GROUNDWATER RESOURCES OF THE DAUPHIN LAKE WATERSHED

GROUNDWATER MANAGEMENT SECTION

WATER SCIENCES & MANAGEMENT BRANCH

MANITOBA WATER STEWARDSHIP

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THE DAUPHIN LAKE WATERSHED

The Dauphin Lake Watershed is located in west-central Manitoba west of Lake Manitoba. It encompasses the lower slopes of the Manitoba Escarpment, which in this area is represented by Riding Mountain and Duck Mountain, and the intervening West Lake plains surrounding Dauphin Lake. Dauphin Lake drains into Lake Winnipegosis via the Mossey River.

The lowlands are a mixture of farming, forests and wetlands, with a minimum elevation of 260 m (855 ft) at the Dauphin Lake shoreline. The highest point in the province is located in this watershed at Mount Baldy, elevation 820 m (2730 ft) along the northwestern border of the area on Duck Mountain. The region is drained by a series of small rivers and creeks draining off the Manitoba Escarpment: Wilson River, Vermillion River, Valley River, Ochre River, Turtle River and Mink Creek. Groundwater discharge provides baseflow to rivers and streams and contributes water to the extensive marshes and wetlands found in significant portions of the watershed.

Figure 1.

Location of Dauphin Lake Watershed

WATER SUPPLY

Water supplies in the region are obtained from a combination of surface and groundwater sources. Surface water is the preferred source because its low mineralization makes it superior for drinking water. Surface water use necessitates a dependable source, usually a reservoir plus water treatment including disinfection facilities and a distribution system. The infrastructure for these systems can be costly and is limited to areas with larger population bases, which may service some outlying areas by pipeline. Groundwater is used in the remainder of the region.

The City of Dauphin obtains its water from Edwards Creek and the Vermilion Reservoir. The towns of Grandview and Gilbert Plains use surface water, supplemented by groundwater. Grandview obtains its water from a reservoir on the Valley River, while two community wells and a pipeline are used to supply 178 rural households in the vicinity. Gilbert Plains obtains surface water from a reservoir on the Valley River, while two community wells supply 152 rural households, which are on a pipeline.

Ste. Rose du Lac uses well water obtained from wells completed in sand and gravel aquifers, while a water co-op supplies nearby households. McCreary obtains its supply from wells completed in sand and gravel, located near the base of Riding Mountain.

PREVIOUS WORK

The primary groundwater investigation for the area was carried out in the early 1970’s and was published in 1973 as Groundwater Availability Study Report #10, Groundwater Availability in the Dauphin Area (Rural Municipality of Dauphin), by the Manitoba Water Resources Branch. Additional groundwater information for the study area was also included in four regional groundwater map sheet studies covering the Duck Mountain 62N (Little and Sie, 1976), Dauphin Lake 62O (Betcher, 1987) and Neepawa, 62J (Betcher 1989) and a very small portion of Riding Mountain, 62K (Sie, 1978).

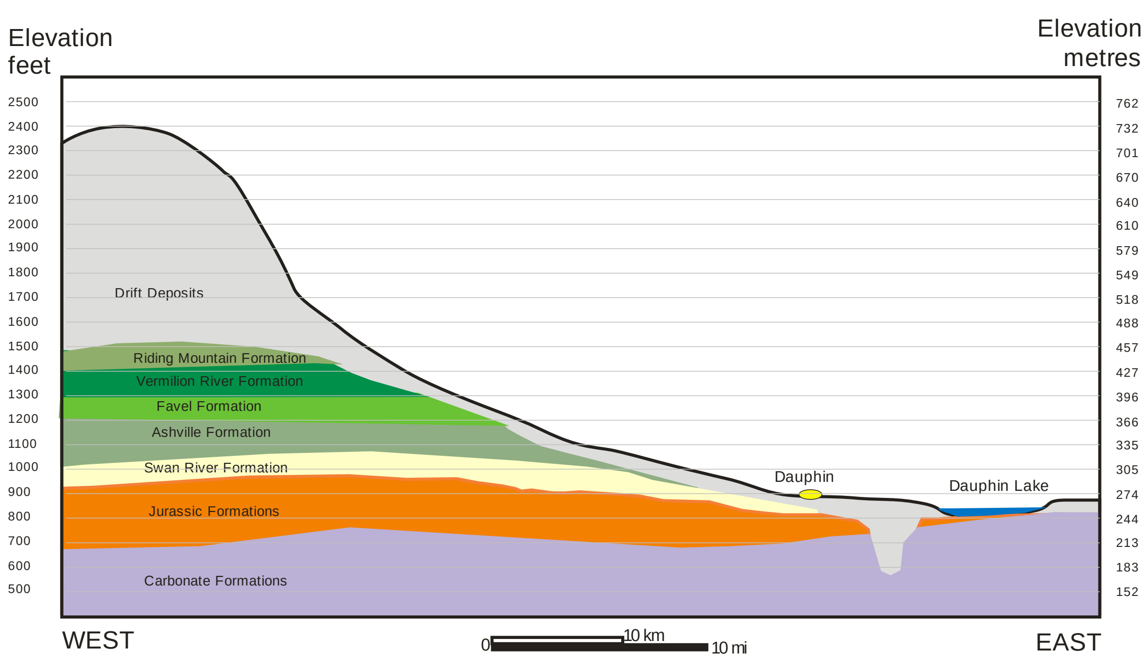
REGIONAL GEOLOGY

The geology of the area consists of unconsolidated materials or "drift", which sit on top of sedimentary bedrock. Unconsolidated materials include units or mixtures of clay, silt, sand and gravel, the bulk of which were put in place by glaciers, or were deposited by more recent features such as streams, rivers and lakes. It also includes soils that developed at the surface.

Bedrock consists of layered sedimentary rock formations, which are relatively flat-lying, dipping very gently to the west. Surface relief on the other hand, is on the order of 500 metres, most of this along the Manitoba Escarpment. Moving west to east, from the escarpment to lowlands of the lake plain the topography cuts through each bedrock formation, moving from Cretaceous age shale, to Jurassic age shale and carbonate rock down to Devonian age carbonate rock. As a result, carbonate bedrock, found close to the surface near Dauphin Lake is buried beneath nearly 500 metres of overlying bedrock and drift beneath Duck Mountain and Riding Mountain as seen in Figure 2.

Figure 2

Representational cross section extending from Duck Mountain in the west to Dauphin Lake in the east, showing geological formations.



Where a rock formation is found directly beneath drift is its subcrop area. Bedrock is mostly buried beneath drift. However, shale exposures or outcrops, may be found along the Manitoba Escarpment and along some streams including the upper reaches of Edwards Creek, Edwards Creek, Vermilion River, Wilson River and Valley River. Bedrock Formations are shown in Map#1, while Bedrock Topography is shown in Map #3.

Cretaceous rock formations form the top of the section, consisting of the Riding Mountain, Vermillion River, Favel, Ashville and Swan River Formations and are located in the west side of the watershed, approximately west of Highway 10. The Reston-Melita Formation of Jurassic age occurs beneath the Cretaceous formations and subcrops in a north to south band in central part of the watershed including the region around Dauphin. The Devonian Souris River Formation lies beneath the Cretaceous and Jurassic formations and subcrops at the south end of Dauphin Lake and in the eastern end of the watershed east of McCreary. Bedrock formations, geological age, aquifer and subcrop area are shown in Table 1:

Table 1. Bedrock Formations

GEOLOGICAL TIME PERIOD	GEOLOGICAL FORMATION	AQUIFER	SUBCROP LOCATION
Devonian	Souris River	Carbonate	South and east margins of Dauphin Lake
Jurassic	Reston-Melita		Dauphin Lake Region
Cretaceous	Swan River	Sandstone	Central plains/lowlands around Dauphin
	Ashville	Shale	Base of Escarpment; between Dauphin and Gilbert Plains
	Favel		Base of Escarpment; between Dauphin and Gilbert Plains
	Vermilion River		Duck Mountain and Riding Mountain Escarpments; Gilbert Plains to Grandview
	Riding Mountain		West of Grandview; Duck Mtn; Riding Mtn

GROUNDWATER AND AQUIFERS

Groundwater is the primary water source in rural areas because it can be accessed on most properties, quantities remain fairly stable over time, infrastructure costs are low and disinfection is generally not required. This makes it the most viable source for individuals and small communities. The quantity of supply and quality of the water are determining factors in whether a groundwater source is viable.

Groundwater quantity is determined by the presence of aquifers. Aquifers are geological units which are porous and permeable enough to supply useable quantities of water to a well. Porosity and permeability are determined by the nature of the geological unit and external factors, mainly fracturing or dissolution. Quality is affected by the type of aquifer and length of time the water has spent in the ground. Generally, shallow groundwater which is locally sourced tends to have the lowest amount of dissolved minerals and is consequently the most desirable for human use in areas where deeper groundwater is saline. Shallow groundwater is more susceptible to contamination from surface sources, and is more likely to have problems with iron and hardness. Supplies may be more susceptible to drought conditions.

In the Dauphin Lake Watershed, sands and gravels deposited by glaciers over top of bedrock are the most commonly accessed aquifer unit. Bedrock aquifers are also commonly used and include sandstone, limestone or dolomite (carbonate) and even shale if sufficiently fractured. Large diameter seepage wells are sometime completed in fine materials such as silt or clay mixtures, when other sources are not available and water requirements are low. Sand and gravel aquifers usually are of limited extent, while bedrock aquifers tend to be more regional in nature.

Even when sufficient quantities of water are available, they may not be usable if quality is poor. Good quality potable water is necessary for human consumption. As mineralization (total dissolved solids content or TDS) increases, water quality diminishes. Water that is too mineralized to be used for drinking water supply may still be useful for household purposes, stock watering or industrial and farmyard uses. Groundwater users will often obtain their supplies from deeper, more dependable sources for watering livestock, mixing chemicals or other industrial uses. At the same time they may have a separate well, with lower production and higher quality requirements for household supply.

