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MINIMIZING GROUNDWATER CONSUMPTION FOR REQUIRED FUGITIVE DUST CONTROL PROGRAMS

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ABSTRACT

Control of fugitive dust emissions from coal ground storage facilities, in most cases, involves the use of water, applied with fixed and/or mobile water spray cannons. Based upon experience at Virginia coal transshipment facilities, the Department of Environmental Quality (DEQ) has issued operating permits that require the use of ~ 8 gallons of water per throughput ton of coal. A facility, with throughput of 20-40 million tons puts a rather large demand on municipal water supplies or local aquifers. In either case, there are incentives to minimize the need for such water. Recycling of dust control water and the capture/storage of rainfall are two options available to reduce the demand on potable water supplies.

Simpson Weather Associates (SWA) has developed and applied a full Water Budget Model (WBM) for designing and operating a fugitive dust control system at a coal ground storage facility. The model uses 30 years of hourly weather data to simulate a model facility's impact on fugitive dust management, storm water management, water treatment, and water discharge. The model yields optimum settling pond size and water retention schemes to

- 1) minimize groundwater demand;
- 2) minimize discharge to streams during a 25+ year storm;
- 3) meet dust control permit requirements during extended droughts; and
- 4) minimize suspension of operations due to insufficient water supply or local flooding.

INTRODUCTION

A common strategy for suppressing fugitive dust emissions from an industrial complex is to use water sprays delivered by tank trucks, in situ spray bars or elevated water cannons. In the case of the ground storage of coal, the water required to maintain dust control can be significant, on the order of several 100 million gallons of water per year. Both existing and proposed ground storage facilities for coal in Virginia are required by the DEQ to employ water (plus surfactants in some cases) to assure compliance with air quality standards for particulates. The quantities of water needed to meet the permit requirements can represent a significant demand on potable water, whether it is supplied via municipality water mains or from dedicated wells.

In addition to reducing the annual consumption of potable water, facility operators are concerned with designing water holding/treatment ponds that will be adequate for dry period (low rainfall) operations as well as sufficient for the retention of major storm water runoffs. A Water Budget Model (WBM) has been developed to provide the basis for sizing the water delivery, retention, treatment and discharge components of the dust control/storm water runoff system at a large coal ground storage facility.

THE WATER BUDGET MODEL

A general flow diagram of the Water Budget Model is illustrated in Figure 1. The primary assumptions made by the model are that water is needed for:

- 1) dust control during coal handling, in particular, at the rotary dumper, stacker/reclaimer and loadout silos;
- 2) dust control for piles;
- 3) the cleaning of storage pads, vehicles and roadways;

- 4) fire control; and
- 5) incidental human consumption, cleaning, etc.

It is further taken that:

- 1) saline water is not acceptable;
- 2) municipal or other public water is not available;
- 3) rainwater will be captured and stored;
- 4) a portion of the water used in dust control will be recycled; and
- 5) ground water will be the source of "make-up" water.

The following discussion of the WBM is based upon a hypothetical design of a facility with a ground storage capacity of 4 million tons, an average working storage of 2.5 million tons, and an annual throughput of 40 million tons.

The WBM was run using three different weather scenarios - a typical year, a design storm and a design drought. The "typical year" data was obtained from a meteorological tower located in Newport News, VA. The criteria for spraying the coal piles was taken to be the K-system required by the Virginia DEQ and described in Emmitt et al. (1996).

A second simulation was done using a design storm of 7.6 inches in 24-hours based upon climatological data from the official NOAA National Weather Service (NWS) station at Norfolk International Airport. This design storm has a return interval of 25 years.

A third water budget was run for a 90-day drought during the months of May, June and July. While there is no official engineering "design drought" for a coal handling facility, it is critical to design the water supply system to handle an extended dry period.

Water Demands

The primary demands for water include the spraying of the coal during its unloading and loading (inline dust control), the spraying of the piles of coal using the K-system (Emmitt et al., 1996), the wetting of roadways and the cleaning of equipment.

