dvz

10 December 2021

Travis Herman
Manager of Public Works
R.M. of McKillop No. 220
113 Ashley St, Bulyea
Saskatchewan S0G 0L0

MEMO

Dear Mr. Herman,

The memo dated 15 November 2021 that I prepared was prepared prior to receiving briefing on the full range of concerns raised in relation to the aggregate development that occurred this year in SE-10-23-23 W2 (Fig. 1). Specifically, there is concern about the impact of the aggregate development on recharge of the wetland situated immediately downstream (Fig. 2). Water stored in the wetland predominantly during wet spring seasons recharges nearby water wells, including municipal wells at Spring Bay. This memo discusses impacts to drainage patterns associated with the aggregate development that occurred this year.

As shown in Figure 2, the wetland extends into all four quarters of section 10-23-23 W2. Moisture conditions were visually assessed in this wetland from satellite images ranging in acquisition date from Apr 1984 to Nov 2021 (Table 1). From these 38 years, only in nine years was the wetland holding significant water in the spring and still holding water in the fall. The driest interval on this record was from 1986 through 1993, when only in 1990 was water visually present in the spring. The wettest period was from 2014 through 2016 when significant water was present both in the spring and in the fall leading into winter.

As summarized in the Nov 15th memo, the aggregate development that took place this year in SE-10-23-23 W2 (herein 'the aggregate development') resulted in a net lowering of grade as measured from Oct 2015 to Nov 2021 in three relatively small areas. These relatively small areas are situated within a larger area where the aggregate extraction and processing work took place (Figs. 3-5).

In terms of changes in surface water flow paths following the aggregate development, changes to the layout of sub-basins can be seen by comparing Figures 6 and 7. In particular, it can be seen that in 2015, part of what later became the aggregate work area drained into the wetland (B1), whereas other parts were internally drained (B2 and B3), with flow terminating in local depressions (sinks). Following aggregate development, the area draining into the wetland was reduced by 22,466 m^2. For an annual precipitation of 420 mm, this would indicate a maximum possible loss of water flowing to the wetland of 9,436 m^3 per year. However, as the extraction areas consisted of sand hills, and high infiltration rates would be expected for sand (e.g., 20 to 40 mm/h), a large proportion of the water available as rain or snowmelt would be expected to soak into the ground rather than runoff into the wetland. Considering the possibility of 50 to 90% infiltration, the amount of water no longer flowing to the wetland would be in the range of 944 to 4,718 m^3.

In terms of streamflow from upstream on the primary ephemeral drainage channel, there will be a loss of water to the wetland if nearby channel flow rises to a water depth exceeding 0.54 m so that it is high enough to spill into the western of the three extraction areas. Hydraulic analysis indicated that channel flow will only flood up into that extraction area if a discharge of 6 m^3/s is exceeded. For the catchment area upstream of this site, with an areal extent of about 12 km^2, a discharge of 6 m^3/s would be estimated to have a return period of 25 to 50 years. Furthermore, given that flow along the channel immediately upstream must pass through a culvert beneath the grid road (diameter of 18 to 24 inches), a flow of 6 m^3/s could not occur without road overtopping. To date, the grid road above this culvert is not known to have been overtopped, not even in any of the wettest of the 38 years assessed from the satellite image analysis summarized in Table 1. Therefore, the occurrence of a flow of 6 m^3/s downstream of the culvert is expected to be a fairly rare event at this site.

If a discharge of 6 m^3/s were to occur downstream of the culvert for long enough to fill the western extraction pit, the volume of water that would be stored within the pit, and thereby would not be available to recharge the wetland, would be 5,927 m^3. In addition, any water soaking into the ground if the pit is filled would also be precluded from wetland recharge. The amount of water soaking into the ground within the pit would depend on the length of time that 6 m^3/s is exceeded at this location. With the sand deposits having now been extracted from the pit, there is less potential for infiltration of surface water, but nonetheless infiltration would still be expected.

Other key controls on wetland recharge include the Highways pit in SW-11-23-23 W2 and the north channel situated at the wetland outlet in NW-10-23-23 W2 (Fig. 2). These controls are unrelated to the aggregate development but should be considered so that impacts from the aggregate development can be put into perspective.

The Highways pit in SW-11-23-23 W2 (Fig. 2) was built directly connected to the ephemeral drainage channel. As a result, for every flow that occurs along the drainage channel, the depressions within the pit must first be filled before water can spill out of the pit and flow downstream. The volume of water that must be stored within the pit before downstream flow can occur is 20,470 m^3. In contrast, only for flows exceeding 6 m^3/s will any water be lost to the pit downstream at SE-10-23-23 W2. For a flow of 6 m^3/s at the Highways pit, a volume of 36,145 m^3 will be present within the pit depressions, and this volume does not include any headwater effects from the culvert downstream. A larger culvert downstream would reduce the headwater ponding effect and thereby reduce the amount of water lost to infiltration into the road embankment and into the area east of the road.

Channels have been cut in two locations to facilitate drainage of the wetland (Fig. 2), a low-level channel ('north channel') and a high-level channel ('south channel'). The channels are understood to have been built in the late 1960s or early 1970s. The north channel functions as the main outlet for the wetland. The north channel is partially blocked by a makeshift dam built sometime between 2005 and 2009 by SaskTel when an underground cable was installed across the channel (Fig. 2). The sill on the crest of this plug is estimated from the 2015 data as 500.65 m elevation, whereas full supply level on the wetland is estimated as 501.15 m elevation. As a result, if grades near the north channel were restored to their natural state, the wetland would have the capacity to store an additional volume of about 55,840 m^3 (wetland area is 111,679 m^2). In other words, the impact of the man-made alterations around the north channel have been for the wetland to lose the potential to store an additional 55,840 m^3 of water in years when abundant moisture is available. From the satellite image analysis (Table 1), it is expected that losses of at least 55,840 m^3 would have been observed in each of the wettest years since 1984, namely, 1996, 1999, 2006, 2007, 2011, 2014, 2015, 2016 and 2017. Prior to the SaskTel plug being installed, these losses would have been much larger, possibly in the order of 150,000 m^3. Note that the SaskTel plug is not expected to have been engineered as a dam. Thus, there is a risk that overtopping of this structure could result in its washout and a rapid release of water that could impact the residence at the ravine at the mouth of this drainage (Fig. 2).