DRIFT AQUIFERS

Drift consists of the unconsolidated geological materials found from land surface, down to bedrock. Although some drift is recently reworked materials, most drift was deposited by glaciers. Drift cover in the Dauphin Lake Watershed varies from no cover at all in some stream beds and cliffs, particularly near Riding or Duck Mountain, to as thick as 125m (410 feet) in buried valleys found east of Dauphin, and at the western edge of the watershed. Mostly it is in the range of 10 to 30 m (30 to 100 ft). Map #2 shows the distribution of wells completed in drift, according to depth, while Map #4 shows drift thickness.

Drift is composed primarily of glacial till derived from local sedimentary rocks. It is clayey to gravelly and is usually grey in colour, often oxidized to brown near the surface. Sand and gravel units are present locally within or at the base of till overlying bedrock and can be as thick as 20 feet (6 m), where present. Thicker sands and gravels may be found where drift is thick. Beach and alluvial deposits may occur at the top of the drift. Water quality varies with each aquifer.

Three larger scale sand and gravel features are found in the area: outwash deposits south of Dauphin Lake, the Dauphin buried valley and the Hatfield buried valley.

Outwash sands and gravels with regional extent are found south of Dauphin Lake in the RM of Ochre River, extending into the southeast corner of the RM Dauphin (Little, 1973). The deposits average 50 feet (15m) in thickness and appear to have high lateral variability from sand and gravel to clay and silt. They cover about 50 square miles (130 km^2). These constitute the aquifer of choice, where present. Water quality is good to fair, in the range of 250 to 1100 mg/L TDS. Dissolved iron tends to be high.

The eastern margin of the **Hatfield Buried Valley** extends into the watershed at its westernmost extent, west of Grandview. Sands and gravels may be found in this aquifer extending to depths of 60 m (200ft) or more. This aquifer is located a sufficient distance from the main population centres in the watershed, to limit its significance as a water source. It is shown as a clustering of wells in Map #2.

The **Dauphin Buried Valley** runs from a northwest to southeast direction in the region between Dauphin and Dauphin Lake. It is a fairly localized feature, which does not appear to correlate or connect to a larger buried valley system. The feature may be interglacial in origin. It is mostly filled with till, but has thick sections of sand and gravel in some locations, up to 36 m (120 feet). The valley may be up to 16 km (10 miles) wide and averages 75m (250 feet) deep. Two closed depressions in bedrock (Tp 24-25 R18 W; Tp 26-27, R 18-19 W) and reach a maximum of 115-125m (380-410 feet) deep are within the broad outline of the valley, and are mainly filled with till. While the presence of the valley improves the groundwater potential of the area, it does not appear to be a regionally extensive feature. It is shown as a clustering of wells in Map #2.

Alluvial deposits are found along streams and are only used when no other shallow sources of water are available. The deposits are recharged from adjacent streams, so wells tend to go dry when stream levels are low. Yields may be low, requiring several wells or a back-up source. The water usually has very low total dissolved solids, although iron may be a problem.

Beach ridge deposits trend in a northwest to southeast direction through much of the area. These are relatively thin, elevated deposits of sand near the surface. They are not a significant source of water. They tend to go dry during winter and during dry periods in summer. Water quality is generally good.

BEDROCK AQUIFERS

Bedrock aquifers are regionally extensive rock formations. They are distinguished by larger-scale rock types of these formations. There are three bedrock aquifers in the Dauphin Lake Watershed, a carbonate aquifer, a sandstone aquifer and a shale aquifer. The shale is a questionable water source, but was included since wells are recorded as being completed in this rock type. Bedrock Aquifers and well completions by aquifer type are show in Map #1

The **Carbonate Aquifer** is found under drift in the eastern part of the watershed in the vicinity of Dauphin Lake. It consists of limestone and dolomite, sometimes with intervening thin shale beds from Devonian and Jurassic geological times. Yields from wells are generally sufficient for household requirements.

Carbonate rock often has a low intrinsic permeability, because the rock may be fairly solid, or it may even contain pore or large openings, which are isolated from each other. Permeability can be enhanced significantly by the presence of fractures and solution cavities, which enhance pore connections and size. Highest permeability is near the land surface, where the rock has been most subjected to by weathering, fracturing and dissolution of rock by percolating water and from compression, expansion and subsequent cracking of the rock by the weight of glaciers.

Groundwater flow through the aquifer is primarily through fractures, bedding planes and some inter-granular reef type porosity, which locally have been enhanced by dissolution or glacial action. Lower permeability zones occur as shale layers or zones where there is a low density of fracturing that may form layers which subdivide the aquifer.

Water quality tends to be in the range of 1000 to over 4000 mg/L TDS. Flowing artesian conditions are found in some wells around Dauphin Lake. Yields can be in the <1 to 30 igpm range, depending on fracture permeability.

The **Sandstone Aquifer** is found under drift in a 15 km wide strip mostly east of Highway 10 around Dauphin. West of Highway 10, the aquifer is found under shale. It is comprised of the Swan River Formation, which is from the Cretaceous time period. It is positioned on top of the Carbonate Aquifer and beneath the Shale Aquifer.

The aquifer is between 12 to 55 m (40 to 190 feet) thick and has a variable composition of shale, with siltstone beds and poorly cemented sandstone beds. The sandstone is prominent, but may be thin or absents in some locations. The sandstone may take the form of thin beds in shale, to beds up to 10 metres (30 ft) thick. The thicker beds constitute important aquifers. The sand is mostly fine-grained, but is occasionally medium or coarse grained.

Yields tend to be in the range of 10 to 30 igpm. Water quality is mostly fair to poor and tends to be relatively low in iron. In recent years, the Sandstone Aquifer has become a more important water source in the area.

The **Shale Aquifer** is found mostly west of Highway 10 and is found under drift or occasionally at surface along stream channels and along the Manitoba Escarpment. Its thickness may exceed 100 metres (300 ft) in the west, thinning to zero toward the east. It is only useful for wells when fractured. A significant number of wells have been drilled into the Shale Aquifer, since it is widespread and drift aquifers were not always present. These wells have a high rate of abandonment.

The Shale Aquifer is made up of the Ashville, Favel, Vermilion River and Riding Mountain formations, from the Cretaceous time period. These are the youngest bedrock formations in the area and have a cumulative thickness of 100 m (300 ft) or more in the west and thinning to zero in the east.

GROUNDWATER FLOW

Groundwater flows from areas of high elevation where it enters the ground, to areas of low elevation where it exits the ground. This occurs on larger and smaller scales, depending on topographic relief. Undulating topography will generate small scale local systems, which are fairly shallow. Larger features, such as Riding Mountain, can generate larger scale intermediate systems which flow deeper and farther, while features like the Rocky Mountains can generate regional systems spanning many hundreds of kilometers.

Water enters the ground as recharge, is stored in a flows preferentially through aquifers and across lower permeability formations called aquitards and exits as discharge. Groundwater storage is a balance between recharge and discharge. In the long term this is relatively stable. In the shorter term, storage may increase when surface water is plentiful or it may decrease during drought.

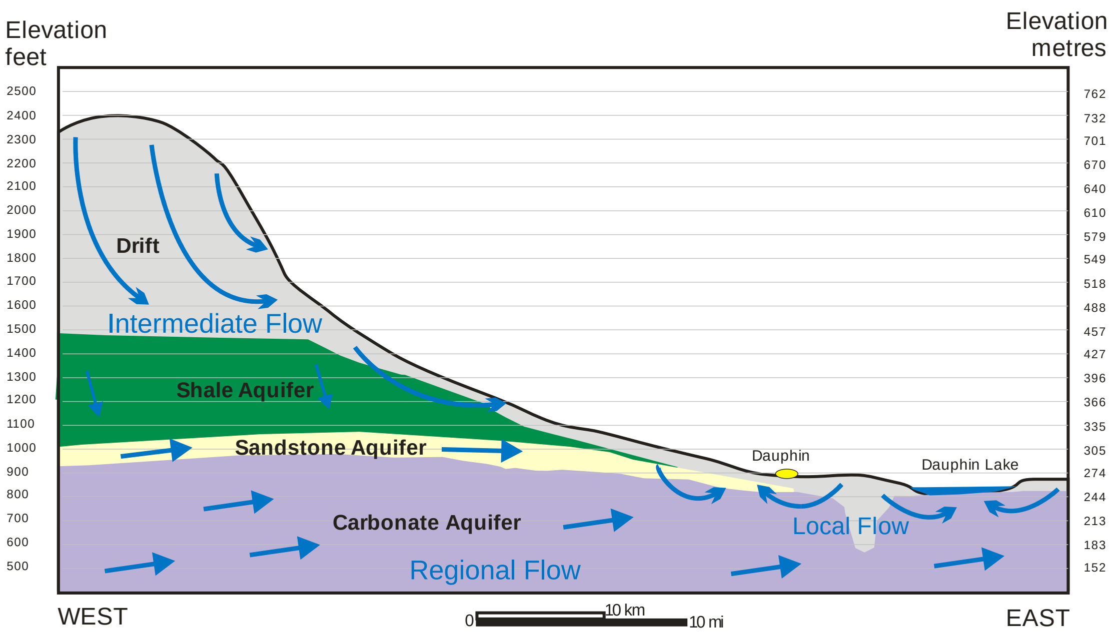
In recharge areas, the water table is often deeper and levels vary more than you would find in a discharge area. Water quality is generally better closer to the point of recharge. Groundwater may be discharged at the surface by way of springs, it may be taken up by the roots of vegetation and transpired through the leaves, or flows into the bottoms of streams or lakes, providing a constant "baseflow".

In shallow unconfined aquifers with a water table the groundwater originates from the same locality and contains few dissolved solids, in the low hundreds. The local scale of the flow systems, and the small areas that they draw upon means that these aquifers are more easily impacted by changes to the environment. Water may take days or weeks to move through the system. Water levels are likely to rise and fall on a seasonal basis, with low water levels occurring in late winter and during summer droughts. Wells in this sort of aquifer may be considered undependable sources of water for this reason. In the Dauphin Lake Watershed we expect to see local flow systems in the near-surface sand and gravel aquifers, particularly features like beach ridges. Intermediate flow systems may develop around more pronounced uplands within or surrounding the watershed, mainly Duck Mountain or Riding Mountain and may take years to decades to move through the ground.

