APPENDIX 3 - Individual Cross-Section Guide

Observations below are organized by the following approximate format:

- Gross subsurface geomorphology
- Basement depth and type below River; Basement depth towards the Rathdrum Prairie center (to the north)
- Sediment type near the Spokane River; sediment type towards the Rathdrum Prairie center
- Estimated water level (from Figure 42, Hsieh et al., 2007). This can be compared in many cases with actual reports of water bearing sediments indicated by blue marks along the right side of driller's logs. These should not be confused with static water marks symbolized as blue lines across each well.
- Miscellaneous information

SEGMENT A

Cross-Section 1

- The Rathdrum Prairie narrows significantly to 3+miles before becoming the "Spokane Valley" west of the Idaho/ Washington state line. This represents a restriction in the system characterized by a narrower volume of SVRP aquifer sediments.

- ¾ of a mile from cross-section 5, on the Idaho road (Washington) Gerstel and Palmer (1994) shot seismic reflection showing an undulating valley floor with a base at 1500 ft; morphology was suggested to be more U-shaped than the refraction velocities measured by Newcomb et al., (1953). Adema (1999; Fig. 10a) suggests a generally v-shaped valley with a lowest elevation of bedrock/sediment interface at 426m (~1400 ft). Adema's cross-section is very similar to the one generated here.

- 200 ft of SVRP aquifer sediments occur below the Spokane River above crystalline basement; the upper 50 ft are unsaturated gravels, which occur with clay. Coarser, cleaner water-bearing gravels and sand occur at depth. The river occurs above a deeper, wider embayment between coarse sands and gravels (Qmb bar facies) with finer-grained sands and clays (eddy bar facies of Qspv) along the southern margin.

- Intervals Q3, Q4 and Q5 consist of mostly very coarse gravels, with some pea gravel and clays occurring below Q5. City of Post Falls and Ranney wells (Section 1) show thick clay or soils at surface.

- ~1980 ft water table – (After Figure 42, Hsieh et al., 2007). Local variability. Zones of cemented gravel to the north.

- Occurrence of Eocene granite on the northern side of the cross section.

SEGMENT B

Cross-Section 3

- Comparison with Kahle and Bartolino (2007) is essentially very similar, although one section suggests shallower to basement trends; further, the triangular valley of the Rathdrum Prairie is probably a pre-

Miocene lake (ergo elevations to basement should be shallowing in the valley narrows near the ID/WA stateline).[1]

- North side of the valley shows relict basalts at depth. Due to lack of data and original pre-Late Tertiary Valley constriction, inflowing basalts may have piled up here damming drainages during the Miocene. Basalt appears to be mostly removed, but reappears on the north side, suggesting the main Missoula flow hit and scoured the southern range front.

- SVRP aquifer sands and gravels are about 80 ft thick below the Spokane River; a University of Idaho research well drilled near to the river suggests higher water levels, mixed lithologies including fine sand and clay. Qspv sands and fine gravels are perched high on the valley side bedrock.

- Significant decomposed basement rocks occur below perched finer Qspv sediments suggesting this area did not receive very strong, early, erosive currents (decomposed rocks shown in green).

- El Paso Gas deep cathodic protection well shows clay at depth (reaching Interval Q2), and significant cemented zones.

- ~1983 ft water table

Cross-Section 5

- Cross-section lines 5 and 6 together show that the river is running very close to, if not directly over crystalline basement. The river is partly connected/ disconnected to SVRP sands and gravels.

- Cross section 5 follows the ***Corbin Road*** that was a line of section for gravity measurements taken by Purves (1969) and reprocessed by Adema (1999). Adema reports a generally smooth floor, and embedded valley along the northern edge, and a shallow bench on both sides of the profile, with a small depression in the present day location of the Spokane River. Lowest elevation of bedrock/sediment interface is 384 m (1260 ft). Whereas a depression below the Spokane River is present here, with this cross-section and others nearby, 1260 ft is significantly deeper than the ~1500 ft bedrock/sediment floor suggested here, or by the valley center extrapolated by Kahle and Bartolino, 2007 (see also located and projected wells 28 BCC1 and 28DAD1 on Cross-Section 7).

- Significant hard pan clay and mixed clays at ~1980 ft occur above saturated gravels near the center. Millikin well in PLS Section 29 suggests hard pan and clays at depth may locally confine the aquifer.