A new figure has been prepared (Fig. 10) to provide additional detail in relation to the question of whether the aggregate development might have any potential to impact groundwater quality or quantity immediately beneath the development site, which was discussed in the Nov 15th memo based on a well situated in SE-10-23-23 W2 (Figs. 8, 9). The figure shows an east-west cross section drawn near the water well, with the section drawn through the deepest part of the deepest of the aggregate extraction zones. Note that the well was not drilled through one of the sand hills, but was drilled through till in the lowland adjacent to the sand hills. The limited thickness of material extracted from the surface during the aggregate development, and the fact that the aquifer where the well has been built is situated 30.9 m beneath the bottom of the deepest part of the nearby pit, it seems unlikely that groundwater in the aquifer immediately beneath the development site will be impacted. The only plausible change would be for possible accentuated recharge of the aquifer due to rainfall and snowmelt infiltrating and flowing into the depression rather than flowing to the wetland.

In terms of reduced recharge to aquifers beneath the wetland and further west, such as the aquifer used for municipal water supply at Spring Bay, any losses of water to the wetland associated with the aggregate development would be negligible as compared with losses associated with wetland outlet accentuation at the north channel, forced storage at the Highways pit and headwater ponding at the culvert downstream of the Highways pit.

In summary, in terms of controls on water supply to the wetland downstream of the aggregate development (Fig. 2), the most important loss of water would appear to be outlet accentuation at the north channel. In years when water is abundant (e.g., 1996, 1999, 2006, 2007, 2011, 2014, 2015, 2016 and 2017), the wetland is losing at least 55,840 m^3 of water due to outflow accentuation at the north channel. This would be the number one area to consider for improving wetland water supply and consequent recharge of aquifers in the area of the wetland. The next most important impact identified is the Highways pit in SW-11-23-23 W2, which removes 20,470 m^3 of water from the stream before flow is able to continue downstream of the pit. The third most important control is the culvert downstream of the Highways pit. When the small diameter of this culvert results in headwater ponding, some of the ponded water soaks into the road embankment and into the ground surrounding the Highways pit rather than flowing downstream. In contrast, the impact of the aggregate development in SE-11-23-23 W2 on water supply to the wetland is essentially negligible when compared with the above factors. That is, water losses to the wetland from rainfall and snowmelt that used to occur on the sand hills that have now been removed at the aggregate development are in the range of 944 to 4,718 m^3 per year, plus there is potential of losing 5,927 m^3 at a recurrence interval in the order of 25 to 50 years (based on a discharge that has not been observed at this site in the last 38 years).

The main ways in which wetland recharge and consequent recharge of nearby aquifers can be improved are presented below in order of decreasing importance:

1. Restore north channel of wetland to natural grades
2. Reclamation of the Highways pit
3. Upgrade culvert downstream of Highways pit

Note that if the Highways pit is reclaimed so that pit depressions are removed, this will mean that more flow will be available to flow through the culvert downstream and a consequent greater probability of road overtopping. As a result, the culvert should be upgraded before or during reclamation of the Highways pit.

In general, that the aggregate development in SE-10-23-23 W2 was kept away from the drainage channel by a minimum setback of 40 m was a very favourable aspect of the development in terms of minimizing impacts to drainage patterns. Though it is not so much the horizontal setback that was favourable, but more so the fact that the edge of the western pit formed is 0.54 m above the nearby channel. When the detailed channel geometry at this site is considered, this means that channel flow into the extraction pit at this site cannot occur until a flow exceeding 6 m^3/s occurs downstream of the nearby culvert. The return period of such an event is expected to be in the order of 25 to 50 years, without accounting for the small diameter of the culvert upstream, which will not pass a flow of 6 m^3/s without road overtopping. Given that channel flow into the extraction pit is only expected during relatively large floods (i.e., larger than any observed in the last 38 years), at those times it is possible that downstream landowners marginal to this drainage system will see the situation as an overabundance not underabundance of water.

The standard to which reclamation of this aggregate development has been brought appears to be very high. It is expected that in one or two years, it will be difficult to visually identify that an aggregate development occurred at this site. If all such developments were reclaimed to this standard, it is expected that the public would have a much better impression of aggregate developments and, as a result, there would be less public outcry when one is being proposed.

Sincerely,

D. van Zeyl, M.Sc., P.Geo.
DVZ Geotechnics Inc.
2155 Edward Street
Regina, SK S4T 4N5
Mobile: 306-999-2294
dave@dvzgeo.ca
http://www.dvzgeo.ca

PROFESSIONAL GEOSCIENTIST
D.P. VAN ZEYL
MEMBER 20859
21 YR. 12 MN. 10 DAY
SASKATCHEWAN

Association of Professional Engineers & Geoscientists of Saskatchewan

CERTIFICATE OF AUTHORIZATION

DVZ Geotechnics Inc.

Number 67043

Permission to Consult held by:

