

## KPDES Permit Compliance: Metals in Wastewater Effluent at Fort Knox

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### Abstract

Prior to constructing a new FOTW, Fort Knox had a history of exceeding KPDES effluent limitations for ammonia and BOD. The new 6 MGD FOTW solved the problem, but metals exceedances became an issue. The exceedances could be linked to several factors: low water-quality based effluent limitations (WQBELs) on the new KPDES permit, high background concentrations of some metals, and high metals in some waste streams.

Fort Knox adjusted its operating practices and negotiated with the agency to achieve compliance. The key elements include the following:

The post implemented a P2 program that includes: prohibiting certain practices, training, inspections, banning detergents, installing silver recovery units, plugging floor drains, and cleaning sewer lines and traps. In addition, a voluntary wastewater pretreatment program and regulation that includes user limits and compliance monitoring is in place.

The FOTW outfall discharged into a zero-flow stream, resulting in the most stringent WQBELs. The effluent enters an aeration ladder that flows through a natural conveyance into the intermittent stream bed at the outfall. The intermittent stream flows 150 yards into Mill Creek, a 2.5 MGD perennial stream. By diverting the effluent directly into Mill Creek, the new permit reflected greater assimilative capacity at the outfall and an increase in WQBELs.

The proposed new permit included a monthly mercury limit of 0.021 µg/l. This is lower than the 0.1 µg/l MDL, and the mercury concentration in Fort Knox' groundwater and surface water. In lieu of the limit, Kentucky agreed to a study of methylmercury in fish tissue in Mill Creek to demonstrate a reasonable potential for mercury in the FOTW effluent. The first-year results in this ongoing study show that fish tissue meets applicable mercury standards.

Through these efforts, Fort Knox reduced metals concentrations and negotiated more favorable permit terms, eliminating violations at the FOTW.

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### Background

Fort Knox is the home of the U.S. Army Armor Center and a U.S. Army Training and Doctrine Command installation. The post covers approximately 110,000 acres in Hardin, Meade, and Bullitt Counties in Kentucky, approximately 35 miles southwest of Louisville. The installation comprises a 5,700 acre cantonment area, training areas, and range and impact areas. Natural runoff from the cantonment area drains into Mill and Otter Creeks, and eventually into the Ohio River. The training mission at Fort Knox involves extensive use of armored vehicles, and as such includes a large amount of armored vehicle maintenance.

The wastewater treatment plant that was in operation at Fort Knox in the 1980s was a rotating biological contactor facility designed to treat 6 million gallons per day (mgd) of wastewater. The first Kentucky Pollutant Discharge Elimination System (KPDES) permit was issued in 1987 and was based on Best Achievable Control Technology that set limitations on ammonia, oil and grease, TSS, and CBOD. The permit had a requirement for monitoring and reporting total metals, but there were no limitations established. Monitoring showed that the RBC facility was not adequately treating the wastewater influent to meet the KPDES limits on ammonia and BOD. To correct this and other problems, Fort Knox replaced the old facility with a 6 mgd waste treatment plant designed to treat domestic sewage using activated sludge and an extended aeration basin.

Before the new plant was completed, as exceedances on discharge monitoring reports began to accumulate at the Kentucky Department of Environmental Protection (KDEP), file trollers from the Natural Resources Defense Council took note and fired off a threat of civil action to Fort Knox, with copies to Region 4, requesting a response detailing the installation's plans for achieving compliance. Fort Knox was able to respond to the threat by pointing to the new FOTW that was scheduled to be built, and the threat receded. The Kentucky Department of Environmental Protection had begun issuing permits with water quality based effluent limitations (WQBELs) when the KPDES permit came up for renewal in 1992. Fort Knox' new KPDES permit included limits on mercury, lead, chromium, silver, copper and cadmium (Table 1). The outfall from the wastewater treatment plant discharged into a zero-flow stream based on the 7Q10, so the metals limits were quite low, and essentially unachievable.

