Appendix A

Environmental Assessment Memo

SUMMIT ENVIRONMENTAL CONSULTANTS LTD.

ISO 9001 AND 14001 CERTIFIED

MEMORANDUM

DATE: **January 26, 2010 (revised May 7 2010)**

TO: TWIN LAKE AQUIFER STUDY FILE

FROM: Alexandra de Jong Westman, M.Sc., R.P.Bio.

RE: **ENVIRONMENTAL ASSESSMENT FOR TWIN LAKES AQUIFER CAPACITY STUDY**

FILE: 7030-002.01

This technical memo summarizes the baseline conditions of Twin Lake, Turtle Pond and Horn Lake as part of the Twin Lakes Aquifer Capacity Study ("the study area"), specifically identifying conflicts with the federal *Species at Risk Act* and the provincial *B.C. Wildlife Act*. As outlined in Summit's proposal to the Regional District of the Okanagan – Similkameen (RDOS), Alexandra de Jong Westman, M.Sc., R.P.Bio., conducted an overview environmental assessment of the baseline conditions of the study area on December 3, 2009.

Climate and Biogeoclimatic Zones

The study area is within the Okanagan Ponderosa Pine biogeoclimatic zone very dry hot variant, grassland phase (PPxh1a; MOFR 2008). This zone is characterized by very hot and dry summers, and cool dry winters (Meidinger and Pojar 1991). The Penticton weather station (#1126150) recorded temperature highs of 28˚C in the summer months, and lows of -5 ˚C in the winter months (EC 2002).

The forests of the PPxh1a landscape are dominated by ponderosa pine. Stands are often very open and parklike with a ponderosa pine canopy and an understory dominated by bluebunch wheatgrass (*Agropyron spicatum*). In fact, the vegetation often consists of a mosaic of forest and grassland. In the grassland phase of the PPxh1, a combination of edaphic and topographic conditions, together with fire enable a grassland complex to establish itself.

Vegetation and Ecological Communities

The terrestrial environment surrounding the study area is heavily disturbed by residential development and cattle ranching. While the forb understory is degraded and dormant at the time of the assessment, the shrub and tree diversity was assessed successfully. In short, the study area was comprised of three distinct ecological communities:

1. Big sagebrush – bluebunch wheatgrass (*Artemesia tridentata – Pseudoroegneria spicata*);
2. Interior Douglas fir – trembling aspen – black cottonwood (*Pseudotsuga menzesii – Populous tremuloides – Betula balsamifera tricocarpa.*); and,
3. Black cottonwood – Saskatoon – rose (*B. balsamifera tricocarpa – Amelanchier alnifolia – Rosa sp.*).

Detailed assessments of the three water bodies and associated upland habitats could not be completed because many plant species are dormant throughout the winter months, only emerging with the spring rains in late April. Therefore, further comment on the vegetation of the area cannot be provided at this time.

Wildlife and Wildlife Habitats

The three factors that most influence the variety of wildlife species in this particular biogeoclimatic zone are short winters with low snowfall, a strategic location between the Great Basin to the south and the boreal forests to the north, and a great diversity of vegetation types. The short, largely snow-free winters attract many animals during the winter months. Mule deer (*Odocoileus hemionus*), white-tailed deer (*Odocoileus virginianus*) and bighorn sheep (*Ovis canadensis*) can migrate long distances (up to 80 km) to winter in this zone. Additionally, the bird diversity is greatest in the Okanagan Valley, boasting over 300 species, with more than 50 species considered rare or endangered.

The intensity of grazing in the area and the low water levels has limited the existing wildlife habitats within the study area. Foraging opportunities for ungulates and sheep are limited because of grazing pressures. It is our understanding that the grazing land within the study area will be left ungrazed for this next year, which will greatly improve the forage for deer and sheep. The study area has some potential for grassland and forest passerine species, with many large ponderosa pine, Interior Douglas fir and deciduous species to provide both cavities and stick-nesting opportunities. Shrub diversity is low, resulting in little potential for ground-nesting bird species. However, the absence of cows for any length of time will allow shrubs and grasses to flourish, providing better habitat for grassland birds.