- Overall, a coarse bouldery top of the Rathdrum Prairie fines downward to fairly well-sorted smaller gravels and clays at depth.

- ~1987 ft water table.

Cross-Section 7

- Abundant coarse sediments in the center of the Rathdrum Prairie. 276 ft Rathdrum well shows well-defined mainly cobble stratigraphy, with minor indications of clay.

- River continues to run close to or over crystalline basement. Hard pan clay, sands, and clay reported near to river (see McGuinnis, and Pettis wells), suggest potential low porosity/ permeability next to river. A large area of cemented gravels occurs near the river and appears to correspond with a local drop in water level.

---

[1] Note: This differs with the idea of an ancestral Spokane River having cut from east to West, described by Kahle and Bartolino, 2007, and matches the gravity data of Oldow and Sprenke (2006). (??)

- Coarse gravels occur towards the center of the Rathdrum Prairie, with some indication of tight silt and clay at depth.

- ~1990 ft water table.

Cross-Section 9

- Wide, shallow crystalline basement shelf running below and isolating the Spokane River on the south side of the cross-section, ahead of the major headland promontory through which the river has cut (where the present dams are).

- The Adema (1999) ***Idaho Road*** profile between cross-section 9 and 11 (Fig. 3) occurs about 3 miles from the ID/WA state line; the subsurface paleovalley essentially doubles in width, and Adema reports an incised channel in the center of the Valley (a paleoRathdrum River?) as well as a perched depression on the north side of the paleovalley, outside of the study area). Lowest elevation of bedrock/sediment interface is 337m (~1106 ft). However average depth of the valley floor is fairly flat in Adema's profile, occurring at ~480m (1575 ft), which overall matches the profile shown in section 11 and 13 (see dashed basement lines behind drawn basement boundary). Section 9 we have drawn accentuating the headland promontory stemming from the range front.

- The Spokane River runs over silt, sands, gravel. Silty sand and gravel appears to give way to coarser, cleaner sediments towards the center of the Rathdrum Prairie.

- ~1993 ft water table

Cross-Section 11

- The strip map shows the Spokane River as it crosses one of many bed rock promontories in Segment B. The River here is partly running over basement, and partly over shallow sand-filled embayments (eddy bar deposits?). Whereas the last cross-sections essentially show a well-cleaned and back-filled basement, Section 11 also shows previously unmapped elements of Tertiary Sediments, basalt and thick red decomposed crystalline basement (see Gilmane and Anderson wells).

- ID Veneer Well in PLS Section 2 finds granite at about 2000 ft suggesting continuity of a promontory at depth. The valley floor deepens to the east toward Cross-Section 13.

- The Spokane River appears to cut into and follow a presumably softer roof pendant of metamorphic rocks with intrusive granites. Otherwise coarse sand and sandy gravel occurs below the river in the nearby embayment

- Sand, gravel and clay "dirty gravel" occur just north of the river, including a 9 foot basalt boulder in the ID Veneer well. Abundant wells further to the north show consistency in sand and gravel lithology (overall generally finer gravels) with some clay reached at depth (~1900 ft). The trend of finer sediments towards the river, and at depth, holds.

- Hughs, Murphy, J. Murphy and Margraff well (PLS Section 11 and 14) show embayment Q5 sediments and perched sandy sediments occurring partly above the river.

- ~1997 ft water level.

SEGMENT C

Cross-Section 13

- Crystalline basement falls off fairly steeply reaching 300+ ft below the river in PLS Section 12 area (e.g., Glenn Ferry Water Sewer well), representative of a more significant inter-promontory SVRP aquifer sediment-filled embayment), to ~100 ft below the river in PLS Section 13 (e.g., Moore-Jorgenson well). From here the river takes a straighter course along the base of the range front, around Harbor Island towards the flanks of Blackwell Hill, before skirting this feature and finding its origin in Coeur d' Alene lake.