Inline Dust Control

It was assumed that water was used in the rotary dumpers to form a curtain spray to contain fugitive emissions during dumping. Based upon experience at Virginia terminals, a nominal water requirement is .75 gal/ton of coal handled. The curtain sprays are operated in a fashion to optimize capture and reuse of the spray water. It is estimated that at least 33% of the spray water can be captured and returned to the water supply pond.

In recognition that some of the incoming coal will require additional water (plus surfactant) to control emissions during stackout, inline sprays (.75 gal/ton) are provided at two more locations. In reclaiming the coal, additional wetting capability (.75 gal/ton) is provided at three selected transfer points.

Based upon a throughput of 40 million tons per year, the reprocessing* of 4 million tons per year and assuming the estimated annual maximum water requirement, the inline dust control, (INLINE) was computed to be 195 million gallons per year (MGY) (assuming all coal is treated with water at all six spray points).

The actual amount of water added to any given coal shipment may vary, depending upon several factors. First, real-time dust monitors at the dumper and other transfer points serve to identify coals that need water for dust control. Second, the amount of water needed to achieve a targeted level of dust control may depend upon the use and effectiveness of a wetting agent (surfactant). In the absence of sufficient data, a very conservative estimate was made: on the average only 50% of the inline spray capacity would be used on the total coal processed.

A further reduction of the "inline" demand is realized when weather conditions are incorporated into the dust control system. Based upon weather data taken from Norfolk, VA, there are approximately 100-120 days per year with rainfalls greater than .10 inch. According to hourly data, it rains 6 out of 24 hours on days with rain and thus no spray water would be needed during that time.

Combining these reduction factors the expected inline water requirements for a typical year was calculated by the simulation model to be 71 MGY.

Coal Pile Dust Control

Control of fugitive dust emissions from the coal piles represents the largest demand for water. Sizing the water supply/delivery system depends primarily upon the estimated water requirements for fugitive dust control during extended dry periods.

In estimating the average annual water demand for dust control from coal piles we have made several assumptions:

- the objective of the pile spray system is to deliver an average of .02" of water in one spray cycle to the surface area of each pile and the surrounding pad area. The value of .02" is based upon amounts found acceptable by the DEQ for coal storage facilities in the Norfolk area,
- except for very extreme (crisis) cases each pile will be sprayed, at most, once per hour, and
- a minimum of 4 spray cycles will be used each day except when it is raining, the temperature is below freezing, or it is foggy.

While we recognize that it may be possible to reduce the water demand by discriminating between coals of different dust potential or between used and unused portions of the storage pad, a maximum treatment is computed and used as a "reference". The amount of water required for a reference spray cycle (assuming no overlapping in coverage) is 84,025 gals/cycle.

To estimate the spray water required during a typical year we have considered the following factors:

- number of hours in a year during which it is raining, below freezing, foggy or snow covered; and
- the number of cycles that would be required under a current DEQ permit. Thirty year's worth of hourly meteorological data obtained locally are used.

To determine the number of water spray cycles that are required for dust control, one cannot use average climate statistics. Instead, hourly weather data must be used to simulate the sequence of demand for dust control. Based upon 30 years of recorded hourly data, the K-system operations were simulated and the average water required to treat the piles was estimated to be 160 MGY.

Road Sprays

The pile spraying system was assumed to cover the primary yard traffic routes and thus no additional water was needed for road surfaces. It was further assumed that any frequently used road not wetted by the coal pile spray system would be paved and cleaned periodically with a spray truck.

Wash Water

A value of 6% (based upon experience) of pile spray water required was used to estimate the amount of water needed per day to clean roadways, vehicles, and other equipment. It was further assumed that with the exception

of the roadways, this cleaning would take place where the water would be recaptured for recycling. A recycle factor of 75% was assumed as a best guess.

Water Supplies

Groundwater should not be the primary source for meeting the demands of a coal storage facility. The annual average and daily maximum amounts of required ground water are the net results of a water budget study and are therefore discussed in Section 3. It is advantageous to find alternative water supplies and ways of increasing the efficiency of water usage.

