

**Kumtor Gold Facilities, Kyrgyzstan: Comments on Water, Environmental
and Related Issues: September 2011**

All page numbers cited are the numbers on the electronic version of the KOC Technical Report (the TR) [Redmond and others (2011)]--not numbers at the bottom of the printed pages.

Summary.

- KOC controls the mine / processing site like a private fiefdom, restricting access only to those it largely controls. Despite claims by Centerra-KOC and the EBRD, the company does not truly allow open access to outside technical experts with respect to water and water quality sampling.
- Unimpacted glacial melt-waters and springs above the Kumtor Mine operations are uncontaminated and contain almost no dissolved minerals. Waste rock has been placed on some glaciers, together with airborne dust. Meltwaters from these glaciers are releasing arsenic and uranium (as a minimum) into the environment.
- KOC has mined out parts of the Davidov and Lysyi Glaciers, and possibly others, to facilitate access to the ore.
- Mine operations are contaminating local ground and surface waters by releasing *elevated concentrations* of numerous contaminants (uranium, arsenic, aluminum, iron, copper, molybdenum, manganese, nickel, zinc, chloride, sulfate, nitrate, ammonia, cyanides) into the environment. Some of these constituents also exceed international water quality standards and aquatic life criteria (see Addendum). Additional organic contaminants are also likely being released into the environment from the use of explosives, process chemicals, fuels, greases, antifreeze, etc.
- Both KOC monitoring and Kyrgyz Commission (2011) water quality data show that contaminants are being released into the environment from mine facilities.
- Contamination sources include: natural rock contaminants from the waste rock, open pit walls and floor, tailings impoundment (both “treated” discharges and indirect seepage); and fuels and greases (mechanical equipment), process chemical spills, explosives, antifreeze and other chemicals.
- These sediments and contaminants flow downstream into the Naryn (later Syr Darya) River. Some contaminant and sediment particles will be trapped behind the various downstream reservoirs. Other contaminants will flow into neighboring Uzbekistan.
- Local citizens have reported that fish populations in the Kumtor River downstream of the mine are greatly depleted since operations began. KOC does not report any toxicity testing data, which would clarify this claim.

Toxicity testing, such as Whole Effluent Toxicity tests (WET) tests, are routinely performed on Canadian and U.S. mine effluents and reported to their governments.

- The Kumtor operations use roughly 4.38 billion liters of water per year, which increases the competition for water in these arid regions with other downstream users. Much of this water has degraded water quality once it returns to the hydrogeologic system.
- Disposal of waste rock on the local glaciers and other mining-related operations have aggravated the already-extreme melting and retreat of the local glaciers, which are the main source of recharge water to the entire local / regional hydrologic system.
- Wastes: As of the end of 2010, Kumtor operations have created approximately 981,354,000 tonnes of waste rock and about 53 million cubic meters (about 89 million tons) of tailings. Both wastes contain numerous contaminants that are released into the environment. Their volumes will continue to increase and the wastes will remain **onsite forever, requiring continual maintenance.**
- Kumtor uses roughly 8 to 10 tons per day of cyanide to remove gold and silver from the ores. That is roughly **3650 tons of cyanide per year.** KOC monitoring data are totally inadequate to define the specific forms of cyanide that remain in the tailings and which are being released into the environment.
- Waters of Lake Petrov are being contaminated by mine operations, probably via a combination of airborne dust / rock particles and inflows of contaminated ground and surface waters from exposed, mineralized rock.
- Kyrgyz observers have alleged that tailings waters are discharged to the Kumtor River during all months of the year, even in winter.
- The tailings impoundment, the Petrov Lake dam and waste rock piles are unstable as they sit on glacial deposits and permafrost, which is now melting. Any significant seismic event could cause a catastrophic collapse of these materials, especially when they are water-saturated.
- No detailed, statistically-reliable databases have been collected (or made public) that define baseline, pre-operational conditions for water quantities (ground and surface waters), water quality, stream and spring flows, spring locations, aquatic biology, soil chemistry, etc. Thus, the public has no standard against which to define contamination has occurred or not. Such detailed data are routinely required to be publicly-released as part of pre-mining environmental studies in Canada, the USA, the E.U., etc.
- No detailed geochemical testing (static / Acid-base accounting, and Kinetic testing) data has been made public that would define whether these rocks are expected to release acidic, contaminated drainages. KOC-Centerra has misleadingly stated that the waste rock do not contain significant sulfide contents. Such tests are routinely required to be publicly-released as part of pre-mining environmental studies in Canada, the USA, the E.U., etc.
- Pit or waste rock waters have frequently coated Kumtor rocks with yellow-orange stains and several drainages contain white chemical precipitates (see Addendum photo). This suggests that KOC may be adding alkaline chemicals

to the drainages (from waste rock and pit) to mask the presence of acidic effluents.

- KOC-Centerra has been unclear regarding the types and quantities of all metal products that are extracting from the Kumtor concentrates refined at the Kyrgyzaltyn refinery.
- Most of the detailed KOC technical documents are not readily-available to either the public or the Kyrgyz regulators, nor have they routinely been translated into either Russian or Kyrgyz.
- Kyrgyz regulators are not allowed to make unannounced audits of the Kumtor site, nor do they have adequate resources (funds, staff, analytical capabilities, etc.) to reliably oversee the water quality monitoring performed at the site. In addition, it is clear the regulators lack the necessary political support to perform truly independent, competent oversight.
- Kyrgyz government staff have commented that they did not observe the addition of preservatives in the field to historic KOC water samples. This observation plus inconsistencies in the KOC monitoring data suggest that much of the historic KOC monitoring data may be unreliable.
- Because KOC hampered the State Commission audit team's activities in September 2011, it is imperative that a more open and detailed, independent audit of Kumtor water quality be conducted in the near future.
- The Kumtor Reclamation Trust Fund contains inadequate funds necessary to truly remediate and maintain this site, long-term. Thus, the actual costs for long-term maintenance and environmental remediation will likely be subsidized by the Kyrgyz government, or be neglected.

Introduction. Obviously metal mining and Kumtor have brought some economic benefits to Kyrgyzstan. The question is always: for whom and at what price?

There is a common myth that we can develop natural resources on a large scale without any significant impacts. This is untrue, and this myth continues in the daily information average Kyrgyz hear and read with respect to the Kumtor Mine. There is no "free lunch". All such projects involve trade-offs: some economic benefits for significant long-term impacts and costs—often environmental and social. Several additional questions arise: Are these impacts acceptable to those impacted? Who will pay the long-term costs? Who decides?

Since the Kyrgyz media is inundated with mostly pro-Kumtor stories, to provide some balance this report attempts to present some alternative information and alternative perspectives. It attempts to consider not simply the short-term benefits, but also the longer-term consequences. The goal is to assist the public and regulators in better understanding these consequences and to minimize the future impacts.

Background. Some Kyrgyz NGOs have been attempting for almost a year to obtain approval to conduct an independent technical audit of the Kumtor Mine. In

August 2011, it appeared they had received approval of the Kyrgyz government for a team of eight experts, including myself, to enter the site and conduct such an audit. In early September, the president of KOC told the Kyrgyz government that the team could enter on some undefined date, **but my entrance into the site was specifically rejected.** Clearly, **KOC is less than interested in real transparency** on water and environmental matters.



Adjacent to the Kumtor mine (September 8, 2011, Photo: Mirjam Leuze)

As a result, *this report* was prepared during September 2011, written largely in Bishkek. Because my entrance into the Kumtor site as part of the official government audit team was forbidden by KOC-Centerra, the contents of this report were *based on the following*:

Travel to Kyrgyzstan from 2 through 16 September 2011;

-Travel to areas immediately adjacent to the Kumtor site on 8 September 2011, where I observed the mine facilities (from a distance) and made field measurements of temperature, pH, and EC;

-Interviews with a former Soviet-era exploration geologist and former Kumtor employees;

-Meetings with other commission experts;

-Meetings with Kyrgyz government laboratory personnel at the State and Central Laboratories;

-Review of the websites for Centerra, Cameco and Kyrgyzaltyn;

- Review of the following documents:
 - KOC Technical Report (2011)
 - KOC Environmental Protection Report (2009)
 - Cameco Annual Information Report (2008)
 - EBRD Mission report (2009)
 - Technical References listed at the end of this report, and others.
- More than 40 years of applied hydrogeological and geochemical experience at hundreds of mine and industrial sites around the world.