- **Idaho Highway 41** gravity profile (Adema, 1999) occurs between cross-section 13 and 15. This gravity profile shows less of an incised valley within the overall bedrock sediment profile. Instead there is a significant positive feature on the southern side of the valley. This is shown as estimated in both cross-section 13 and 15. Overall the Idaho Highway 41 profile shows the deepest part of the wide, smooth undulating bedrock/sediment surface occurring about 4 kilometers from the southern range front, about ½ mile north of the limit of cross-sections 13 and 15. Lowest elevation of the paleovalley floor (bedrock/sediment interface) is 319m (~1046 ft). Overall cross-sections 13 and 15 help develop the southern part of the Highway 41 profile, and show gross agreement (obviously with lack of well coverage below 300 ft).

- The Moore-Jorgenson well (PLS Section 13) set the pattern for a shallower basement below the river; Profile of cross-section 12 (dashed) better matches geophysics data and chosen depth to basement of Kahle and Bartolino (2007) – (see located projected wells 51N 05W 36 BAC1, 50N 05W 01 CBBB1, 50N 05W 12 BCDA1). Potential for significant basement undulations occur in and out of the plane of this cross-section (becoming less so as one moves east).

- Below the river coarse gravels grade to finer gravels. Pea gravel, sand, and minor very coarse gravel and clay also occur at depth. Sandy clay and cemented hard sand occurs at ~1900 ft in Interval Q3 (e.g., 1995 City of Post Falls well, PLS Section 1). Within this interval fine sand occurs with sandy clay and clay, which appear to compartmentalize available water (see latter well and 1974 City of Post Falls well).

- Sands, blue clay, and brown clay occur in Knox well (PLS Section 12) indicative of the probable finer nature of sediments in Cedar Creek embayment on the south side of the river (note also unlikely discontinuity of Qsrv sediments east-west across Cedar Creek(?).

- Overall SVRP sediments (top 300 ft) represent Intervals Q3, Q4 and Q5: they coarsen-upward from fine sand and clay bearing units, coarse gravel with 3-4 inch cobbles, and boulders. Fining-upward stacking patterns are possible.

- ~2001 ft water level. Consistent with drillers reports of water bearing intervals.

Cross-Section 15

- Section 15 represents a significant change from the general hydrogeologic trends seen in Segment D (cross-sections 17, 19, 22, 24) and Segment B.

- A NNW trending fault crosses the Spokane River at river mile 106. Immediately east, a remnant of Grande Ronde basalt occurs above thick clay units (Ts?), and shale bedrock and decomposed granite. The Spokane River runs up against this basement, which drops off in the subsurface to the north. Moving away from the river to the north, the sediment/crystalline basement is relatively shallow compared to cross-sections in Segment D (to the east) where also more Miocene rocks and sediments were accommodated over markedly deeper crystalline basement. The Miocene depositional system also later resisted erosional plucking forces of the Missoula Floods, leaving an erosional edge as suggested in Segment D cross-sections and in Plate 1.

- Sediments near the river are poorly differentiated. Abundant silt mixed with coarser materials is reported in Pine Villa Park and Water well (PLS section 6), which ultimately found water in clean washed coarse sands, above either a basement knoll or a significant granitic boulder over 7 ft thick. If this boulder is not basement occurring about ½ mile north of the river, at an elevation of ~1970 ft (~150 ft below the river surface,) then a perhaps more conservative estimate to crystalline basement is shown as occurring ~350 ft below the river or at ~1700 ft elevation. This is about the same as basement in the following cross-sections 17 and 19, and general depth to crystalline basement in the rest of Segment D. However the addition of Miocene basalt and sediments at depth reduce the actual volume of SVRP sediments under or near to the Spokane River.

- Strip map/cross-section 15 shows a small amount of the upper Grande Ronde basalt (TgrN2) occurring on both sides of the fault, but also regionally dying out here (see possible explanation below). The Doerfler and Pfau wells (with red location points suggesting positive identification of address) show a small amount of basalt at the surface, presumably a continuation of the outcrop pattern seen further east (also clearly seen in cross-section 17).

- Ross Point is a later reshaped terrace that rises 150+ ft above the rest of the Rathdrum Prairie and is comprised of sand and fine gravel, a remnant flood bar that is actually older than the younger surficial sediments that cut and onlap this feature. We do not know how far Qgrp (gravels of Ross Point) extend below this outstanding geomorphological feature, nor why it occurs here, strangely in conjunction with subtle linear features as expressed in surface contours, and a dashed fault line somewhere below in the subsurface (see original Breckenridge and Othberg, 1999-Surfical Geologic map)

- Silt clay lenses, and tight sand are reported within interval Q4, with some coarse to very coarse gravels (interval Q3?) occurring at depth (e.g., Ross Point Systems well, PLS Section 6).

