HOMESTAKE
ALBUQUERQUE OFFICE

Alan D. Cox
Manager - Grants & Southwest U.S.

29 October 2003

U.S. Nuclear Regulatory Commission
Office of Nuclear Materials Safety and Safeguards
Division of Fuel Cycle Safety and Safeguards
Chief of Fuel Cycle Facilities Branch (Mailstop T8-A33)
C/o Document Control Desk
11545 Rockville Pike
Two White Flint North
Rockville, MD 20852-2738

Attn: Mr. Bill VonTill, Site Manager

Re: **Grants Reclamation Project**
Docket No. 40-8903
License No. SUA-1471
Milestone Extension Request – Attachment #2 Replacement

Dear Mr. Von Till:

It was brought to my attention today that our mail-out package on the above referenced issue (sent to you yesterday) did not contain the full text of Attachment #2. Enclosed please find a complete copy of the technical paper.

We apologize for this oversight and hope it has not created an inconvenience. If you have any questions, please don't hesitate to contact me in our Albuquerque office at (505) 287-4456 or my cell phone (505) 400-2794.

Sincerely yours,

HOMESTAKE MINING COMPANY
Alan D. Cox

Enclosures (1)

1) Full text of paper entitled "Flushing of water from mill tailings at the Homestake Grants Reclamation Project" - Proceedings of the Tenth International Conference on Tailings and Mine Waste, 12-15 October 2003, Vail, Colorado, USA

Cc: B. Spitzberg, NRC
M. Purcell, EPA
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G. Hoffman, Hydro Engineering, Casper
ABQ File
Grants File

NMSS01

Flushing of water from mill tailings at the Homestake Grants Reclamation Project

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ABSTRACT: Dewatering of uranium tailings at Homestake Mining Company's Grants uranium mill site has proven to be more difficult than initially predicted. The removal of *in-situ* water in the tailings pile is important in controlling the potential for long-term impacts to the local ground-water system. The use of fresh water injection to drive the water to adjacent collection/recovery wells was initially evaluated in 2000. A complete flushing program for the tailings pile was initiated in 2002 with an average total injection rate of 302 gpm into 152 wells. Production from the tailings dewatering wells has increased to above 100 gpm after declining to below 35 gpm prior to the initiation of the injection/flushing program. Testing to date has indicated that the injection/flushing program is successful in reducing uranium, molybdenum and selenium concentrations in the tailings pile to levels that minimize potential for impact to the local alluvial ground-water system.

1 INTRODUCTION

A large-scale ground-water restoration program has existed at Homestake's Grants Project since 1977. The removal of the source (tailings seepage) is important to enable restoration of ground water at this site. A dewatering program of these tailings was initiated in 1995 and proved difficult to maintain the desired rates from approximately 130 dewatering wells. Fresh water injection has been added to the dewatering program to increase the dewatering rates and drive the high concentration water to the dewatering wells since the year 2000.

2 TAILINGS HISTORY

The large tailings pile contains 22 million tons of uranium tailings from operations of a mill between 1958 and 1990. The large tailings pile was constructed by cycloning the tailings with deposition of the sand material forming the outer dikes and slimes flowing inside of the dikes to ponds. Pools of water were maintained in the west and east cells during the operation of the Grants mill. Re-contouring of the large tailings began in 1993 and was completed in 1995. Figure 1 shows the present topography of the tailings site which shows elevations that are approximately 90 feet high above the flat alluvial plain. Hydraulic tailings deposition at the site has resulted in segregation of the silt and clay particles (slime) in the center of the pile's two cells. The segregation of the slimes in the inner portion of the pile has resulted in smaller permeabilities which makes the dewatering program difficult.

2.1 *Tailings condition*

Tailings wells were drilled in 1994 and 1995 to define the hydrologic conditions in the tailings. Figure 2 shows the approximate locations of the two slime areas and the sand dikes that surround the slimes. The perimeter of the tailings and a center dike are composed of primarily tailings sand, while the inner portion of the tailings consist of mainly slimes. Sand and slime lenses are also present in areas dominated by the other type of milled tailings material. The cross section shown on Figure 2 shows the approximate locations of the sand and slime tailings. This cross section shows the base of the tailings with a perched alluvial sand beneath the base of the tailings. The tailings and the perched sand are in direct contact in some areas of the large tailings pile. The tailings and perched alluvium contact areas are more prevalent on the east, southeast and south central sides of the tailings but local areas of contact exist throughout the tailings.