There are three surface water resources in the study area: Twin Lake, Turtle Pond and Horn Lake. Both Twin and Horn lakes are fish-bearing, stocked with brook (*Salvelinus fontinalis*) and rainbow (*Oncorhynchus mykiss*) trouts; as well as carp (*Cyprinus carpio*). Because of the topography and the dam at the outlet of Turtle Pond to Horn Lake, Turtle Pond, fed by Horn Creek, has remained fishless, allowing amphibian species such as the rare tiger salamander (discussed below; B.C. CDC 2009) and the Great Basin spadefoot (*Spea intermontana*), to flourish. Other amphibian species likely inhabit Turtle Pond; however, because of the timing of this assessment, all amphibians are currently hibernating and could not be surveyed for. From observations made in 2006, Western Painted turtles did inhabit the Turtle Pond; however, since 2006 the population of turtles has disappeared with the lack of water in the pond (Pers. Com Brown C. 2010). During the site visit it was observed that there would not be adequate water to support a turtle population in the pond at this time.

Species at Risk

Over 100 rare and endangered plants, and over 90 wildlife species have the potential to occur within the study area, based on the available habitat types and geographical location (B.C. CDC 2009a; Attachment 1 and 2). Furthermore, there is one amphibian, one bird and one plant all considered rare and endangered, documented within the study area (Table 1). In addition to these three, the Turtle Pond also is suitable habitat for the desert-welling Great Basin spadefoot, an amphibian physically similar to frogs, but genetically closer to toads. While not documented within the study area, large populations are known within the Twin Lakes and White Lake basins (B.C. CDC 2009b).

Table 1 Species at Risk Recorded within the Study Area.

COMMON NAME	SCIENTIFIC NAME	SARA STATUS*	BC STATUS†	DOCUMENTED LOCATION
Tiger salamander	*Ambystoma tigrinum*	Endangered	Red	Turtle Pond (2006)
Brewer's sparrow	*Spizella breweri breweri*	-	Red	Twin Lakes (1991)
Showy phlox	*Phlox speciosa* ssp. *occidentalis*	Threatened	Red	Twin Lake Road, White Lake Road, Eastview Road (2008)

Source: B.C CDC 2009b.

Tiger Salamanders

This salamander is uniquely adapted to living in desert conditions, withstanding massive droughts and heavy rainfalls. Restricted to only the Okanagan Valley from Osoyoos to Summerland, the tiger salamander is able to hibernate below ground for many tens of years, emerging only when the terrestrial environment is conducive for breeding (MOE 2008). A further adaptation to living in a desert, which can prove to be quite hostile, this salamander can alter its development by forgoing metamorphosis from larva to adult, and instead adopt a padogenic form (MOE 2008). This form is sexually mature, but maintains physical attributes of a fully-aquatic larva thus avoiding the hostile terrestrial environment and living forever in an aquatic environment. Miraculously, these padogens can reproduce normally, producing larvae which can opt to become fully-metamorphosed adults, providing that the terrestrial environment has become more conducive for that life stage.

Based on the last survey in 2006, Turtle Pond was providing aquatic habitat to metamorphosed adult salamanders, young non-padogenic larvae and egg masses (B.C.

* SARA Status pertains to the federal status given to a species by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and protected by the *Species at Risk Act* (SARA).

† B.C Status pertains to the provincial status given to a species based on the status of their populations within the province of B.C. "Red-listed" Includes any ecological community, and indigenous species and subspecies that is extirpated, endangered, or threatened in B.C.

CDC 2009b). It is our understanding that 2006 was the last year that Turtle Pond had substantial amounts of water. It is likely that these salamanders are hibernating within the soft sands and silts around the periphery of the pond and upland areas until the pond provides suitable habitat again. Because both Horn and Twin lakes are stocked with fish, it is unlikely that the salamanders are using these water bodies because of the high chance of predation.

