PARSONS BRINCKERHOFF

Memo

Date 29 October 2011

To Nick Sibbel
Environmental Approvals Manager - RTD
Tiwest Pty Ltd
PO Box 22
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From Keith Brown

Ref 2142182B/001-DMS-MEM-001 RevA

Subject Dongara Mineral Sands Project Groundwater Modelling - Dredge Mining

Dear Nick,

The following document provides the results of a hydrogeological assessment undertaken by Parsons Brinckerhoff Australia Pty Ltd (Parsons Brinckerhoff) on behalf of Tiwest Pty Ltd to estimate inflows and likely drawdown impacts assuming dredging as the preferred mining option at Dongara. The dredge mine plan used in this assessment for the Dongara Mineral Sands Project is presented in Appendix A.

1. Background

The first step in undertaking the assessment was to characterise dredge mining operations at the Dongara Mineral Sands Project. The following describes conceptual understanding of dredge operations and the implications to groundwater for each pit:

- At the Hebe pit the groundwater table is close to or below the 15 metre maximum draft required for the dredge to operate. It was, therefore, assumed that no dewatering would be required and that the volume of water entering the pit will be equivalent to the volume of material removed over the period of mining;
- To retrieve mineral sands from the deepest sections of the Zeus pit, in addition to accounting for replacing the volume of material removed from the pit as discussed for the Hebe pit, dewatering will be required to ensure a maximum draft for the dredge of 15 metres is not exceeded;
- To recover mineral sands from above the groundwater table the water level will need to elevated at the Hades and Heracles pits to ensure a minimum draft for the dredge of 6 metres is maintained; and,
- An annual abstraction of 5 GL will be required for dredge mining operations. This water will be sourced from the Yarragadee aquifer.

2. Description of methodology

The following describes the approach adopted by Parsons Brinkerhoff to complete this assessment:

- Impacts to the groundwater table as a result of dredge mining operations were determined using the existing groundwater numerical model. A full description of the conceptual and numerical model can be found in the report 'Modelling of Groundwater Impacts at the Proposed Dongara Mineral Sands Project' (Parsons Brinckerhoff, 2011);
    - At the Hebe pit, the volume of material removed from the pit over the mining period was estimated based on the specific yield and used to calculate an inflow rate. The inflow rate was then divided by the pit area over a six month mining period and input into the numerical model.
    - At the Zeus pit the drain cell package in the numerical model was used to ensure the maximum operation draft of 15 metres was not exceeded. For each six-month mining period the minimum elevation required from an individual block was used for all the remaining blocks. This ensured the maximum potential drawdown impact contours for that period were modelled.
    - At the Hades and Heracles pits recharge was applied to the numerical model over the area of mine blocks for each six-month mining period. For each six month mining period the maximum elevation required for an individual block over that period was used for all the blocks. This ensured that the maximum potential increase in water level for that period was modelled.
    - Abstraction from the Yarragadee aquifer of 5 GL/annum was simulated in the numerical model using 6 bores pumping at a rate of ~ 26 L/s. Location of the bores is shown on Figure 1.
    - Demeter and Dionysus were not included in the assessment as they were considered not suitable for dredge mining.
- Accounting of inflows to the pits as a result of dredging were determined as follows:
    - At the Hebe pit inflows were calculated using a spreadsheet model to estimate inflows as a result of removing material from the pit void.
    - At Zeus pit inflows as a result of lowering the water table were obtained from outflow into the drain flow package in the numerical model and volumes of material removed from each pit estimated from the spreadsheet model.
    - At Hades and Heracles pits the required recharge rates to elevate the water table were obtained from the recharge package in the numerical model and volumes of material removed from each pit estimated from the spreadsheet model.

3. Caveats

The following provides caveats used in the undertaking of this assessment.

- Hebe and Zeus pits were assessed using slightly different methods. Unlike the Zeus pit, the Hebe pit does not require dewatering to ensure that the 15 metre draft limit of the dredge is not exceeded. The drawdown at Hebe was attributed to the volume pit material removed from the pit void only. At the Zeus pit the required water level decline was more than that estimated as a result of removing the material alone. Therefore, for the Zeus pit the potentially greater drawdown impact of dewatering was modelled.