- ~2014 ft water level.

SEGMENT D

Cross-Section 17

- Immediately noticeable here is preserved Miocene Basalt and Latah Formation at depth below the Spokane River, occurring above a very thick decomposed regolith (unit Ts/YXgn), in turn above more competent unaltered basement. This marks the western limit of thick Grande Ronde basalt flows and Latah Formation in the subsurface along the southern margin of the study area. This geological discontinuity is possibly originally fault controlled, with basalt and sandy clays being preserved against Missoula flood erosion due to a buttressing effect against crystalline basement immediately to the west (i.e., a secure contact against crystalline bedrock in cross-section 15).

- Note that Harbor Island wells are hung from a heavy black line on this cross-section *in front* of the main line of section (i.e., Quaternary deposits do not occur below, but in front of Miocene rocks).

- Cross-section 15 shows a small amount of overlapping upper Grande Ronde basalt (TgrN2), occurring on both sides of the fault, but also dying out here. Whereas pre-existing eroded paleorelief is mainly thought to have controlled the distribution of basalt in the region (i.e., not active faulting) this has been previously challenged by Derkey and Hamilton (2002). The sharp fault associated discontinuity described here, as followed by overlap, suggests that the fault may have been active associated with deposition of the lower Grande Ronde basalt flows (here 100 to 200 ft thick) becoming less of a factor during emplacement of TgrN2. This follows a similar sequence of events described by Derkey and Hamilton (2002) on the Latah Fault in Hangman Creek. Even if the fault is actually older, it still may have had a subsequent effect on residual early Cenozoic paleorelief, and ultimately on the location of basalt flow emplacement. Note: there is one more occurrence of basalt further to the west in Cross-Section 11 in the Anderson well (PLS Section 11), although this well could be misfiled (see cross-section 11 discussion).

- As hypothesized in this work, the southern mountains, which now intersect with the Spokane River west of Section 15 were strongly stripped by successive flood currents perhaps helping to explain the lack of basalt in Segments A, B and C. Basalt and Latah Formation plays an important role in the SVRP aquifer subsurface configuration through the rest of the study area (Segment D, Area E, Area F).

- Near the river sand and gravel is common, with clay and silty sand and gravel near the surface being partly associated with surficial unit Qal. Harbor Island, just down stream from cross-section 17 line, is a Basalt Island in the river mantled by abundant Missoula flood sands and gravels of Intervals Q4 and Q5. Domestic wells do not reach water in these sediments, however, drilling deeper to gain small amounts of water from thick Miocene Basalts, Latah Formation or even basement below these units. North of the river cemented sand and gravels are reported.

- The dramatic feature of the gravels of Ross Point can be seen cut and overlain by younger gravels of Qgg (gravels of Green Ferry). Course sands and pea gravels occur at depth, with one well showing a thick succession of cobble gravels to 460 ft (Williams Pipeline well, PLS Section 32). A detailed representative stratigraphic section for this area in shown in **Plate 3** showing occurrence of sand sizes and gravel sizes. A thick unit of fine sand occurs below coarser sand and gravel units in interval Q4.

- 2026 ft water table.

Cross-Section 19

- In this cross-section and the rest of the cross-sections in Segment D area, a number of possible SVRP aquifer floors are shown, using a combination of reasoning and scant data from the region's near river driller's logs. What is immediately striking in this cross-section is the lack of basalt and Latah Formation below the Spokane River, in comparison to both the cross-sections one mile east and west of this one (Cross-section 17 and 22). This suggests that a concentration of flood water force removed basalt and Latah Formation from this area (this is also illustrated in Plate 1). Thus the Spokane River appears to overlie an extra thick accumulation of Quaternary sands and gravels in this area. Clear evidence for Basalt and Latah Formation can be found in cross-sections 17, 22, and 24 so it is shown here as a possible relict subsurface terrain.

- Near to the river occurs fine gravel, sand, with clay and silt fractions. One 2 ft thick basalt boulder was encountered in Finney Craft Boat Co., well. Between tighter intervals, cemented intervals, and more washed sands at depth, it seems that water-bearing units near and below the river are discontinuous.