The Dauphin Lake Watershed lies at the discharge end of a very deep, regional groundwater system, originating in the Rocky Mountains of Montana. Circulation through this system may take thousands of years from start to finish. This water is found in deeper bedrock aquifers and it flows toward the land surface in this area, gradually mixing and diluting with shallower groundwater flow systems. Because of its long residence time, the water has dissolved significant amounts of minerals, particularly salts from the rock framework. This makes the water saline. Evidence of this regional system can be seen as salt springs and somewhat salty lake water for Lake Manitoba and Lake Winnipegosis.

Figure 3.

West to East Cross Section of the Dauphin Lake Watershed showing Aquifers and conceptualized flow systems.



GROUNDWATER QUALITY

When a water supply is developed, both quantity and quality must be considered. Quantity must be sufficient to meet demands, while quality determines the usability of the water. High quality water is preferred for human consumption. According to the *Canadian Drinking Water Standards*, total dissolved solids (TDS) of drinking water should be less than 500 mg/L. The 500 mg/L guideline is an aesthetic objective, which means that higher TDS is tolerable, but not ideal in regard to palatability. While it is possible for surface water to meet this objective in most situations, groundwater is usually more mineralized. For drinking water purposes, 1000 mg/L TDS is widely accepted as a tolerable limit in well water, although concentrations as high as 1500 mg/L are sometimes tolerated.

Mineralized water, high in total dissolved solids, may have issues with taste, odour, appearance and hardness. Some dissolved salts, such as sodium or sulphate may be poorly tolerated by the body. Hard water will scale baths, pipes, water heaters, kettles and coffee pots and create soap scum. High iron may impart a poor taste and may stain laundry and fixtures.

Groundwater quality can vary considerably depending on the nature and permeability of the aquifer, geology, age of the water and groundwater flow systems. Water that is found in deeper aquifers, particularly when it is discharging from deep regional flow systems, not only is more mineralized, but also more saline, high in sodium and chloride salts. Shallower groundwater in sands and gravels and shallow bedrock that has been refreshed locally by rain and snow has the best quality. Hardness and iron are sometimes an issue as calcium and bicarbonate tend to be the dominant dissolved minerals. Shallow groundwater also is the most vulnerable to contaminants from the surface such as micro-organisms or chemicals. Deeper groundwater found mostly in bedrock is usually less susceptible to contamination. The water may be softer as a result of chemical interactions at depth. Salinity tends to be higher and may be borderline or high for human consumption, but usually is acceptable for livestock or for industrial purposes (Table 2). Total Dissolved solids are shown in Map #5 for drift aquifers and Map #6 for Bedrock Aquifers.

Table 2

Recommended limits of Total Dissolved Solids

TDS Concentration Limit mg/L	**For consumption by:**
500	Humans (good)
1000	Humans (fair)
1500	Humans (poor)
3000	Cattle
6500	Horses
10,000	Industrial processes (varies with use)

Sampling of well water usually involves testing for the following major ions: calcium, magnesium, sodium, potassium, bicarbonate, sulphate, chloride, iron, fluoride along with pH, hardness and alkalinity. Bacteriological samples may also be taken. Routine parameters of interest are shown in Table 3.

Table 3

Some routinely tested parameters affecting water suitability

Quality Constituent	Limit (mg/L) Canadian Drinking Water Standards	Limit type (AO or MAC)*	Comment
TDS	500	AO	Usually for surface water supplies.
Hardness	200 poor; 500 bad	AO	Soap scum and scaling
Iron	0.3	AO	Iron stain, taste
Nitrate	10	MAC	Risks for infants
Fluoride	1.5	MAC	Brittle bones/teeth
Sulphate	500	AO	Laxative effect
Chloride	250	AO	Mildly corrosive
Sodium	200	AO	Blood pressure

**Aesthetic Objective or Maximum Allowable Concentration*

Bacteriological testing is often done for total coliform bacteria and Escherichia coli (E. Coli). Coliform bacteria are a common bacteria and their presence in water is often an indicator of fecal contamination. The presence of E. Coli, a specific type of coliform bacteria is considered diagnostic of fecal matter. Parasites such as giardia and cryptosporidium are usually spread by fecal matter from livestock and wild animals and may be another concern. Soils and rock act as natural filters that remove micro-organisms, given sufficient time and distance. As a consequence well water is generally safe to drink, unless the process has been circumvented. This may happen if heavy loads of manure are applied to land in excess of the capacity of the land to filter it, such as around stockyards, or if there is a ready conduit where water can circumvent the filtering process, such as sink holes in limestone or if the integrity of well construction and sealing is compromised.

Within the Dauphin Lake Watershed, water quality varies depending on location, and whether a well is completed in drift or in bedrock. Water quality is generally better in drift aquifers than in bedrock in this region.

In drift aquifers the range in total dissolved solids concentrations varies from about 500 to 2000 mg/L. TDS concentrations are over 1000 mg/L in most of the agricultural areas, and over 1500 in regions around Dauphin and Ste. Rose. In bedrock aquifers, TDS concentrations are mostly in the range of 1500 mg/L to 4000 mg/L or higher. This means that water in bedrock is not recommended for household drinking water, but may still be acceptable for stock watering or industrial uses. Poorer quality water over 2500 mg/L TDS concentrations is found in the agricultural regions extending from Gilbert Plains to McCreary.

Nitrates are generally within the range specified for Canadian Drinking Water Standards, less than 10 mg/L, and are often less than 1 mg/L. Variations in nitrate concentrations in wells are often localized or well-specific, indicative leaching from manure or other nitrate sources such as septic systems. Within the Dauphin Lake Watershed, nitrate concentrations above drinking water standards are mostly found in shallower wells completed in drift. These are more commonly found north of Highway 5 in the region west of Dauphin Lake, and in a strip along Highway 5, south of Dauphin Lake. Nitrates in well water are shown in Map #7 for drift aquifers and Map #8 for bedrock aquifers.

Hardness follows a similar pattern to total dissolved solids in that water tends to be harder when total dissolved solids are high. Although there is not a significant difference, drift aquifers tend to have softer water than bedrock in this watershed. In general, water with over 100 to 200 mg/L hardness is considered to be “hard” water, with 500 mg/L being very hard. This means that all groundwater in the region is hard or very hard. Hardness is shown for drift aquifers in Map #9 and for bedrock aquifers in Map #10.

WATER TREATMENT

Well water is often treated to improve its quality. Water treatment systems may be installed to deal with particular problems if they are not too severe. Activated carbon filters may be useful for palatability, minor taste, odour and colour issues. They are most effective at removing organic compounds and sediment as well as some dissolved substances, such as hydrogen suphide and chlorine. They are not generally suited for removing salts and certain other inorganic dissolved solids, microbes, sodium, nitrates, fluoride or hardness, although some higher end filters may reduce these.

Hard water is usually treated with a water softener. Water softeners add salt to the water. The sodium in the salt replaces the hardness-causing calcium and magnesium removing them from the water. Water softeners will also remove minor amounts of iron and manganese. Because of the added sodium, softened water is generally not used for drinking.

Specialized sand filters are available to deal with excessive iron. These will also deal with manganese and hydrogen sulphide.

Reverse osmosis filters may be used to remove substantial amounts of most inorganic substances (such as salts, metals, minerals) most microorganisms including cryptosporidium and giardia, and most, but not all, inorganic contaminants.

Reverse osmosis successfully treats water with high dissolved solids including salts, metals, minerals, most microorganisms including cryptosporidium and giardia and many inorganic contaminants. Many reverse osmosis systems use activated carbon pretreatment, which increases effectiveness against organic contaminants.

WELL DISTRIBUTION AND AQUIFER UTILIZATION

Well distribution and subsequent water use is mainly in the agricultural areas along the lake plain. Few wells are found in the mainly forested uplands of Riding Mountain and Duck Mountain.

When groundwater maps were made of the area in 1973, an overwhelming majority of wells were shallow, completed in sands and gravels. At that time only four wells existed in the Swan River sandstone, compared to over 200 today. In the Carbonate aquifer there were about 100 wells up to 1973, compared to around 274 today. Once deeper aquifer targets were mapped they were more heavily utilized, including deep sand and gravels, sandstone and carbonate bedrock. A significant number of wells were completed in what are normally considered to be aquitards, including shale, and silt or clay. These most likely are indicative of a lack of options and high proportions of these wells were never completed, or have been abandoned or sealed.

Wells in Water Stewardship's database are classified according to aquifer type. There are 3301 wells listed for this watershed. Of the main types of completion zones, around 56% of all wells were completed in drift deposits. Carbonate rock was the second most common aquifer with just over 8% of wells. Around 8% of wells were completed in shale and around 6.5% in sandstone. Nearly 13% of wells were dry or abandoned and another 8% were in unknown aquifers, and mostly represent data from a field verified survey. A breakdown of wells by aquifer type is shown in Table 4.

Table 4

Number of Wells by Aquifer

AQUIFER TYPE	NUMBER OF WELLS	% OF WELLS
All aquifers (total)	3301	100
Sand and Gravel	1718	52.0
Carbonate	274	8.3
Unknown or Other	271	8.2
Shale	266	8.1
Sandstone	211	6.4
Silt or Till	136	4.1
Dry (abandoned)	425	12.9

Wells completed in sand and gravel drift are found in all areas of the watershed. It is likely that these have been a traditional source of water, are cheaper to drill and are most likely to have low total dissolved solids.

In the region surrounding Dauphin Lake and in the R.M of Ste. Rose a majority of wells are completed in the Carbonate Aquifer. Shale is the third most common aquifer for well completion, probably because it is the dominant bedrock in most of the watershed.

The fourth most common completion, wells in sandstone are found in a band extending northwest to southeast from the R.M. of Ethelbert almost to McCreary. Most well completions are in the R.M. of Dauphin and the R.M. of Ochre River, as well as the R.M. of Ste. Rose.

Wells completed in silt or till make up about 6.5% of all wells and are distributed across the plain area. If used at all, these are most likely to utilize a large diameter well bore to compensate for low production rates.

