of hazards created by improper management of pit waste.

With the growth of horizontal drilling (a horizontal well may have as many as six or more fractures) and extremely deep wells (e.g., the 20,000+ feet deep well in Roane county), [1] the existing Permit's rationale (already challenged by developments in environmental science) is out of touch with reality.

A copy of the current General Water Pollution Control Permit can be downloaded from the West Virginia Department of Environmental Protection website at http://www.wvdep.org/Docs/16150_General%20Water%20Pollution%20Control%20Permit%20.pdf.

Only pages 9 through 11, 14 through 17 have been transcribed.

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[1] An experimental well to be drilled (as of autumn 2008) by Chesapeake Energy. All footnotes to the 1985 Fact Sheet are my own.

Analytical Characteristics of Pit Waste

Detailed analytical data on treated pit waste is presented under item no. 8 of this fact sheet. The DWR[2] has analytical data on (a) drill cuttings, (b) wastewaters generated during surface casing, production casing and stimulation (fracing), and (c) pit waste after intermediate stages of treatment.[3] The DWR also has analytical data collected from other states and sources. It should be noted that the specific analytical characteristics (and hence toxicity) of pit waste vary from pit to pit depending upon the geographical location, drilling process and drilling additives used. Generally speaking, however, the major pollutants in pit waste are certain metals, organics (measured as TOC)[4], crude oil and chloride.

Metals can be attributed to mainly drill cuttings which are mineral particles generated by drilling into subsurface geologic formations. Only very small amounts of metals can be attributed to drilling additives used.[5] Metals include, but are not limited to, aluminum, manganese, cadmium, vanadium, boron, barium, beryllium, lead, molybdenum, tin, cobalt, yttrium, chromium, copper, iron, nickel, titanium, zinc and mercury. The major metals present are typically iron, aluminum, manganese and barium.

Organics can be contributed by drilling additives.[6] Very small amounts of organics can be contributed by the water soluble petroleum fraction of the crude oil which is encountered during drilling.[7] Trace quantities (in ppb or ppm range) of toluene, benzene, xylene and ethylbenzene have been found in the pit waste. It should be noted that many of the organics are biodegradable, some are volatile, some are nontoxic and some can be oxidized. On the other hand, some can be toxic and/or non-biodegradable. It is very difficult (and extremely expensive) to identify each and every organic chemical present in pit waste and to predict the overall toxicity of the pit waste, because very little is known about the synergistic (or antagonistic) effect of the various chemicals present.

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[2] DWR is the Division of Water Resources of the then Department of Natural Resources.
[3] The Fact Sheet has 3 tables. Table A presents data for 40+ wells before and during treatment. Table B presents data on those same wells after treatment and settling. Table C presents extensive analysis of constituents of 5 pits. Portions of Table C are reproduced on an Excel spreadsheet on our website, http://members.citynet.net/sootypaws/Woods/gaswell/pitfluids.xls
[4] TOC is Total Organic Carbon.
[5] Weighing additives can contain heavy metals such as arsenic, lead and mercury.
[6] The present Permit prohibits use of additives that contain diesel or kerosene.
[7] Particularly high levels of benzene and other volatiles are found in some wells. If there's been a bump or kick during drilling, organics can heavily contaminate the drilling fluid.

Crude oil is encountered during drilling. It is very toxic and the source of the water-soluble petroleum fraction as mentioned earlier.

Chloride can be attributed mainly to the hydrochloric acid used for fracing, brine encountered during drilling, and salts used as drilling additives.

Acute Toxicity of Pit Waste

Acute toxicity of pit waste is generally determined by a bioassay test. Toxicity varies from very low to very high depending upon the concentrations of the various pollutants present. The DWR has carried out a number of bioassay tests.