Discipline	Sk. Reg. No.	Signature
Geotechnics	20859	
		10 Dec 2021

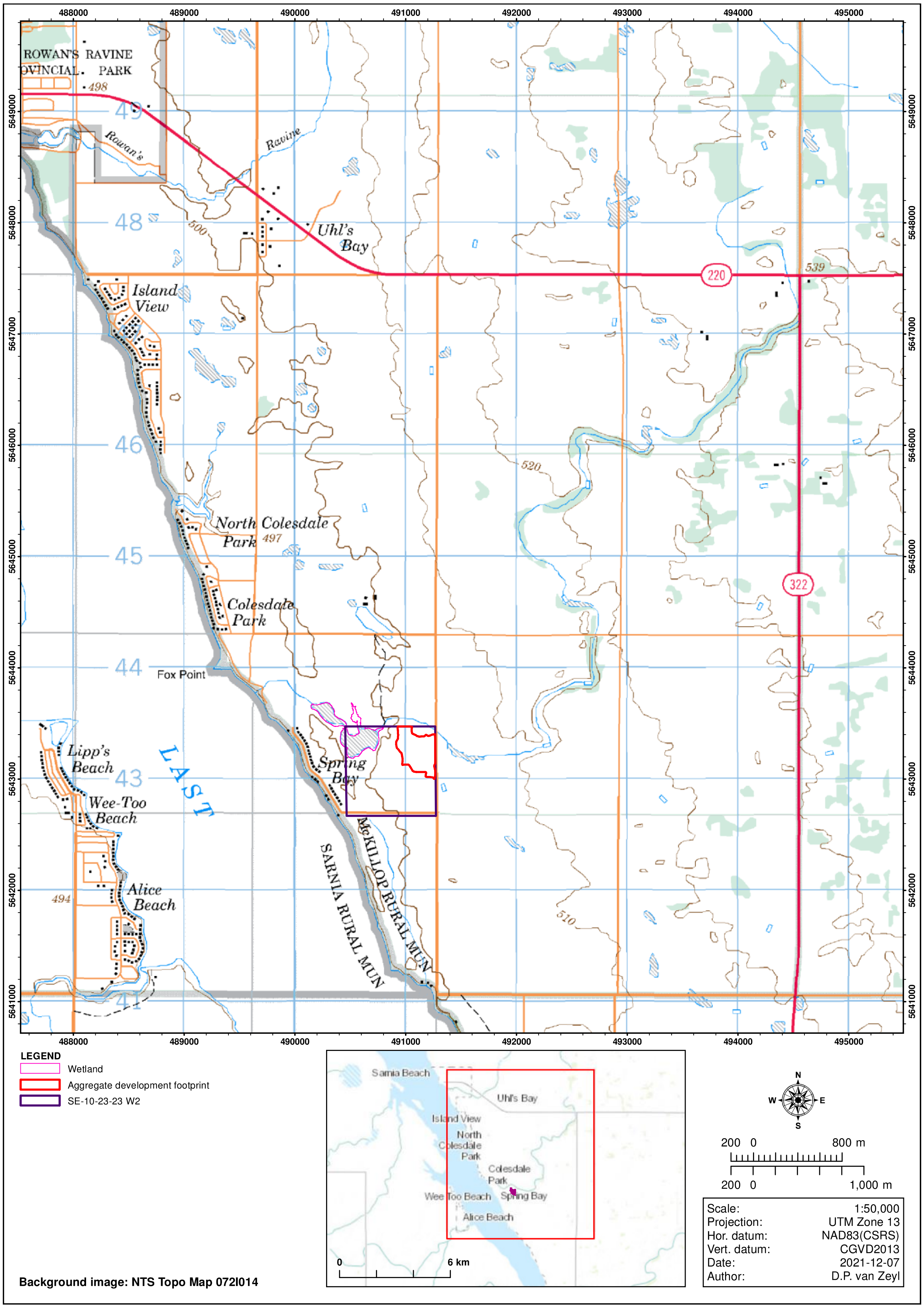

Figure 1 Overview topographic map showing location of aggregate development.

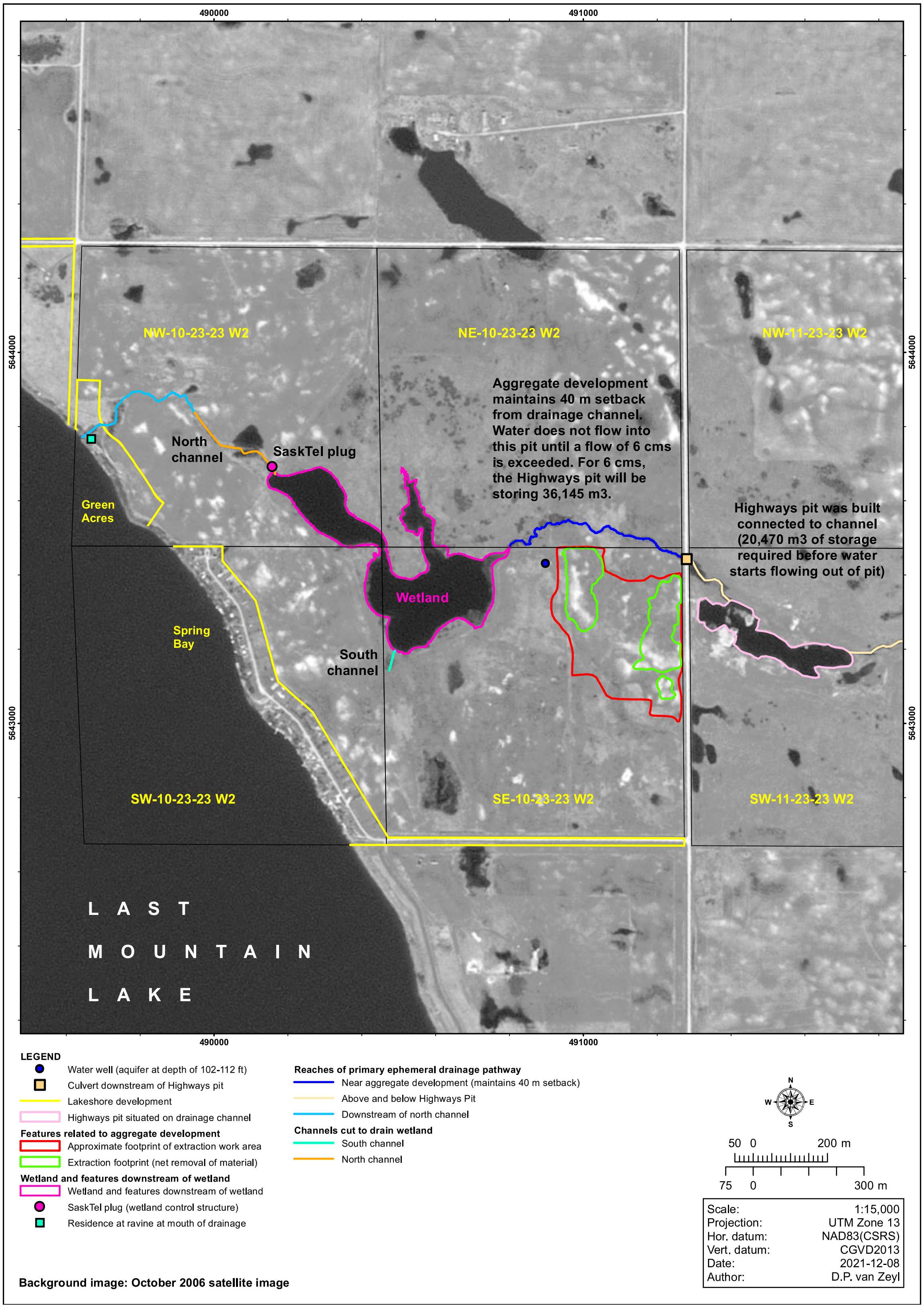

Figure 2 Overview of aggregate development and nearby features discussed in text.