Other or unknown aquifers also make up a sizeable proportion of the wells. Wells with this designation are concentrated in the region north half of the R.M. of Dauphin. These are related to a well inventory by the Intermountain Conservation District between 2008 and 2010. Well reports are generally unavailable for these wells.

Dry holes account for a substantial 13% of all wells drilled. They are fairly evenly distributed across the lowland area. Wells designated as "dry" did not indicate aquifer type.

A significant proportion (64%) of shale completions are designated as "abandoned" or "sealed", which suggests these were not successful wells, or that the area was targeted for test hole drilling because of a lack of water supplies. In comparison, only 8% of wells in carbonate and 7.5% of sand and gravel wells were abandoned or sealed.

Most wells in the watershed are relatively shallow: of the 3282 wells, 66% are less than 30 metres (100 ft) deep; 24% are between 30 to 60 metres (100 to 200 ft) and 10% were over 60 metres (200 ft). For any aquifer type, wells are predominantly less than 30 metres deep, with the exception of carbonate, where most aquifers were in the 30 to 60 m depth range (100 to 200 ft). Deep sand and gravel wells, often in the range of 60 to 90 m (200-300 ft) are found in the Hatfield Buried Valley, the Dauphin Buried Valley and at the base of Duck Mountain.

The seven deepest wells drilled in the watershed include all aquifer types, but none are known to be in use. These range in depth from 137m (450 ft) to 195m (640 ft). The deepest production well is located on a farm and is completed in the carbonate at a depth of 134 m (440 ft).

GROUNDWATER MANAGEMENT

Groundwater in Manitoba is regulated under a number of Acts and Regulations: *The Environment Act*; *The Water Safety Act*; *The Water Rights Act*; *The Ground Water and Water Well Act* and *The Health Act*. Other Acts may indirectly affect groundwater. For example, groundwater may be affected by developments covered under *The Mines and Minerals Act*. Groundwater management is under the jurisdiction of the Department of Water Stewardship, which includes a Groundwater Management Branch and a Groundwater Licensing Branch.

The Environment Act provides legislation protecting groundwater quality, while *The Water Rights Act* is the key piece of legislation governing the management of groundwater supplies. *The Ground Water and Water Well Act* deals with water well regulation. The Act covers all sources of groundwater and all water wells completed by a drilling contractor before and after the Act was introduced in 1963. With the exception of controlling flowing wells and pollution prevention, the Act does not cover household wells dug by the well owner with their own equipment.

Groundwater is managed sustainably when the rate of water removal does not cause long term, irreversible declines in water levels or other undesirable impacts. A budget is determined by estimating the amount of groundwater stored in an aquifer, based on well tests and hydrogeological mapping, as well as the amount of water entering and leaving the aquifer through recharge and discharge.

When groundwater budgets are not known, it is still possible to manage the resource on a well by well basis, providing that the cumulative demands of the existing wells are not causing long term detrimental effects on surrounding wells or groundwater features.

Groundwater pumping tests are carried out when a well is required for more than simply domestic use and a license is required. Groundwater pumping tests are done to determine the maximum sustainable pumping rate of the well and to assess the potential effects on water levels in surrounding wells. The pumping test is able to tell us whether recharge is sufficient to offset water withdrawals at this site and to provide assurance that groundwater development is within the ability of the aquifer to supply this water without there being adverse effects on the aquifer and surrounding users.

Since there are few large scale developments in the Dauphin Lake Watershed, water demands are not excessive. Centralized supplies, mainly for municipal use involve groundwater or surface water or a combination of the two, including pipelines to outlying areas.

Some districts lack good quality aquifers and as a consequence rely on small scale distribution of surface water or groundwater supplies from a centralized source. Should there be a large scale demand for groundwater in the future; additional assessment of long-term sustainability would be needed at that time.

The Province of Manitoba through the Department of Water Stewardship, Groundwater Management Section maintains a network of more than 500 groundwater observation wells in the agricultural regions of the province. Monitoring primarily involves continuously recording of water levels, plus occasional water quality sampling. This may be done in undeveloped areas to observe how the aquifer responds to the natural environment, or it may be done in developed areas to determine impacts on groundwater from major production wells. When water levels are compared from developed to undeveloped areas, it helps to distinguish the effects of pumping from natural fluctuations caused by changes in seasons and in the climate. This allows groundwater supplies to be carefully managed so that these resources are available in the long term.

Groundwater monitoring may also be mandated at specific sites in licenses or permits issued under *the Environment Act* or licenses issued under *The Water Rights Act*.

In the Dauphin Lake Watershed, there are eight provincial monitoring wells, five currently active, located near McCreary, Ste Rose and Dauphin. The wells are listed in table 1.

Table 6

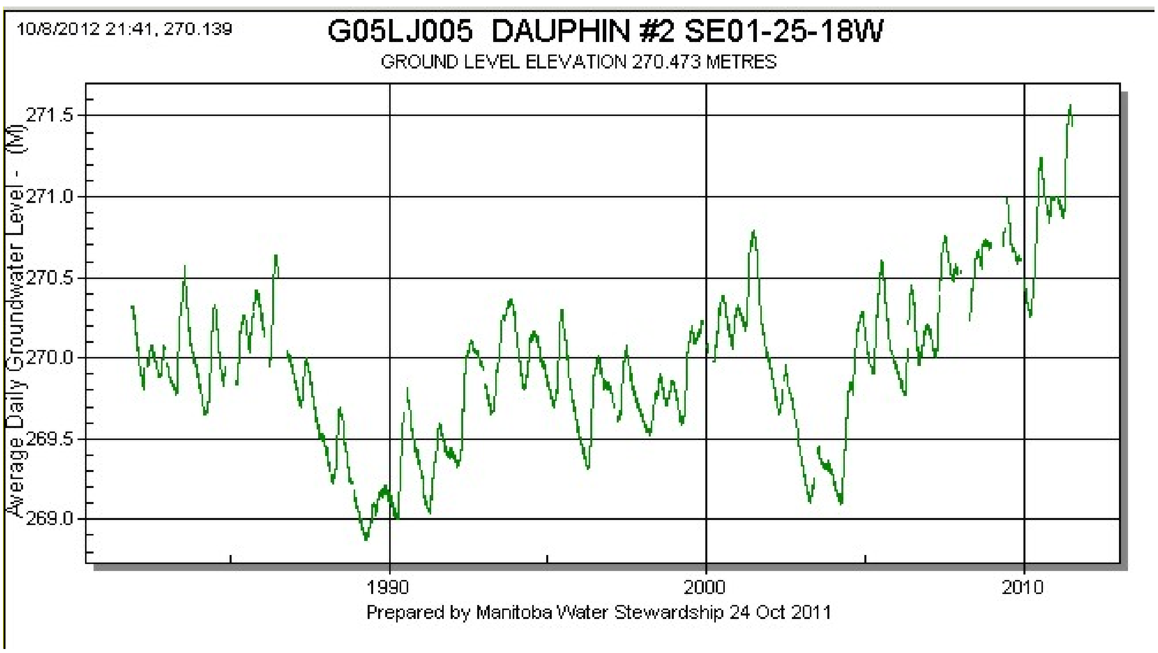
Provincial Observation Wells in the Dauphin Lake Watershed

Name	Land Location	Station #	Depth feet	Aquifer	Monitoring Record	Status
McCreary #1	SE-30-20-15W	G05LJ001	40	Sand and Gravel	1965-1981	Abandoned
McCreary #2	SE-30-20-15W	G05LJ004	40	Shale gravel	1965-2010	Active
Wilson Creek #1	SW-30-20-15W	G05LJ006	46.5	Shale gravel	1987-	Active
Sainte Rose #2	NE-08-24-15W	G05LJ007	29	Sand	1968	Inactive
Sainte Rose #1	SE-10-24-15W	G05LJ008	50	Sand and gravel	1987-	Active
Sainte Rose SPP#1	NE-15-25-15W	G05LJ009	107	Sand and gravel	1994-	Active
Dauphin #1	SE-01-25-18W	G05LJ003	81	Sand and gravel	1970-1981	Inactive
Dauphin #2	SE-01-25-18W	G05LJ005	45	Gravel	1981-2011	Active

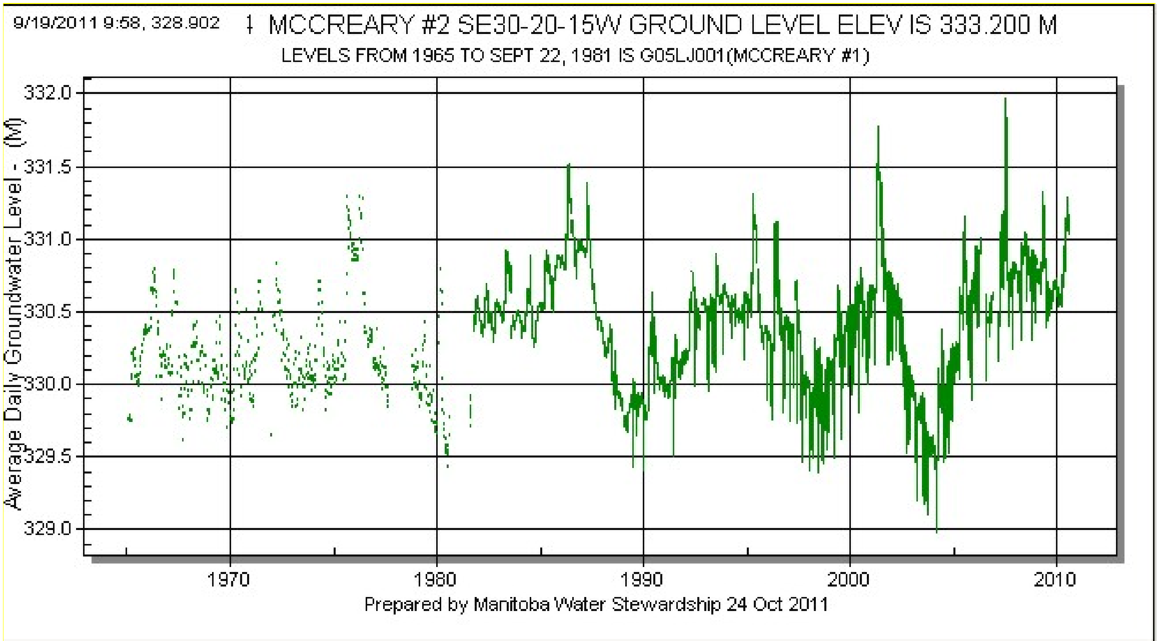
Figure 4.