Great Basin Spadefoot

The Great Basin spadefoot is currently provincially blue-listed and federally designated as Threatened (B.C.CDC 2009a,b). Relying on ephemeral ponds and flooded fields, the spadefoot is an opportunistic and explosive breeder, coming out from their hibernation sites below ground during the heavy spring rains. Like the tiger salamander, the spadefoot can survive for many years below ground, waiting for the ideal wet spring to emerge and reproduce. Although only about 8 cm long, these little amphibians can travel up to 1 km to reach appropriate breeding grounds. Unfortunately, roads and other urban development are increasingly fragmenting their migration routes and foraging habitats. As well, changes in the environment resulting in fewer heavy spring rains and fewer ephemeral ponds because of development have reduced spadefoot habitat to less than 10% of what was available 30 years ago (Wind 1999). Turtle Pond is ideal spadefoot habitat, not only being ephemeral, since water evaporation rates determine the rate of spadefoot tadpoles to metamorphosis, but also because of the bunchgrass upland habitat is ideal hibernating and foraging habitats (COSEWIC 2007).

Brewer's Sparrow

Although Brewer's sparrow are unlikely to be directly impacted by the fluctuating water table, small localized populations are within the study area. Requiring mature and large sagebrush for nesting, these ground-nesters are highly susceptible to over-grazing and other ground disturbances. These drab songbirds are highly specialized in their habitat requirements, and thus are found primarily in the South Okanagan, from Penticton south to Osoyoos, with a small isolated population along the Thompson River between Kamloops and Spence's Bridge (Sarell and McGuinness 1996). While it is recognized that this groundwater study has no impacts on the Brewer's sparrow, consideration should be given to the impacts of any proposed development or cattle range expansion in the area on this rare bird.

Showy Phlox

Showy phlox is one of 6 species of *Phlox* in B.C., out of 16 in Canada (COSEWIC 2004). Showy phlox is a perennial herb with a somewhat shrubby base. The erect stems rise from a woody taproot, extending upwards of 40 cm in height. Highly specific in its habitat requirements, this phlox species is restricted to only a few sites in the Okanagan Valley, specifically around Penticton to Skaha Lake, in the upper grasslands around Osoyoos, and the Twin Lakes study area (B.C CDC 2009b; COSEWIC 2004). Like the Brewer's sparrow, this plant is unlikely to be directly impacted by the fluctuating water table, particularly because it is highly adapted to a desert environment. However, like the Brewer's sparrow, urban or other development within the limited range of this species will have detrimental impacts on the local and provincial populations. In Canada, *Phlox* *speciosa* is Red-listed in British Columbia, and has a Subnational Natural Heritage Status Rank[‡] of Critically Imperiled (S1) in British Columbia (B.C CDC 2009a). This provincial rank is applied to taxa that are extremely rare or especially vulnerable to extinction. Based on the present field data, this ranking likely requires revision.

Impacts of Water Management

At present, water licenses are provided based on an instantaneous and potential water content of lakes or streams, as is the case in the Twin Lakes study area. Therefore, when development increases and the environment changes, the water licenses do not typically reflect these changes and water shortages can result. Humans are not the only animals impacted by the reduction in available water. Wildlife, particularly those dependent on ponds and lakes as providers of habitat and food sources, are significantly impacted.

Although resilient to long periods of time underground, the rare tiger salamanders cannot survive indefinitely. Therefore, continued over-use of the water resources in the area and preventing the salamanders from emerging and breeding, has the potential to extirpate the Turtle Pond tiger salamander population. To date, critical habitat[§] as defined by the *Species at Risk Act*, has yet to be identified for tiger salamanders. The ramifications are that unless there is water in the pond (whereupon the pond is protected by the *B.C Water Act*[**]), or direct harm to the animal occurs (whereupon the *B.C Wildlife Act* and *Wildlife Amendment Act*[††] apply), this salamander and its habitat has little protection. However, this should not be a deterrent for applying good stewardship practices to both water management and habitat conservation of and around Turtle Pond.