When the new plant came on line in 1995, the ammonia and BOD exceedances ceased as the facility performed as planned. Unfortunately the monitoring results for the metals showed that effluent limitations for metals were being exceeded, and KPDES compliance was still an issue. There were several reasons for not being able to meet the KPDES limits for some of the metals, including: very low WQBELs on the KPDES permit, high background concentrations of some of the metals in the surface, ground, and drinking waters at the installation, and high metals concentrations in some of the waste streams emanating from the industrial activities on post.

Modifying the treatment process to remove metals in the FOTW influent was rejected as a possible alternative. Pollution prevention and modifying the conditions of the permit were selected as the first options for achieving compliance. In summary, Fort Knox adjusted its operating practices and conducted negotiations with KDEP to achieve compliance. The remainder of this paper discusses the key elements of the Fort Knox KPDES compliance program.

### Wastewater Pretreatment Program

Fort Knox voluntarily developed and implemented a wastewater pretreatment program to monitor and control the sources of metals in wastewater influent. The program follows federal guidance directed toward municipal wastewater treatment systems and includes all of the major elements of a municipal wastewater pretreatment program as codified in 40 CFR 403.8(f), although the installation does not have an industrial user permitting system. The post implemented the program as Fort Knox regulation 200-1.

The effluent limitations that were initially imposed on the industrial users were based on an assumed treatment efficiency at the FOTW. This assumed efficiency was translated into a maximum headworks load applied to the total domestic and industrial wasteload. The resulting limits were very low and impossible for some of the industrial dischargers to meet. A more detailed analysis of the wastewater pretreatment limits was conducted in 1998. The objective of the analysis was to determine the actual treatment efficiencies of the FOTW and to compare that information to the mass contributions from the industrial users. The concentration and volume of the domestic component of the influent was taken into consideration. The new industrial user limits for metals were calculated using a decile approach, which resulted in industrial limitations that were protective of the KPDES permit conditions but were achievable at the industrial-user level (Table 1).

Two separate comprehensive industrial discharge surveys have been conducted to pinpoint the activities most likely to discharge wastewater that will not meet the pretreatment standard. On the basis of mass, the majority of the metals load comes from four sources: 1) the domestic wastestream; 2) infiltration and inflow (I/I); 3) a small municipality within the post boundaries that has a contract for Fort Knox to treat its waste; and, 4) the post hospital. The high mass contribution reflects high flow rates from these sources, with more than 80% coming from the domestic and I/I components.

Industrial users have their feet held to the fire through a rigorous monitoring program that is implemented by the Fort Knox Environmental Management Division. Fort Knox has used the

information collected in the surveys to focus monitoring and pollution prevention on the two dozen or so activities on post that contribute high concentrations of regulated pollutants. Monitoring is conducted by a full-time staff equipped with a field vehicle and automatic samplers. Ten manholes have been fitted with specially designed monitoring inserts to facilitate the use of the samplers. Metals analyses are performed by an outside laboratory.

The pretreatment program prohibits certain practices. The prohibitions include a ban on the use of detergents. Satellite accumulation areas are used for waste POL and other hazardous materials as part of a rigorous waste fluid pick up and inventory program. Silver recovery units were installed where photo processing occurred. Floor drains were plugged so that wayward troops are not tempted to use them as disposal receptacles. And sewer lines and P-traps were cleaned out. Fort Knox has been garrisoned since 1903, as a significant amount of potentially polluting materials had accumulated in the collection system. Prior to being removed, accumulated medical and dental waste associated with on-post clinics could have been a significant contributor of mercury to the FOTW.

### KPDES Permit Renewal

Fort Knox maintains a very open relationship with KDEP, which allows them to work through issues with the agency from a teamwork perspective. When the post's permit came up for renewal in 1997, the Division of Water at KDEP was aware of the difficulties Fort Knox was having meeting some of the lower limits on metals. This was especially true for mercury, which had an effluent limitation that was lower than the detection limit for the approved method of mercury analysis. The positive relationship with the agency was extremely helpful during the permit renewal process. Fort Knox was assisted in permit negotiations by the Corps of Engineers and the Center for Health Promotion and Preventive Medicine.