Hydrographs for the Dauphin #2 and McCreary#2 provincial groundwater observation wells. Both wells monitor mainly ambient conditions and illustrate responses seasons and to periods of wet and dry years, with dry periods noted around 1989-1990 and 2003-2004. The McCreary well also shows a continuous cycling of short term fluctuations caused by interference from a nearby production well. Groundwater levels have been rising since 2005 in response to generally higher precipitation amounts throughout much of southern Manitoba. Short term, smaller scale fluctuations are seen in the hydrograph for McCreary#2 caused by interference from a nearby municipal production well.

Dauphin #2



McCreary #2



AQUIFER PROTECTION

Vulnerable aquifers may be defined as locations where the aquifer is found close to the ground surface and unprotected or poorly protected from impacts originating at the land surface by overlying low permeability clays and tills. This is particularly the case of shallow aquifers because the well intake is close to the surface. Groundwater in aquifers in these areas is more likely to be susceptible to contamination by natural and anthropogenic microorganisms, or inorganic, or organic substances.

A variety of methods have been developed to determine aquifer vulnerability, some quite complex. Factors often considered include aquifer depth, thickness of clay or shale over the aquifer and groundwater flow directions. Generally in Manitoba, if the top of an aquifer is within six metres of ground surface it is considered vulnerable. For the Dauphin Lake watershed region, shallow, bored wells completed in shallow sands and silts or in carbonate rock would be more at risk than deeper wells in buried sands and gravels or in sandstone.

Vulnerability indicates areas that could be at risk, if a contamination source is present. Vulnerability will not predict that contamination will or will not occur or the severity of an impact.

It is the responsibility of a well owner to ensure that their water supply is properly constructed and maintained. Water well contamination often results from improper construction, maintenance or protection of wells. Protecting a well from contamination is an important consideration when choosing a well site and for construction and maintenance. Wells should be located on elevated sites where surface water will drain away from the well bore. The well casing should be intact and the well annulus sealed with grout. Wells should be properly maintained and properly sealed when they are no longer needed. Land use planning, whether it is local farming practices, or siting of industrial, residential, transportation of waste storage facilities can be used to ensure that wells are protected. Regulatory controls and engineering techniques can also be helpful.

SUMMARY

The Dauphin Lake Watershed encompasses a lowland area between the Manitoba Escarpment (Duck Mountain and Riding Mountain) and Dauphin Lake. The west lake plain is an important agricultural region, serviced by the city of Dauphin. Upland areas along the Manitoba Escarpment are sparsely settled if at all.

Rural and some town residents depend on groundwater for their domestic supplies. Most groundwater is sourced from sand and gravel aquifers, mostly of limited extent. Water is available from bedrock, mostly in the northeastern part of the watershed from sandstone and carbonate. There has been a shift to deeper wells including the use of bedrock aquifers in the last 40 years. Because of its higher mineralization and salinity, water from bedrock aquifers is better suited for stock watering, farm and industrial operations than as a drinking water supply. Bedrock aquifers are only available in the eastern half of the watershed.

Mapping of the Hatfield and Dauphin Buried valleys may allow those aquifers to be better utilized as water sources. The Swan River Sandstone should also be investigated for its usefulness as a regional aquifer. Because the Dauphin Lake Watershed is situated in a regional saline groundwater discharge zone, water quality is an important issue as it can determine if and how an aquifer may be exploited. To date, residents have been able to find supplies that meet their demands. This has involved conjunctive use of surface water and groundwater and the development of centralized supplies in some locations.

The reliance on relatively shallow groundwater sources means that wellhead protection and/or aquifer protection are issues worth exploring for this watershed. Potential contamination sources are relatively few. Risks come from larger livestock and agricultural operations, and from overland flooding along with septic systems, lagoons, underground storage tanks or chemical spills. Nitrates, an indicator of contamination risk from manure, were mostly within reasonable limits. Well surveys in the region north of the City of Dauphin turned up a number of older, shallow wells not previously recorded in the groundwater database. Efforts to locate and properly seal abandoned wells and education on practical methods for well protection and maintenance are issues that should be explored.

If in the future, the Watershed Plan identifies a need for detailed work in the watershed, a field-verified survey of water wells would be beneficial to various aspects of the program. As quality, particularly salinity is as important a concern as quantity. Water treatment options are another topic that should be addressed. Some aquifers may become useful to residents in the future as improved water treatment options become available.

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GROUNDWATER MANAGEMENT SECTION

MANITOBA WATER STEWARDSHIP 2011

REFERENCES

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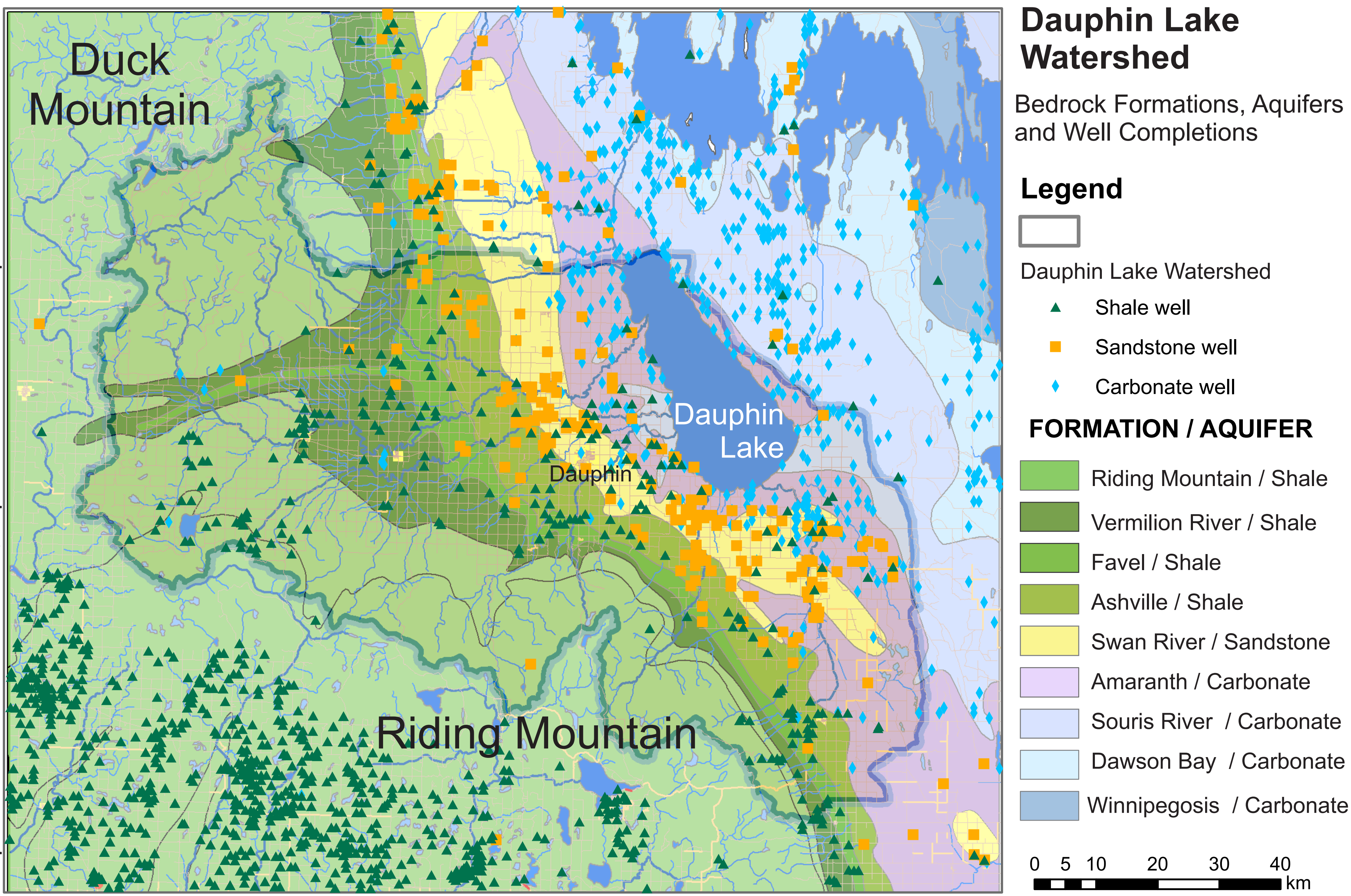
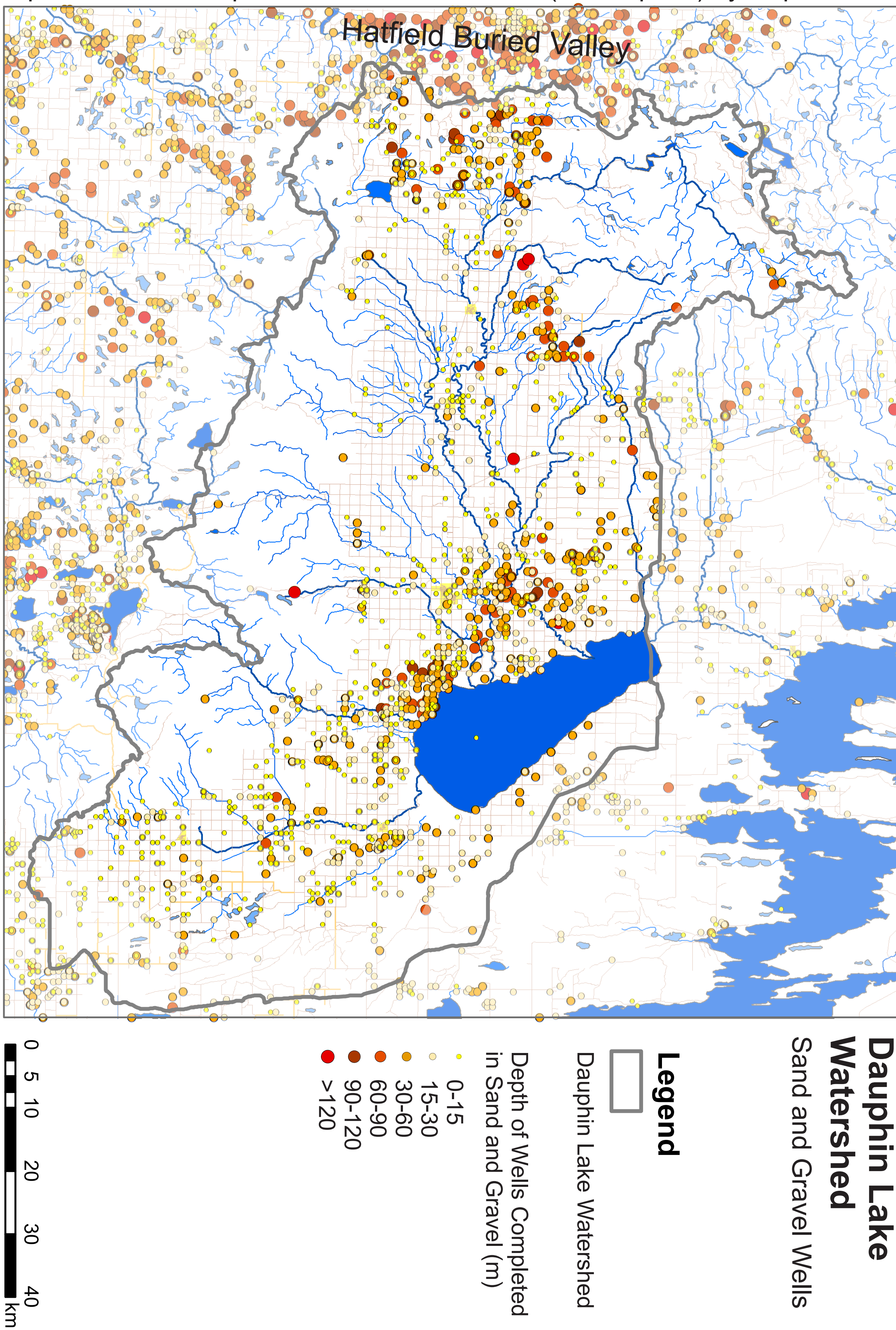
Sie. D. 1978. Groundwater Availability Map Series. Riding Mountain Area (63C). Manitoba Natural Resources, Water Resources.