Recommendations and Good Stewardship Practices

At present, the provincial and federal governments are reliant on good stewardship practices for the protection of tiger salamander habitats, both aquatic and terrestrial. Habitat protection and securement against future development or alteration is of utmost importance for the conservation of this species. For the Twin Lakes study area, such measures could include:

1. Cattle exclusion fencing around the perimeter of Turtle Pond at the high-water mark to prevent fore-shore disturbance, in-pond disturbance and pollution from cow defecation;
2. Enhancement of the foreshore environment through the planting of both aquatic and riparian vegetation to repair the degradation resulting from cattle access;
3. Revisions to water licenses to prevent drastic changes in water levels in Turtle Pond to stabilize the aquatic environment; and

[‡] Taxa ranked as Critically Imperiled typically have five or fewer occurrences or very few remaining individuals (<1000; BC CDC 2002).

[§] Critical habitat is vital to the survival or recovery of wildlife species. The habitat may be an identified breeding site, nursery area or feeding ground. For species at risk, these habitats are of crucial importance, and must be identified and included in recovery strategies or action plans, though only a few species have critical habitat defined (Government of Canada 2008).

[**] The *B.C Water Act* protects wetlands and streams from misuse, including water removal of unlicensed users, alterations to the stream or wetland structure

[††] The *B.C Wildlife Act* protects most vertebrates from direct harm or harassment, and regulates hunting and trapping. The *B.C Wildlife Amendment Act* Allows the provincial government to list animals, fish, plants, or invertebrates as species at risk, and to define and protect the residence of a listed species at risk. Listing provides prohibitions against the killing, harming, harassing, importing, exporting, trafficking, possession, and transport of that species on both provincial Crown land and private land except as authorized by regulation, permit, or agreement (Ministry of Environment 2007).

4. Restriction of further development in the Twin Lakes area so that water resources are not further depleted.

References

B.C Conservation Data Centre (B.C CDC). 2009a. B.C Species and Ecosystem Explorer. Online at: http://a100.gov.bc.ca/pub/eswp/ (Accessed December 10, 2009).

B.C Conservation Data Centre (B.C CDC). 2009b. Conservation Data Centre Mapping Service. Online at: http://www.env.gov.bc.ca/atrisk/ims.htm (Accessed December 10, 2009).

Brown, Coral. 2010. Bryer Manwell (Summit) personal communication with Coral Brown on February 23, 2010. C. Brown is a long time resident of Twin Lakes and is a member of the Lower Nipit Improvement District.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2007. COSEWIC Assessment and Update Status Report on the Great Basin Spadefoot (*Spea intermontana*) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. Vii+34pp (www.sararegistry.gc.ca/status/status_e.cfm).

Ministry of Environment (MOE). 2008. Recovery Strategy for the Tiger Salamander (*Ambystoma tigrinum*), Southern Mountain Population in British Columbia. Prepared by the Southern Interior Reptiles and Amphibian Recovery Team for the Ministry of Environment. Victoria, B.C.

Ministry of Environment (MOE). 2007. B.C Wildlife and Wildlife Amendment Act. Online at: http://www.env.gov.bc.ca/fw/wildlifeactreview/ (Accessed December 22, 2009).

Sarell MJ and KP McGuinness. 1996. Status of the Brewer's Sparrow (*Spizella breweri breweri*) in British Columbia. Prepared for the Ministry of Environment, Land and Parks. Victoria, B.C.

Wind E. 1999. Effects of Habitat Fragmentation on Amphibians: What do We Know and Where do We Go From Here? Proceedings of a Conference on the Biology and Management of Species and Habitats at Risk. 2:885-895.