Table 1 Moisture conditions in wetland assessed from satellite images

Year	Moisture conditions in wetland visually assessed from satellite images
1984	Looking dry 08 Apr to 01 Oct
1985	Holding significant water 11 Apr, dry by 17 Aug
1986	Looking dry 01 Jun to 23 Oct
1987	Looking dry 03 May to 01 Oct
1988	Looking dry 19 Apr to 12 Oct
1989	Looking dry 22 Apr to 29 Sep
1990	Holding some water 11 May, dry by 28 Jun
1991	Looking dry 12 Apr to 19 Sep
1992	Looking dry 14 Apr to 23 Oct
1993	Looking dry 17 Apr to 10 Oct
1994	Holding significant water 04 Apr, dry by 23 Jun
1995	Looking dry 07 Apr to 14 Sep
1996	Holding significant water 09 Apr, still holding some water 02 Oct
1997	Holding significant water 12 Apr, dry by 05 Oct
1998	Holding some water 30 Mar, dry by 27 Jul
1999	Holding significant water 02 Apr, still holding some water 27 Oct
2000	Holding some water 26 Mar, dry by 25 Jul
2001	Looking dry 23 Apr to 16 Oct
2002	Looking dry 13 Jun to 17 Sep
2003	Holding some water 28 Mar, dry by 19 Aug
2004	Holding some water 30 Mar, dry by 11 Jul
2005	Holding some water 02 Apr, dry by 23 Jul
2006	Holding significant water 12 Apr, still holding some water 14 Oct
2007	Holding significant water 08 Apr, still holding some water 15 Sep
2008	Holding some water 25 Mar, dry by 31 Jul
2009	Holding some water 13 Apr, dry by 18 Jul
2010	Holding some water 31 Mar, dry by 06 Aug
2011	Holding significant water 05 May, still holding some water 28 Oct
2012	Holding some water 04 Apr, dry by 09 Jul
2013	Holding some water 05 May, dry by 26 Jun
2014	Holding significant water 26 Apr, still holding significant water 19 Oct
2015	Holding significant water 06 Apr, still holding significant water 07 Nov
2016	Holding significant water 08 Apr, still holding significant water 18 Nov
2017	Holding significant water 27 Apr, still holding some water 04 Oct
2018	Holding some water 16 May, dry by 05 Sep
2019	Holding some water 01 Apr, dry by 04 Jun
2020	Looking dry 03 Apr to 10 Sep
2021	Looking dry 22 Apr to 15 Oct

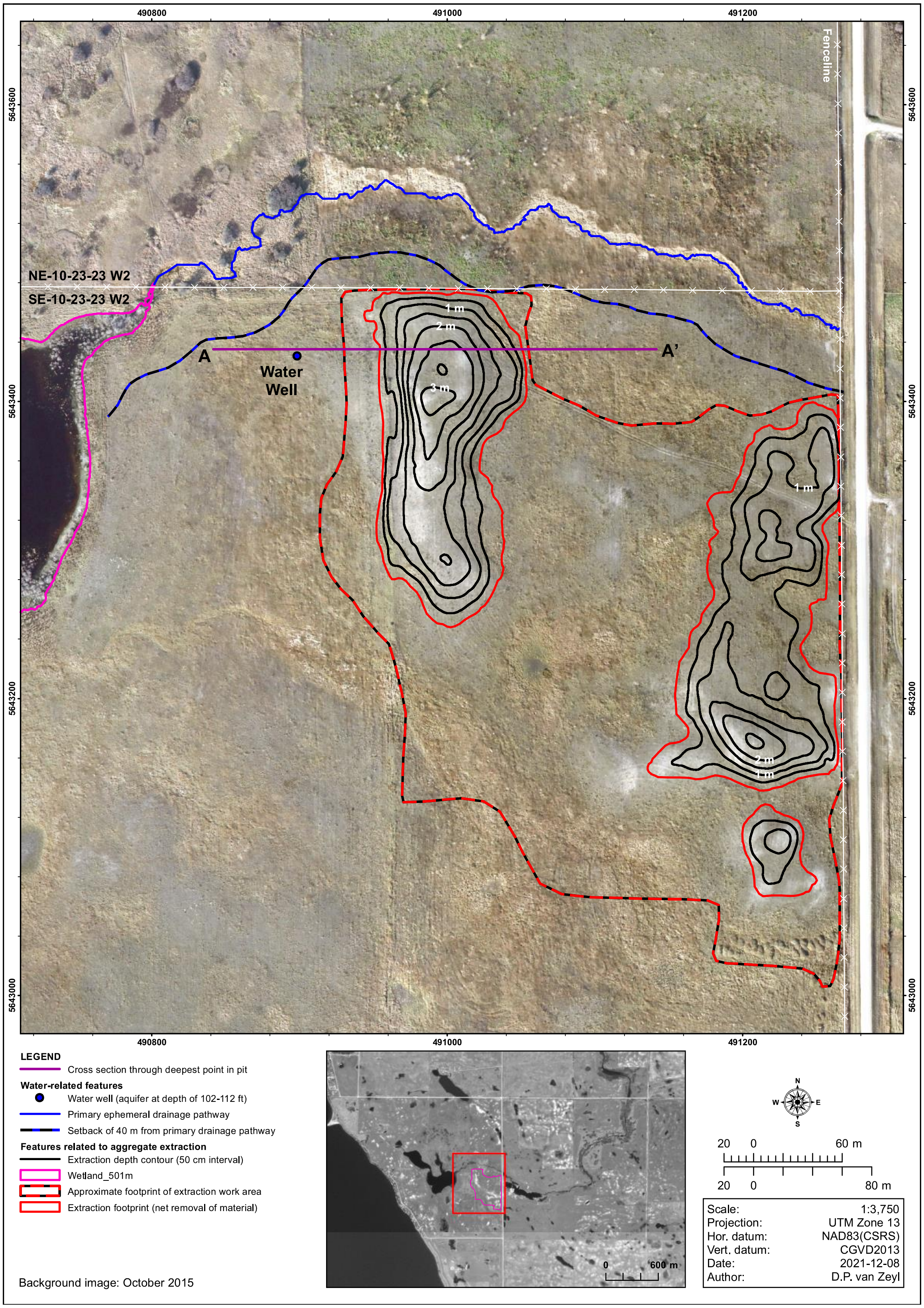

Figure 3 Map of aggregate extraction area with October 2015 background image.