On the backside of the Fort Knox FOTW, effluent enters an aeration ladder that flows through a natural conveyance to the outfall where it enters the zero-flow intermittent stream bed. The intermittent stream flows 150 yards into Mill Creek, a perennial stream that also carries the wastewater effluent from the village of Radcliff, which enters Mill Creek on Fort Knox just above the confluence of the intermittent stream that carries the Fort Knox effluent. The drainage area of Mill Creek is only approximately 50 square miles, but because of the limestone upland geology there is a sustained base flow that prevents the 7Q10 from being a no-flow condition.

By doing some minor earthwork, Fort Knox was able to prevent the wastewater effluent from entering the intermittent stream bed. The effluent now flows parallel to the intermittent stream and enters Mill Creek several yards downstream from the old confluence. KDEP assigned the stream a 7Q10 of 3.5 cubic feet per second (cfs), which effectively doubled the metals limits on the KPDES permit, as can be seen in Table 1.

This provided substantial relief on the ability to meet the limit on lead, but Fort Knox was not yet out of the woods with respect to mercury. The new monthly average for mercury was going to be 0.000021 milligrams per liter (mg/l), which is hard to measure using a method that reports to 0.0001 mg/l. KDEP

was aware that the mercury concentration in natural waters in the vicinity of Fort Knox exceeded the monthly average limit, and allowed Fort Knox to conduct an annual study to determine if there was a reasonable potential to expect elevated mercury concentrations in the FOTW effluent. In lieu of a numerical limit for the monthly average, the KPDES permit has a monitor only requirement for mercury while the study is being conducted.

The reasonable potential analysis involves collecting bottom feeder and predator fish species from upstream and downstream runs in Mill Creek, and determining whether the mercury concentration exceeds a limit that is safe for human consumption. The limit, which was established by the U.S. Food and Drug Administration, is 1 part per million (ppm) based on the analysis of methyl mercury in fish tissue. Fort Knox has conducted two fish-tissue studies since the permit was issued. The results of both studies show that the concentration of methyl mercury in fish tissue is between 0.05 and 0.29 ppm, and the ratio of the upstream and downstream concentrations is approximately one. The U.S. EPA reports that the national average for mercury concentration in sport fish is 0.36 ppm. These results support Fort Knox' contention that any mercury in its effluent is present because of a natural condition.

### Challenges

There are several significant challenges that must be met in order to maintain compliance with the KPDES effluent limitations at the Fort Knox FOTW. As is the case at all military facilities, probably the most difficult continuing challenge in sustaining a pollution prevention or wastewater pretreatment program is the high rate of turnover at the motor pools. Troops are trained annually in best management practices (BMPs), spill prevention, control and countermeasures, waste management, and storm water pollution prevention. Signage is utilized extensively, as is the post newspaper and other personnel communication forums. EMD also maintains a scheduled semi-annual inspection program and spot inspections. Self inspection and reporting is an enforced BMP.

Fort Knox was required to install a gauging station on Mill Creek as one of the conditions of the new KPDES permit. The station is upstream of the FOTW outfall. The purpose of the station is to support the 7Q10 low-flow measurement on which the WQBEL calculation is based. The United States Geological Survey installed a continuous stream gauge in 1998. With only a year's worth of data, it appears that a typical low-flow condition is closer to 0.5 cfs, rather than the 3.5 cfs used to calculate the current WQBELs. 1999 has been one of the driest years ever recorded in Kentucky, so the 7Q10 is not expected to be appreciably lower. Performing the WQBEL calculations using a 7Q10 value of 0.5 cfs brings the effluent limits back to levels comparable to the 1992 KPDES permit. The stream stage as recorded at the station can be seen in real time at [http://www.dky.lsv.er.usgs.gov/rt-cgi/gen\\_stn\\_pg?station=03301700](http://www.dky.lsv.er.usgs.gov/rt-cgi/gen_stn_pg?station=03301700).