Appendix C

Details on the OBWB

Groundwater Balance Analysis Tool

Appendix C

GWBAT Components and Assumptions

The spreadsheet has seven basic components including the following:

1. Aquifer Description Component: This section describes the aquifer number, and the type of aquifer, which aquifer/ surface water body the aquifer will discharge to and any of the adjustment factors.
2. Aquifer Characteristics Component (A): This section represents the physical characteristics of the aquifer and the basis for a Darcy's Law calculation. Aquifer input parameters included: hydraulic conductivity, saturated thickness, gradient, width, length, and porosity.
3. Water Balance Component (C): This section of the spreadsheet accounts for all estimated recharge and discharge influences on the aquifer and calculates a monthly flow estimate, independently of the Darcy's Law calculation in (A). Recharge (input) is treated as positive and discharge (output, for example extraction) is negative.
4. Comparison Component (D): This section of the spreadsheet calculates the difference between the Darcy's Law calculation in (A) and the Water Balance (C). The net difference between the two is treated as a monthly change in aquifer storage. A positive number is treated as an increase in storage and a negative number as a decrease. The change in storage is subsequently applied over the footprint area of the aquifer and, accounting for influence of porosity on storage volume, a change in saturated thickness for the aquifer system is determined. The change in thickness is transferred to the starting saturated thickness in the next column representing the next month.
5. Graph of Saturated Thickness Component (Page 2): This is a graphical representation of the data output from the spreadsheet model, specifically the temporal trend of saturated thickness throughout the 11-year trial time period. The graph provides immediate feedback of changes made to input parameters in Component A and can be used as a visual tool for sensitivity analysis.

6. For the 1996 to 2006 trial period the drought experienced in the Valley between 2000 and 2003, represented a key calibration point for all of the water balances completed, which required a saturated thickness (i.e., water level) decline during the drought period and recovery thereafter, as was observed in a number of BC MoE Observation wells in the Basin during that period. For the 2010 to 2040 trial period predicted precipitation from the climate models provided by Okanagan Climate Data Interpolation Model provided calibration data the graphical feedback was useful to visually assess the sensitivity of input parameters on the solution. In cases where the saturated thickness changed rapidly or trended upwards or downwards over an extended period of time, it was necessary to increase the starting saturated thickness (to change the effective horizontal hydraulic conductivity), or change the factor applied to infiltration from stream losses.
7. Several assumptions were incorporated into the spreadsheet modeling (GWBAT Tool) over the trial time periods.
8. Contributions of recharge from adjacent bedrock systems were assigned a constant value equivalent to 85% of total annual recharge determined for the bedrock aquifer, divided by 12 to derive a monthly amount.
9. Temporal changes in infiltration from surface flow were apportioned by applying a monthly adjustment factor to monthly precipitation. A stream loss factor and other adjustment factors were also applied. From more information regarding the adjustment factors please refer to the OBWB Groundwater Supply and Demand Study (Golder and Summit 2009).
10. For the 1996 to 2006 trial period the monthly precipitation adjustment factor was determined for each of the 132 months over the 11-year trial period by dividing the actual amount of precipitation recorded during a specific month at the Coldstream climate station, by the mean monthly value for that same month at the station. For the 2010 to 2040
11. To account for snow accumulation and freshet surface water runoff, the monthly precipitation factor for consecutive months from November through April was

cumulatively added and then divided by six (the number of months), to determine a relative annual amount. Freshet surface water runoff was assigned as streamflow over the freshet period, during April through August. Additional contributions to streamflow via rainfall were also assigned, using the precipitation adjustment factor.

12. Precipitation during September was directly attributed to surface water runoff. Precipitation during October, November, December, January, February and March was assigned to snow accumulation for the following year snowmelt and freshet surface water runoff.
13. The above assumptions are reflected in the calculation formulae used in each GWBAT run.