While the water-related goals of the government audit team were hampered by my exclusion from the site visit, other members of the team collected water quality samples on 20 September 2011. I reviewed the laboratory analyses of these water samples in late October- to early November 2011. Thus, in November 2011, I prepared an **Addendum, (included at the end of this report)** which discusses my observations based on these laboratory data.

Control Dilemma: Kumtor Operating Company (KOC) controls the collection and flow of essentially all of the project-related information (environmental, social, investment, etc.) to the public and regulators. KOC pays for and directs the collection and distribution of all project technical information. Truly independent environmental and social information is not available.

The recent KOC Technical Report (March 2011) is **not an independent report**. The main author is an employee of Centerra, and the other authors are consultants who have been paid handsomely by KOC / Centerra / Cameco over many years. Centerra supplied the data and information used by the report authors. This is especially obvious with regard to water and environment opinions.

Reports Not Available: Most of the detailed KOC technical reports (hydrogeology, water quality, aquatic resources, geochemical and metallurgical testing, etc.) one routinely finds at similar mine sites in, for example Canada, are **not available** to the Kyrgyz public, and apparently not to the Kyrgyz regulators. **Most importantly, the significant detailed, technical reports are prepared only in English and have not been translated into either Kyrgyz or Russian.** One exception: the yearly Environmental Protection Reports are translated into Russian.

The KOC Technical Report (2011) fails to present detailed technical information on *baseline* (pre-mining) water quantity, water quality conditions; aquatic biologic conditions—fish and invertebrate populations. It fails to present any data on the detailed chemical compositions of the Kumtor ores, waste rock, tailings or tailings effluents. It fails to present any detailed hydrogeologic data, including well data, aquifer tests, pit inflow studies, etc. It fails to present any geochemical data / testing [i.e. static acid-base accounting (ABA) or kinetic testing], or the results of

metallurgical testing of simulated tailings and effluents—which are routinely included in Feasibility Studies. **Such detailed information is routinely made public in mining technical reports in Canada, the U.S.A, Western Europe, and most other highly-developed countries.**

Refined Products: Kyrgyzaltyn. Since late 1996, production from the Kumtor Mine has yielded 7.8 million ounces of gold (Redmond, and others, 2011). The website for the Kyrgyz company that refines the gold bars, Kyrgyzaltyn, (http://www.kyrgyzaltyn.kg/kumtor_en) states that the average annual production is about 19 tons of gold and 6 tons of silver (as of 2009). Information presented by Rafailovich and others (2008) suggests that the bars may include commercially-valuable quantities of other metals such as the platinum group metals, especially palladium, platinum, and osmium, and possibly tellurium and tungsten. Given the recent interest in rare earth elements (REE), it would also be interesting to know their concentrations in the ores.

Water Use and Increased Water Competition. Mine operations (process plant operations, domestic uses, dust suppression, etc.) require the extraction and use of about 500 cubic meters per hour of water from Petrov Lake (p.34). Thus, KOC extracts about 4,380,000,000 liters per year. (4.38 Billion liters / year). The volume of water needed for Kumtor operations will likely increase as production increases. The Water Usage Permit allows KOC to draw 6.3 million cubic meters per year (about 6.3 billion liters per year) from Petrov Lake (p. 133). **One assumes that KOC pays no price for the water itself.**

Extraction of such vast quantities of water by Kumtor inevitably reduces the supplies available to downstream users for all their daily activities (agriculture, livestock, drinking, domestic, etc.), impacts fish populations, and increases the overall competition for water downstream.

Numerous documents confirm the severe **melting and retreat of the glaciers**, which are the ultimate source of the local waters. This pattern of glacier melting further increases the **water competition problems** as less glacial melt-water is available to supply the rivers and ground waters of the Kumtor-Naryn basin. In the future, with many more mines operating, this may lead to further international disputes between Kyrgyzstan and Uzbekistan.

In addition, much of the water from Kumtor becomes increasingly contaminated as it contacts mine wastes and is used at the site—despite the types of water treatment processes employed by KOC. Thus, downstream users are impacted. Water contamination is discussed further below.

Production. Since late 1996 the Kumtor Mine has yielded 7.8 million ounces of gold (Redmond, and others, 2011). The website for the Kyrgyz company that refines the gold bars, Kyrgyzaltyn, (http://www.kyrgyzaltyn.kg/kumtor_en) states

that the average annual production is about 19 tons of gold and 6 tons of silver (as of 2009).

Wastes / Impacts. This metal production has also produced massive quantities of waste: **approximately 981,354,000 tonnes of waste rock (p. 39) and about 53 million cubic meters (about 89 million tons) of tailings as of the end of 2010 (p.127).** The volumes of both types of wastes will continue to increase as operations progress.

Mining involves exposing, blasting and crushing formerly buried rock that contains high concentrations of dozens of different metals, metal-like elements and other rock minerals. These mining actions greatly increase the surface area of the exposed rock particles, which increases the tendency for these mineralized rocks to chemically-react with the local waters. Thus, the natural rock components are released into the nearby waters, both as dissolved contaminants and sediment particles. Such processes increase the concentrations of contaminants and sediment particles in the environment, *even when the waters are not acidic*. However, if significant concentrations of sulfide minerals, especially various forms of iron sulfide (pyrite, marcasite, etc.) are present in the exposed rocks, natural sulfuric acid is formed, greatly increasing the rate at which the metals and other rock contaminants are released into the environment.



Water flow from the open pit (September 20, 2011, photo: Mirjam Leuze)

Some of the Kumtor rocks contain significant concentrations of pyrite, and

other iron sulfide minerals, which when exposed to air, water and bacteria via mining can release acid and rock contaminants into local waters and soils. While the Technical Report presents no detailed data on the sulfide content of the Kumtor rocks, it mentions the presence of sulfides and pyrite briefly (p. 10,12; 53, 54, 126). However, it **misrepresents the potential for water contamination** by stating on p.122: “The waste does not have any acid generation potential because of its high carbonate content.” On p.139 they state: “The data presented indicated that the acid rock drainage (ARD) potential of both waste dumps and tailings is very low, but that sulphate released from the waste dumps may present a long-term concern.”

No sulfide data are shown and the reader is led to believe that water contamination is not and will not occur. This is false. Water contamination is occurring and acidic waters may develop in the future. Martin and others (1999) report the average sulfide content of Kumtor ores to be from 3 to 4 %; average sulfide content of the waste rocks to be about 1%. These authors also report that water samples had elevated Total (unfiltered) concentrations of iron, copper, nickel and zinc. **Waste rock with sulfide concentrations as low as 0.2 % eventually became acid at the Zortman Mine, U.S.A.** The presence of significant amounts of sulfide minerals in Kumtor rocks is indicated in the following technical sources independent of KOC (i.e. Martin and others (1999); Rafailovich and others (2008); PorterGeoconsultancy: <http://www.portergeo.com.au/database/mineinfo.asp?mineid=mn964>).

In an industry-funded study of **100s of metal-sulfide mines throughout North America**, Todd and Struhsacker (1997) found that **all sites exhibited some degree of water quality degradation, long-term.**

Normally, in such remote environments, most natural ground and surface waters and glacial melt-waters *at some distance from mineralized rocks* are extremely pure, having very low dissolved solids and low measurements of electrical conductivity. **Generally these waters contain so little dissolved material that the addition of minute amounts of contaminants will change their chemistry drastically** (Moran & Wentz, 1974; Kelley & others, 2010). Near Kumtor, this is true for the “control” / up-gradient measurements I made on 8 September 2011, but **it is also clear that mining activities have already contaminated the waters of Petrov Lake** (see discussions below).

Metals and Metal-like Elements in Kumtor Ores and Wastes. In addition to economic concentrations of gold and silver, the mineralized rocks at the Kumtor site also contain elevated concentrations of numerous other metals and metal-like elements, such as arsenic, antimony, barium, bismuth, cobalt, chromium, copper, lead, mercury, molybdenum, nickel, selenium, strontium, zinc, tellurium, tungsten; together with commercial concentrations of platinum, palladium and osmium (Rafailovich and others, 2008).