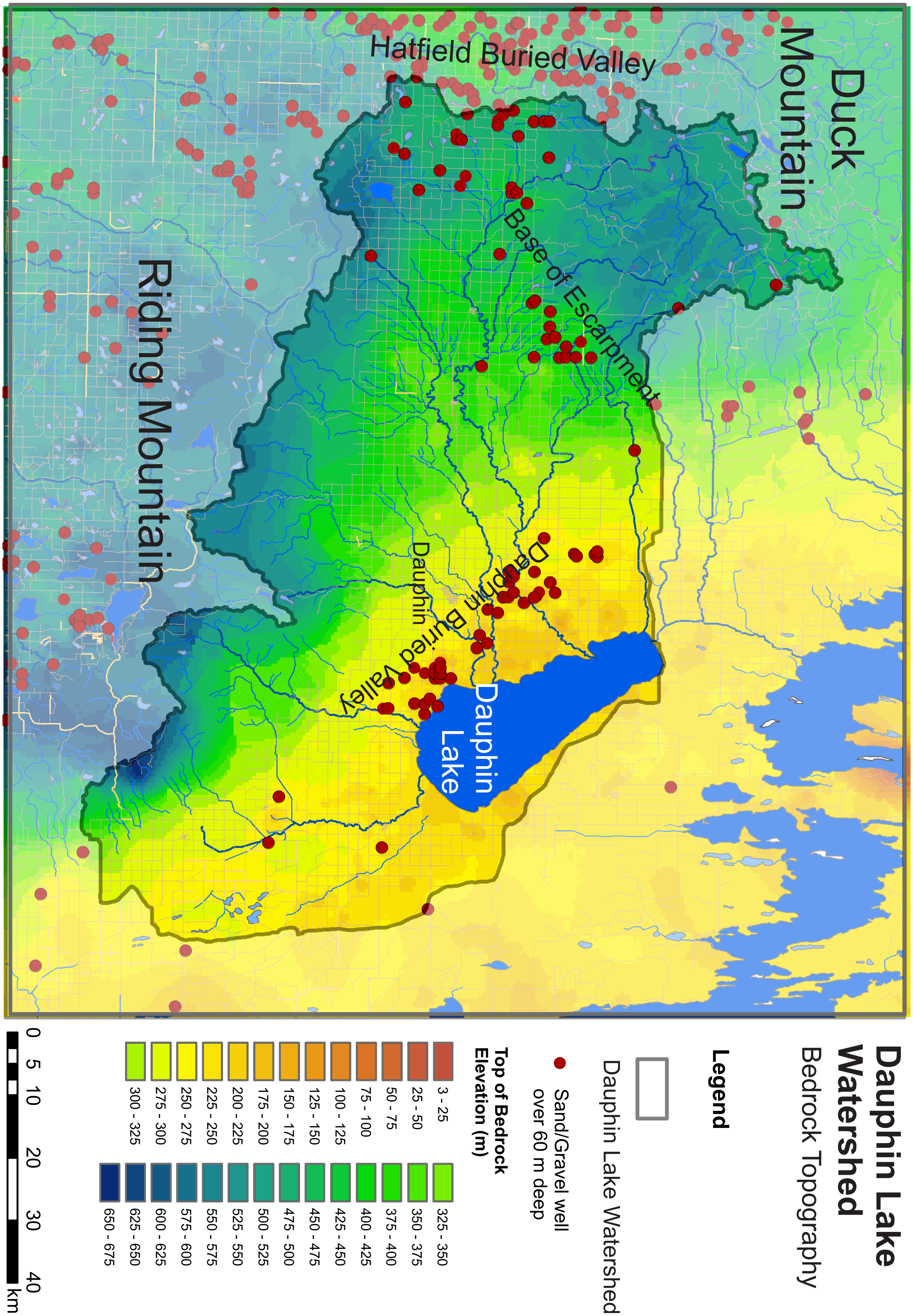
Map #1 - Bedrock Formations, Aquifers and Well Completions



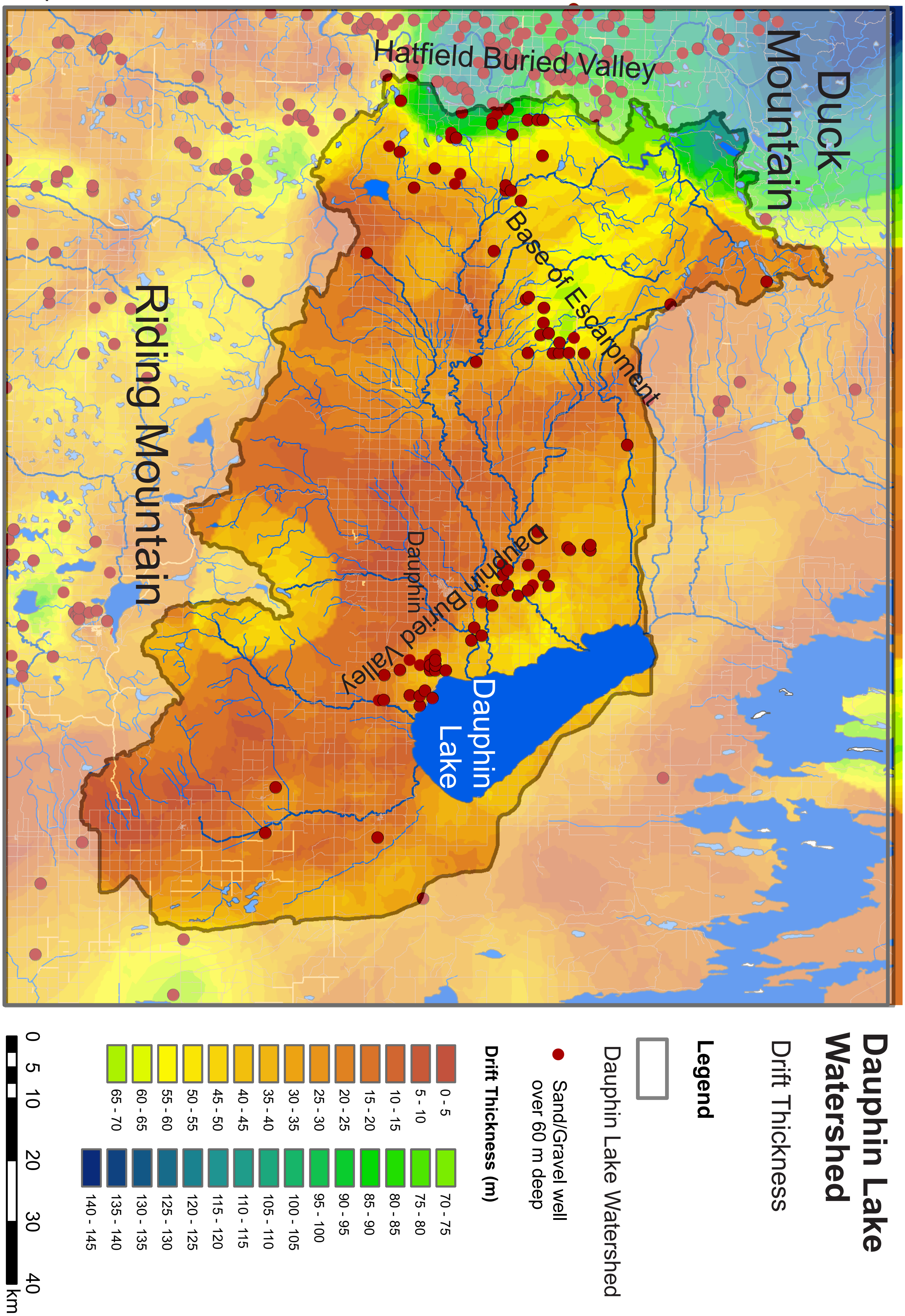
Map #2 - Wells Completed in Sand and Gravel (Drift Aquifer) by Depth Interval