Major pollutants (or pollutant indicators) generally responsible for acute toxicity are: Low pH, very high pH, high concentrations of metals, organics (TOC) and chloride. The pH can be easily controlled in the range of 6.0 to 9.0 to eliminate any toxicity related to either high or low ranges of pH. Most metals can be readily precipitated out and removed by hydroxide precipitation (by adding lime or caustic), aeration and settling. Data collected by the DWR indicate that more than 95% of total iron present in the pit waste can be removed by this treatment scheme. Therefore, acute toxicity due to metals can be controlled. It should be noted that long-term chronic or bioaccumulative effects of trace quantities of a number of metals have not been studied and hence are unknown. However, the one-time nature of these operations reduces any high degree of concern. Acute toxicity due to organics can be significantly reduced by aeration (volatilization and oxidation of organics) and <u>extended</u> settling (biodegradation of organics).[8] In addition, a special mixture of mutant bacteria and powdered activated carbon can also be used for this purpose. Acute toxicity due to chloride can be reduced by using reverse osmosis. However, the cost and problems associated with the operation and maintenance in the field make this alternative unattractive. Concentrations of chloride, however, can be minimized by (a) minimizing the use of hydrochloric acid for fracing (in other words by encouraging foam fracing), (b) by not dumping unused frac fluids containing hydrochloric acid in the pit, (c) by not dumping brine from oil or gas production wells or other sources into the pit and (d) by not discharging only stimulation flowback into the pit. Another alternative is to segregate stimulation flowback, treat it and dispose of it via underground injection.

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[8] Biocides are commonly used as additives and would drastically inhibit biodegradation of organics.

In light of this information, the proposed running treatment system based on the DWR's best professional judgment (BPJ) would include the following treatment steps:

(a) Oil skimming to remove free (or floating) oil from the pit. This will help to minimize the concentration of the water soluble petroleum fraction (such as benzene, toluene, xylene, ethylbenzene) which is leaching out from the free (crude) oil. Therefore, this treatment step is highly essential. It will also lead to increasing the efficiency of aeration.

(b) Hydroxide precipitation (addition and mixing of lime or caustic soda) to precipitate out dissolved metal ions as hydroxide for removal by physical means such as settling. Use of lime is preferred because sodium and potassium salts are harmful to the environment.

(c) Aeration for BOD reduction, oxidation and volatilization of organic pollutants. This process will also increase the efficiency of metal removal by changing the oxidation state of metals (such as iron) and increasing the dissolved oxygen content of the pit waste.

(d) Extended settling for at least 10 days, preferably 20 days, to improve the settling of suspended particles and to allow additional biodegradation of toxic drilling additives.[9] The later function is very important in reducing the toxicity of the pit waste.

(e) pH adjustment if the pH of the pit waste is not in the range of 6 to 9 S.U. for stream discharge (6 to 10 S.U. for land application).

(f) Use of a suitable filtering device (hay bales, filter bag or filter canister containing fine metal screen) at the end of discharge line to prevent the discharge of sludge into the waters of the State. Such a device may not be required if the pit waste is to be land applied.

It should again be noted that these treatment steps will not lower the chloride content of the pit waste. Treatment steps (a to e) are required for stream discharge or land application. In addition to the above mentioned treatment steps, a selected mixture of bacteria and coagulants or flocculants may be used.

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[9] As noted before, biodegradation would be hampered by the presence of a biocide.

Effluent limitations are proposed for the following parameters:

1. pH -- is a conventional pollutant. It shall be between the range of 6 -- 9 S.U. to provide complete protection for the life of freshwater fish species and bottom dwelling invertebrate fish food organisms. Outside of this range, fish suffer adverse physiological effects increasing in severity as the degree of deviation increases until lethal levels are reached. The proposed limits are equivalent to the applicable water quality standards.

The pH of water applied for irrigation purposes (land application) is not normally a critical parameter. Compared with the large buffering capacity of the soil matrix, the pH of applied water is rapidly changed to approximately that of the soil. The greater danger in acidic soils is that metallic ions such as iron, manganese or aluminum may be dissolved in concentrations which are subsequently directly toxic to plants. Under alkaline conditions, the danger to plants is the toxicity of sodium carbonates and bicarbonates either directly or indirectly. Considering acidic rain and acidic soil in West Virginia the DWR proposes a pH range of 6.0 -- 10.0 S.U. for land application.