A geologist on the Soviet-era exploration team at Kumtor from 1976 through 1985, who worked for the Moscow Research Institute, Geologic Expedition for Colored Metals, stated the deposit contained “anomalous concentrations of gold and silver plus **uranium, copper**, aluminum, iron and tungsten.” This person further stated that the Soviets considered underground mining of gold, copper and aluminum, and that “a government commission in the late 1970s to 1980s predicted significant impacts on drinking water quality, the environment, and the glaciers if the deposit was developed using open-pit methods.” (Barskoon, 9 September 2011).

All of the chemical elements mentioned above can potentially be mobilized from the Kumtor wastes and facilities. Many of these chemical constituents have forms that are mobile in waters under a wide range of pH conditions, and do *not* require the formation of acidic conditions to be released into the environment. These include, for example, forms of uranium, arsenic, antimony, copper, mercury, selenium, molybdenum, nickel, zinc, etc.

Waters in contact with mine wastes (waste rock, ore stockpiles, tailings) and the exposed pit walls (and underground workings) routinely contain concentrations of such contaminants that are greatly elevated above those found in waters not in contact with mine wastes. This is common for waters from metal-mine sites around the world.

Additional Sources of Mine Contaminants. In addition to the rock components, mine waters are routinely contaminated by: explosives, process chemicals, fuels, oils and greases, antifreeze, sewage waste, herbicides and pesticides.

KOC states that consumption of **explosives** is about 0.25 kg per tonne of ore or waste (p.121). Using the KOC data (p.39; about 76.4 million tonnes ore and 981,354,000 tonnes of waste rock), one calculates that **roughly 264.4 million kg of explosives have been used at Kumtor.**

The actual quantities of **cyanide** used to extract the gold and silver are not stated in any documents I have seen. However, in the film “All That Glitters”, by Czech filmmaker, Tomas Kudrna (2008), **a Kumtor spokesman states that cyanide use is between 8 and 10 tons per day. That means KOC uses between 2920 and 3650 tons of cyanide per year.**

Most similar gold mine and processing facilities use **tremendous quantities of fuels and other processing chemicals**, but no specific data are provided in the Kumtor TR. In the Environmental Impact Assessment prepared for a proposed gold mine in Romania, Rosia Montana, [actually a proposed expansion of an existing, historic gold mine], the estimated use of diesel fuel per year is 16,470,590 liters / yr. and gasoline is 820,588 liters / yr. This same gold mine was estimated to consume millions of kilograms of the following chemicals over the life of the mine: Diesel Fuel, Lubricants, Fuel Oil, Hydrochloric acid, Lime,

Sodium cyanide, Sodium hydroxide, Sodium metabisulfite, Ammonium nitrate, Copper sulphate. Quantities and types of chemicals used at Kumtor are likely similar to those at Rosia Montana.

Many of the natural rock components (metals / metalloids, etc.) and the other mine-related process chemicals / fuels / explosives release forms of chemicals into local waters that are extremely toxic to fish and other aquatic life. Many are also toxic to humans and other animals if ingested, in some cases acutely, or slowly over significant periods of time.

Residues from the massive use of explosives, release ammonia, nitrate and residues of fuel oil into the environment. Free ammonia is roughly as toxic to cold-water fish as free cyanide. Both gasoline and diesel release components that can act as cancer-causing agents to many organisms. Mining companies routinely spray used oil and other chemicals onto roads to suppress the dust, which releases additional contaminants.

Release of Contaminants. Kumtor Mine **wastes and operations are obviously releasing numerous chemical constituents into the environment.** This conclusion is based on observations and field measurements of water temperature, pH and electrical conductance made in the field from *immediately outside the Kumtor boundary* up-gradient of the tailings and in the Kumtor River about 5 km downstream of the tailings (8 September 2011). The electrical conductance (EC) of up-gradient waters not near any mine facilities was between 80 and 90 microS / cm, which indicates very dilute waters having a total dissolved solids of roughly 50 mg / L. The EC measurement made in the Kumtor River approximately 5 km downstream of the tailings was 630 microS / cm. Thus, the downstream river water contains roughly eight times the quantity of dissolved chemicals than does the up-gradient water. EC measurements will not reveal which specific chemicals are dissolved, but it clearly demonstrates that contaminants are being added from the mine facilities.

These conclusions are also based on review of water quality data included in the **KOC 2009 Environmental Protection Report (EPR)**, satellite imagery of the site and roughly 40 years of experience evaluating mining and other resource-related water and contamination issues.

The KOC 2009 EP Report data (p.D.1) show data from 2005 through 2009 (averages only) for numerous locations, including the outflow from **Petrov Lake (Point W1.1)**. **These data demonstrate clearly that the average EC (electrical conductance) for these lake waters has increased consistently from 0.196 to 0.521 milliSiemens / cm [equal to averages of 196 to 521 microSiemens / cm] from 2005 through 2009. This indicates that some form of mine contamination is entering into the Lake, either as dust or seepages from wastes and mine facilities (pit, exploration boreholes, etc.).**



Petrov Lake (September 20, 2011, photo: Mirjam Leuze)

Other monitoring data in the 2009 EPR also indicate that mine activities are **releasing contaminants from the waste rock** on / near the Sarytor and Lysyi Glaciers (monitoring sites W2.4, 2.2, 3.1) into local surface and ground waters. KOC data from snow samples at sites A1.3 and A1.4 show average EC values that are *very low in some years [i.e. average EC = 53, 37 and 20 microSiemens per cm at Station A1.3 for 2005, 2006, and 2008 respectively, indicating that, without contamination from the mine wastes and dust, the natural glacial melt-waters have almost no minerals dissolved in them.*

Many of the other chemical determinations in these KOC data show “inconsistencies” in the relationship between field EC and total dissolved solids (lab), for example, suggesting problems in the sampling and sample preservation methods employed. Of course, lab analytical problems might also be involved, but experience indicates that most such discrepancies result from sampling and sample handling problems. Kyrgyz State staff that participated in these historic sampling exercises did not see preservatives being added to the bottles in the field, and report significant discrepancies between the analytical results obtained from duplicate samples sent to the State and KOC laboratories. **Such inconsistencies raise doubts about the reliability of the historic KOC monitoring data.**

The KOC EPR data fail to include any analyses of uranium or any related naturally-radioactive constituents, which should be included given the information from past Soviet-era exploration findings.

Unfortunately, KOC declined to provide our team with English-versions of this Environmental Protection Report which would have allowed a much more thorough review of these data.

Treatment of Tailings Effluents / Cyanide. KOC states that the liquid portions of the waste effluents (the tailings) from the process plant are treated using the INCO cyanide decontamination process. This process is frequently employed to treat ores containing iron sulfides, or where iron cyanide complexes are present in the effluents in significant concentrations. It involves the addition of SO₂, air, and a copper catalyst to break down cyanide. While this process does reduce free and WAD cyanide concentrations, it results in the formation and release of several other byproducts that are toxic to aquatic organisms, such as: cyanate, thiocyanate, sulfate, ammonia, nitrate, some free cyanide, metal-cyanide complexes, and elevated copper concentrations. Such treated effluents also contain elevated concentrations of **other metals** [i.e. aluminum, antimony, arsenic, copper, cobalt, lead, mercury, manganese, molybdenum, iron, selenium, strontium, thallium, sulfate, chloride, alkalinity], some at concentrations **higher than before INCO treatment.**

Most Canadian gold sites that use the INCO process are able to generate effluents that comply with the official cyanide discharge standards. However, many of these effluents are **still toxic to organisms in bioassay tests** (Dr. George Dixon, toxicologist, U. of Waterloo, personal communication, 1999). Thus, these complex solutions produce toxicity effects we do not understand, probably as a result of synergistic effects, or they contain toxic constituents that are not being detected or regulated (Moran 2000, 2002).