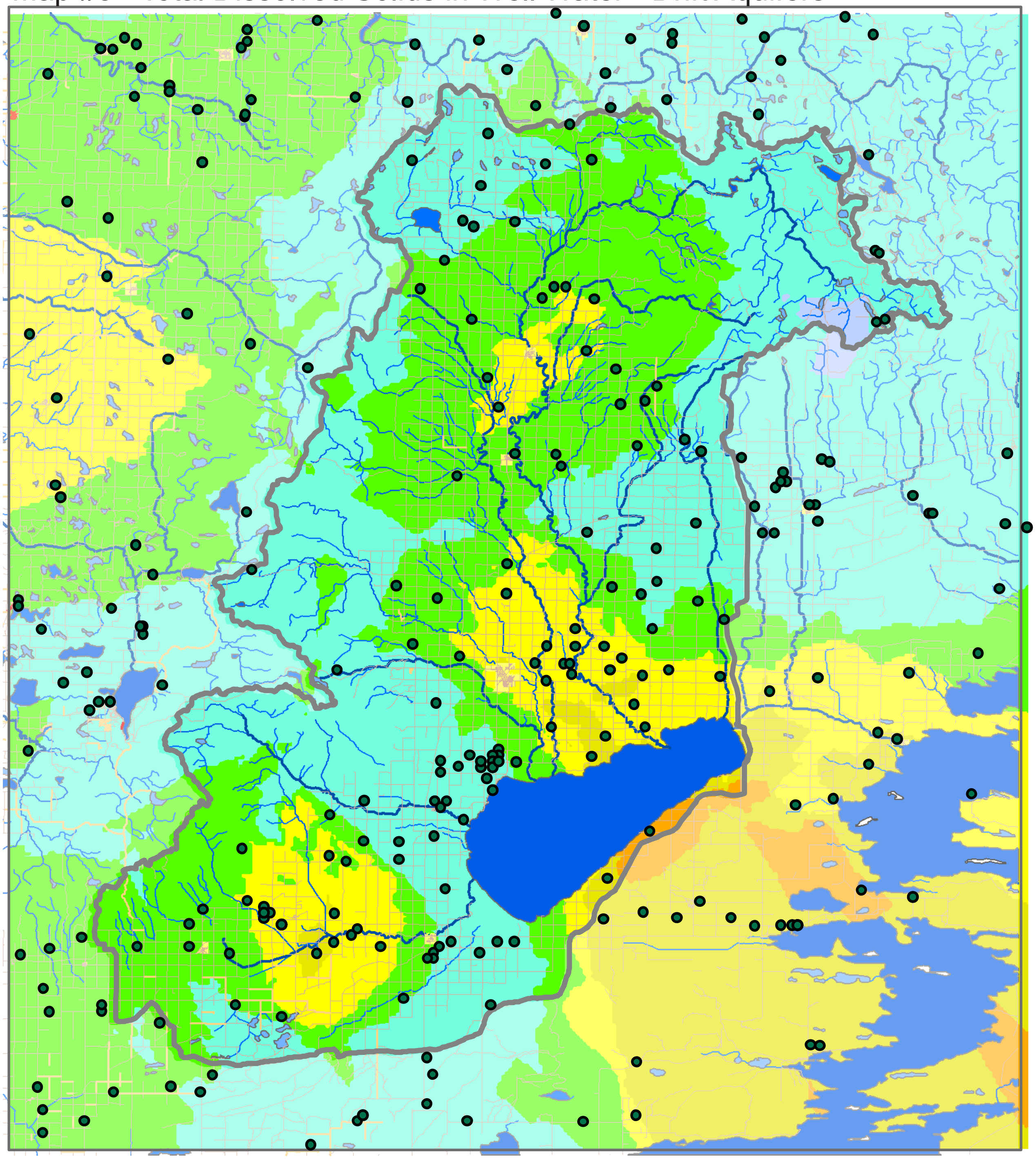
Map #3 - Bedrock Topography



Map #4 - Drift Thickness



Map #5 - Total Dissolved Solids in Well Water - Drift Aquifers



Dauphin Lake Watershed

Total Dissolved Solids in Well Water - Drift Aquifers

Legend

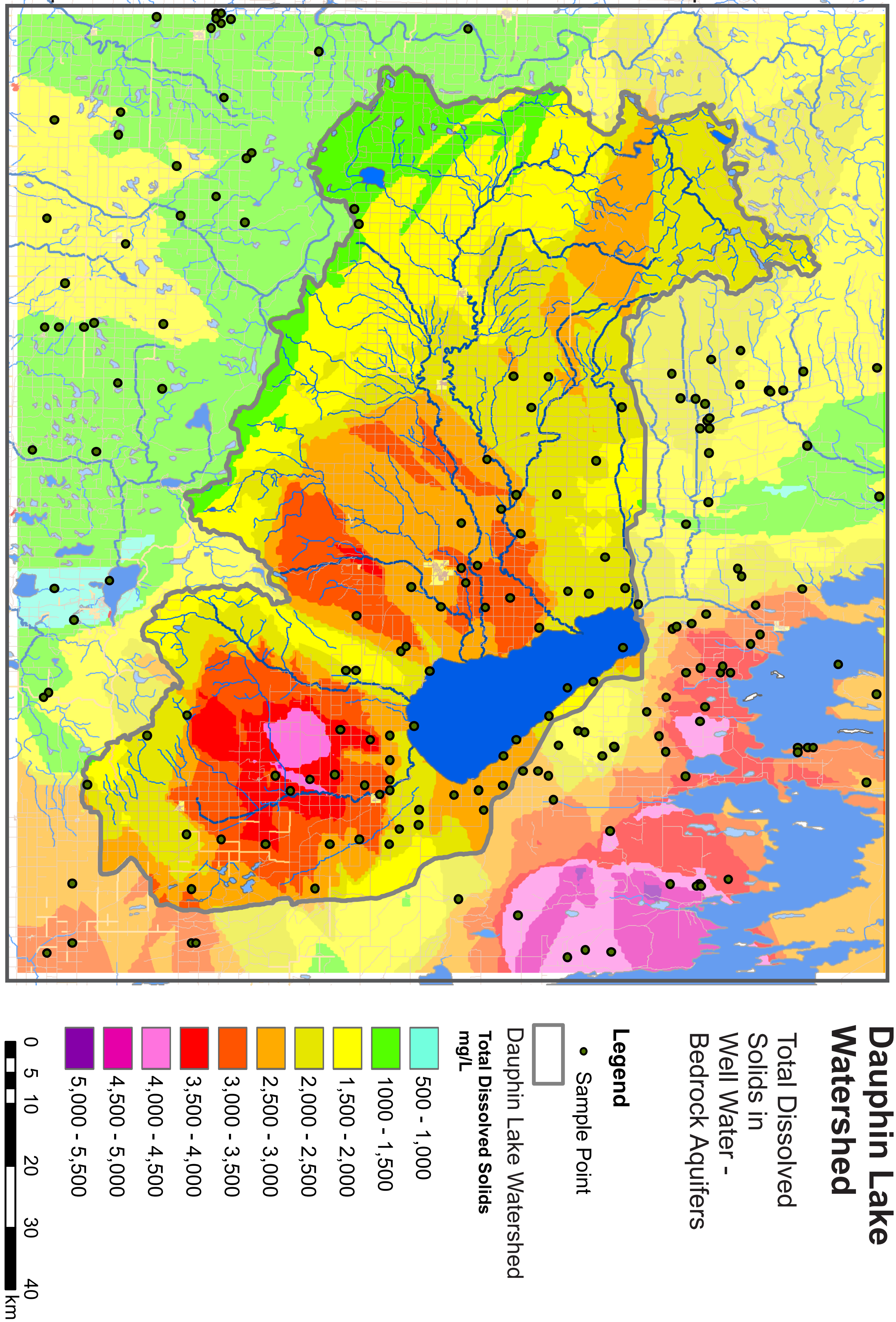
- Sample Point
- Dauphin Lake Watershed

Total Dissolved Solids mg/L

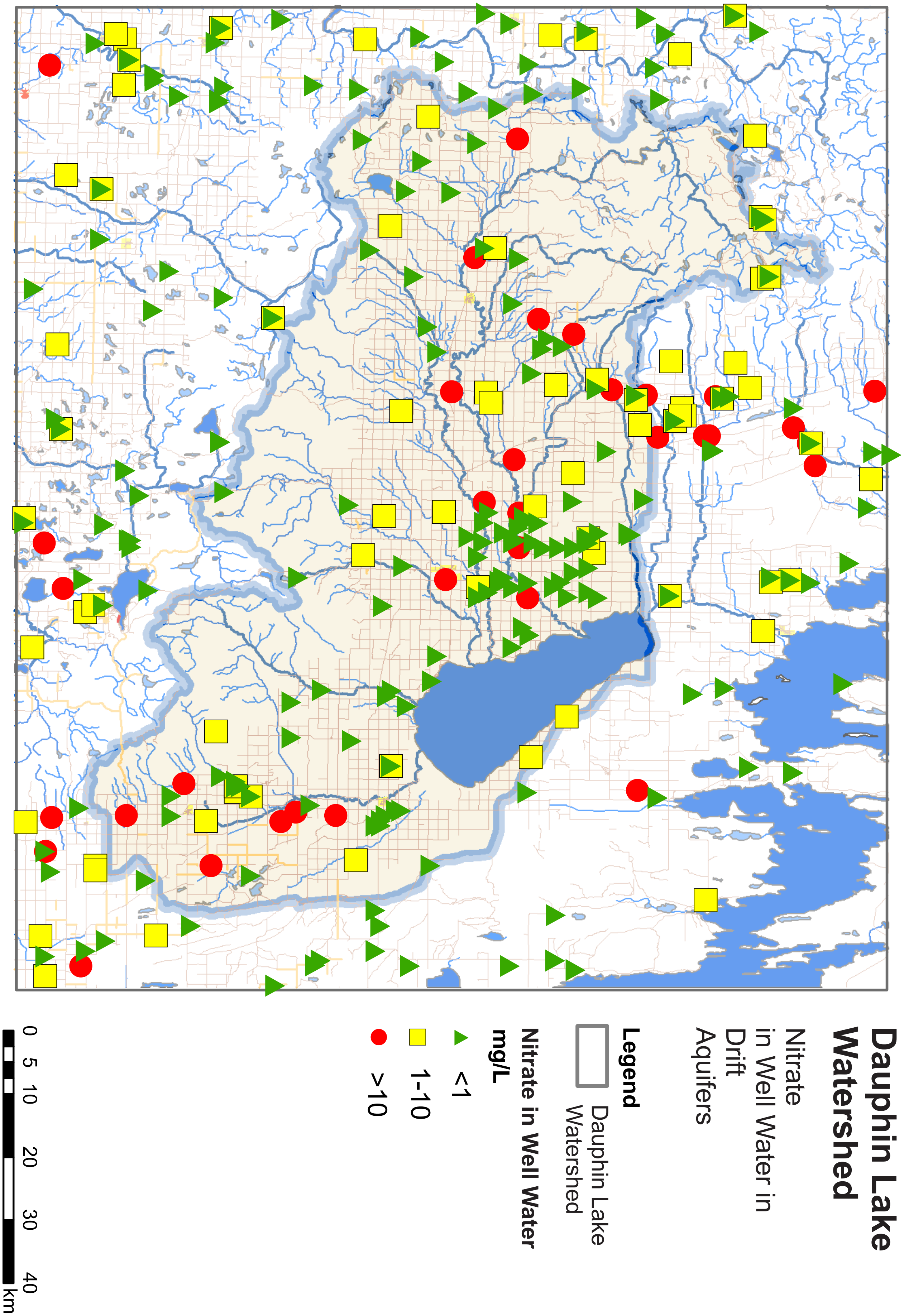
- < 500
- 500 - 1,000
- 1,000 - 1,500