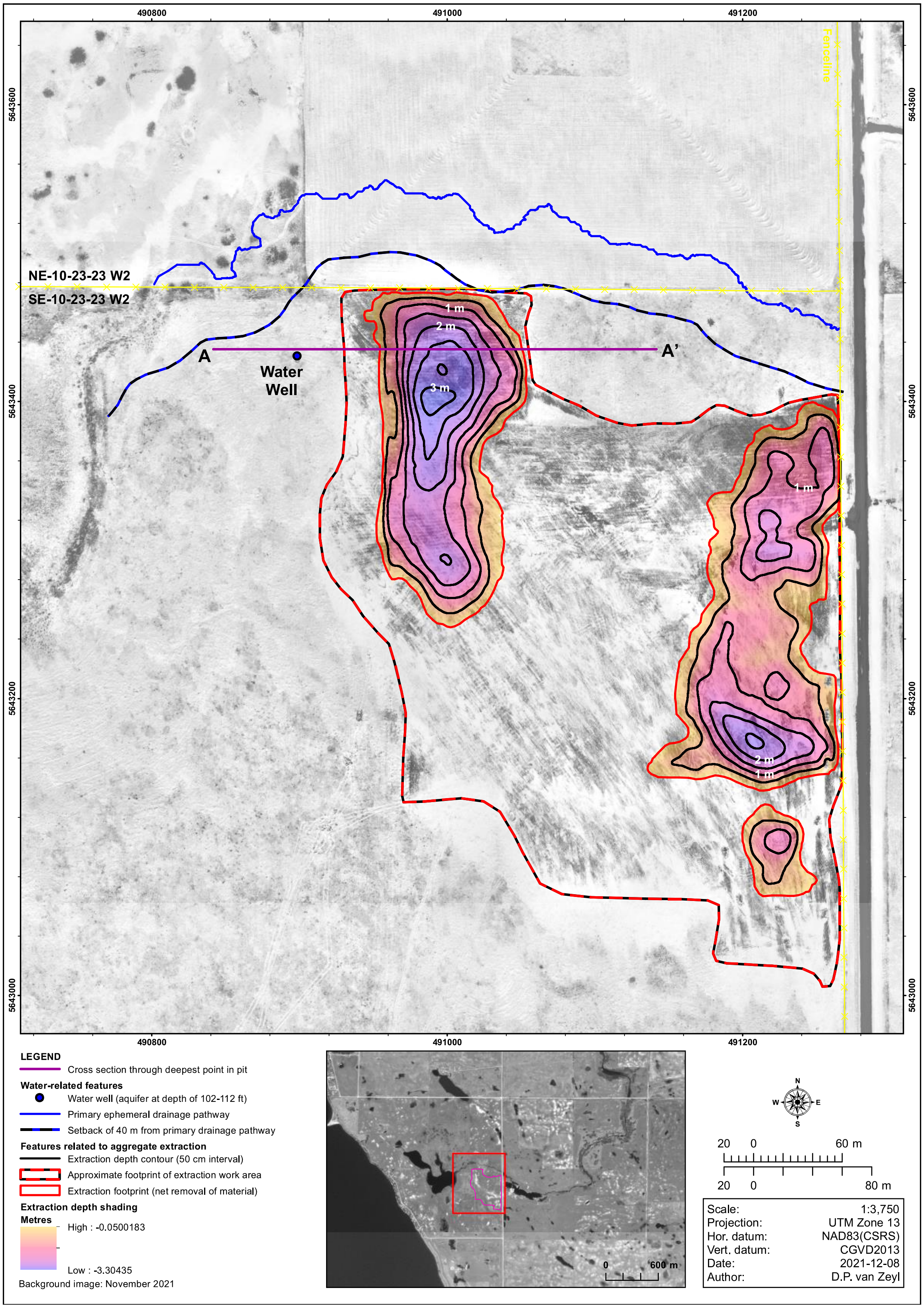

Figure 4 Map of aggregate extraction area with November 2021 background image.