Effluent Discharges. KOC claims that about 5 million cubic meters (**about 833 million liters per month; 5 billion liters per half-year**) of INCO-treated tailings effluent are discharged to the Kumtor River only from May through October (p.127). A former Kumtor employee alleges that effluents are actually **discharged during all months**, even in the winter. Given the **inadequate storage volume** of the tailings facility and that neither the tailings nor the Kumtor River freeze during winters, **continual effluent discharge seems possible, even likely.** Winter discharges would be most damaging to river water quality because reduced river flows would provide little dilution of the contaminants.

Conversations with several local people and one former Soviet exploration geologist indicate that fish populations in the Kumtor River were previously much larger and declined rapidly after the start of mine operations.

Studies of the toxicity of metals to cold-water fish, most specifically salmon, show that a slight increase in the dissolved copper concentration, to roughly 2 micrograms / liter (2 parts per billion) will cause disorientation of salmon and disrupt their ability to spawn successfully (Woody, 2007, 2011). Salmon are quite closely related to mountain trout.

Pit Water Issues. The Technical Report states that seasonal glacier melt-waters and “relatively minor” amounts of ground water flow into the Central Pit at a rate up to 1000 liters / sec (p.122). However, on p. 76, it states: “Pumping wells located around the southwest perimeter of the pit have been pumping groundwater continuously.” This implies that actual volumes of ground water inflow may be higher than is described. Cameco’s 2008 Annual Information Rept. (AIR), p.89-91, discusses the presence of pressurized, unfrozen water in glacial sediments behind the SE wall of the Central Pit. The surface of the sediments is frozen, thus the water behind the frozen zone is under pressure. No actual hydrogeologic data are presented in the Technical Report or the Cameco Annual Information Report, so it’s impossible to evaluate the actual details. Nevertheless, these are significant volumes of water, equal to **86.4 million liters per day, or about 31.5 billion liters per year.**

Regardless of the source, these waters contact the pit walls and interior rock and pit floor, dissolving soluble minerals, explosive and fuel residues, thereby increasing the concentrations of contaminants and sediments in these pit waters. These large volumes of chemically-degraded pit inflow are then pumped out and discharged to some unknown location in the environment.

Kumtor Facilities and Wastes are Unstable. The Kumtor facilities were constructed on what was solid **permafrost**, which is now beginning to melt in places. **Global climate change** seems responsible for some of the melting and glacial retreat, **but Kumtor activities have also aggravated these processes by exposing formerly buried dark rocks (exposed pit rock, waste rock, etc.), by placing waste rock on the glaciers, and via vibrations generated by explosions and the use of heavy mine equipment.**



Waste rock on the Davidov Glacier (September 2011, Photo: Robert Moran)

The TR states that **Kumtor has previously placed waste rock on some of the glaciers, which has increased their rate of melting and rates of down-gradient movement.** Most such waste rock is dark colored and, according to geotechnical experts who have worked at Kumtor, the **rock placed on glaciers heats up to about 30 degrees C in the sun, even in winter when air temperatures reach -40C.**

These waste rock piles are **up to 120 m high**, and are **extremely unstable. Several dump failures have occurred; at least one blocked the flow of the Chon-Sarytor River (p.78).** On p.79, the TR states: **“Should the waste dump become water-saturated, its stability could be compromised, particularly under seismic loading, and a catastrophic slope failure could result in a flow-slide that impacts the people and facilities downstream.”** Wells in the southeast perimeter of the Central Pit have been sheared off by movement of rocks / sediments within days to weeks after installation. Waste dumps may have aggravated the situation (p. 76).

The Kumtor tailings impoundment dam (see KOC Figure 3) is slowly moving downhill and its shape is deforming (P.127-128). This instability is due partly to the factors discussed above, but is likely enhanced by the relatively high temperatures of the tailings when they come from the process plant (a highly - contaminated mix of about 50% solids, 50% liquids) which would increase permafrost melting. Such deformation and movement of the tailings

structure, combined with the partial melting of the permafrost raises concerns about a catastrophic failure of the tailings impoundment--especially if a severe earthquake were to occur (see discussion below).

At present, the tailings facility is insufficiently large to hold the anticipated 88 million cubic meters of tailings (p. 127), which equals about 148 million tons of tailings. Thus, the dam height must be raised, or a new facility must be constructed (p. 128-129). The present tailings dam height is 36 meters. A former Kumtor employee reports that water in a channel bypassing the tailings can be seen leaking from the channel into the tailings, increasing the volume of tailings materials and further aggravating the structural instability of the tailings. [The Kumtor River starts from Lake Jukuchak, is diverted to the channel in an attempt to bypass the tailings.] **This same former employee and a senior technical consultant to Kumtor also stated that the area occupied by the tailings was previously a wetlands.**

Petrov Lake is a glacial lake upgradient of the Kumtor mine tailings. All of the factors described above raise concerns that the natural glacial moraine dam impounding Petrov Lake and the tailings dam below are both structurally unstable and could fail if a significant earthquake occurs. Aleshin and others (2011) state that these conditions are extremely risky and could result in a catastrophic collapse of the Petrov Lake dam, which might also damage the Kumtor tailings impoundment. This might cause a rapid release of masses of contaminated water and sediments (the tailings) into the Kumtor River, endangering downstream people, facilities, downstream rivers, and would likely kill much of the mountain trout population and other aquatic organisms. Such a collapse could negatively-impact waters throughout much of the Naryn River basin, which flows into Uzbekistan.

Discussions with Isabek Torgoev, a member of the Kyrgyz National Academy of Sciences, and consultant to Kumtor provided information that supported the opinions in this section.

Seismic Issues. The TR presents no detailed data or information on the history of seismic events / earthquakes in the Kumtor area. Numerous independent authors have described the Tien Shan range as one of the most seismically active regions of the world known for major earthquakes (Bowman, et.al. 2004, Dzhanuzakov et al., 1980; Kondorskaya and Shebalin, 1982).

The combination of the melting of the permafrost, the instability of the tailings dam, Petrov Lake dam, the waste rock piles, etc., in conjunction with a large earthquake means that the site has many serious risks for potentially catastrophic release of these materials down the valley.

Long-term, Slow, Semi-invisible Water Contamination. Again, these stability problems (Petrov Lake, waste rock and tailings) together with the lack of any

synthetic geo-membrane liner under *the base* of the tailings almost ensure that contaminated waters are being released into the underlying glacial sediments and ground waters. Long-term, slow leakage of contaminated tailings waters is the norm at most metal-mine operations, worldwide, even where tailings facilities are totally lined. Ultimately, contamination of the nearby ground waters usually leads to contamination of the local surface waters. **Our recent field activities have collected data indicating that the Kumtor facilities are contaminating the surface waters down-gradient of their operations (see discussions above and below).**

Mining of the Glaciers. Kumtor has also mined out parts of the Davidoff and Lysyi Glaciers, and possibly others, to facilitate access to the ore. Mining of glaciers and loading with waste rock would be treated as an extremely volatile environmental / water resource issue in places like Latin America (i.e. Pascua Lama on the border between Chile and Argentina). The Pascua Lama region is only slightly drier than Kumtor, which receives a mere 323 mm of precipitation in an average year.

Dust. Travel to and from the Kumtor site reveals that uncontrolled, blowing dust is a major problem and is likely adding significant concentrations of contaminants to the surrounding rivers, lakes (i.e. Petrov Lake) soils, vegetation, and may be transported onto some of the glaciers. If portions of the roads were constructed with waste rock, the dust would contain elevated metal concentrations. It is likely that waste oils and other chemicals have been discharged onto the road for dust suppression, which would also increase the release of contaminants.

Underground Operations. Construction of two declines (inclined tunnels) is well advanced and KOC expects completion in 2013 (p. 23); “both declines experienced poor ground conditions...” (p.113). The underground ores contain much higher gold concentrations than those in most open-pit areas.

Underground / high grade ores: 628,000 oz. at 12.1 g / ton
1.4 M oz. at 15.3 g / ton

In Soviet times, many underground tunnels (shafts, declines, adits) were constructed. These showed evidence of orange-yellow oxidation of the sulfide ores, which indicate the formation of acid.

Orange staining on rocks and white residue (September 20, 2011, Photo: Mirjam Leuze)



Financial Liabilities.

Inadequate funds are held by the Kyrgyz government to pay for actual clean-up---especially if unexpected bankruptcy of the company occurred, or if actual, long-term water contamination was revealed. Such contamination would require construction and continual operation of a high technology water treatment plant, possibly forever---if the Kyrgyz wish to clean the waters for other uses, especially to allow the return of a healthy fishery.