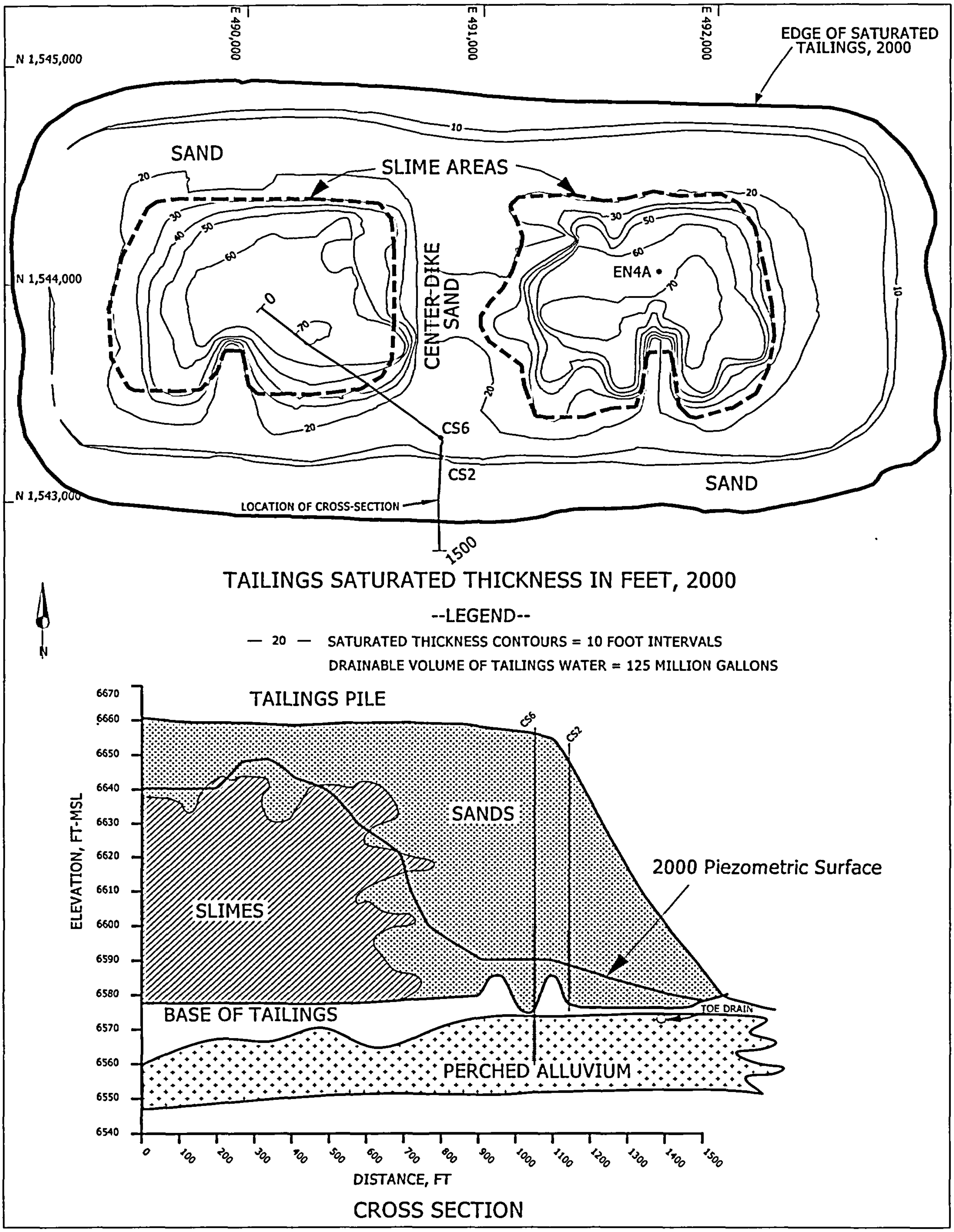

FIGURE 2. TAILINGS SATURATED THICKNESS WITH SAND AND SLIME AREAS AND CROSS SECTION

The northwest quarter of the tailings has less direct local contact. All dewatering wells have developed a direct contact between the perched alluvium and the tailings. The perched alluvial sand contains tailings water and therefore has been considered part of the tailings system relative to the dewatering program. The toe drains, which are shown on Figure 1, were installed prior to the recontouring of the tailings and are located approximately 10 feet below the original land surface and extend into the perched alluvium.

Typical horizontal hydraulic conductivity for the tailings sand is 1 foot per day while hydraulic conductivity of the slime material is roughly 0.01 feet per day. Average specific yields (drainable fraction of water) for the sand and slime tailings are 0.14 and 0.08, respectively.

2.2 *Tailings drainable water volume*

The saturated thicknesses have been used along with the specific yields of the sand and slime tailings to define the volume of drainable water. The amount of drainable water in 2000 prior to the initiation of the injection program was 125 million gallons. Figure 2 shows the saturated thickness of tailings in the pile. Saturated thicknesses range from greater than 70 feet in the slimes area to zero saturation near the toe drains. The outside sand dike typically contains slightly less than 20 feet of saturation.