- The area of the pits used in the numerical model and spreadsheet calculations is based on the surface footprint as supplied by Tiwest.

- Mining was conducted over six monthly stress periods.

- The 5 GL/annum abstracted from the Yarragadee includes a component of water required to recharge the Hades and Heracles pits.

- For the purposes of modelling dredge mining at Dongara a number of operations were simplified with regard to understanding the water balance at the mine. No other mine operating water losses were included in the assessment.

- The hydraulic characteristics of the Superficial aquifer are sufficient to fill the pit void over each mining period.

Please refer to Parsons Brinckerhoff (2011) for full model description and limitations.

4. Results and discussion

Results and discussion of dredge modelling at the Dongara Mineral Sands Project are summarised as follows:

- Figure 1 shows the maximum groundwater contours (drawdown and mounding) in the Superficial aquifer generated from the numerical modelling. The blue contours with positive values denote areas of drawdown and the red contours with negative values show areas of groundwater mounding. The maximum drawdown at the Zeus and Hebe pits is approximately 5 metres. The magnitude of drawdown in the area of the pits is significantly less than previously modelled. The mound at the Hades and Heracles pits reflect the minimum 6 m draft requirements for the dredge at these pits.

- Drawdown due to abstraction in the Yarragadee aquifer while having relatively minimal impact in the areas of mine dewatering does impact on the 0.25 metre drawdown contour in the Superficial aquifer. Please refer to the discussion of hydrogeological conceptualisation with regard to the connection between the Superficial aquifer and the Yarragadee aquifer in the Parsons Brinckerhoff (2011) report.

- Figure 2 shows the estimated drawdown in the Yarragadee aquifer as result of the 5 GL/annum abstraction. The abstraction was simulated with six bores. Abstraction is double that used in previous modelling as evidenced by the larger drawdown and extent.

- Table 1 below gives the estimated inflow rates based on a six month mining period for the Dongara mining pits. The majority of flow; either inflows at the Zeus and Hebe pits or recharge at Hades and Heracles pits is due to the removal of material in the pit and its subsequent replacement with water.