Costs to construct high-technology treatment plants at similar metal-mine sites, with similar volumes of effluent, often cost \$10 to \$20 million dollars (U.S.), capital costs. The construction costs at Kumtor could be much higher given the remote location. **Plant operation and maintenance costs** vary greatly, but could easily be \$1 million to 3 million dollars per year, possibly forever.

Obviously, these amounts are much greater than any site closure costs presented in the TR (P.139), which were **not based on conservative assumptions about future water quality**. In the Closure Plan of 2007, Golder estimated total costs to be \$24.2 million. Also, it is clear that the money present in the Reclamation Trust Fund, \$7.4 million (net of salvage), is totally inadequate to pay for operation of such a water treatment facility (p.132), if one is needed.

Long-term versus Short-term. While it is common for the public and media to focus mostly on spectacular catastrophic events---like a tailings dam collapse---the more likely, serious problem at Kumtor is the slow, mostly-invisible leakage of tailings contaminants from the impoundment coupled with the long-term release of contaminants from the waste rock, ore stock piles, pit walls and pit drainage, effluents from the INCO “treatment plant”, and ultimately from the future, high-grade underground workings. One must recall that Kumtor began active operations in 1996 and is presently anticipated to continue until at least 2021 (original estimated closure was 2008). **While operations may cease in 2021, the wastes will remain on the site forever. Most importantly, following closure, KOC will gradually reduce and then stop active maintenance of all facilities. At that point, who will carry out all of the activities necessary to ensure that wastes remain covered, that water diversions function correctly, that potentially-contaminated ground water is collected, pumped and treated---in such an inherently unstable environment?**

References:

Aleshin, Y. G., I.A. Torgoev, S.A. Erokhin, G.E. Ashirov, K.A. Abirov, 2011, Geophysical Study of Glacial Lake Petrov Moraine Dam Breach Hazards: International Association Engineering Geology and the Environment (IAEG), EngGeo Conference Papers, p. 156-160; 6-8 Sept. 2011, Moscow.

Bowman, Dan, Andrey Korjenkov, and Naomi Porat, 2004, Late-Pleistocene seismites from Lake Issyk-Kul, the Tien Shan Range, Kyrgyzstan: Sedimentary Geology Vol.163, p. 211 – 228.

Kelley, K.D., J.D. Lang, & R.G. Eppinger, 2010, Exploration Geochemistry at the Giant Pebble Porphyry Cu-Au-Mo Deposit, Alaska: Soc. of Econ. Geologists: No. 80, p.17-23.

Martin, J.C., B. E. Halbert, M.E. Anderson, 1999, Acid Rock Drainage Assessment Programs at the Kumtor Gold Mine, Kyrgyzstan, and the Bogoso Gold Mine, Ghana: Sudbury '99; Mining and the environment II; conference proceedings, Volume 1: pdf.library.laurentian.ca/medb/conf/Sudbury99/AcidicDrainage/AD30.PDF

Moran, R.E. and D.A. Wentz, 1974. Effects of metal-mine drainage on water quality in selected areas of Colorado, 1972-1973. Colorado Water Conservation Board. Water Resources Circular No. 25, 250 pp.
<http://co.water.usgs.gov/publications/pubsnonusgs.html>

Moran, Robert E., 2000, Cyanide in Mining: Some Observations on the Chemistry, Toxicity and Analysis of Mining-Related Waters: *in* Proc. Central Asia Ecology—99, Lake Issyk Kul, Kyrgyzstan, June, 1999. Available at:
<http://www.earthworksaction.org/publications.cfm?pubID=60>
www.zpok.hu/cyanide/baiamare/docs/MoranCyanidePaper0799.rtf
www.claim-gv.org/docs/morancyanidepaper.pdf

Moran, Robert E., 2002, De-coding Cyanide. A Submission to the European Union and the United Nations Environment Programme: Sponsored by Hellenic Mining Watch, Ecotopia, CEE Bankwatch, FOE Europe, FOE Hungary, FOE Czech Republic, Food First Information and Action Network, Minewatch UK, and Mineral Policy Center, 25 pg.
[Available at: http://www.hnutiduha.cz/publikace/studie/kyanidova_studie.pdf,
www.mineralpolicy.org/publications/,
[http://www.eireview.org/eir/eirhome.nsf/\(DocLibrary\)/15583282B873481185256BFB00609501/\\$FILE/Decoding%20Cyanide%20\(Feiler\).pdf](http://www.eireview.org/eir/eirhome.nsf/(DocLibrary)/15583282B873481185256BFB00609501/$FILE/Decoding%20Cyanide%20(Feiler).pdf)
http://aa.ecn.cz/img_upload/8b4cb37fba47da1c76cf3e44aa940cd2/decodingcyanide.pdf

Rafailovich M.S., Seltmann R., Fedorenko O.A., Golovanov I.M. & Nikonorov V.V., 2008, Geology and metallogeny of giant gold deposits Kumtor, Muruntau and Bakyrchik (comparative analysis): Centre for Russian and Central Eurasian Mineral Studies (CERCAMS), Metallogeny of Central Asia from Kazakhstan to Xinjiang—Research in Progress; The Natural History Museum, London.

Redmond, Dan, Henrik Thalenhorst, Jack Seto, 2011 (March 22), Technical Report on the Kumtor Gold Project, Kyrgyz Republic: prepared for Centerra Gold, Inc., 156 pg. Available at:
<http://www.centerragold.com/properties/kumtor/>

Todd, J.W. and D.W. Struhsacker, 1997, Environmentally Responsible Mining: Results and Thoughts Regarding a Survey of North American Metallic Mineral Mines: Society for Mining, Metallurgy, and Exploration Preprint 97-304, Littleton, Colorado.

Woody, C.A., 2007, Summary of: Copper: Effects on Freshwater Food Chains and Salmon: A literature review: <http://www.fish4thefuture.com/>

Woody, C. A. and B. Higman. 2011. Groundwater as Essential Salmon Habitat In Nushagak and Kvichak River Headwaters: Issues Relative to Mining. Fisheries Research Consulting and Ground Truth Trekking. 18 pp.

About Robert Moran:

Dr. Robert Moran has more than thirty-nine years of domestic and international experience in conducting and managing water quality, geochemical and hydrogeologic work for private investors, industrial clients, tribal and citizens groups, NGO's, law firms, and governmental agencies at all levels. Much of his technical expertise involves the quality and geochemistry of natural and contaminated waters and sediments as related to mining, nuclear fuel cycle sites, industrial development, geothermal resources, hazardous wastes, and water supply development. In addition, Dr. Moran has significant experience in the application of remote sensing to natural resource issues, development of resource policy, and litigation support. He has often taught courses to technical and general audiences, and has given expert testimony on numerous occasions. Countries worked in include: Australia, Greece, Bulgaria, Mali, Senegal, Guinea, Gambia, Ghana, South Africa, Iraqi Kurdistan, Oman, Pakistan, Kazakhstan, Kyrgyzstan, Mongolia, Romania, Russia (Buryatia), Papua New Guinea, Argentina, Bolivia, Chile, Colombia, Guatemala, Honduras, Mexico, Peru, El Salvador, Belgium, Canada, Great Britain, United States.

Robert E. Moran, Ph.D.
Michael-Moran Assoc., LLC
Water Quality/Hydrogeology/Geochemistry
Golden, Colorado, U.S.A.
remwater@gmail.com

Addendum.
Prepared November 2011.

Comments on Commission Water Quality Data (field and Lab) from Kumtor Site Visit, 20 September 2011

The following *comments* are made without having been allowed access to the mine site and without having seen either the field measurements made by the Kyrgyz State Environmental Protection Laboratory or the data collected by KOC on 20 Sept. 2011.

Analytical data from the two Kyrgyz government laboratories are summarized in *Table 1*, together with field water quality measurements made by Dr. Kalia Moldogazieva (20 Sept. 2011). *Table 2* summarizes the main water quality standards and criteria for Kyrgyzstan, Canada and the U.S.A.