3 TAILINGS DEWATERING

The tailings dewatering program has consisted of vertical wells using submersible pumps to remove the tailings water. Details of the dewatering program were presented in Hoffman & Cellan (1998). The tailings dewatering program currently includes numerous pumping wells that produce a few tenths to a few gallons per minute. The maintenance of wells pumping continuously at very low rates in this high concentration water has resulted in more frequent pump replacement than normal. Maintaining a constant pumping rate has also been difficult in some wells. Dewatering wells also act as vertical drains to drain tailings water to the perched sand if they are not producing. Toe drains were installed around the tailings in 1993 and are also used to intercept the tailings seepage and are part of the total dewatering program. Figure 1 shows the location of the dewatering wells and toe drains on the large tailings pile. The dewatering program consists of approximately 130 dewatering wells as of 2002.

3.1 *Dewatering history*

Dewatering of the slime uranium tailings at the Grants Project started with a test program in 1995. A full scale dewatering program was initiated in 1996 producing an average total rate of approximately 50 gallons per minute of water from the large tailings pile. Well yields have varied from a few tenths to a few gpm with very few wells substaining more than 2 gpm. The average dewatering rate per well was less than 0.5 gpm prior to the initiation of the injection program. Table 1 presents the actual tailings well dewatering rates in gallons per minute (gpm) from 1995 through 2002. This table also presents the actual pumping rates from the toe drains for this same period. The dewatering system was not used in 1998 and was used on a very limited basis in 1999 due to limited storage volume in the evaporation ponds. The program was reinitiated in 2000 with the total dewatering program producing only 35 gpm. The dewatering program was not able to meet the desired extraction volume due to the declining well yields with time. A fresh water injection program was tested in 2000 to determine the benefits to increasing dewatering rates and the reduction in concentrations. The complete flushing program was installed prior to 2002 and demonstrated that the total dewatering production rate would exceed 100 gpm with the injection/flush program. The dewatering in 2002 was also limited due to evaporation pond volume. The dewatering efforts from 1995 through 2002 have produced a total of 98 and 100 million gallons of water from the tailings wells and toe drains, respectively.

Table 1. Actual Tailings Dewatering Rates in gpm.

	Year							
	'95	'96	'97	'98	'99	'00	'01	'02
Tails Wells	11.2	17.5	40.5	0	0.2	23.6	59.9	33.9
Toe Drain	33.7	29.4	22.9	19.6	16.8	15.2	18.3	34.2
Total	44.9	46.9	63.4	19.6	17.0	38.8	78.2	68.1

Note; Actual Volume: Tails Wells = 98 and Toe Drain = 100 million gallons.

The toe drain pumping rate declined each year from 1995 through year 2000. A small increase in the rate of pumping from the toe drains occurred in 2001 with a significant increase in 2002 due to the fresh water injection into the tailings. The rates of water produced by the toe drains would have continued to significantly decline with time without the fresh water injection program and therefore the volume of water produced by the toe drains would have been significantly less than the volume that will be

produced by the drains with the fresh water injection program.

3.2 *Projected dewatering rates*

The combination of dewatering with the fresh water injection program will enable larger extraction rates to be obtained. Table 2 presents the projected dewatering rates from 2003 through 2007. Evaporation pond capacity is limited so the projected rates for 2003 and 2004 are lower than potential production rates. An additional 152 and 47 million gallons of water are projected to be produced from the tailings dewatering wells and the toe drains respectively from 2003 through 2007.

Table 2. Projected Tailings Dewatering Rates in gpm.

	Year				
	'03	'04	'05	'06	'07
Tails Wells	30	60	80	60	60
Toe Drain	50	30	10	0	0
Total	80	90	90	60	60

Note; Projected Volume: Tails Wells = 152 and Toe Drain = 47 million gallons.

The toe drains are expected to produce an average of 50 gpm for 2003. A larger rate of production from the toe drains would likely be possible for 2004 but the pumping rate is expected to be reduced to 30 gpm in 2004. A portion of the toe drain water, which has concentrations less than a conductivity of 15 mmhos/cm, will be allowed to migrate through the partially saturated alluvium to the alluvial aquifer. The toe drain water that contains lower concentrations will help flush higher concentrations in the partially saturated alluvium down to the alluvial aquifer for eventual collection. Therefore, allowing some of the toe drain water to migrate to the alluvial aquifer is considered beneficial and this process will start in 2004. The rate of drainage to the toe drains is expected to start to decline in 2005 but the concentrations of the water in the toe drains are also expected to be significantly less and therefore only 10 gpm is projected to be pumped from the toe drains in 2005.

The dewatering wells are projected to be operated through 2007. The concentrations in the tailings are expected to be small in 2007 and therefore continued operation of the dewatering is not expected to be beneficial.

4 FRESH WATER INJECTION

Fresh water injection into the uranium tailings at the Grants Project was initially tested in 2000. This testing showed that the dewatering well production was increased substantially with the injection. It also showed that the concentrations were reduced substantially in the tailings. The test demonstrated that the fresh water injection into the tailings was worthwhile even with the increased volume of water to be pumped. A total of 106 new 2-inch wells were completed only in the tailings for the fresh water injection program. These new wells were used along with 46 existing wells to inject the fresh water into tailings.