Table 1: Flows per Pit

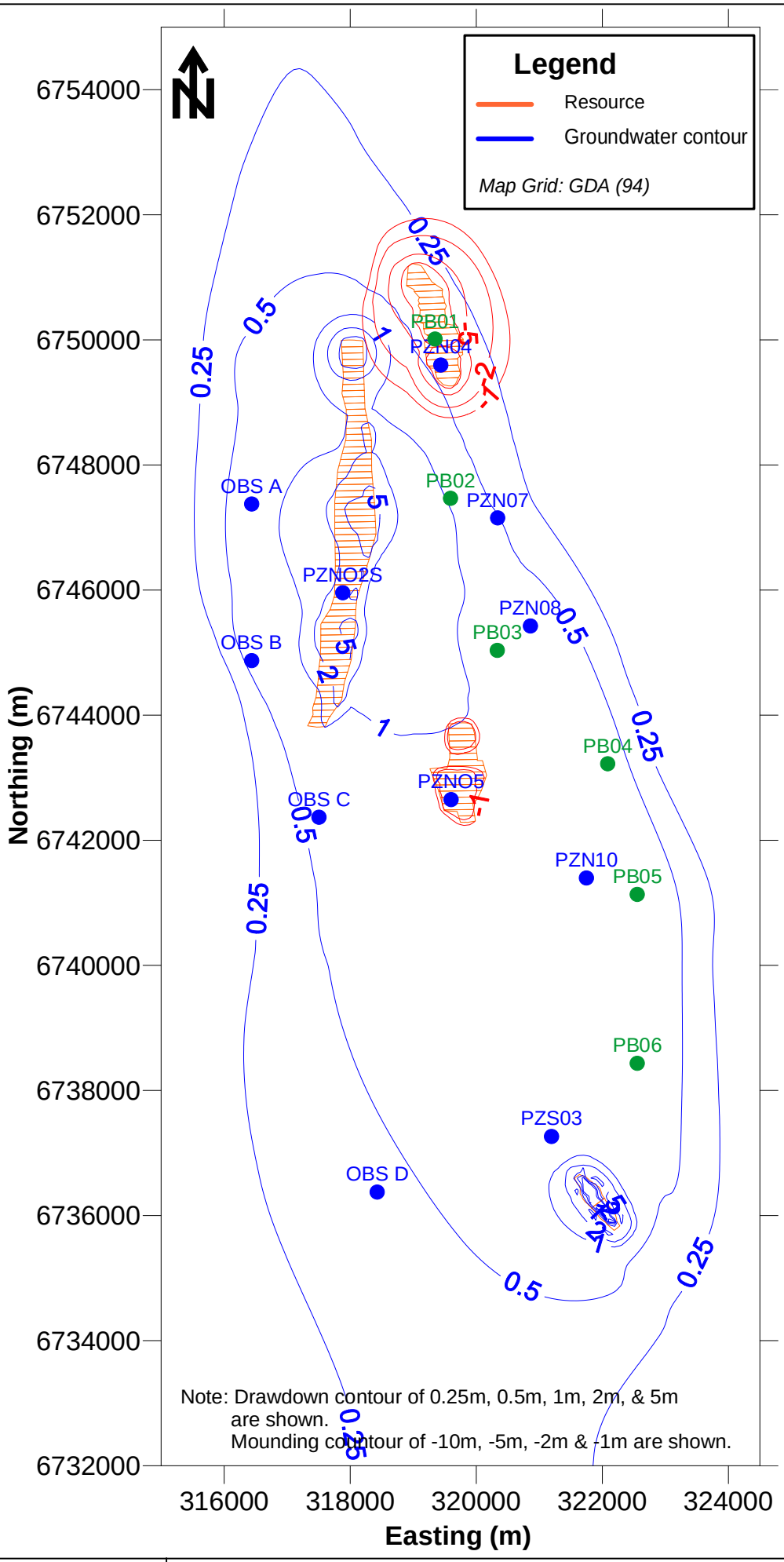
Pit	Time start (day)	Time end (day)	Drain outflow (L/s)	Recharge (L/s)	Pit Volume (L/s)	Total Flow (L/s)
Zeus	1	184	10		264	274
Zeus	184	366	13		160	173
Zeus	366	550	16		172	188
Zeus	550	731	10		170	180
Zeus	731	915	6		105	111
Zeus	915	1096	9		183	192
Zeus	1096	1280	13		156	169
Zeus	1280	1461	15		104	119
Zeus	1461	1645	13		101	114
Zeus	1645	1827	8		142	150
Zeus	1827	2011	6		167	173
Zeus	2011	2192	5		188	193
Zeus	2192	2376	0		239	239
Zeus	2376	2466	45		110	155
Hades	2466	2577	0	74	35	109
Hades	2577	2741	0	39	33	72
Hades	2741	2922	0	0	37	37
Hades	2922	3106	0	50	47	97
Hades	3106	3288	0	56	54	110
Hades	3288	3472	0	66	60	126
Heracles	3472	3653	0	28	51	79
Heracles	3653	3837	0	19	54	73
Heracles	3837	4018	0	9	27	36
Heracles	4018	4202	0	0	70	70
Heracles	4202	4383	0	29	50	79
Hebe	4383	4383	0		200	200