- At about 1900 ft in the bottom of the Idaho Water Co. well (PLS Section 4), a 10 foot thick blue sandy clay was encountered. An unusually thick, 9 ft brown sandy clay also occurs in the Armstrong well (PLS Section 33) although this unit occurs about 200 ft higher within a stratigraphy, clearly dominated by Quaternary flood gravels. Although the origin of both units are unclear, and probably quite different, the lower **sandy blue clay**, like the 50+ ft of sandy gray clays in the bottom of the Golf Course well, (PLS Section 3, in cross-section 22), do not yield water in a zone otherwise viewed well below the water table. It is possible that the bottoms of these wells either reach thicker deposits associated with quaternary glacial lakes, or that they reach the bottom of the SVRP aquifer, terminating in tight sediments of the Latah Formation.

- **Blue sandy clay**: In the Moscow area, sandy blue clay occurs in the Latah Formation, and is either associated with altered ash or arkosic sand having undergone intense alteration. Blue sandy clay is also reported from other locations in the study where it occurs clearly interbedded within Quaternary sediments (e.g., at ~2900 ft in Hughes well, PLS Section 11, cross-section 11; at ~2400 McCormack well, PLS section 10, cross-section 22; at ~1950 ft in the 2003 City of Coeur d'Alene well, PLS Section 19, cross-section 30 and 32). This fairly rare lithology also occurs between basalt flows in the Latah Formation in the Marrow well, PLS Section 19, Cross-section 32).

- Forest Industries and Armstong wells (PLS section 33) show a dramatic switch from coarse gravel to finer-grained sediments below 2090 ft, potentially indicating a significant break in sedimentation and depositional environment. This possible depositional surface was later cut and removed by subsequent floods, as suggested by coarse sediments at about the same elevation in the nearby USFS well (PLS Section 34). Of course there are lateral variations across all intervals, making such statements highly speculative. Whereas the Armstrong well reports clean fine gravel towards its base at ~1950 ft in Interval Q3/Q4, the USFS well shows intervals of clay and gravel with clay at the same interval.

- 2032 ft water level. (Generally appears somewhat higher than individual wells showing water production at slightly deeper intervals).

Cross-Section 22

- Still one mile north of cross-section 19, a jump in cross-section number occurs as there is a switch to closer spaced cross-sections (see Figs. 2 and 4 for clarification).

- Cross-sections 22 and 19 are drawn more tentatively as there is little data at depth. Because in cross-section 22 there are abundant mega-basalt clasts of relict, partly slumped(?) basalt bedrock, there is reason to draw the alternate deep subsurface views shown in cross-section 19. Sandy clays at the bottom of the Golf Course well shown in cross-sections 22, 24 and 25, and City of Coeur d'Alene 2000 (cross-sections 25 and 26), and Idaho Water Co. well, and City of Coeur d'Alene 2006 (cross-section 28) are alternatively correlated to Tertiary Sediments (Latah Formation) and the base of the SVRP aquifer. Kahle and Bartolino (2007) reasonably correlated these fines with Pleistocene lake deposits that episodically occur on the Rathdrum Prairie at depth, apparently between cataclysmic Missoula Flood sediments (this would increase the actual SVRP aquifer depth, even though in both cases water would be partly controlled by tighter clay-rich horizons). Section 22 shows significant resistant basalt outcrops in the subsurface, which protected underlying, and in some cases interbedded fine-grained Latah Formation sediments.

- Q1 and Q2 are shown differentiated, and clearly the result of erosional and depositional processes interacting with basalt flows. Such an information window into these intervals is lost as one goes west. As the basalt was differentially eroded, and we have no deep well data, various interpretations are proposed here. Note that the Tertiary Sediments (Latah Fm.) have been found to be 600-900 ft thick near Hayden Lake, north of Coeur d'Alene (Anderson, 1927). The Pan Handle Health District well (PLS Section 3), for example reached 8 ft of basalt at 1970 ft – interpreted as either a massive boulder or a continuation of discontinuous basalt flows (and therefore associated Latah Formation in the subsurface). The nearby Golf Course well suggests either that these units were locally cut out, or that individual basalt flows were not originally laterally connected (a feature true of invasive basalt units).