4.1 *Tailings injection history*

Fresh water injection was initiated in 2000 to test the feasibility of the fresh water injection program. Table 3 presents the average yearly rate that was injected into the tailings from 1995 through 2002 with projected injection through 2007. The full program in 2002 averaged 302 gpm of water injected into the tailings. A total of 277 million gallons of fresh water have been injected into the tailings through 2002. Figure 1 shows the locations of the fresh water injection wells.

Table 3. Actual and Projected Tailings Injection Rates in gpm.

	Actual Injection Rates							
	Year							
	'95	'96	'97	'98	'99	'00	'01	'02
Tails Wells	0	0	0	0	2	61	162	302

	Projected Injection Rates				
	Year				
	'03	'04	'05	'06	'07
Tails Wells	300	300	0	0	0

Note; Actual Volume: Tails Wells = 277 million gallons and Projected Volume: Tails Wells = 315 million gallons.

4.2 *Projected tailings injection*

The tailings injection program is planned to be continued through 2004. The fresh water injection program is expected to average 300 gpm for 2003 and 2004, as tabulated in the lower portion of Table 3. This will be an additional 315 million gallons of fresh water injection. The total fresh water injection volume from 2000 through 2004 should be slightly less than 600 million gallons of injection at the end of the program.

The total volume of injection water from 2000 through 2007 is significantly greater than the total dewatering volume for this same period. Table 4 lists the volumes since the start of injection in mil-

lion gallons. A total of 297 million gallons is expected to be produced from the tailings dewatering wells and toe drains from 2000 through 2007 while the injection volume is expected to be 592 million gallons. This is a net addition of 295 million gallons to the tailings (expressed as a negative withdrawal in Table 4). The average seepage rate of water beyond the toe drains would need to average 70 gpm over this period of time to prevent an increase in the volume of water at the end of 2007 above the volume that existed in 2000. The average seepage rate is likely to be near 70 gpm; therefore, the volume in storage at the end of the dewatering program is expected to be close to the volume that existed in 2000.

Table 4. Tailing Production Volumes Since the Start of Injection in Million Gallons, 2000-2007.

	Total Dewatering	Total Injection	Net Withdrawal
Tails Wells	214	592	
Toe Drain	83	0	
Total	297	592	-295

4.3 *Tailings concentrations*

The tailings initially contains water with a total dissolved solids (TDS) of approximately 30,000 mg/l with typical uranium and molybdenum concentrations of 40 and 100 mg/l respectively. The reductions in concentrations were initially demonstrated in the sand tailings at injection well CS6. Tailings well CS2 was monitored 90 feet downgradient of CS6. Figure 3 presents the plot of the chloride, TDS, sulfate, selenium, uranium and molybdenum concentrations versus time since the CS6 injection started. The injection concentrations are also shown on this graph and are slightly elevated due to the use of mildly impacted alluvial water as the injection source. The upper figure of the three major constituents shows that the concentrations decline to a relatively stable level after approximately 220 days of injection. These three restoration curves are fairly similar and each are slightly above the injection concentration indicating that some tailings water is still draining from lower permeability zones in this area or a minor lateral gradient introduces some unaffected tailings water at well CS2. This data indicates that a source of tailings water of approximately 10% is being mixed with the injection water at CS2. The uranium and molybdenum concentrations behave very similar to the major constituents with the uranium concentrations declining to the injection concentration while molybdenum concentrations declined to slightly above the injection concentration. Selenium concentrations increased in the tailings water early during the test prior to the arrival of the injection water at CS2. This increase in selenium concentrations may have been due to the increase in water level in well CS2 resulting from injection. The selenium concentrations subsequently declined similar to other constituents as injection continued.

The changes in the slime tailings were tested at slime well EN4A which is 11 feet away from injection well EN5 (see Figure 2 for location of well EN4A). Slightly higher concentrations existed in the tailings at EN4A prior to the fresh water injection into well EN5 than those at well CS2. Figure 4 presents the plot of the chloride, TDS, sulfate, selenium, uranium and molybdenum concentrations versus time since injection into well EN5 started. The injection concentrations are also shown on this graph and are lower concentrations than the injection concentrations used for the well CS2 test. The upper figure presents the three major constituents of chloride, TDS and sulfate which show a decline in each of these three constituent concentrations to a fairly steady level between 310 and 420 days after injection started. A smaller decline was observed after the major decrease of concentrations. The second step down in concentrations is thought to be due to the water flowing through the lower permeability slime material. Therefore, the actual ground-water velocity through the lowest permeability in this slime is significantly slower than indicated by the 50% change in these conservative parameters. The extrapolation of the second step of concentrations back to the 50% change would indicate that the ground-water velocity through the lowest permeability slimes may be approximately 0.03 feet per day. This is a realistic ground-water velocity for the slime material.