- 1,500 - 2,000
- 2,000 - 2,500
- 2,500 - 3,000
- 3,000 - 3,500

0 5 10 20 30 40 km

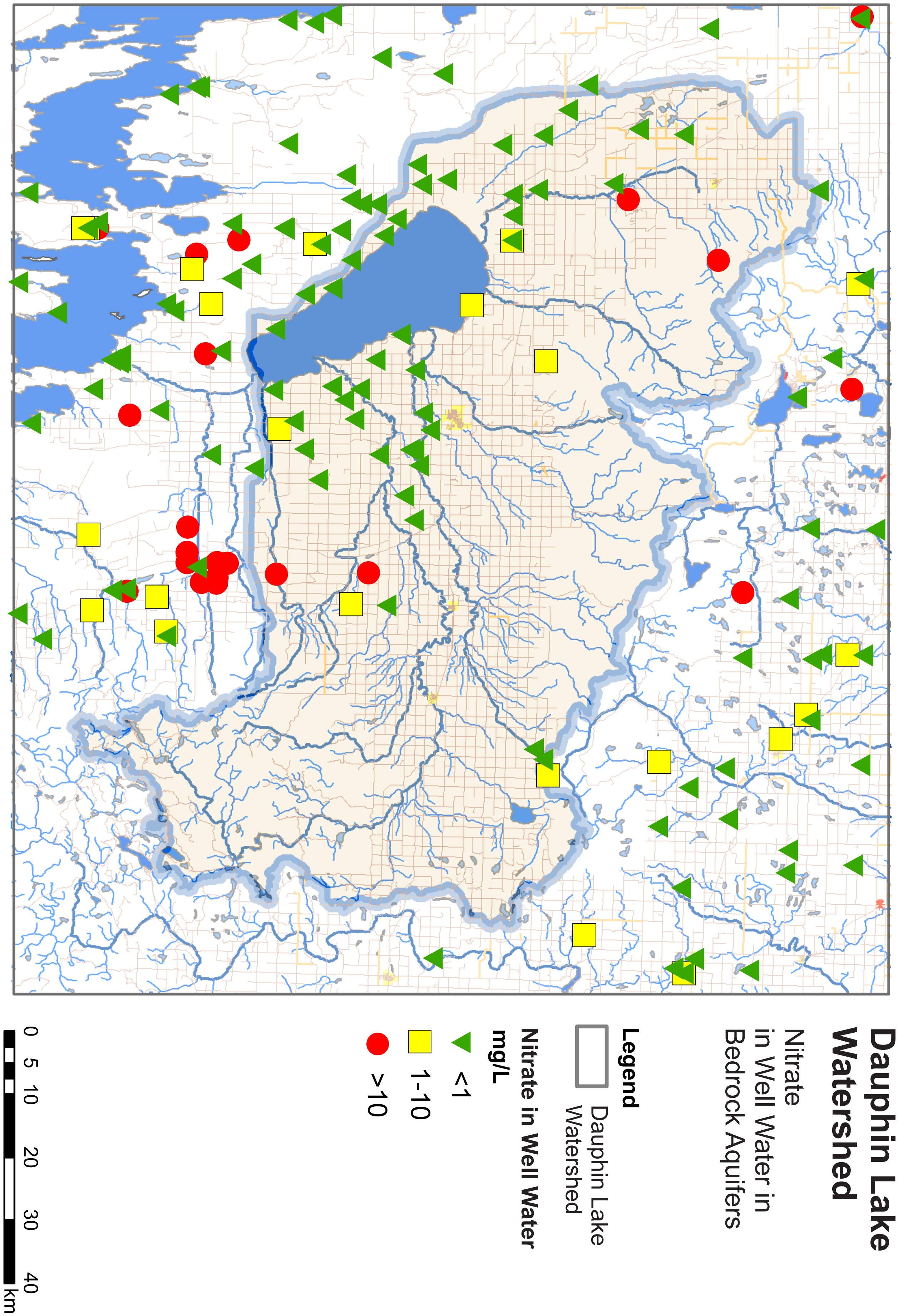
Map #6 - Total Dissolved Solids in Well Water - Bedrock Aquifers



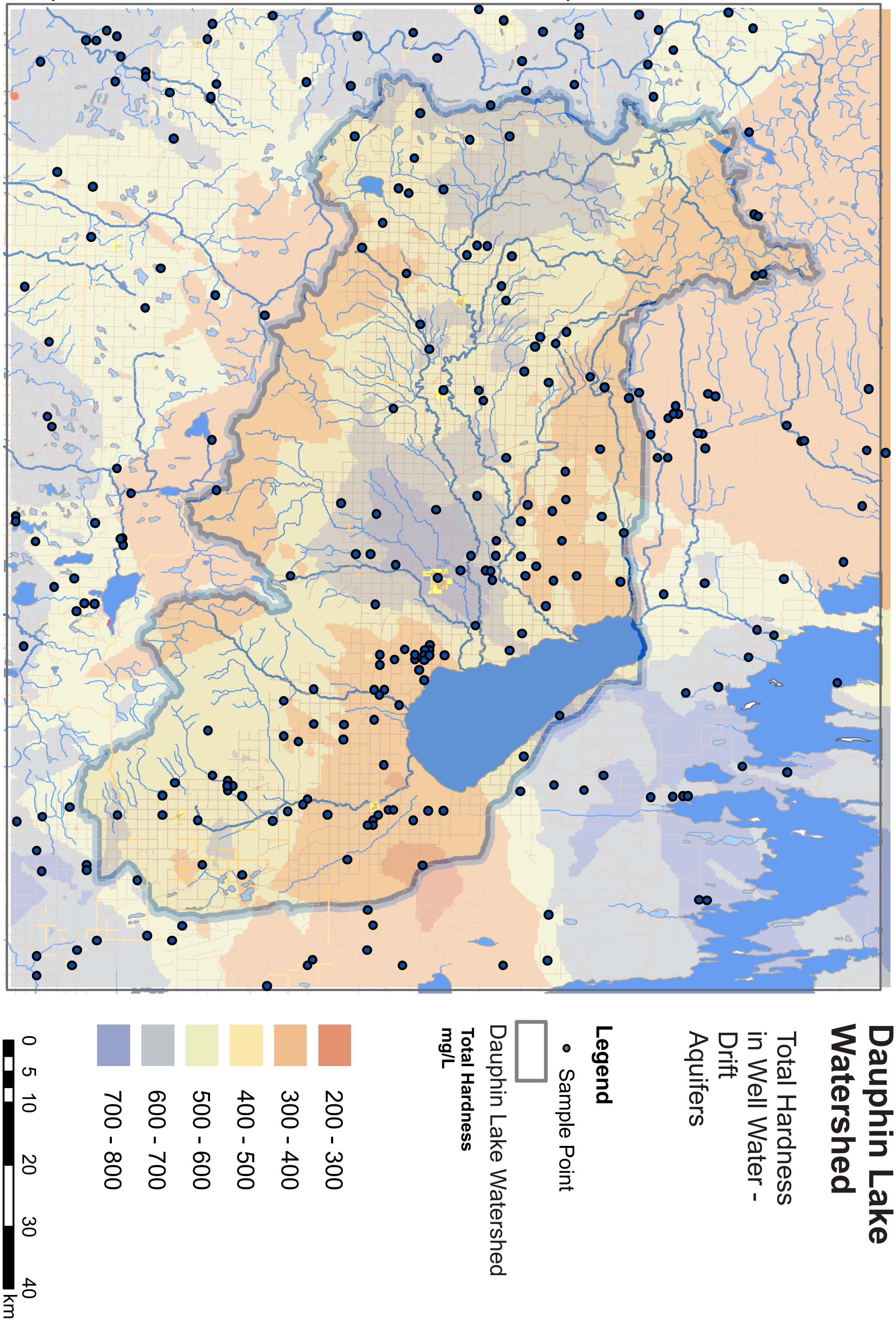
Map #7 - Nitrate in Well Water - Drift Aquifers



Map #8 - Nitrate in Well Water - Bedrock Aquifers



Map #9 - Total Hardness in Well Water - Drift Aquifers



Map #10 - Total Hardness in Well Water - Bedrock Aquifers