- Near the river, fine sand and gravel occurs, but drillers went deeper into Miocene basalt and Latah Formation to find additional water. Thus the aquifer directly below the river appears fairly thin and dry, suggesting that pore space near to the river is tight.

- Sediments further north show the regional coarsening-upward facies trend. On the other hand, the Heath District well shows intervals of clay in the upper and lower portions of the log, separated by a thick coarse sand unit, which must partly correlate to the nearby Golf Course well showing a thick interval of sand and brown silt (overall fairly small grain sizes). These sediments should be noted and compared with the coarser intervals of the USFS wells further north. Thus the concept of laterally discontinuous grain sizes associated with mega flood/fluvial/debouched subaqueous flood/lacustrine processes must remain the main paradigm for understanding Quaternary lithology distribution in the study area. Furthermore, in this cross-section USFS wells to the north show multiple intervals of cementation and caliche and the Central Premix well shows one level of cementation again closer towards the Spokane River. It is unclear why these intervals occur, other than to invoke paleowater table effects.

- Several well sorted sands, sandy clays, and sandy plant and charcoal bearing facies were identified in the Latah Formation on Blackwell Hill (Grader, fieldwork). These units occur here as a thick interbeds below the Wanapum Formation of the Priest Rapids Member, within the top of the Columbia River Basalt Group (see cross-sections 22 and 24 and B-B', Fig. 4). Note also that nearby basalt outcrops at the bottom of Blackwell Hill on its south side, are pillow basalts indicative of the complex patterns of subaqueous to subearial environments of deposition associated with Latah Formation. Interestingly these facies together with the general geologic history (minus the effects of the Missoula outburst floods) are essentially identical to those in the upper Latah Formation in Moscow, Idaho (see Fairley et al., 2005). Well data drilled near to perched Missoula Flood deposits high on Blackwell hill (Qgc) show that some gravelly sands are common in the Latah Formation at this interval, whereas in the subsurface the unit is typically dominated by clay, silt, sandy clay, and some cleaner well-sorted sands. The base of the Latah Formation, or the pre-Basalt dam stream deposits in the Moscow area can be very coarse rounded gravels. These may occur at depth in the SVRP paleovalley system.

- 2038 ft water table.

Cross-Section 24

- Deeper SVRP aquifer wells in cross-section 24 are based on some reuse of well data from nearby cross-sections. Abundant evidence shows subsurface trends of thick basalt and Latah Formation seen also in cross-sections 22 and 17 (with significant omission of these features due to erosion seen in cross-section 19). These units occur in the subsurface from approximately I-95 back to Blackwell Hill. At the very least, large boulders of basalt occur north of this position, entrained in Quaternary deposits. A Miocene valley floor limit is suggested in Plate 1.

- Numerous wells show crystalline basement below the Miocene system. Thick basalts below the river are either broken extensive flows, or massive boulders of basalt injected with sands and gravels; or, the latter are more unusual, coarse sediments associated with Latah Formation facies (see *A).

- As discussed above, sediment at the bottom of the Golf Course well could be interpreted as sandy clays of the Latah Formation. For example if one looks at Kahle and Bartolino's (2007) work just north of this area in the Hayden Lake area (see their cross-sections I – I' and K – K'; for example wells 51N 04W 12 ABA1 and 52N 03W 19 DD1), there is evidence for very thick Tertiary sediments below the Priest Rapids basalt (see also in the bottom of the McCormick and ACI wells here in PLS section10). Such sediments typically contain thick clay deposits, and theoretically could be laterally more continuous below Quaternary sediments (their basalt cap having been eroded). Clearly it is likely that most of the fine-grained deposits encountered by drill bits 300 ft to 400 ft below the surface in the center of the Rathdrum Prairie represent glacial lake deposits (see Note *B). Typically these fine-grained units are interbedded with coarse-grained turbidities, for example those that occur at the Truck Gardens site in Latah Creek, 20 miles south of this location between 1800 ft and 1950 ft elevation (Rigby, 1982).

- In the northern part of the cross-section, below unit Qgg, occur cemented gravels, clay seams, and a 10 ft interval of brown sandy clay. This is seen at about the same interval in sections further to the west, suggesting a possible partially preserved soil feature or more likely glacio-lacustrine units which are locally cut. Again, this suggests heterogeneous stratigraphy due to cut and fill depositional processes.