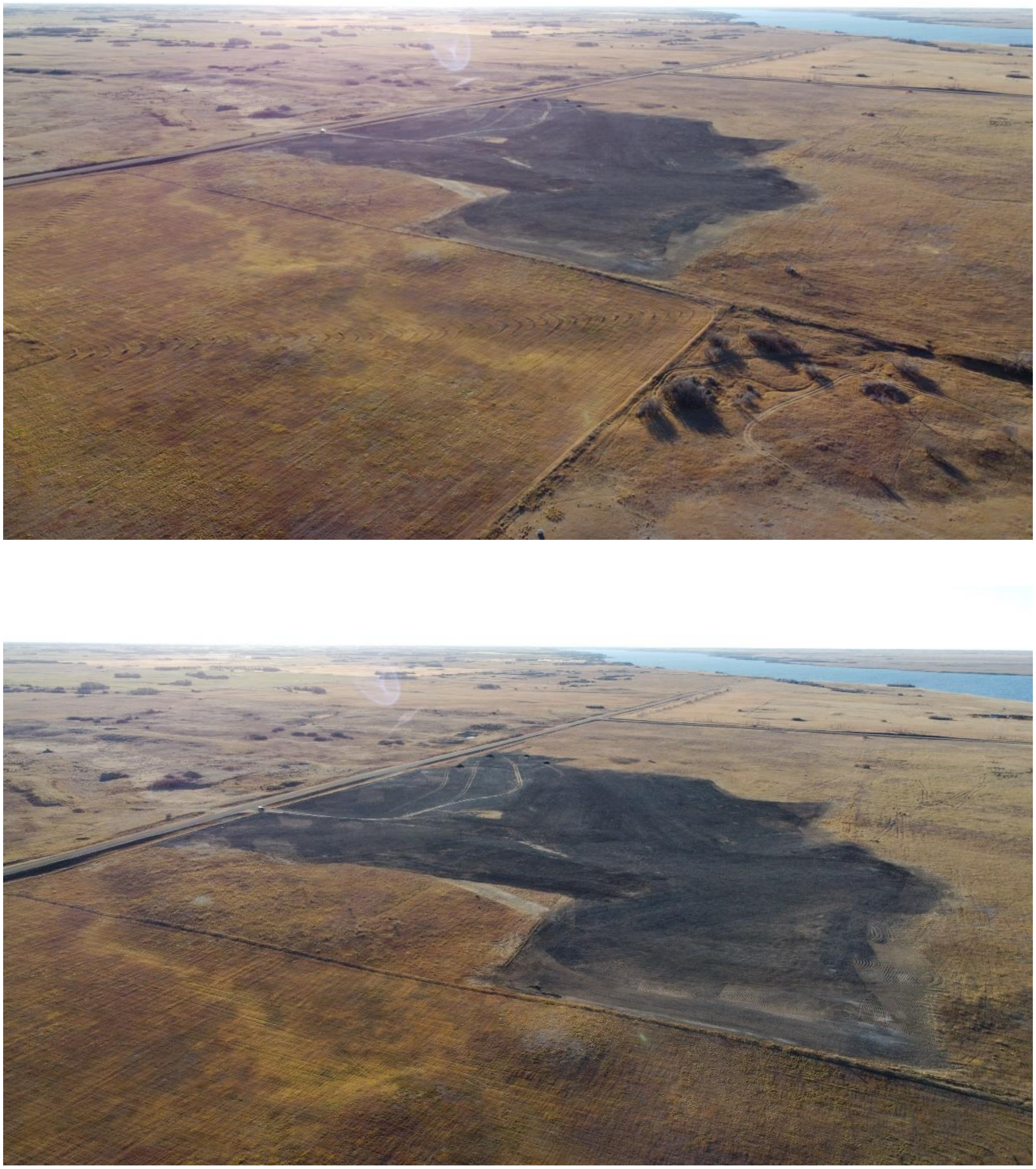

Figure 5 Oblique aerial photos showing aggregate extraction area (08 Nov 2021).

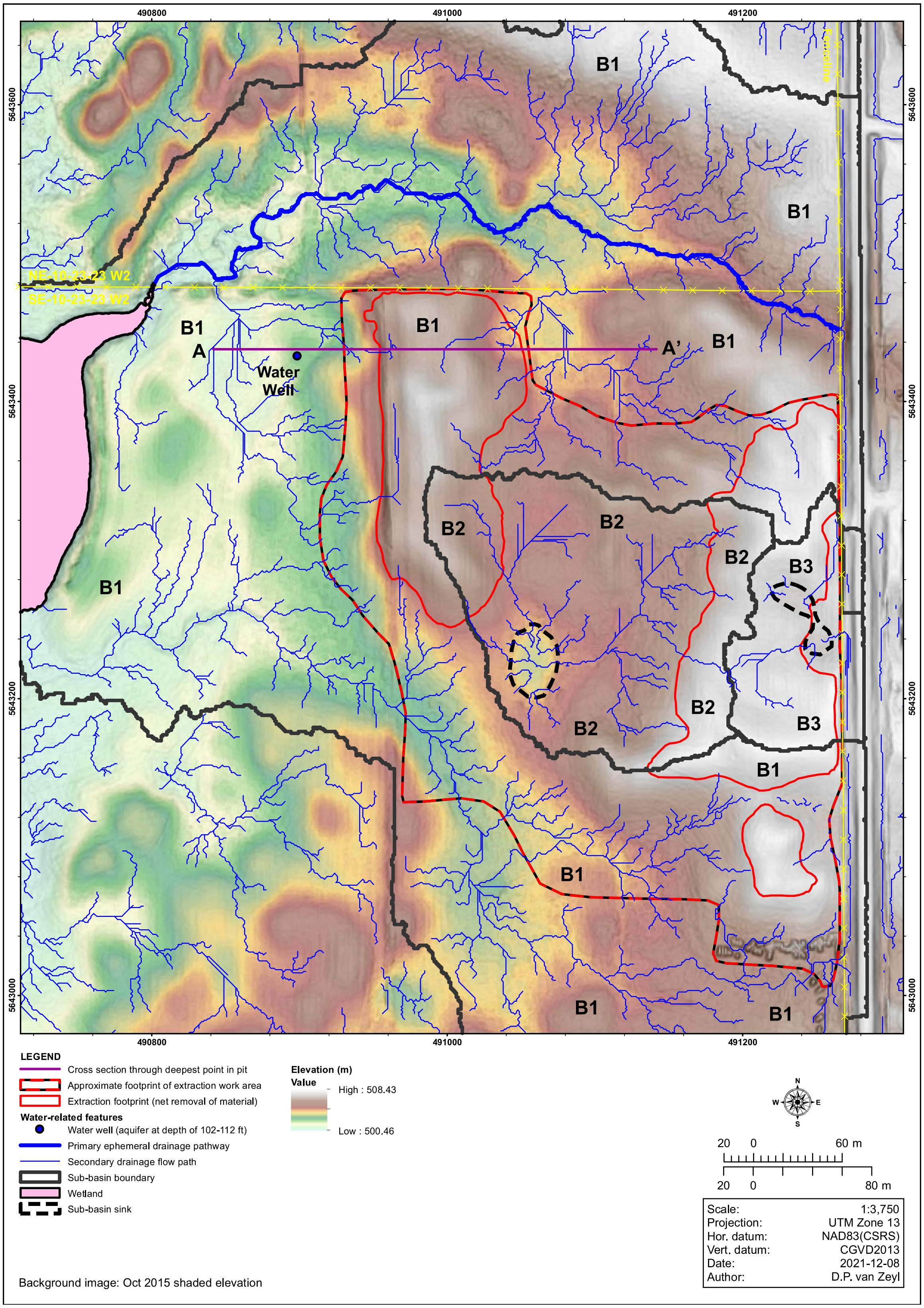

Figure 6 Map of aggregate extraction area with October 2015 topo background image.

