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Mr. Rob Mann
Alberta Sulphur Terminals Ltd.
10501 Barlow Trail SE
Calgary, Alberta
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Dear Mr. Mann:

RE: 24 HOUR PUMPING TEST AT ALBERTA SULPHUR TERMINAL'S PROPOSED SULPHUR FORMING AND SHIPPING FACILITY

INTRODUCTION

HAZCO Environmental Services (HAZCO), a division of CCS Income Trust (CCS), retained WorleyParsons Komex to conduct a 24 hour pumping test at AST's proposed sulphur forming and shipping facility (the Site). The 24 hour pumping test was conducted in June 2007 to confirm results of a two-hour test conducted in 2005 (Komex, 2005) and to better assess the suitability of the upper bedrock groundwater zone identified on Site as a possible water supply for the proposed facility.

SITING INVESTIGATION

During the 2005 siting investigation for the facility (Komex, 2005) a provisional pumping well (well 05-01B) was installed in the saturated sandstone layer that appeared to be the highest groundwater yielding zone encountered on site. Well 05-01B was installed as a 4 inch diameter well (well casing radius of 50 mm), screened from approximately 7.3 to 16.5 m below ground surface (mbgs) in a predominant sandstone interval overlain by clay shale and till.

A two-hour pumping test (and two-hour recovery) was conducted on well 05-01B to determine the potential aquifer yield. Analysis of this pumping test concluded that the upper bedrock zone had an estimated yield of about 11.4 m^3/day and a transmissivity of 4.6 m^2/day. Given the variable geological conditions encountered at the Site, it was hypothesized that a lower yield could be observed over a longer period of time (Komex, 2005).

METHODOLOGY AND RESULTS

Pumping Test

On June 4, 2007 a down-hole submersible pump was installed in well 05-01B to accommodate the pumping test. A constant-rate pumping test was conducted on well 05-01B on June 5 and 6, 2007. Drawdown was recorded during the pumping and recovery phase of the test using manual readings with a water level tape and a pressure transducer. The well was pumped at an average rate of 8.5 L/minute for 24 hours. The pump was then turned off and aquifer recovery was monitored for an additional 7 hours. Over this period, the well recovered to 95% of the maximum drawdown of 3.5 m.

The drawdown of groundwater levels was observed in monitoring wells in the vicinity of the pumping well; the nearest well was approximately 120 m away. No drawdown was observed at any of the monitoring wells located outside of this radius.