Yours sincerely

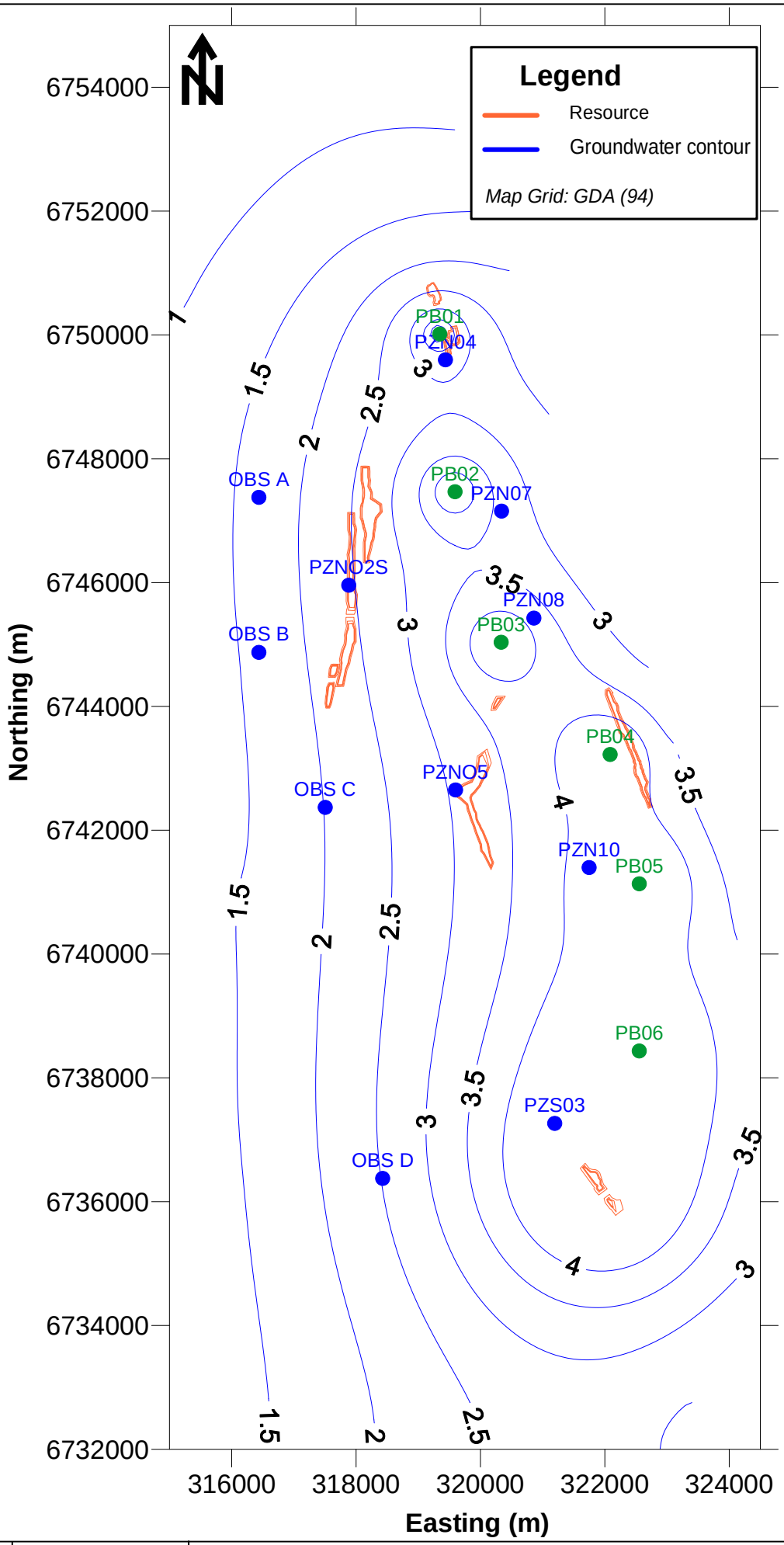
Keith Brown
Principal Hydrogeologist
Parsons Brinckerhoff

Reference

Parsons Brinkerhoff, 2011. Modelling of groundwater Impacts at the Proposed Dongara Mineral Sands Project. Parsons Brinckerhoff Australia Pty Ltd report prepared for Tiwest Pty Ltd.