2. Settleable Solids and Total Suspended Solids (TSS) -- TSS is a conventional pollutant. Settleable materials, which blanket the bottom of waterbodies, damage the invertebrate populations, block gravel spawning beds, and if organic, remove dissolved oxygen from overlying waters. Therefore, control of solids in the pit discharge is highly essential. Average concentrations of TSS in recently collected treated effluent data is 89.2 mg/l. Twelve out of 42 discharges had TSS concentrations in excess of 100 mg/l (in other words 71.4% of total discharges had TSS of less than 100 mg/l). Data collected during earlier demonstration periods also indicate that 70% of pit discharges had TSS concentration of less than 100 mg/l. The problem of high TSS can be mainly attributed to the sludge being discharged in the effluent. Therefore the DWR proposes the use of a filtering device for stream discharges to resolve this problem. The DWR further proposes to limit the concentration of TSS to 100 mg/l (maximum). This limitation will be applicable to a composite sample collected during stream discharges only. Reasons for justification of this limit are (a) the proposed extended settling period of at least 10 days and the proposed use of a filter, (b) flocculants or coagulants to control TSS are available, (c) BAT or BPT limit for TSS in case of coal mining industry is 70 mg/l (maximum) and (d) various states -- Louisiana, Mississippi, Texas and Oklahoma -- have TSS limitations in the range of 45 -- 100 mg/l (maximum) for pit discharges. Unfortunately, no valid expedient field test procedure for TSS exists. Therefore, the use of the settleable solids test is proposed to evaluate the overall effectiveness of the treatment process. This test will be

carried out on samples taken before the discharge and during the discharge. This data will be reviewed to set up limitations for settleable solids.

It should also be noted that suspended solids can have a significant impact on the land depending upon their composition. Identifiable effects of suspended solids on irrigation use of water include the formation of crusts on top of the soil which inhibits water infiltration, plant emergence and impedes soil aeration and the formation of films on plant leaves which blocks sunlight and impedes photosynthesis. Therefore, the Division encourages the use of a discharge device for land application that insures that the discharge shall be from near the surface of the water level in the pit. Such a device would also be useful for stream discharges.

3. Free (or floating) Oil -- Field and laboratory evidence has demonstrated both acute lethal toxicity and long-term sublethal toxicity of oils to aquatic organisms. The long-term sublethal effects of oil pollution refer to interferences with cellular and physiological processes such as feeding and reproduction and do not lead to immediate death of the organism. Bioaccumulation of petroleum products presents especially significant public health problems of the tainting of edible aquatic species. Oil pollutants may also be incorporated into sediments. There is evidence that once this occurs in the sediments below the aerobic surface layer, petroleum oil can remain unchanged and toxic for long periods since its rate of bacterial degradation is slow. The persistence of unweathered oil within the sediment could have a long-term effect on the structure of the benthic community. Also, the water soluble fraction of crude oil contains toxic organic pollutants such as benzene, xylene, ethylbenzene, toluene, etc. Therefore, it is proposed that there shall be no discharge of free or floating oil in the discharge in other than trace amounts. At no time shall the discharge impart a visible sheen on the receiving stream, to satisfy Series I, Section 3 of the Administrative Regulations. It is proposed that the final discharge sample shall not contain any free oil. Free oil shall be skimmed and removed from the pit before additional treatment and before the discharge, if necessary.

4. Dissolved Oxygen (DO) -- A minimum concentration of DO to maintain good fish population is 5.0 mg/l. DO in drinking water supplies is desirable as an indicator of satisfactory water quality in terms of low residuals of biologically available organic materials. In addition, DO in the water prevents the chemical reduction and subsequent leaching of iron and manganese principally from the sediments. Therefore, a limitation for DO in the pit discharge is highly desirable. Another important objective of such a limitation is to assure that aeration of pit waste is properly carried out and hence the degradation of oxygen demanding materials has been carried out up to an

acceptable level. Unfortunately, there is not enough data on concentrations of DO either immediately after aeration or before the pit discharge. Therefore, the DWR proposes to monitor for DO before the pit discharges This data will then be reviewed for a possible establishment of limitations for DO.