In 1997 when Fort Knox was re-applying for its permit, the approved method for measuring mercury in wastewater was EPA Method 245.1. Since the permit was issued, U.S. EPA has promulgated Method 1631, which lowers the practical quantitation limit for mercury to  $5 \times 10^{-7}$  mg/l. The new method involves clean-sampling techniques, is expensive, and can be performed by only a limited

number of laboratories. Had Method 1631 been promulgated in 1997 the monthly average limit would have been inserted into the permit. States in the Great Lakes basin are applying low WQBELs for mercury as part of the Great Lakes Initiative. In most cases, an intake credit is available to address situations where the mercury concentration in the raw water supply exceeds the effluent limit. Kentucky does not have this provision in its KPDES regulations. Should the monthly average limit for mercury be reinserted into the Fort Knox KPDES permit it may not be possible to meet the limit and comply with the permit.

Finally, Fort Knox has a substantial problem with I/I in its wastewater. This condition is not necessarily unexpected in a 100-year old collection system. During large rain events, flow through the FOTW can peg the gauge at 20 mgd and jeopardize the operation of the plant. As part of the 1998 wastewater survey and a separate I/I project, flow monitoring and chemical sampling was performed to determine the extent to which I/I contributed to the volumetric waste stream and the total mass loading of pollutants to the FOTW. The results of the study showed that during moderate storm events, the proportion of total flow attributable to I/I was more than 70%. Analytical results showed that up to 86% of the lead and mercury in the wastewater influent were attributable to I/I during storm events. In fact, during rainy weather, 98% of the lead and mercury in the FOTW influent is being carried by domestic base flow and the I/I, which makes pollution prevention at the industrial users seem like an inconsequential relief.

Because the Fort Knox KPDES permit does not have a mass limitation, metals resulting from I/I are not a compliance issue; however, given the volume of I/I, removal of this stream would not only be beneficial to the operation of the plant, but would also contribute to the Army's overall pollution prevention initiatives by reducing the volume of sludge produced at the FOTW, decreasing the use of chemicals at the FOTW that are necessary to treat the large I/I component, and minimizing the mass of pollutants discharged to Mill Creek through the FOTW outfall. In addition, it is not inconceivable that mass limits will appear on the next permit.



Table 1 – Fort Knox KPDES Permit and FOTW Information (mg/l)

	1992 KPDES Limits		1998 KPDES Limits		Pretreatment Program Industrial User Limits		FOTW Monitoring Data (Average)	
	Daily Max	Monthly Avg	Daily Max	Monthly Avg	Initial <sup>2</sup>	Revised	Influent	Effluent
Cadmium	0.0039	0.0011	0.007	0.002	0.004	0.015	0.0008	0.0002
Copper	0.018	0.012	0.026	0.02	0.012	0.36	0.0205	0.003
Chromium VI	0.016	0.011	---	---	0.011 <sup>3</sup>	---	N/A	N/A
Lead	0.082	0.0032	0.134	0.009	0.01	0.025	0.0124	0.0048
Mercury	0.0024	0.000012	0.0024	Report	0.0002	0.026	0.0008	0.0002
Silver	0.004	---	0.008	Report	0.0025	0.10	0.0019	0.0013
CBOD	22.5	15	22.5	15	500	523	133	3.86
TSS	45	30	45	30	500	608	127	6.22
Ammonia	3.0	2.0/5.0*	3.0	2.0/5.0 <sup>1</sup>	60	40	15	ND

1. - November 1 through April 30
2. - Limits are in place for other metals not listed
3. - Based on total chromium
4. - N/A = not applicable; ND = not detected