TIWEST	Rev: B Date: 21/09/11 Drn: AN Chkd: KB	**Tiwest Joint Venture** Modelling of groundwater impacts related to mining at Tiwest Dongara lease **Maximum modelled groundwater level change - Dredging Scenario & Yarragadee abstraction (observed in the superficial aquifer)** **Figure 1**
PARSONS BRINCKERHOFF	**Job No.: 2142182A** \\auperf\perdata\A656-WAT\PROJ\2142182A_Tiwest_Surface\05_WrkPapers\Reports\Dongara Model Report Sept 2011\Figures\Grapher	



TIWEST	Rev: B Date: 21/09/11 Drn: AN Chkd: KB	**Tiwest Joint Venture** Modelling of groundwater impacts related to mining at Tiwest Dongara lease **Maximum modelled groundwater drawdown - Dredging Scenario- Yarragadee abstraction (observed in the Yarragadee aquifer)** **Figure 2**
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Appendix A

Deposit	Pit	Strip Nbr	Centroid X	Centroid Y	Pit Floor RL	Pit Width (Floor)	Mining Seq	Spir Fd t	Quarter Started	Quarter Finished
Zeus	1	blk1	317481.781	6743847	6	85	1	1	Jul-15	Jul-15
Zeus	1	blk2	317512.969	6743929	6	85	2	181,238	Jul-15	Jul-15
Zeus	1	blk3	317562.969	6744032	5	110	3	293,256	Jul-15	Jul-15
Zeus	1	blk4	317599.781	6744131.5	4	175	4	517,359	Jul-15	Jul-15
Zeus	1	blk5	317646.656	6744232	5	220	5	538,574	Jul-15	Jul-15
Zeus	1	blk6	317670.094	6744332	4	235	6	562,706	Jul-15	Oct-15
Zeus	1	blk7	317683.406	6744432.5	4	235	7	566,788	Oct-15	Oct-15
Zeus	1	blk8	317699.938	6744533	3	240	8	577,587	Oct-15	Oct-15
Zeus	1	blk9	317719.875	6744633.5	3	263	9	736,189	Oct-15	Jan-16
Zeus	1	blk10	317738.688	6744734	3	295	10	946,971	Jan-16	Jan-16
Zeus	1	blk11	317758.031	6744834	2	305	11	1,013,608	Jan-16	Apr-16
Zeus	1	blk12	317773.625	6744934	1	315	12	1,031,186	Apr-16	Apr-16
Zeus	1	blk13	317781.75	6745034.5	2	320	13	984,199	Apr-16	Jul-16
Zeus	1	blk14	317789.531	6745134.5	2	330	14	911,572	Jul-16	Jul-16
Zeus	1	blk15	317796.313	6745234.5	2	340	15	956,814	Jul-16	Oct-16
Zeus	1	blk16	317802.656	6745335	1	355	16	1,079,341	Oct-16	Oct-16
Zeus	1	blk17	317808.219	6745435	1	365	17	1,171,250	Oct-16	Jan-17
Zeus	1	blk18	317831.75	6745534	2	305	18	1,062,055	Jan-17	Apr-17
Zeus	1	blk19	317864.5	6745635	3	245	19	874,509	Apr-17	Apr-17
Zeus	1	blk20	317894.719	6745736	3	215	20	764,443	Apr-17	Apr-17
Zeus	1	blk21	317915.063	6745836.5	5	195	21	699,502	Apr-17	Jul-17
Zeus	1	blk22	317938.688	6745938	6	195	22	669,061	Jul-17	Jul-17
Zeus	1	blk23	317957.063	6746038.5	5	225	23	755,179	Jul-17	Oct-17
Zeus	1	blk24	317974.781	6746139	5	255	24	847,552	Oct-17	Oct-17
Zeus	1	blk25	317992.563	6746239	4	285	25	938,778	Oct-17	Jan-18