The lower graph on Figure 4 contains the plot of the selenium, uranium and molybdenum concentrations versus time. Selenium concentrations observed during the test are similar to injection concentrations and therefore do not indicate significant changes in this constituent. The decline in uranium and molybdenum concentrations is similar to the major constituents. The uranium and molybdenum concentrations indicate that restoration of these two constituents would be very similar to the conservative parameters and concentrations will reach very low levels as the injection water moves through the slime material.

The test of the flushing of the slime material with fresh water indicates that the rate of ground water movements through this material will be very slow

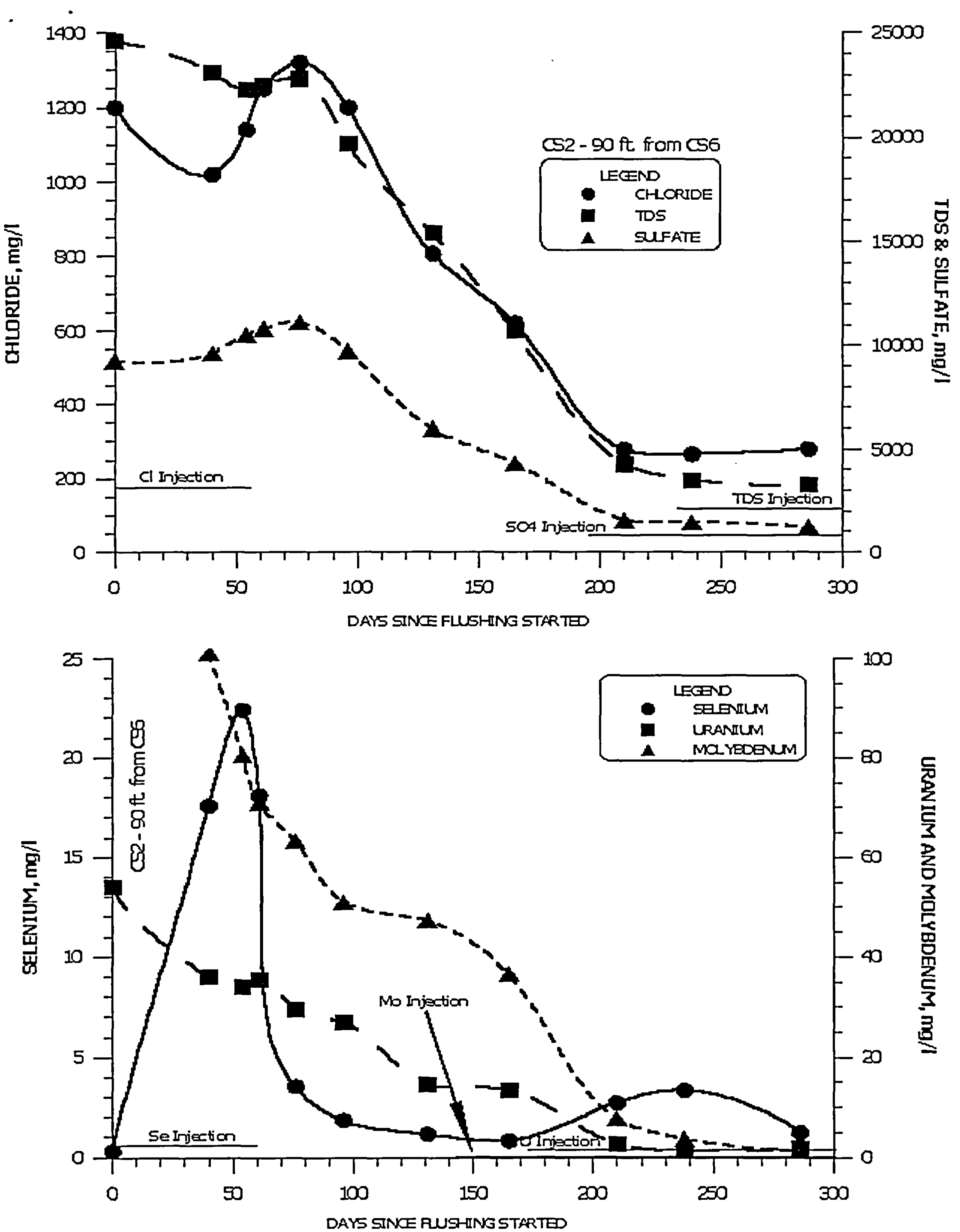

Figure 3. Chloride, TDS, Sulfate, Selenium, Uranium and Molybdenum Concentrations for Well CS2 versus Time Since Well CS6 Injection Started.