Rainfall

Rainfall represents a significant source of water if properly captured and stored. Not only can rainfall be stored but it also negates the need for other water usage during and immediately after rain events.

Our estimates of rainwater available for capture are based upon the following:

48.5" (4.0') of rain per year

capture areas

pad - 6.8×10^6 ft²

inbound loop (includes pad) - 19.3×10^6 ft²

outbound loop - 10.3×10^6 ft²

runoff factor (% of incident water)

bare ground - 25%

pad - 95%

coal piles - 73%

The total amount of rain water runoff potential (gals):

loop area (w/o pad)	171.3 MGY
pad (30% open)	57.5 MGY
coal piles	<u>103.0 MGY</u>
Total	331.8 MGY

While the amount of rain water potentially available for dust control exceeds the estimated water demands, not all of that water survives evaporation or can be stored. In our simulation we have made the conservative assumption that only if it rains more than 0.25 inches within a 24-hour period will there be any runoff from the pad and piles that is actually available for capture. In other words, 0.25 inches of rain is lost to pooling on tops of piles, inhibited flow in drainage ditches and evaporation.

The model facility has perimeter ditches. These ditches carry water from the non-pad areas into the storage ponds. However, only under very heavy rain conditions should there be significant return from those ditches. The amount of water from these ditches that can actually be captured for use in the dust control system will depend upon the antecedent conditions of the soil and the pond levels at the time of the rainfall event. This potential water supply is not incorporated into the WBM at this time.

Coal Pile Flow Through

This is the most difficult term in the water budget to assess. It also has the potential of being a significant source of water. By "coal water yield" we include any water that exits the pile from the bottom. This water could be

coal moisture that was imported with the coal or it could be some of the rain or spray water that infiltrated and flowed through the pile.

Using soil analogies (sand/silt) we can only make a very rough estimate of what this term might be. If the coal loses 1% weight due to gravitational drainage, then there is ~ 100 MGY available for retention. Based upon laboratory experiments, we estimate that the infiltration water (from rain) is released by the pile within 24 hours.

There is significant uncertainty in these estimates. There is the likelihood that much of the drainage would occur during non-rainy periods and would therefore evaporate before getting to the retention pond. We have assumed that 75% of the leachate will evaporate before being captured. The total flow through is reported primarily for water chemistry computations.

Recycled Water

Not all of the water sprayed on or toward the coal is absorbed. This is particularly true for the in-line dust control at the rotary dumper and loadout silos. Some of this water can be captured and recycled. The exact amount depends on the design of the dust control system. For the model facility we have assumed that 33% of the rotary dumper water and 75% of the water used to clean pads and vehicles can be recycled. All other inline spraying should be absorbed by the coal and effect the desired dust control.

WATER BUDGET RESULTS

All of the factors and budget components discussed in the preceding sections have been incorporated into the Water Budget Model. Thirty individual years of operation were simulated producing time series such as the one for 1974 shown in Figure 2. The model was also run for 2 design situations, the results for which follow.

Typical Year

A plot of the daily water demand during a 'typical year' for dust control and the groundwater requirements to maintain pond levels is provided in Figure 3. A summary of the water budget for this typical year follows:

Kilogallons of water associated with:	
Inline dust control	71099
Pile dust control (2668 cycles)	26491
Wash water	13589
Total water demand	311179
Captured rain water	113108
Recycled control water	14885
Pile flow through water	121440
Evaporation	99962
Total surface supply	149470
Groundwater required	161581
Total water supply	311051
Discharge required	819
Total rainfall (inches)	48.47

From this simulation we see that with a facility designed to use storm runoff, pile drainage and recycling of dust suppression water can meet nearly 48% of its water needs without use of fresh water from the ground supply. Given the limited capacity for storage of storm runoff, approximately ~ 1 MGY must be discharged. However, even this amount of "lost" water can be reduced by using the storage pads (with a berm) as a surge pond during heavy rains.

A Year With a 90-day Drought

In this simulation (Figure 4) we have used the same data used in the typical year case but have zeroed the rain for 90 consecutive days and have kept the minimum number of pile spray cycles per day at 4.