Zeus	1	blk26	318009.938	6746339	3	320	26	1,019,816	Jan-18	Jan-18
Zeus	1	blk27	318024.156	6746439.5	4	345	27	1,102,016	Jan-18	Apr-18
Zeus	1	blk28	318038.188	6746540	4	375	28	1,191,552	Apr-18	Apr-18
Zeus	1	blk29	318050.719	6746640	3	405	29	1,295,692	Apr-18	Jul-18
Zeus	1	blk30	318063.25	6746740.5	2	435	30	1,390,041	Jul-18	Oct-18
Zeus	1	blk31	318075.781	6746840.5	2	460	31	1,503,924	Oct-18	Jan-19
Zeus	1	blk32	318081.156	6746940	0	475	32	1,620,507	Jan-19	Jan-19
Zeus	1	blk33	318078.563	6747040	0	470	33	1,585,936	Jan-19	Apr-19
Zeus	1	blk34	318075.969	6747140	0	465	34	1,584,172	Apr-19	Jul-19
Zeus	1	blk35	318073.375	6747240	0	460	35	1,560,436	Jul-19	Oct-19
Zeus	1	blk36	318070.75	6747340	0	455	36	1,525,110	Oct-19	Jan-20
Zeus	1	blk37	318068.781	6747440	1	445	37	1,474,559	Jan-20	Apr-20
Zeus	1	blk38	318069.125	6747540	4	430	38	1,351,641	Apr-20	Apr-20
Zeus	1	blk39	318069.719	6747640	6	410	39	1,232,993	Apr-20	Jul-20
Zeus	1	blk40	318070.281	6747740	6	395	40	1,117,218	Jul-20	Oct-20
Zeus	1	blk41	318070.813	6747840	7	380	41	1,013,921	Oct-20	Oct-20
Zeus	1	blk42	318074.313	6747940	7	365	42	935,040	Oct-20	Jan-21
Zeus	1	blk43	318086.406	6748040.5	9	335	43	903,536	Jan-21	Jan-21
Zeus	1	blk44	318099.094	6748140.5	10	310	44	869,130	Jan-21	Apr-21
Zeus	1	blk45	318111.813	6748240.5	10	285	45	815,323	Apr-21	Apr-21
Zeus	1	blk46	318124.469	6748341	9	255	46	732,370	Apr-21	Apr-21
Zeus	1	blk47	318130.906	6748441	9	230	47	619,575	Apr-21	Jul-21
Zeus	1	blk48	318121.656	6748541	10	210	48	559,730	Jul-21	Jul-21
Zeus	1	blk49	318111.688	6748641	11	190	49	511,422	Jul-21	Jul-21
Zeus	1	blk50	318101.656	6748740.5	13	170	50	474,454	Jul-21	Oct-21
Zeus	1	blk51	318091.656	6748840	14	150	51	445,816	Oct-21	Oct-21
Zeus	1	blk52	318077.906	6748941.5	14	150	52	442,673	Oct-21	Oct-21
Zeus	1	blk53	318062.813	6749041	11	165	53	489,982	Oct-21	Oct-21
Zeus	1	blk54	318049.563	6749140.5	9	185	54	517,989	Oct-21	Jan-22
Zeus	1	blk55	318049.281	6749240	10	180	55	463,304	Jan-22	Jan-22
Zeus	1	blk56	318051.75	6749339.5	11	170	56	392,769	Jan-22	Jan-22
Zeus	1	blk57	318052.5	6749440	12	160	57	348,548	Jan-22	Jan-22
Zeus	1	blk58	318048.219	6749540.5	11	160	58	374,430	Jan-22	Jan-22
Zeus	1	blk59	318043.781	6749640	9	160	59	420,116	Jan-22	Apr-22
Zeus	1	blk60	318039.375	6749740	7	160	60	475,758	Apr-22	Apr-22
Zeus	1	blk61	318034.938	6749840	6	165	61	546,017	Apr-22	Apr-22
Zeus	1	blk62	318026.219	6749942.5	5	165	62	290,018	Apr-22	Apr-22
Plant Move	1	M					63	96,000	Apr-22	Apr-22
Hades	1	blk_1	319560.344	6749337.5	39	135	64	270,137	Apr-22	Jul-22