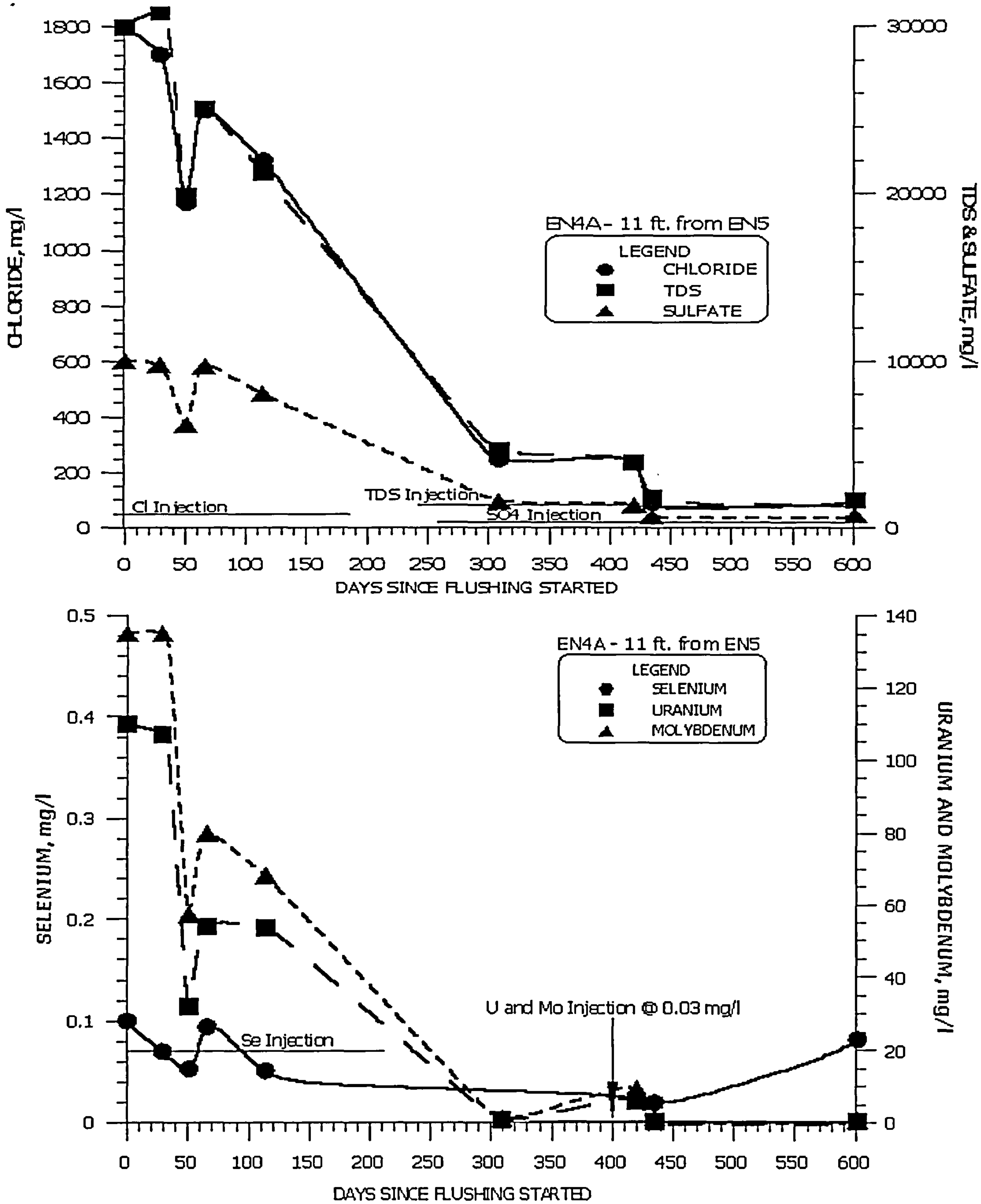

Figure 4. Chloride, TDS, Sulfate, Selenium, Uranium and Molybdenum Concentrations for Well EN4A versus Time Since Well EN5 Injection Started.

as expected. This test indicated it may take 5 years for the injection water to travel 50 feet through the slime material. The changes in the key parameters of uranium and molybdenum indicate that the flushing of concentrations through the slimes, even though very slow, will be very successful.

Figure 5 presents the conductivities in mmhos/cm for the tailings water in April 2003. This figure shows patterns where concentrations are less than 10, between 10 and 20, between 20 and 30, and greater than 30 mmhos/cm. Conductivity in the entire tailings area except for the outer edges of the sand dike was greater than 30 mmhos/cm prior to the fresh water injection. This figure shows that conductivity in large areas has been decreased substantially by the fresh water injection program. The majority of the tailings conductivities are expected to be significantly below 10 mmhos/cm at the end of the fresh water injection and dewatering program. Concentrations are expected to increase slightly after the injection ceases as some lower permeability lenses gradually drain.

4.4 *Constituent removal*

The fresh water injection, while increasing the residual volume of water in the tailings, will ultimately allow extraction of a greater volume of mobile constituents from the tailings. In the absence of fresh water injection, the collection rates from the tailings would continue to decline and the rate of extraction of mobile constituents would parallel the dewatering rate.