Note: The Central Laboratory failed to report important analytical determinations for uranium, manganese, molybdenum, mercury, aluminum, arsenic from the K-10 (tailings piezometer) and K-11 (Kumtor River downstream of mine facilities) samples. Also, the Central Laboratory failed to report nitrate, nitrite, chloride, sulphate, and hydrocarbonate for the two glacier melt-water samples (L-1 & L-2). These unexplained irregularities may be related to a sample which arrived late at the laboratory.

Observations:

1-The waters on the mine site and immediately downstream are not used for human consumption purposes, with the exception of those from Petrov Lake, which are presumably treated in some manner. Hence, rather than simply compare these data to Maximum Permissible Concentrations (MPCs), it is more suitable to also consider the general trends of the concentrations from up-gradient to down-gradient, and through time. This allows one to better understand the geochemical processes that are occurring. Secondly, these data should also be compared to standards and criteria for other water uses, especially those for aquatic life.

2-It is unclear what specific forms of cyanides are determined by the Kyrgyz analytical laboratories (free, WAD, Total).

3-It is assumed that all laboratory analyses are for unfiltered waters, thus these are equivalent to Total metal / anion concentrations.

4-Given the iron-manganese staining of the rocks and the white precipitates in several of the photos (taken by team member Mirjam Leuze), the frequent description of pyrites in the Kumtor rocks / ores, and the high electrical conductivity measurements at several sites (K-4, K-5- K-6, K-7, K-8, K-9, K-11), I assume that KOC is adding some form of alkaline

compounds (i.e. calcium carbonate, lime, etc.) to the various water discharges to elevate the pHs and lower the concentrations of some of the trace constituents. This also would mask the formation of acid waters.

5-Some data from the Central Laboratory may be missing. Some metal determinations were missing from the site 11 analysis (the most downstream site on the Kumtor River). Also, the "Test Record Sheet" numbers (at the tops of the pages) are not in consecutive order.

6- KOC clearly had prior warning of the site visit by the Commission team. Hence the results shown may not be representative of site conditions that exist when no prior warning is given. Such biased data have been noted at numerous mine sites around the world.

Conclusions:

1-Where glacial melt-waters are not in contact with any mine-related wastes, **they have almost no minerals dissolved in them.** KOC data from snow samples at sites A1.3 and A1.4 show average EC values that are *very low in some years [i.e. average EC = 53, 37 and 20 microSiemens per cm at Station A1.3 for 2005, 2006, and 2008 respectively]*. These electrical conductivity values are equivalent to dissolved solids concentrations of roughly 10 to 30 mg / L; similar to that of most commercial deionized water.

Where waste rock or mine dust has come in contact with glaciers, it is clear they are contaminating the glacier melt-waters, as shown by elevated concentrations of uranium at L-1 and L-2, and the unacceptably-elevated arsenic concentration (109 micrograms per liter) at L-2 (melt waters from the Lysyi Glacier; 2011 Commission data).

2-The Kumtor mine facilities are obviously releasing numerous contaminants into the environment from the waste rock piles, the tailings, and the process and blasting compounds, as a minimum.

3-Data from the *Central Laboratory* show that the following contaminants are *significantly elevated* at the sampling sites below. **Where site numbers are shown in blue, the concentrations equaled or exceeded Kyrgyz or International MPCs (maximum permissible concentrations) for either standards or aquatic life / agricultural criteria (guidelines).**

| | <u>Site Number (K or L)</u> |
|-------------|-----------------------------|
| uranium | 3,4,6,7,8,9, L-1, L-2 |
| arsenic | 1,2,3,4,6,8,9, L-2 |
| aluminum | 1,2,5 |
| molybdenum | 3,5,6,8,9 |
| manganese | 1,7,8,9 |
| chlorides | 5,6 |
| sulphate | 3,4,5,6,7,8,9,10 |
| nitrate | 5,6,7,8,9,10 |
| bicarbonate | 4,8,9 |

These data clearly indicate that oxidation of sulfides is occurring and that numerous trace constituents are being released from the waste rock, tailings and explosives.

4-The data from the *Kyrgyz State Environment Protection and Forestry Laboratory* show that the following constituents / contaminants have significantly elevated concentrations at the following sites. **Where site numbers are shown in blue, the concentrations equaled or exceeded Kyrgyz or International MPCs (maximum permissible concentrations) for either standards or aquatic life / agricultural criteria (guidelines).**

Site Number (K-)

| | |
|------------------|---------------------|
| Conductivity | 3,4,5,6,7,8,9,11 |
| Suspended Solids | 2,3,7,11 |
| Ammonia | 3,5,6,7,8,9,11 |
| Nitrate | 3,5,6,7,8,9,11 |
| Chloride | 4,5,6,10 |
| Sulphate | 3,4,5,6,7,8,9,10,11 |
| Iron | 3,5,6,10 |
| Copper | 5,6 |
| Zinc | 3,4,5,6,7,8,9 |
| Nickel | 4,5,7,8,9 |
| Cyanides | 3,4,5,6,7,11 |

-Obvious Waste sources:

Tailings: sites K-4 and K-10;

Waste rock and open pits: K-7,8,9, etc.

-K-11: This is the **most downstream site** sampled by the Commission team. Water at this point still contains *elevated concentrations of ammonia, nitrate, sulfate, and cyanides*. All of these constituents and other contaminants are likely responsible for the decline in the fish populations downstream that were reported to our team. In addition, the measured electrical conductivity (909 micro S / cm) is quite elevated when compared to probable baseline values, likely below 80 to 100 micro S / cm (See discussions of KOC data below).

For unexplained reasons, **the Central Laboratory failed to report analytical determinations for uranium, manganese, molybdenum, mercury, aluminum, arsenic from the K-11 samples. Thus we cannot verify the actual concentrations or loads of these metals that are leaving the mine site via the Kumtor River. Nor can we verify the concentrations of numerous other potential contaminants at this site (and other sites), such as antimony, selenium, thallium, numerous organic compounds, etc.---because these laboratories were unable to perform the additional determinations.**

-Because the mine has operated for many years, we don't know all the sources of wastes that may be buried / invisible throughout the area. Thus, we may not know all of the sources of materials that are contributing contaminants to the waters.

-These data indicate clearly that more detailed, independent sampling should be performed to include a more extensive list of chemical constituents such as antimony, selenium, strontium, thallium, thorium, radium, gross alpha and beta, organic pollutants, oil and greases, organic carbon, etc.

-The very high conductivity measurements at sites K-5,6,7,8,9 indicate that significant concentrations of dissolved chemical contaminants are being mobilized into the local waters and environment. It is likely that the Total Dissolved Solids in many of these waters is between about 1600 and 2000 mg / L.

Additional Conclusions from main Moran Report.

Release of Contaminants. Kumtor Mine **wastes and operations are obviously releasing numerous chemical constituents into the environment.** This conclusion is based on observations and field measurements of water temperature, pH and electrical conductance made in the field from *immediately outside the Kumtor boundary* up-gradient of the tailings

and in the Kumtor River about 5 km downstream of the tailings (8 September 2011). The electrical conductance (EC) of up-gradient waters not near any mine facilities was between 80 and 90 microS / cm, which indicates very dilute waters having a total dissolved solids of roughly 50 mg / L. The EC measurement made in the Kumtor River approximately 5 km downstream of the tailings was 630 microS / cm. Thus, the downstream river water contains roughly eight times the quantity of dissolved chemicals than does the up-gradient water. EC measurements will not reveal which specific chemicals are dissolved, but it clearly demonstrates that contaminants are being added from the mine facilities.

These conclusions are also based on review of water quality data included in the **KOC 2009 Environmental Protection Report (EPR)**, satellite imagery of the site and roughly 40 years of experience evaluating mining and other resource-related water and contamination issues.