Water Balance Analysis Process and Quality Review

The water balance process used the following approach:

1. Initial (preliminary) characterization of aquifer physical and hydraulic properties was completed.
2. Stream interaction and precipitation infiltration factors were estimated based on the adopted methodology.
3. Aquifer characterization values and provided time-series data (total extraction data from RHF. Systems Ltd.) were compiled into a single source data spreadsheet so that data could be easily transferred to the GWBAT spreadsheets.
4. Inputs from adjacent up gradient aquifers were incorporated.
5. Anthropogenic inputs and outputs (monthly) were incorporated from time-series data.
6. The monthly and annual changes in aquifer storage based upon the initially applied values were assessed by examining the graphical output in the GWBAT.
7. If there were large or unreasonable changes in storage, then adjustments were made to aquifer parameters such as hydraulic conductivity, thickness and gradient within reasonable ranges until a best-fit solution was arrived at.
8. A best or good-fit solution was considered to be a graph of change in thickness (i.e., a hydrograph) that mimicked the overall pattern of groundwater levels in nearby

representative observation wells, if applicable, during the trial periods. Ideally, the amplitude of the saturated thickness changes would appear similar to observation well hydrographs. For the future scenarios the best fit solution was considered to be a graph of change in thickness (i.e., a hydrograph) that mimicked the overall pattern of the predicted precipitation.

9. An independent QA/QC review of each GWBAT was performed by the senior hydrogeologist who did not prepare the initial water balance analysis. This review included checking formulae and verifying if inputs and outputs were properly incorporated (e.g., comparing values in cells to provided time-series source data such as irrigation return flow).
10. A final check was made on each GWBAT to verify that the proper labels were applied to each aquifer, and that the aquifer and node reporting relationships were accurate. This final check was made by a hydrogeologist who was not involved in the aquifer characterizations, the water balancing or the QA/QC review of the water balances.

Aquifer 221 Extraction, Return and Precipitation Data
Monthly Values 2010 - 2040

This describes the production and limitations of the monthly extraction, deep percolation and precipitation data for aquifer 221 developed for Summit Environmental Consultants Ltd. for the 2010 - 2040 time period. The methodologies and algorithms use to calculate the water demand and deep percolation are documented separately (*Irrigation Water Demand Model – Technical Description*); this description deals with the steps specific to Summit's request.

Precipitation Averaging

The precipitation data was extracted from gridded climate data files produced by the Okanagan Climate Data Interpolation Model (Guy Duke, University of Lethbridge). The model's outputs are daily precipitation, minimum temperature and maximum temperature values for each cell of a 500m x 500m mesh covering the Okanagan Valley. The grid cell mesh was then intersected with other layers in a GIS environment, including the bedrock and alluvial aquifers to form a resultant database. Every polygon in the resultant database can be identified as to its intersecting climate cell, aquifer, and many other feature types; most feature types break the surface into separate polygons in the resultant coverage. The climate cells and aquifer lines, in particular, form new polygons in the output coverage such that the areas of climate cells only partially intersected by an aquifer are readily available. Figure 1 shows the intersection of the climate grid cells (regular checkerboard lines) with aquifer 221 (light blue).