Fresh water injection functions as a drive for higher concentration water within the tailings. The collection wells initially extract the higher concentration tailings water at increased rates due to the greater saturated thickness and gradients used by the injection. The concentrations in the collections wells will decline as the fresh water injection front reaches the well. Ideally, the injection front would be fairly steep and would result in an abrupt decrease in concentration as the front reached a collection well. This would allow sequential termination of collection in local areas with very limited extraction of fresh water. The heterogeneities in the tailings material, non uniform flow paths, and natural dispersion processes will smear the injection front and result in collection of mixed water at intermediate concentrations. However, the mass of volume of constituents extracted is dramatically greater with the injection/collection combination. Figure 6 presents the amount of removal of pounds of uranium with injection for each year in the upper graph. The lower graph presents the cumulative mass of removal of uranium with the injection system. The projected cumulative removal with only a dewatering system is less than one-half the volume with injection. This illustrates the effectiveness of the injection in facilitating constituent removal in a timely manner.

5 CONCLUSIONS

The use of fresh water injection along with the dewatering program at the Grants Project site is beneficial. The volume of total well dewatering from the Grants site without the fresh water injection would have been significantly less than 100 million gallons. With the fresh water injection program, approximately 250 million gallons of dewatering with wells is expected from the tailings by the end of the dewatering program. This volume will be approximately twice the volume of drainable water in the tailings prior to the fresh water injection program but the pumping of the additional volume is deemed necessary to obtain the removal of a large percentage of the high concentration water.

The volume of water in storage in the tailings at the end of dewatering in 2007 is likely to be similar to the volume in storage in 2000 prior to the fresh water injection. Concentrations in the tailings water are expected to be low enough that the impacts to the alluvial aquifer will be minimized.

REFERENCES:

Hoffman, G.L. & Cellan, R.R. 1998. Slime dewatering at the Homestake's Grants Project. *Proceedings of the Fifth International Conference on Tailings and Mine Waste; 98:* 299-308. Rotterdam:Balkema.