The KOC 2009 EP Report data (p.D.1) show data from 2005 through 2009 (averages only) for numerous locations, including the outflow from **Petrov Lake (Point W1.1)**. **These data demonstrate clearly that the average EC (electrical conductance) for these lake waters has increased consistently from 0.196 to 0.521 milliSiemens / cm [equal to averages of 196 to 521 microSiemens / cm] from 2005 through 2009. This indicates that some form of mine contamination is entering into the Lake, either as dust or seepages from wastes and mine facilities (pit, exploration boreholes, etc.).**

Other monitoring data in the 2009 EPR also indicate that mine activities are **releasing contaminants from the waste rock** on / near the Sarytor and Lysyi Glaciers (monitoring sites W2.4, 2.2, 3.1) into local surface and ground waters. KOC data from snow samples at sites A1.3 and A1.4 show average EC values that are *very low in some years [i.e. average EC = 53, 37 and 20 microSiemens per cm at Station A1.3 for 2005, 2006, and 2008 respectively, indicating that, without contamination from the mine wastes and dust, the natural glacial melt-waters have almost no minerals dissolved in them.*

Many of the other chemical determinations in these KOC data show “inconsistencies” in the relationship between field EC and total dissolved solids (lab), for example, suggesting problems in the sampling and sample preservation methods employed. Of course, lab analytical problems might also be involved, but experience indicates that most such discrepancies result from sampling and sample handling problems. Kyrgyz State staff that participated in these sampling exercises did not see preservatives being added to the bottles in the field, and report significant discrepancies between the analytical results obtained from duplicate samples sent to the State and KOC laboratories. **Such inconsistencies raise doubts about the reliability of the KOC monitoring data.**

The KOC EPR data fail to include any analyses of uranium or any related naturally-radioactive constituents, which should be included given the information from past Soviet-era exploration findings.

Unfortunately, KOC declined to provide our team with English-versions of this Environmental Protection Report which would have allowed a much more thorough review of these data. Only after the Commission audit had been completed, KOC-Centerra put a link on the web (<http://www.kumtor.kg/en/environment-protection/>) to the English version of the 2010 Annual Environmental Report.

Table 1: Analytical Data from State Commission Water Samples: 20 September 2011
[Field Measurements and Laboratory Determinations]

| Analysis by* | Parameter | Sampling / measurement locations** | | | | | | | | | | | | |
|--------------|----------------------------------|------------------------------------|-----------|------------|---------|------------|-----------|------------|------------|---------|------------|--------------|---------|---------|
| | | K1 (W1-1***) | K2 (W1-3) | K3 (W 1-4) | K4 | K5 (T8 -1) | K6 (T8-4) | K7(W2 2-L) | K8 (W22-P) | K9 | K10 (Pz10) | K11(W 1.5.1) | L1 | L2 |
| Field Meas. | pH (units) | 8.8 - 9.1 | 8.11-8.54 | 8.63 | - | 9.02 | 8.8 | - | - | - | - | - | - | - |
| State lab | | 7.44 | 8.16 | 8.26 | 7.85 | 8.72 | 8.5 | 7.98 | 7.39 | 7.61 | - | 8.04 | - | - |
| Field Meas. | Conductivity, Micro Siemens / cm | 152 | - | 490 | - | 2500 | 2700 | - | - | - | - | - | - | - |
| State lab | | 99 | 139 | 497 | 1251 | 2390 | 2730 | 1921 | 2570 | 2480 | - | 909 | - | - |
| Field Meas. | Temperature, C ^o | 5.4 | 6.8 | 10.1 | - | 10.3 | 9.8 | - | - | - | - | - | - | - |
| State lab | | 9.4 | 5.4 | 9 | - | 9 | 9.1 | - | - | - | - | 9 | - | - |
| | Elements, mg/L | | | | | | | | | | | | | |
| State lab | Suspended substances | 9.4 | 116 | 101 | 8.8 | 16.2 | 20.4 | 984 | 18 | 27 | - | 107 | - | - |
| State lab | ammonium nitrogen | <0.039 | <0.039 | 1 | <0.039 | 4.6 | 6.8 | 5.4 | 5.4 | 4.8 | - | 1.72 | - | - |
| Central Lab | nitrate | <1.0 | <1.0 | 8.86 | <1.0 | 54.046 | 50.945 | 89.486 | 279.09 | 296.81 | 38.984 | - | - | - |
| State Lab | nitrate nitrogen | 0.7 | 0.7 | 2.5 | 1.1 | 12.6 | 10.6 | 12.6 | 23 | 23.8 | - | 5.9 | - | - |
| Central lab | nitrite | <0.01 | 0.02 | 1.34 | <0.01 | 7.9 | 10.25 | 0.73 | 0.715 | 0.98 | 0.96 | - | - | - |
| Central lab | Chloride | 4 | 8 | 21 | 121 | 148 | 140 | 12 | 16 | 19 | 17 | - | - | - |
| State lab | chloride | 1.4 | 1.4 | 2.1 | 108 | 108 | 110 | 6.4 | 14 | 14 | 366 | 4.3 | - | - |
| Central lab | sulphate | 40.74 | 50.2 | 155.55 | 377.35 | 768.68 | 946.04 | 1069.9 | 1137.8 | 1171.1 | 361.71 | - | - | - |
| State lab | sulphate | 17 | 23 | 140 | 366 | 379 | 413 | 409 | 416 | 406 | 466 | 406 | - | - |
| Central Lab | Hydrocarbonate - ion | 34 | 43 | 55 | 201 | 88 | 92 | 125 | 302 | 314 | 85 | - | - | - |
| Central Lab | carbonate -ion | 3 | 6 | 6 | <3.0 | 15 | 9 | <3.0 | <3.0 | <3.0 | 3 | - | - | - |
| State lab | iron | <0.05 | <0.05 | 0.21 | 0.05 | 0.78 | 0.24 | 0.08 | <0.05 | <0.05 | 1.8 | 0.07 | - | - |
| State lab | Copper | <0.0006 | <0.0006 | <0.0006 | <0.0006 | 0.349 | 0.04 | <0.0006 | <0.0006 | <0.0006 | <0.0006 | <0.0006 | - | - |
| State lab | zinc | 0.0036 | 0.0079 | 0.0564 | 0.0529 | 0.281 | 0.0898 | 0.333 | 0.811 | 0.0116 | 0.003 | 0.0067 | - | - |
| State Lab | nickel | <0.01 | <0.01 | <0.01 | 0.06 | 1.35 | <0.01 | 0.17 | 0.1 | 0.08 | <0.01 | <0.01 | - | - |
| State Lab | general chrome | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | - | - |
| State Lab | chrome 6 valent | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | - | - |
| State Lab | Cyanides | <0.005 | <0.005 | 0.02 | 0.01 | 31.6 | 0.08 | 0.02 | <0.005 | <0.005 | <0.005 | 0.03 | - | - |
| State Lab | Cadmium | <0.0002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | - | - |
| State Lab | Lead | <0.0002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | - | - |
| Central Lab | Uranium | <0.008 | <0.008 | 0.032 | 0.015 | <0.008 | 0.01 | 0.051 | 0.115 | 0.107 | - | - | 0.011 | 0.012 |
| Central Lab | Manganese | 0.1 | 0.05 | 0.045 | 0.025 | <0.02 | 0.033 | 5.35 | 0.505 | 0.66 | - | - | <0.02 | <0.02 |
| Central Lab | Molybdenum | <0.002 | <0.002 | 0.21 | <0.002 | 0.27 | 0.024 | <0.002 | 0.036 | 0.018 | - | - | <0.002 | <0.002 |
| Central Lab | Mercury | <0.0005 | <0.0005 | <0.0005 | <0.0005 | <0.0005 | <0.0005 | <0.0005 | <0.0005 | <0.0005 | - | - | <0.0005 | <0.0005 |
| Central Lab | aluminium | 0.185 | 0.11 | <0.04 | <0.04 | 0.149 | <0.04 | <0.04 | <0.04 | <0.04 | - | - | <0.04 | <0.04 |
| Central Lab | Arsenic | 0.021 | 0.006 | 0.034 | 0.006 | <0.005 | 0.007 | <0.005 | 0.005 | 0.0082 | - | - | <0.005 | 0.109 |

*Analyses of samples made on 20 September 2011 by:

- State Lab (Kyrgyz State Lab, Environment protection and forestry),
- Central Laboratory, Kyrgyz Ministry of Natural Resources,
- FM : field measurements made by Commission team

**Sampling/Measurement locations:

- K1. Water from Petrov Lake, near water pump station
- K2. Kumtor River upgradient the treated waters discharge
- K3. Kumtor River downstream 1km after treated waters discharge
- K4. Tailing, the most lower point (well)
- K5. Drainage/sewage waters arriving to the treatment facilities
- K6. Water after treatment facilities
- K7. Water from the mine's pit (bottom)
- K9. Water from the bottom point of waste rock at Davidov Glacier
- K8. Stream from a Davidov moraine
- K10. Water from piezometer in the bottom of the dam
- K11. Kumtor River 7 km downstream from a discharge point (on an exit at mine)
- L1. Melt Water from Sary-Tor Glacier
- L2. Melt Water from Lysyi Glacier

***Sampling sites correspond to Kumtor operational monitoring stations with designations noted in Annual Environmental Report 2009.