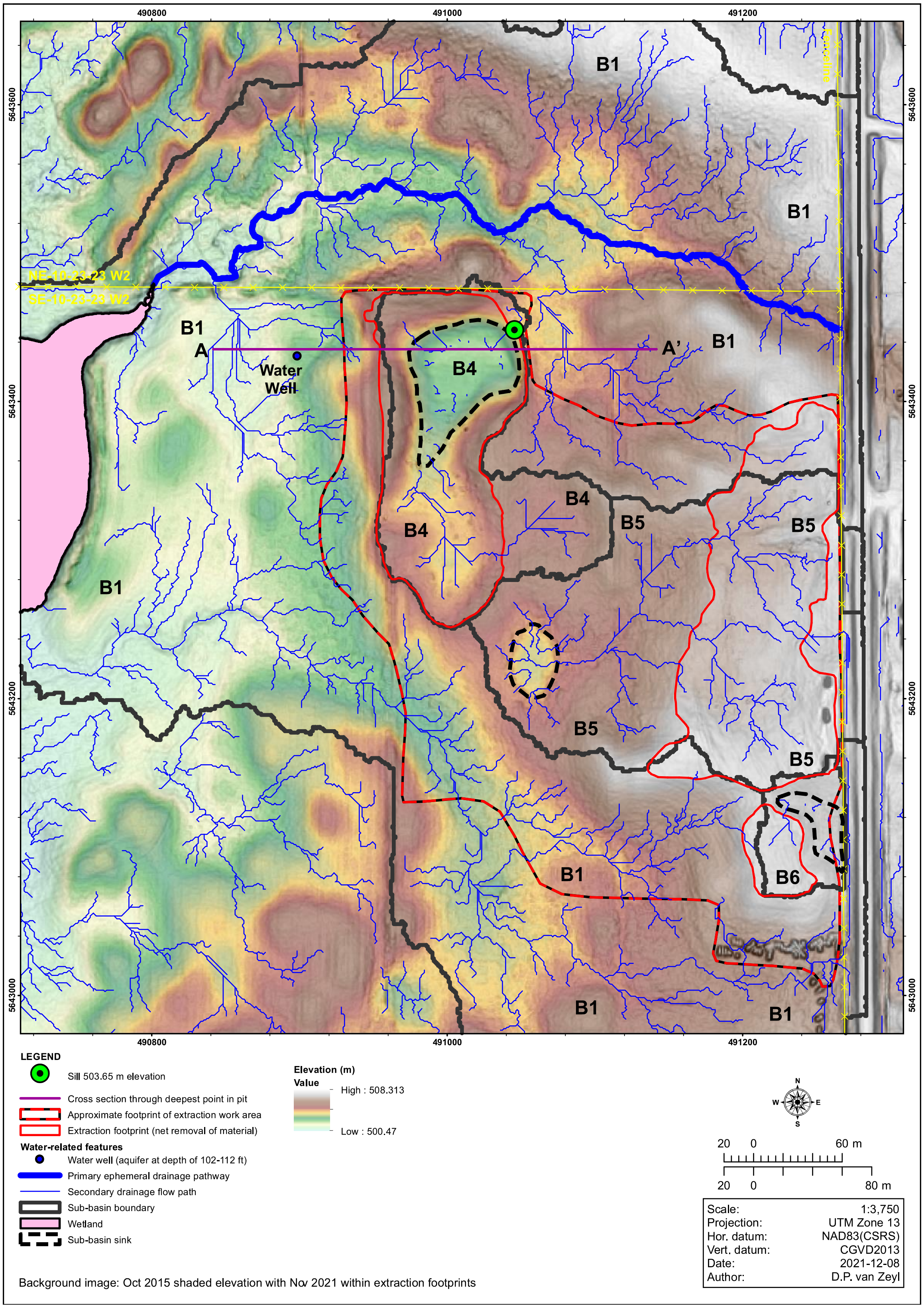

Figure 7 Map of aggregate extraction area with November 2021 topo background image.

Water Security Agency ***Water Well Driller's Report***

Page 1 of 1
14-Nov-2021
WSaskWWDR01

Well Name: **J&W CONSTRUCTION LTD.** WWDR #: **234129**

Well Location

Land Location	**SE-10-023 -23 -W2**	Location of Well (in Quarter)	
LSD	**00**	**0**	ft from N/S Boundary
Reserve		**0**	ft from E/W Boundary
RM:	**220**		
NTS Map:	**72I14**	Major Basin:	**05**
Elevation (ft)	**1641**	SubBasin:	**75**
Aquifer			

Well Information

Driller	**HAYTER DRILLING LTD**
Completion Date	**2020.06.19**
Hole #	**00000001**
Install Method	**Drilled**
Borehole Depth (ft)	**140**
Bit Dia (in)	**7.9**
Water Level	**100**
Flowing Head	**0**
Water Use	**Domestic**
Well Use	**Withdrawal**
Completion Method	**Well Screen And Gravel Pack**
E-Log	**Yes**

Well Casings

Length (ft)	Btm (ft)	Dia (in)	Material
105	**102**	**5**	**P.V.C.**
0	**0**	**0**	
0	**0**	**0**	

Well Screens

Length (ft)	Bottom (ft)	Dia (in)	Slot (in)	Material
10	**112**	**4**	**10**	**Stainless Steel**
0	**0**	**0**	**0**	
0	**0**	**0**	**0**	

Pump Test

Draw Down	**0**	ft
Duration	**3**	hrs
Pumping Rate	**6**	igpm
Temperature	**0**	deg. F
Rec. Pumping Rate	**5**	igpm

Lithology List

Depth (ft):	Material	Colour	Description
8	Till	Brown	Sandy
11	Sand & Gravel	Unknown	Unknown
94	Till	Grey	Unknown
98	Till	Grey	Sandy
102	Till	Grey	Unknown
112	Sand	Unknown	Fine
140	Till	Grey	Silty

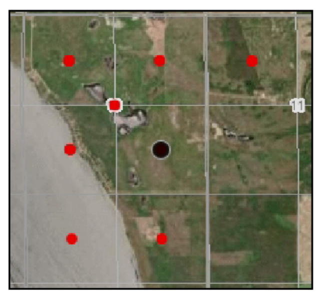

Figure 8 Water well record for well situated in SE-10-23-23 W2 (location Fig. 2).