Data Analysis

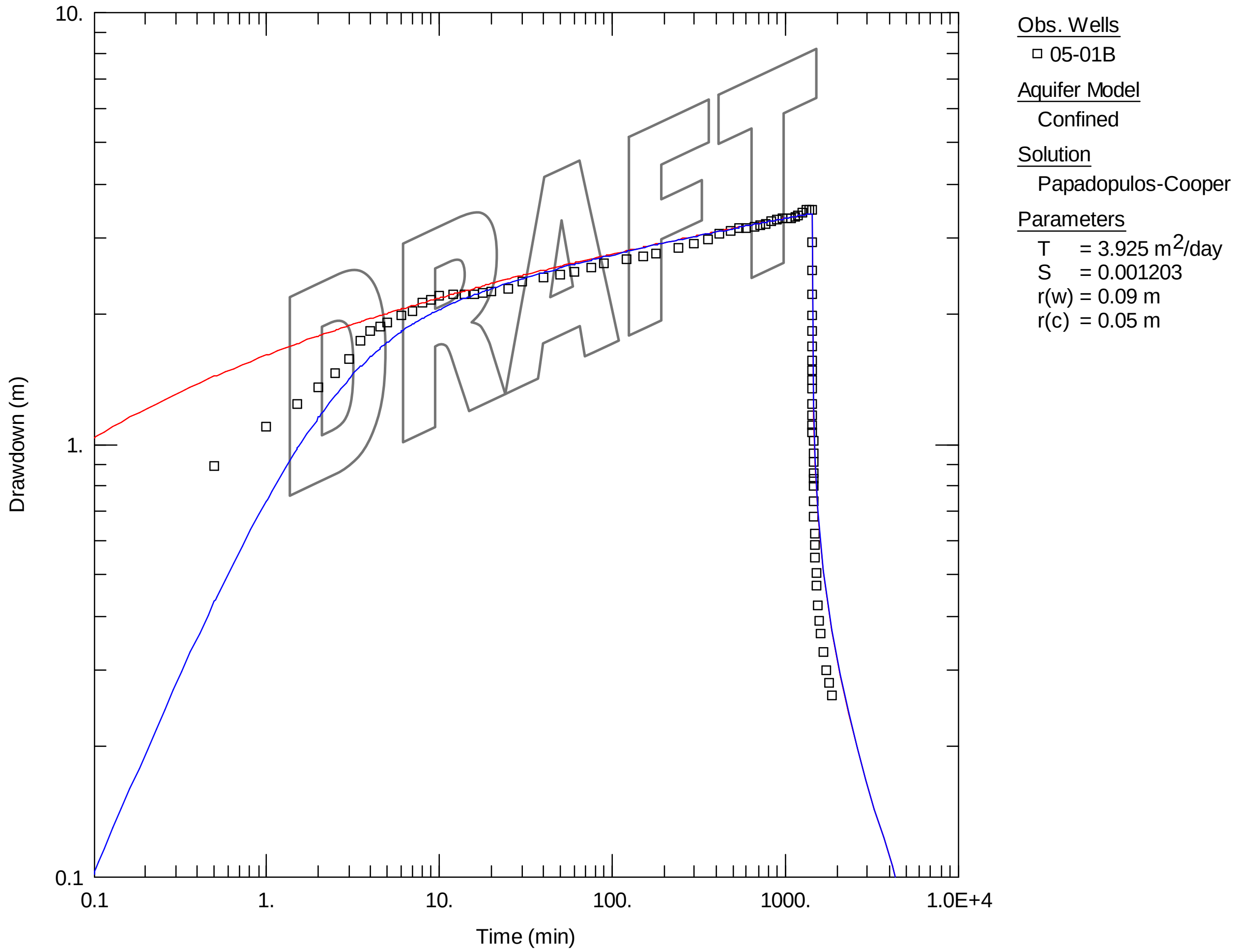
The transducer data and the manual measurements were found to be consistent. The manual readings were used for the aquifer test interpretation. The Papadopolous-Cooper (1967) type curve solution for a pumping-recovery test in a confined aquifer was used to infer transmissivity (T) and storativity (S) of the lower bedrock aquifer from the drawdown data. The Papadopolous-Cooper type curve solution is similar to the Theis (1935) solution with the exception that the former solution accounts for wellbore storage (i.e. large diameter wells) whereas in the Theis solution wellbore storage effects are neglected.

The main assumptions of the Theis solution are:

- aquifer has infinite areal extent
- aquifer is homogeneous, isotropic and of uniform thickness
- pumping well is fully penetrating
- flow to pumping well is horizontal
- aquifer is confined
- flow is unsteady
- water is released instantaneously from storage with decline of hydraulic head
- diameter of pumping well is very small so that storage in the well can be neglected

This last assumption of the Theis solution is overcome with the Papadopolous-Cooper type curve solution.

Aqtesolv© version 4.01 developed by HydroSOLVE Inc[1]. was used to determine aquifer hydraulic properties from the constant rate pumping test. In determining optimal parameters for the Papadopolous-Cooper solution, the well casing radius r(c) was kept fixed at 50 mm while the effective well radius r(w) was calculated from the data together with aquifer T and S. The calculated effective well radius of about 90 mm is in agreement with the expected range of values for a 102 mm (4 inch) well. Aquifer transmissivity and storativity were determined to be T = 4 m^2/day and S = 1 x 10^{-3}, respectively. Because the analysis only incorporates data from the pumping well, aquifer storativity cannot be determined with precision given that data from observation wells are needed for this purpose (Kruseman and de Ridder, 1994). The aquifer test analysis is illustrated graphically in the figure below, with the Papadopolous-Cooper type curve solution shown in blue and the Theis solution shown in red.