Kilogallons of water associated with:	
Inline dust control	72205
Pile dust control (2813 cycles)	238807
Wash water	14328
Total water demand	325340
Captured rain water	77804
Recycled control water	15512
Pile flow through water	115088
Evaporation	95119
Total surface supply	113205
Groundwater required	211187
Total water supply	324392
Discharge required	0
Total rainfall (inches)	33.72

It is clear from the table above that the demand for water only increased 14 MG for the year (section 4.1) but the groundwater requirement increased by nearly 50 MG, due to the extended absence of rainfall.

SUMMARY

A water budget model has been developed and applied to a 'model' coal ground storage facility to provide the basis for designing the dust control water supply system and predicting the discharge of treated water. A properly designed facility can provide nearly 50% of its water requirements through the capture of rainwater, and the recycling of dust control water, combined with adequate sizing of retention and treatment ponds.

ACKNOWLEDGMENT

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REFERENCES

Emmitt, G.D., L.S. Wood, E.M. Calvin and S. Greco, 1996: PROCONTROL: Automated fugitive dust control system. Paper to be presented at the Environment Virginia '96 Meeting, Lexington, VA, April.

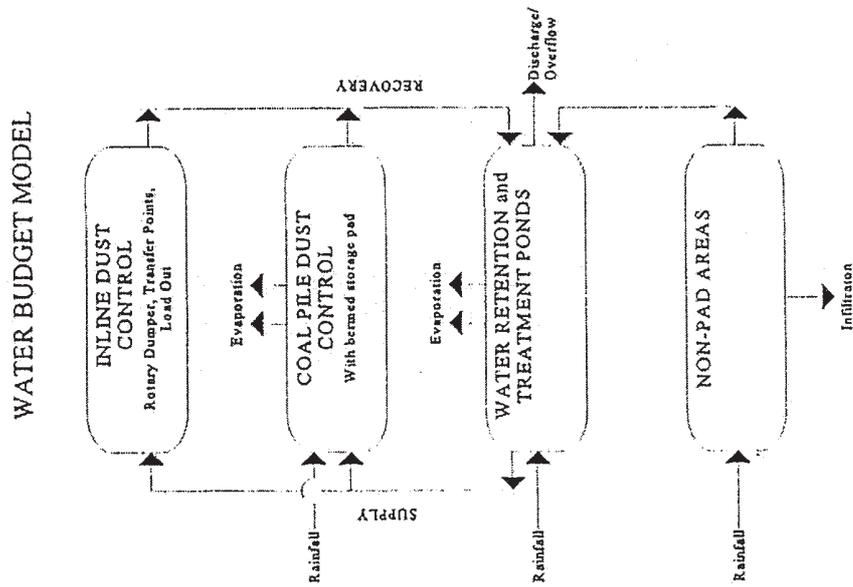


Figure 1. Flow Diagram for Water Model Budget

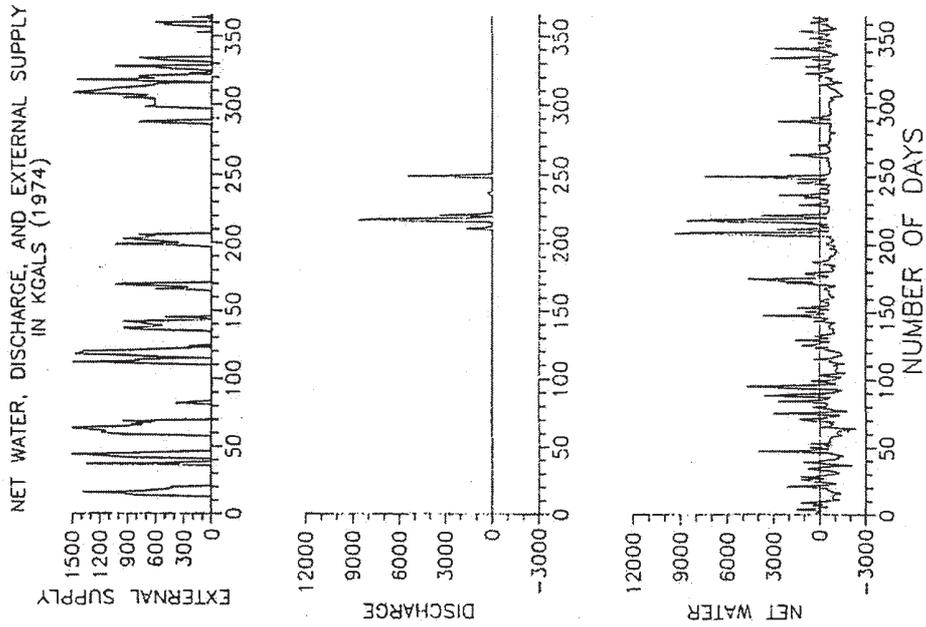


Figure 2. Example of One Year's WBM Simulation of the Model Coal Handling Facility

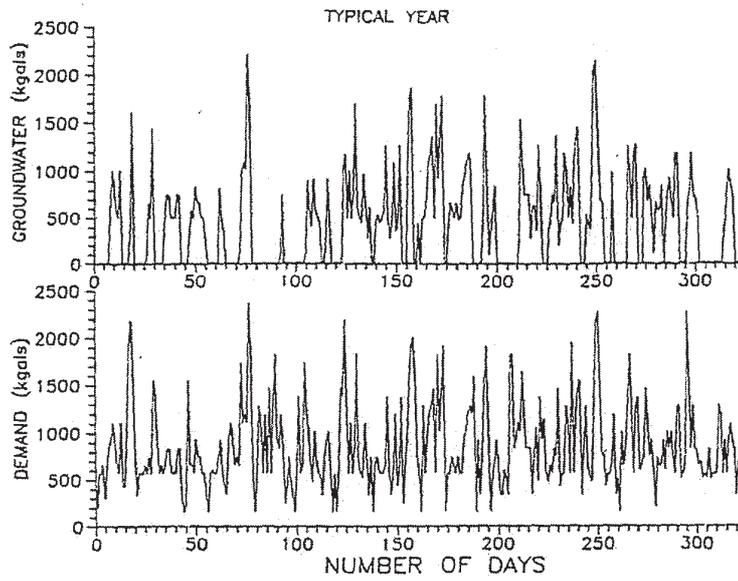


Figure 3. DEMAND (Dust Control) and GROUNDWATER (Municipal Supply)

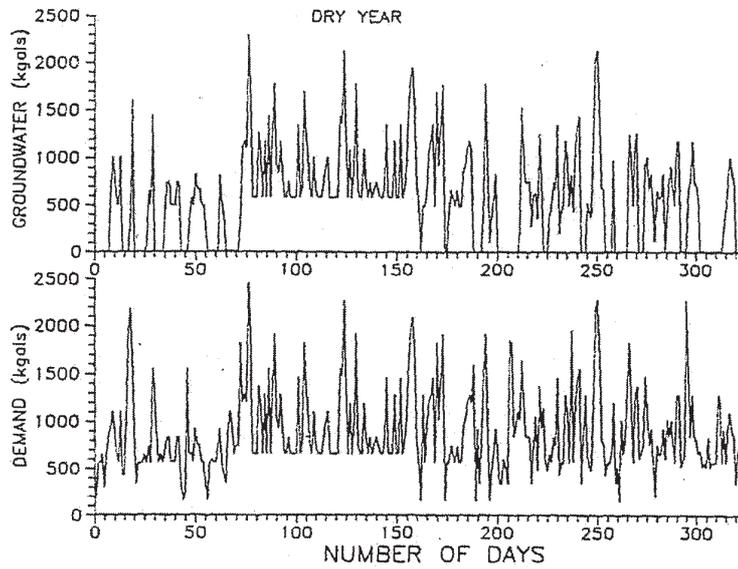


Figure 4. Same as Figure 3 Except a 90-Day Dry Period is Included