Lithological log for water well 234129

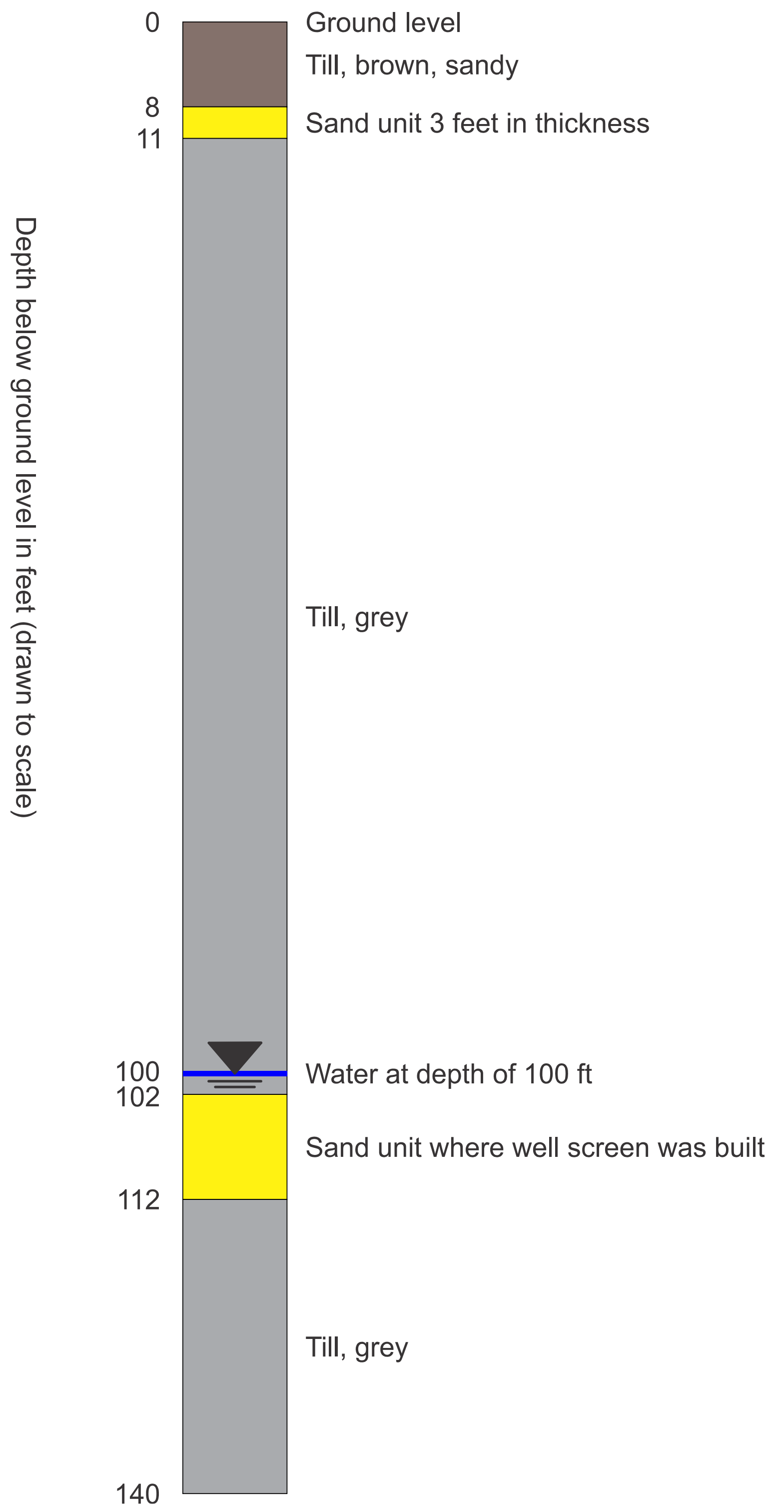

Figure 9 Lithological log for water well situated in SE-10-23-23 W2 (location Fig. 2).

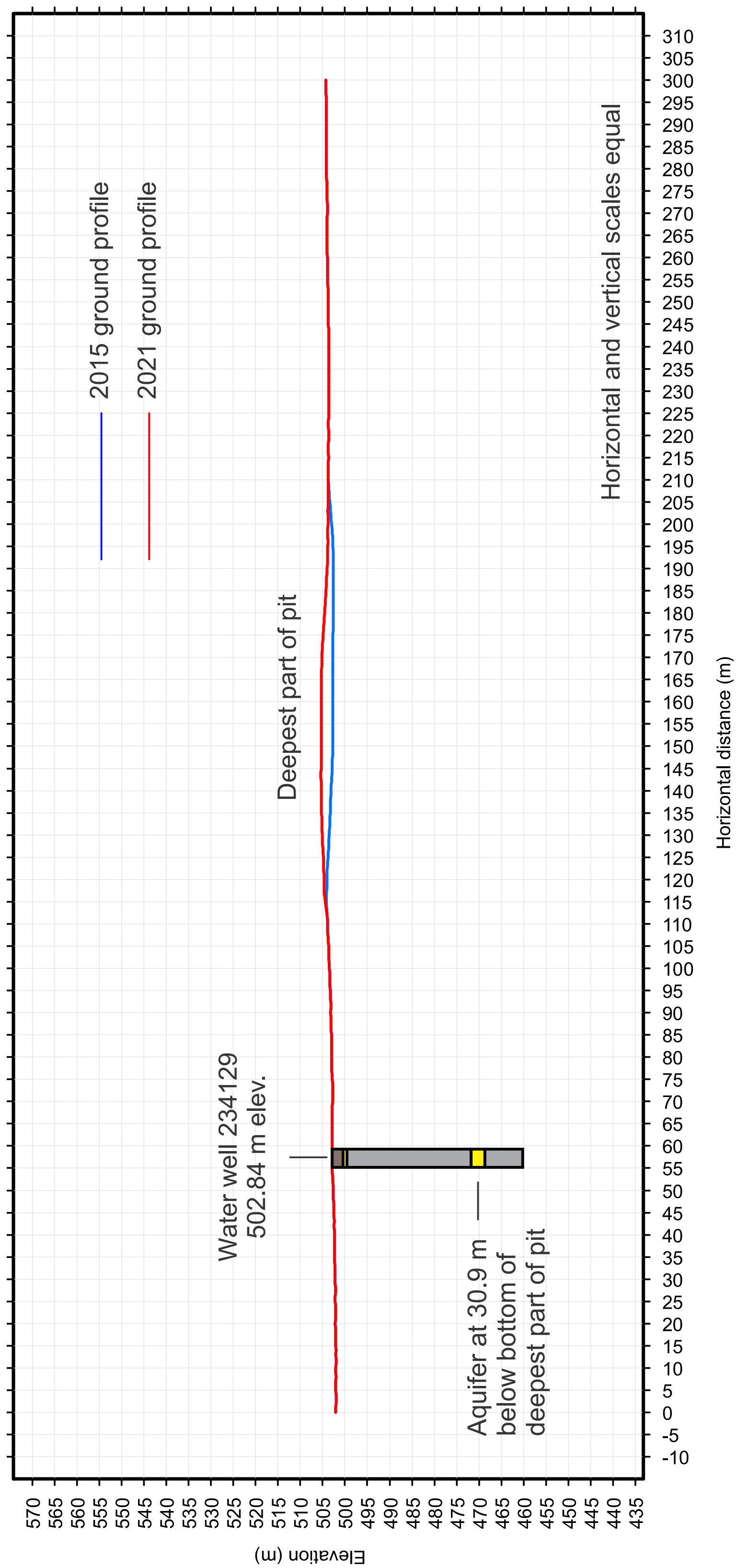

Figure 10 Section A-A' showing deepest part of pit adjacent to water well log (location Fig. 3).