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[1] www.aqtesolv.com

Comparison of the Papadopolous-Cooper solution with the Theis solution using identical aquifer parameters illustrates that the measured drawdown and recovery for the constant rate pumping test were influenced by wellbore storage effects during the first 10 to 20 minutes of the test. The Theis solution predicts a faster increase in drawdown during initial pumping compared to the Papadopolous-Cooper solution. This suggests that early in the test, pumped water was partly derived from the well bore. After about 10 to 20 minutes, the two solutions predict nearly identical drawdown for the pumping well, indicating that well bore storage effects become negligible. The good match of the Theis solution to the late-time drawdown data further indicates that the aquifer behaved as confined over the duration of the test, with no indication of leakage or recharge from overlying strata.

No drawdown was observed in any of the monitoring wells in the vicinity of the pumping well, with the nearest well located at a distance of 120 m. Based on this latter information, a distance-drawdown analysis (not shown) suggests an upper limit to aquifer transmissivity of about 4 m^2/day.

Aquifer Long-Term Yield

The long-term yield of the aquifer was estimated using the Farvolden method (AENV, 2003):

$$Q_{20} = (0.68)(T)(H_a)x0.7$$

In Farvolden's equation, H_a represents the available drawdown to the top of the aquifer, which was determined to be about 6 m bgs. With a transmissivity of 4 m^2/day, Q_{20} was determined to be about 11.4 m^3/day (8 L/min).

CONCLUSIONS

The results from the 24 hour, June 2007 pumping test confirm the results of the 2 hour pumping test completed in support of the Environmental Impact Assessment (EIA).These results indicate that it may be possible to satisfy some of the makeup water requirements for the facility from a groundwater source, but that it is unlikely that the entire makeup requirement can be achieved from groundwater over the long term. The conclusions drawn in the EIA (AST, 2007; Volume IIB, Section 2) with regard to the feasibility of an on-Site makeup groundwater supply remain valid and an off-Site supply of water may be required.

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CLOSURE

We trust that this report satisfies your current requirements and provides suitable documentation for your records. If you have any questions or require further details, please contact the undersigned at any time.

Sincerely,
WorleyParsons Komex

Jos Beckers, Ph.D.	Gordon J. Johnson, M.Sc., P.Eng.
Senior Hydrogeologist	Regional Director - Infrastructure

REFERENCES

Alberta Environment (AENV). 2003. Groundwater Evaluation Guideline, information required when submitting an application under the Water Act, February 5, 2003.

Alberta Sulphur Terminals Ltd. 2007. Bruderheim Sulphur Forming and Shipping Facility Environmental Impact Assessment.

Komex International Ltd. (Komex). 2005. Siting Investigation Report, Proposed Sulphur Forming Facility, Bruderheim, Alberta. Unpublished report prepared for HAZCO Environmental Services Ltd. C62720000. October 2005.

Kruseman, G.P. and N.A. de Ridder. 1994. Analysis and Evaluation of Pumping Test Data. Second Edition. Publication 47. International Institute for Land Reclamation and Improvement, Wageningen, the Netherlands.

Papadopulos, I.S. and H.H. Cooper. 1967. Drawdown in a well of large diameter, Water Resources Research, vol. 3, pp. 241-244.

Theis, C.V., 1935. The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using groundwater storage, Am. Geophys. Union Trans., vol. 16, pp. 519-524.