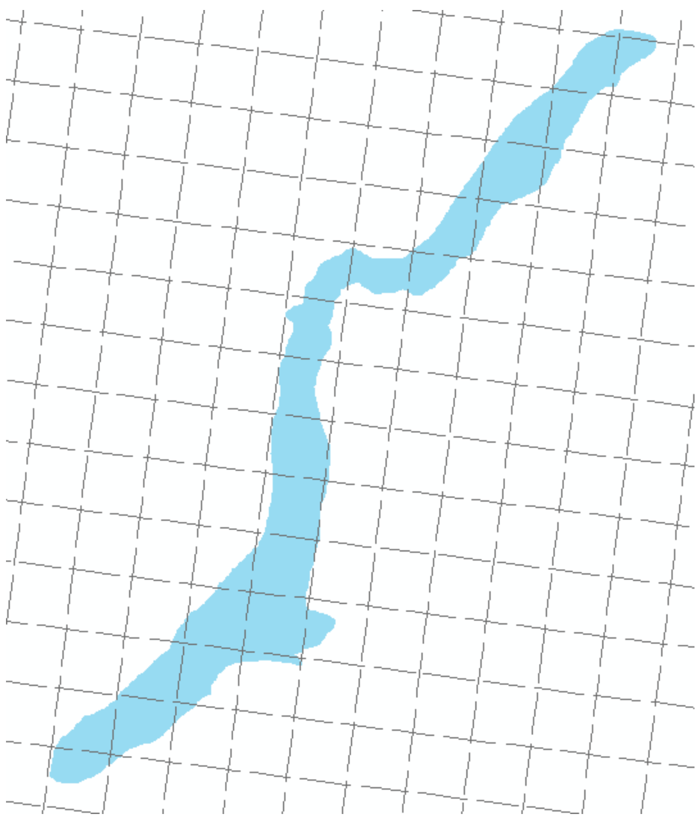

Figure 1 – Aquifer 221 / Climate Cell Grid Intersection

The daily precipitation depths (millimetres) for each grid cell were totalled to monthly values and then combined into a single total for the aquifer by multiplying the cell values by the ratio of their intersected areas with the aquifer. This gives a weighted average of the individual cell values for the overall monthly precipitation depth. Precipitation volumes (cubic metres) were summed directly from the individual cell depths multiplied by their intersected areas (no averaging).

Extractions

The Irrigation Water Demand model was used to model the projected water requirements for the years 2010 – 2040. Through a table of *source linkages* (Lars Uunila, Polar Geoscience Ltd.), the calculated water demands were then distributed across the various aquifers and surface sources. For example, the Twin Lakes Water Utility is listed in the source linkages table as obtaining 100% of its supply from aquifer 221. A neighbouring water use area designated as *Other_57* gets 37.7% of its water from aquifer 221 and the remainder from several other aquifers and surface nodes. Figure 2 below shows the water use areas near aquifer 221.