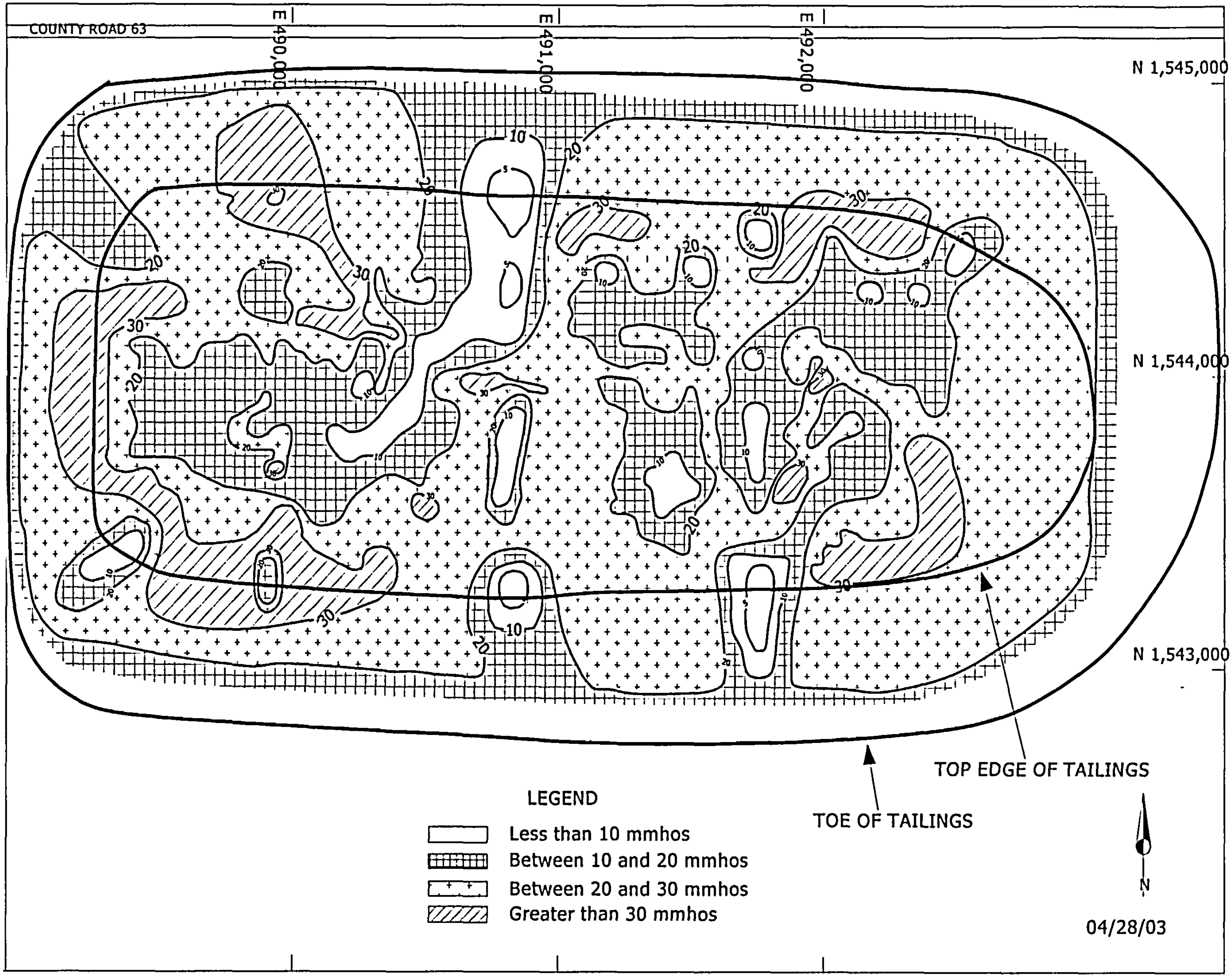

Figure 5. Tailings Water Conductivity in mmhos/cm.

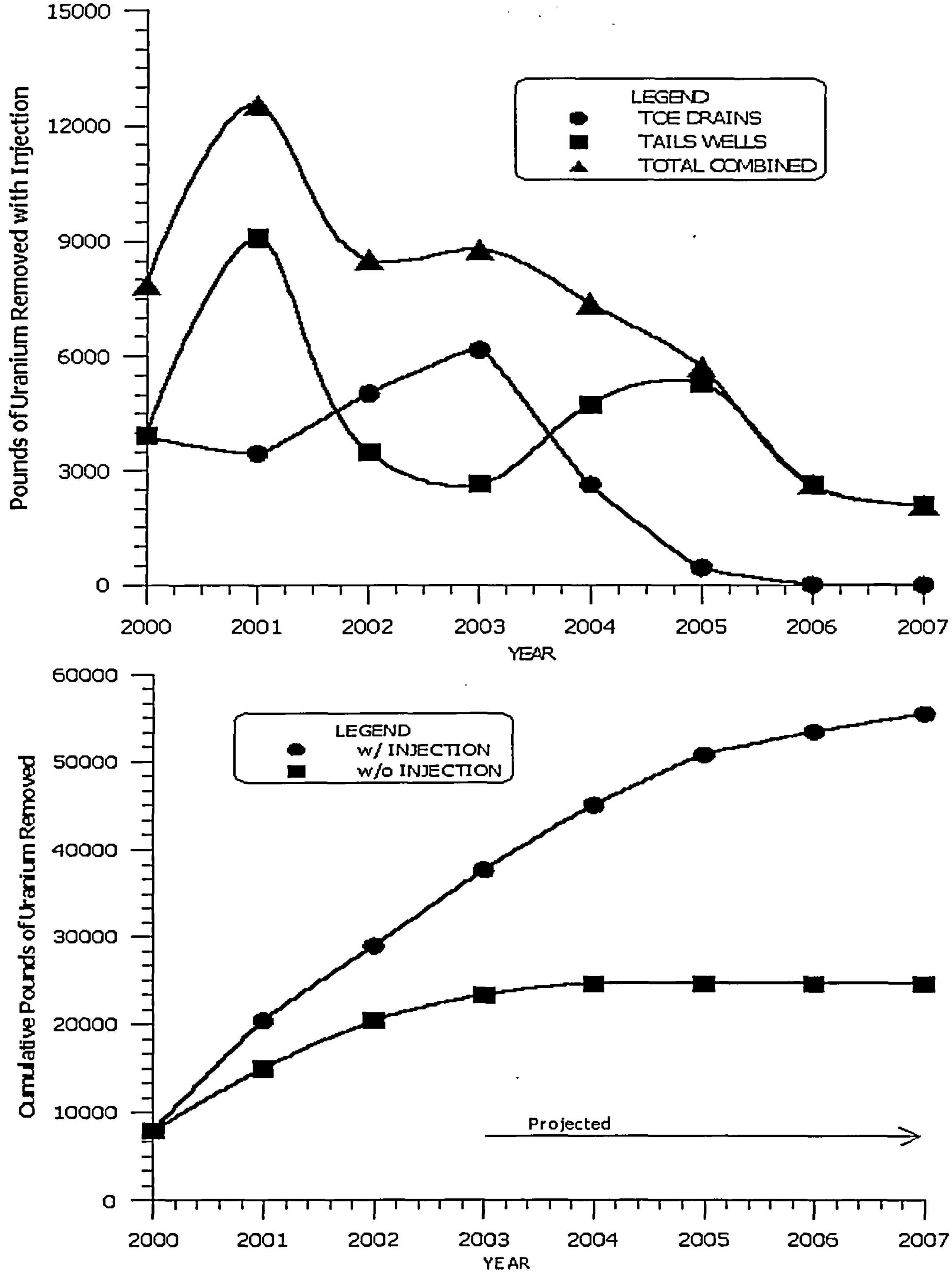

Figure 6. Pounds of Uranum Removed from the Tailings With and Without Injection.