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Appendix 1 Pump Test Data

Pumping Test Data Sheet

Bruderheim 05-01B

Test Date 5-Jun-07 Test Start Time 0900

Total Elapsed Time (min)	Phase Elapsed Time (min)	Water Level (mb TOC)	Drawdown (m)	Meter Flow Rate (L/min)	Meter Cumulative Flow (m3)	Calculated Cumulative Flow (m^3)
``	0	0.000	---	0	0	0
0.5	0.5	0.8	0.800			
1	1	1.005	1.005			
1.5	1.5	1.15	1.150			
2	2	1.27	1.270			
2.5	2.5	1.37	1.370			
3	3	1.49	1.490			
3.5	3.5	1.65	1.650			
4	4	1.74	1.740			
4.5	4.5	1.78	1.780			
5	5	1.83	1.830			
6	6	1.89	1.890			
7	7	1.94	1.940			
8	8	2.04	2.040			
9	9	2.07	2.070			
10	10	2.11	2.110	9	0.057	0.067
12	12	2.13	2.130			
14	14	2.13	2.130			
16	16	2.14	2.140			
18	18	2.15	2.150			
20	20	2.165	2.165	8	0.127	0.147
25	25	2.205	2.205			
30	30	2.296	2.296	9	0.196	0.226
40	40	2.35	2.350			
50	50	2.388	2.388			
60	60	2.407	2.407	8	0.44	0.5
75	75	2.465	2.465			
90	90	2.534	2.534	9	0.667	0.757
120	120	2.596	2.596	8	0.903	1.023
150	150	2.632	2.632	7	1.148	1.298
180	180	2.665	2.665	7	1.384	1.564
240	240	2.758	2.758	8	1.858	2.098
300	300	2.821	2.821	6	2.332	2.632
360	360	2.884	2.884	9	2.804	3.164
420	420	2.975	2.975	9	3.3	3.72
480	480	3.016	3.016	7	3.76	4.24
540	540	3.064	3.064	8	4.189	4.729
600	600	3.083	3.083	9	4.632	5.232
660	660	3.107	3.107	8	5.045	5.705
720	720	3.128	3.128	6	5.45	6.17
780	780	3.149	3.149	8	5.855	6.635
840	840	3.182	3.182	7	6.268	7.108

Total Elapsed Time (min)	Phase Elapsed Time (min)	Water Level (mb TOC)	Drawdown (m)	Meter Flow Rate (L/min)	Meter Cumulative Flow (m3)	Calculated Cumulative Flow (m^3)
900	900	3.21	3.210	6	6.697	7.597
960	960	3.234	3.234	9	7.123	8.083
1020	1020	3.243	3.243	8	7.568	8.588
1080	1080	3.254	3.254	7	8.015	9.095
1140	1140	3.272	3.272	7	8.465	9.605
1200	1200	3.286	3.286	8	8.899	10.099
1260	1260	3.357	3.357	9	9.389	10.649
1320	1320	3.391	3.391	9	9.896	11.216
1380	1380	3.401	3.401	7	10.404	11.784
1440	1440	3.395	3.395	0	10.851	12.291
1440	0	3.395	3.395	Pump Turned Off		
1440.5	0.5	2.85	2.850			
1441	1	2.44	2.440			
1441.5	1.5	2.14	2.140			
1442	2	1.91	1.910			
1442.5	2.5	1.745	1.745			
1443	3	1.605	1.605			
1443.5	3.5	1.485	1.485			
1444	4	1.4	1.400			
1444.5	4.5	1.325	1.325			
1445	5	1.265	1.265			
1446	6	1.16	1.160			
1447	7	1.09	1.090			
1448	8	1.03	1.030			
1449	9	0.982	0.982			
1450	10	0.94	0.940			
1452	12	0.875	0.875			
1454	14	0.829	0.829			
1456	16	0.78	0.780			
1458	18	0.751	0.751			
1460	20	0.722	0.722			
1465	25	0.656	0.656			
1470	30	0.6	0.600			
1480	40	0.542	0.542			
1490	50	0.503	0.503			
1500	60	0.465	0.465			
1515	75	0.423	0.423			
1530	90	0.391	0.391			
1560	120	0.343	0.343			
1590	150	0.31	0.310			
1620	180	0.285	0.285			
1680	240	0.25	0.250			
1740	300	0.22	0.220			
1800	360	0.2	0.200			
1860	420	0.182	0.182			

Note: Calculated cumulative flow accounts for leak detected in fttings estimated at 1 L/min