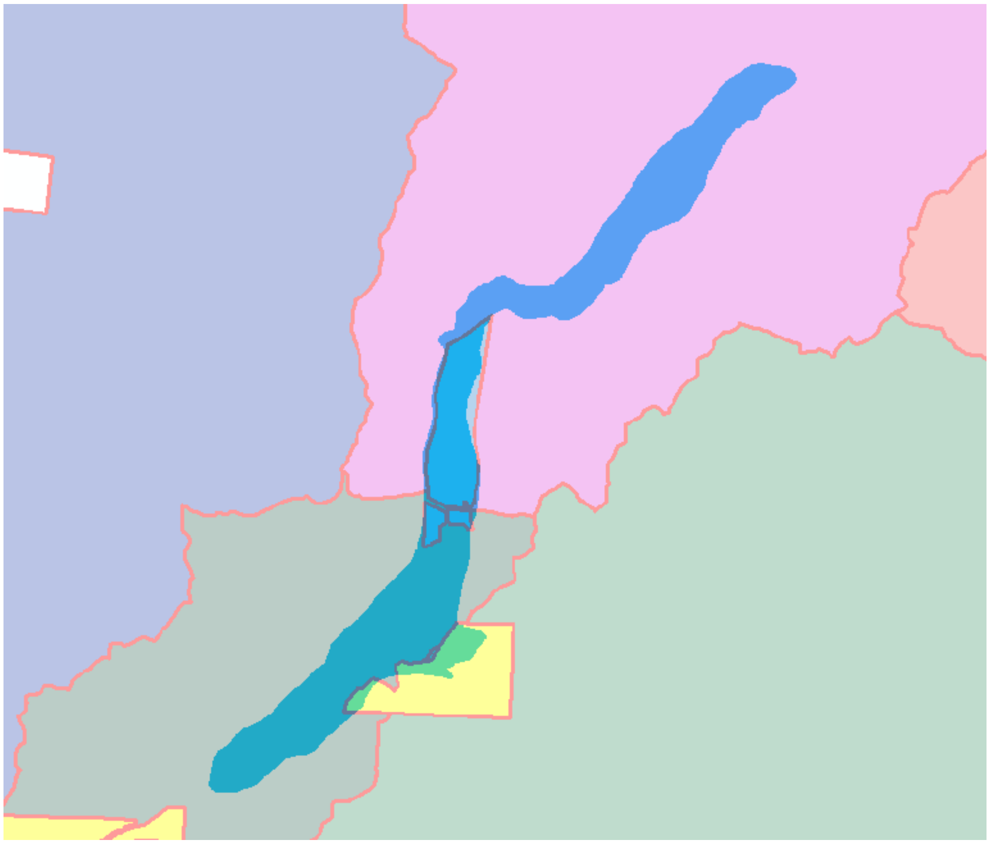

Figure 2 – Water Use Areas extracting from Aquifer 221

The yellow water use area in Figure 2 is the Lower Nipit Improvement District; the source linkages table does not indicate that it obtains any of its water from aquifer 221 even though it partially overlaps the aquifer.

All water uses attributable to aquifer 221 were totalled in the output results.

Returns

Returns to the aquifer represent deep percolation volumes and are associated only with water demands occurring directly on top of the aquifer. In the results tables, there are months with a non-zero water extraction value, but with no associated deep percolation; this is because the extractions are servicing water demands (and associated return flows) in areas outside of aquifer 221.

Losses to deep percolation are controlled by an irrigation management practices selection during the water demand modeling, and in general, this is fixed at a *poor*, *average* or *good* setting for all crops and all locations for a year. For the Okanagan Basin Water Board scenarios upon which these results are based, however, the modeling of the irrigation management practices is somewhat more complicated: an *average* management practices setting is used for all agricultural crops, and all domestic outdoor (landscaping) irrigation starts as *poor* management but converts to the *average* setting over the course of the 31 year modeling period. For a full description of the methodology used to phase in the management practices conversions, see the documentation describing the scenarios (*Okanagan Valley Water Demand Data – Scenario Modeling*).

Distribution Losses
For the OBWB scenarios, all water demands calculated by the demand model were increased by 5% to represent losses due to distribution networks. These losses are not part of the deep percolation values since they may not be occurring over the aquifer.

Month 0
The irrigation water demand model calculates an annual soil moisture deficit representing the amount of water that the farmer must add to the soil before the start of the growing season in order to begin with a full moisture reserve. While this may be added in various months, such as after the growing season has ended or prior to the next season's start, the deficit is attributed to month 0 in the results tables. Month 0 should be excluded from any calculations that involve averaging, such as determining a simple average monthly precipitation for each year.

Scenarios
The two sets of results produced for this request are intended to provide upper and lower estimates for the water demand over the 31-year period:

Scenario 4
- CGCM2.A2 climate model
- increased agricultural land
- higher rate of population growth

Scenario 9
- CGCM2.B2 climate model (reduced CO_2 emissions)
- current agricultural landbase
- expected rate of population growth

For a specified year, the outdoor water demand for the B2 climate variant may be higher than the A2 model, but in general, the reduced CO_2 emissions for the B2 should produce a lower irrigation requirement.

Table Structure
The data was provided in two Excel spreadsheets (one for each scenario) with the following columns:

year
- 2010 - 2040

monthNumber
- 0 - 12

avg_precip_mm
- precipitation depth in millimetres calculated as a weighted average of the climate cell values

total_precip_m3
- volume of precipitation onto the aquifer in cubic metres

indoor_extraction_m3
- volume extracted for indoor water uses (residential, industrial, commercial and institutional)

outdoor_extraction_m3
- volume extracted for outdoor water uses (domestic landscaping, agricultural, golf courses, etc.)

total_extraction_m3
- total extraction volume

percolation_m3
- volume returned to the aquifer through deep percolation