Table 2. SELECTED INTERNATIONAL AND KYRGYZ WATER QUALITY STANDARDS AND GUIDELINES

| Parameter | Units | US EPA | US EPA Aquatic Life ¹ | | Canada Agricultural ² | | Canada ³ | Canada ^{4,5} | Kyrgyz ⁶ |
|------------------|-------|-----------------------------|----------------------------------|----------------|----------------------------------|---------|---------------------|-------------------------|------------------------|
| | | Drinking Water ⁷ | Acute | Chronic | Irrig. | Livest | Drinking Water | Freshwater Aquatic Life | Cultural and household |
| pH | Units | 6.5-8.5 | 6.5 | 9.0 | | | 6.5-8.5 | 6.5-9.0 | 6,5-8,5 |
| TDS/Conductivity | mg/l | 500 | | | 500-3500 | 3000 | 500 | | |
| Tot Susp Solids | mg/l | | | | | | | | 350 |
| Turbidity | NTU | | | | | | | | |
| COD | mg/l | | | | | | | | |
| Bioch Ox Dem | mg/l | | | | | | | | |
| Oil+Grease | mg/l | | | | | | | | |
| Total N | mg/l | | | | | | | | |
| Total Phos | mg/l | | | | | | | | |
| Sodium | mg/l | | | | | | 200 | | |
| Chloride | mg/l | 250 | 860 | 230 | 100-700 | | 250 | | 350 |
| Cl, tot res | mg/l | | 0.019 | 0.011 | | | | | |
| Sulfate | mg/l | 250 | | | | 1000 | | | 500 |
| Sulfide | mg/l | | | 0.002 | | | | | |
| Nitrate | mg/l | 10(as N) | | | | 100 | 10(N) | 13 | 10,2 |
| Nitrite | mg/l | | | | | | 1 | | 3,3 |
| Ammonia(as N) | mg/l | | 0.002 to 0.325 | 0.032 to 0.049 | | | | 0.019 | 1,5 |
| Flouride | mg/l | 4.0 (2.0) | | | 1.0 | 1.0-2.0 | 1.5 | 0.12 | |
| Aluminium | mg/l | 0.05-0.2 | 0.75 | 0.087 | 5.0 | 5.0 | 0.1 | 0.005-0.1 | 0,2- 0,5 |
| Antimony | mg/l | 0.006 | | | | | 0.006 | | |
| Arsenic | mg/l | 0.01 | 0.34 | 0.15 | 0.10 | 0.025 | 0.005 | 0.005 | 0,01 |
| Boron | mg/l | | | | | | 5 | | |
| Cadmium | mg/l | 0.005 | 0.002 | 0.00025 | 0.0051 | 0.08 | 0.005 | 0.000017 | 0,001 |
| Chromium,hex | mg/l | | 0.016 | 0.011 | 0.008 | 0.050 | | 0.001 | 0,05 |
| Chromium (tot) | mg/l | 0.1 | | | | | 0.05 | | 0,5 |

¹ US EPA Water Quality Criteria for Aquatic Life—acute(Ac)and chronic(Chr): <http://www.epa.gov/OST/standards/index.html#criteria>

² Canadian Guidelines for the Protection of Agricultural Water Uses(1999)—Irrigation (Irrig.) and Livestock (Livest.): http://www2.ec.gc.ca/ceqg-rcqe/agrtbl_e.doc Due to space limitations, I=irrigation, and L= livestock.

³ Canadian Environmental Quality Guidelines, Dec. 2004, Summary Table: http://www.ccme.ca/assets/pdf/e1_062.pdf

⁴ Canadian Council of Ministers of the Environment, 2003, Canadian Water Quality Guidelines for the Protection of Aquatic Life.

⁵ Canadian Council of Ministers of the Environment, 2011, Canada Environmental Quality Guidelines for the Protection of Aquatic Life. Available at: <http://ceqg-rcqe.ccme.ca/>

⁶ Kyrgyz State standards SEV part 1, 1977 for Total Suspended solids/conductivity, pH, chloride, nitrate, ammonia, nickel, cyanides; Kyrgyz guidelines for sulphate D. Alekin; State standards 4192-82 for nitrite; State Standard 18165-89 for Aluminium; methodical directions 31-11/05 for arsenic; methodological directions 08-47/091 cadmium, chromium, copper, lead, zinc; State standard 4974-72 for manganese; methodological directions 31-11/05 for mercury; state standard 18308-72 for molybdenum; OMG (OMГ) 5-01 for uniranium.

⁷ U.S. Environmental Protection Agency (US EPA) Drinking Water Standards: <http://www.epa.gov/safewater/mcl.html#inorganic> Arsenic standard in becomes effective January 2006.; US EPA, 2002, National Recommended Water Quality Criteria: 2002. EPA-822-R-02-047

| Parameter | Units | US EPA | US EPA Aquatic Life ¹ | | Canada Agricultural ² | | Canada ³ | Canada ^{4,5} | Kyrgyz ⁶ |
|-------------------|------------|-----------------------------|----------------------------------|---------|----------------------------------|---------|---------------------|-------------------------|------------------------|
| | | Drinking Water ⁷ | Acute | Chronic | Irrig. | Livest | Drinking Water | Freshwater Aquatic Life | Cultural and household |
| Copper | mg/l | 1.3 (1.0) | 0.013 | 0.009 | 0.2-1.0 | 0.5-5.0 | 1 | 0.002 - 0.004 | 1 |
| Iron(tot) | mg/l | 0.3 | | 1 | 5 | | <0.3 | 0.3 | 0,3 |
| Lead | mg/l | 0.015 | 0.065 0.025 | 0.0025 | 0.20 | 0.10 | 0.01 | 0.001 - 0.007 | 0,01 |
| Manganese | mg/l | 0.05 | | | | 0.2 | <0.05 | | 0,1 |
| Mercury | mg/l | 0.002 | 0.0014 | 0.00077 | | 0.003 | 0.001 | 0.000026 | 0,0005 |
| Molybdenum | µg/l | | | | 10-50 | 500 | | 73 | 0,25 |
| Nickel | mg/l | | 0.47 | 0.052 | 0.2 | 1.0 | | 0.025 - 0.15 | 0,02 |
| Selenium | mg/l | 0.05 | | 0.005 | 0.02-0.5 | 0.05 | 0.01 | 0.001 | |
| Silver | mg/l | 0.1 | 0.0032 | 0.0019 | | | | 0.0001 | |
| Thallium | mg/l | 0.002 | | | | | | 0.0008 | |
| Uranium | µg/l | 30 | | | 0.01 | 0.2 | 20 | 15 - 33.0 | 0,1 |
| Zinc | mg/l | 5 | 0.12 0.12 | 0.12 | 1.0-5.0 | 50.0 | 5 | 0.03 | 1 |
| Alpha, Gross | picoCi/L | 15 | | | | | | | |
| Radium | picoCi/L | 5 | | | | | | | |
| Cyanide (total) | mg/l | | 0.022 | 0.0052 | | | 0.2 | 0.0005 | 0,035 |
| Cyanide(free) | mg/l | 0.2 | | | | | | | |
| Cyanide WAD | mg/l | | | | | | | | |
| Chlor,tot resid | mg/l | | | | | | | | |
| Phenols | mg/l | | | | | | | 0.004 | |
| Fecal Coliform | MPN/100 ml | | | | | | <5 | 100 | |
| Tot. Colif. | | | | | | | <5 | 1000 | |
| Temp (increase) | | | | | | | | | |
| Salinity (change) | | | | | | | | | |