Hades	1	blk_2	319550.469	6749443	29	260	65	567,529	Jul-22	Jul-22
Hades	1	blk_3	319521.438	6749542.5	36	250	66	536,495	Jul-22	Jul-22
Hades	1	blk_4	319461.781	6749638.5	37	395	67	1,226,888	Jul-22	Oct-22
Hades	1	blk_5	319479.75	6749741	37	415	68	1,576,632	Oct-22	Jan-23
Hades	1	blk_6	319484.188	6749839.5	34	475	69	1,694,691	Jan-23	Apr-23
Hades	1	blk_7	319484.563	6749939.5	27	500	70	2,216,619	Apr-23	Jul-23
Hades	1	blk_8	319488.875	6750037.5	35	395	71	1,503,967	Jul-23	Oct-23
Hades	1	blk_9	319433.094	6750137.5	35	390	72	1,563,838	Oct-23	Oct-23
Hades	1	blk-10	319374.219	6750231.5	35	240	73	1,157,618	Oct-23	Jan-24
Hades	1	blk_11	319287.438	6750332.5	40	310	74	947,557	Jan-24	Apr-24
Hades	1	blk_12	319304.25	6750432.5	44	305	75	726,497	Apr-24	Apr-24
Hades	1	blk_13	319303.719	6750534	45	335	76	1,296,113	Apr-24	Jul-24
Hades	1	blk-14	319289.156	6750632	43	315	77	1,164,097	Jul-24	Jul-24
Hades	1	blk_15	319259.125	6750733.5	50	305	78	1,016,768	Jul-24	Oct-24
Hades	1	blk-16	319195.281	6750829.5	46	300	79	705,297	Oct-24	Oct-24
Hades	1	blk_17	319100.031	6750924	35	280	80	965,059	Oct-24	Jan-25
Hades	1	blk_18	319068.438	6751023	34	205	81	697,284	Jan-25	Jan-25
Hades	1	blk_19	319036.313	6751135	32	125	82	201,341	Jan-25	Jan-25
Plant Move	2	M					83	96,000	Jan-25	Jan-25
Heracles	1	blk1	319854.375	6742341.5	28	125	84	173,358	Jan-25	Jan-25
Heracles	1	blk2	319803.031	6742445.5	25	130	85	368,176	Jan-25	Apr-25
Heracles	1	blk3	319714	6742538.5	22	335	86	781,082	Apr-25	Apr-25
Heracles	1	blk4	319723.156	6742640	20	385	87	1,122,486	Apr-25	Jul-25
Heracles	1	blk5	319736.875	6742740	18	480	88	1,379,124	Jul-25	Jul-25
Heracles	1	blk6	319741.938	6742839.5	16	555	89	1,716,116	Jul-25	Oct-25
Heracles	1	blk7	319739.5	6742939.5	16	625	90	2,043,843	Oct-25	Jan-26
Heracles	1	blk8	319731.844	6743039	16	700	91	2,631,194	Jan-26	Jul-26
Heracles	1	blk9	319738.781	6743134.5	16	445	92	1,590,482	Jul-26	Oct-26
Heracles	1	blk10	319826.969	6743238	16	295	93	1,050,581	Oct-26	Oct-26
Heracles	1	blk11	319795.594	6743339	18	280	94	1,123,555	Oct-26	Jan-27
Heracles	1	blk12	319790.031	6743439	19	270	95	1,046,084	Jan-27	Jan-27
Heracles	1	blk13	319782.406	6743539	20	265	96	1,031,168	Jan-27	Apr-27
Heracles	1	blk14	319773.438	6743639	19	260	97	1,062,011	Apr-27	Apr-27
Heracles	1	blk15	319761.438	6743738.5	19	250	98	824,928	Apr-27	Jul-27
Heracles	1	blk16	319745.406	6743829.5	19	235	99	3,357	Jul-27	Jul-27
Plant Move	3	M					100	168,000	Jul-27	Jul-27
Hebe	1	blk1	322064.344	6736021.5	13	170	101	157,990	Jul-27	Jul-27
Hebe	1	blk2	321791.375	6736389	12	225	102	434,679	Jul-27	Jul-27