5. Total Iron -- The DWR proposes a maximum concentration of 6.0 mg/l for total iron in the pit discharge. Data recently collected by the DWR indicate that such a concentration of total iron can be easily achieved in the proposed treatment. Out of 43 pit discharges, only 2 pit discharges had total iron concentrations in excess of 6.0 mg/l with average concentration of 1.29 mg/l. Treatability studies carried out recently indicate that more than 95% of total iron present in untreated pit wastewater can be easily removed by hydroxide precipitation, aeration and settling. It should be noted that coal mining guidelines (40 CFR Part 434) specify effluent limitations of 6.0 mg/l (as a daily maximum) and 3.0 mg/l (as a monthly average) for new coal preparation plant associated areas. Since one-time non-continuous discharges are not conducive to monthly average limitations, the proposed limitation of 6.0 mg/l (as maximum) for total iron is quite reasonable. It should not impose any undue restriction on the industry.

It should be noted that the proposed limitation for total iron should also assure appropriate removal of other metals. In other words, it will serve as an indicator for all the metals as afforded in Series II, Section 6(c) (6) (ii)(B) of the Administrative Regulations. Note also that a similar approach has been followed in coal mining guidelines.

6. Chloride -- Considering the provision of Real Time Water Quality Control and anticipated operational and maintenance problems with reverse osmosis units in the field, the DWR proposes a maximum concentration of 25,000 mg/l for chloride in the pit discharge. This limitation should not impose any undue burden on the industry as a whole. The main objective of this limitation is to discourage the (a) dumping of produced water (from production wells) and/or unused frac water (or acid) in the pit and (b) discharge of only stimulation flowback which has very high concentrations of chloride and very high associated toxicity. It should be noted that other states -- Louisiana and Texas -- do not allow the use of flow-controlled discharges to control chloride concentrations in the pit discharge.[10]

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[10] Pit categories 2, 3 and 4 are now permitted to have maximum chlorides of 12,500 mg/l and to receive fracture fluids and flowback. A level of 25,000 mg/l of chlorides can be landsprayed with permission from an inspector. The current Permit, while it allows fracture fluids or flowback in pit categories 2, 3 and 4, disallows, in G7(b), “the dumping of unused frac fluid or acid into the pit.”

If concentrations of chloride in the pit waste exceed 25,000 mg/l, the operator upon notification to the DWR representative must advise what other disposal method option (a listed in the site registration application form) will be utilized.

It should also be noted that the DWR is not proposing limitations for total organic carbon (TOC), chemical oxygen demand (COD), or specific organic priority pollutants (which are present in trace quantities -- in ppb level) because they are not true indicators of the toxicity of the pit waste.[11] Instead, the DWR is planning to carry out biomonitoring of the actual pit discharges on a temporary basis. If the biomonitoring data indicates a potential toxicity problem because of organics, then the general permit will be modified. Meanwhile, the DWR is proposing biomonitoring of the pit content before the discharge only if the discharge is going to take place in trout waters. Such a measure is essential because trout are the most sensitive to the pollutants and the treatment system and its effectiveness are not completely defined. Refer to Attachment A for bioassay test procedure. Survival rate of at least 80% (in bioassay test) is proposed to approve the discharge into a trout stream.[12]

This transcription is being placed on the Sootypaws website in the Gas Well section as part of our examination of drilling waste management. The website is at http://members.citynet.net/sootypaws and our blog is at http://sootypaws.livejournal.com.

[11] The determination of actually what are the most important pollutants is extremely hard to obtain. It's impossible to test for everything and the variability of toxics and quantities is due to formation drilled to, additives used and practices of the operator. As long as one of the most important qualifiers in testing is cost to the operator, little realistic progress in evaluating environmental and public health hazards is possible.

[12] When discharge was allowed into streams and rivers, the bioassay test used flathead minnows. The test evaluates mortality during a period of exposure to a pollutant, so a higher number (presented as percentage of total) of surviving minnows means less toxicity.