- Sediments below the Spokane River are shallow (80 ft or less) and consist of some water-bearing coarse cobble units, however nearby wells also contain abundant clays and silts. Apparently there were no producing sediments and water was sought below SVRP aquifer sediments in the basalts or basement below (see Riverhouse Wells, PLS Section 10).

- 2038 ft water table.

AREA E

Cross-Sections 25, 26 and 28, larger scaled cross-sections A-A', B-B'

- Cross-section 25 occurs at a quarter section break between cross-sections 24 and 26 (i.e., occurs within one quarter mile of the latter cross-sections) and provides transitional geology between Tubbs Hill to the east and Blackwell Hill to the west. It also provides context to the monitoring wells at the Yacht Club on Blackwell Island and on the other side of the river near North Idaho College. More detailed, larger scaled cross-sections A-A' and B-B' show the geological relationships here in this "Head of the Spokane River" / "Edge of Lake Coeur d'Alene" area.

- Cross sections 25, 26 and 28 show a shallow basement sill at ~1850 ft connecting Black Hill to Tubbs Hill, below an approximately 300 ft thick interval of coarse Quaternary deposits, which mainly represent interval Q3 – Q5. The deepest part of this subsurface saddle should occur somewhere between cross-section 26 and 28. The 2003 City of Coeur d'Alene well (14 AA1) reaches 15 ft of fine sands and clay near 1900 ft, which are probably glacio-lacustrine sediments (lithofacies commonly part of the Q2 interval). It is reasonable to assume from nearby data in cross-sections 24, 28, 30 and 32, that residual Miocene elements occur, and this has been schematically shown in the east-west cross-section B-B'. These Miocene rocks originally filled a Cenozoic cut stream valley, and were themselves removed by cataclysmic erosional processes of Missoula Floods. This was apparently followed by a period of glacio-lacustrine conditions, which were then overlaid by or partly cut out by cataclysmic coarse flood sand and gravel associated with large-scale ripple wave forms and cross-bedding (see below).

- Cross-sections that intercept Lake Coeur d'Alene remain true to the lake bathymetry reported on the Coeur d'Alene Quadrangle. Also cross-sections have utilized the seismic cross-section showing giant current ripples supplied on the bottom of the surficial map of Breckenridge and Othberg (1999). We are unsure of the thickness of the late Pleistocene and Holocene outwash and lake beds that drape over the coarse Pleistocene deposits mentioned above. Likewise we are unsure of the time to depth conversions not shown for this data. Best estimates have been provided, however the thickness values given in the cross-sections offered here may be significantly less than shown. There are few detailed or deeper well logs associated to help control this. Mega ripples shown on the seismic data (and schematically drawn on cross-section 25, 26, 28 and in B-B') show large-scale cross-bedding and transport direction southward into the Lake Coeur d'Alene basin, possibly above more planar-bedded gravels, and/or lacustrine beds.

- It should is noted that while Breckenridge and Othberg (1999) considered the giant ripples in the subsurface to be part of what we have defined as Interval Q5– i.e., unit gcd on their map (or unit Qcd in Appendix 2b), the "Gravel of Coeur d'Alene" is described by these authors as "*mixed deposits of poorly to moderately sorted stratified cobbly sands and sandy gravels carried by outburst floods and also currents of reverse outflow from Coeur d'Alene Lake…. 20 to 80 feet thick."* and which "*…form giant current ripples in the lake bottom revealed by seismic profiles."* However, if one compares the average elevation from the top of unit Qcd in the City of Coeur d'Alene and the bottom of the lake (i.e., the top of the Late Pleistocene and Holocene sediments that overlie the mega ripples below the lake), there is an elevation difference of about 200 ft. This suggests either that the Gravel of Coeur d'Alene is either much thicker and is draped over the Coeur d'Alene Lake basin, or alternatively, that sediments comprising the mega ripples are associated with a deeper Interval or older event (i.e., part of Q3/Q4 interval). We provide the latter interpretation in cross-section B-B,' all factors equal.

- Sediments near the river and on Blackwell Island include sand and gravel, but always with a component of silt (see Marina Yacht Club monitoring wells in PLS Section 14), including thin Holocene alluvial silt deposits. It is not clear from the driller's logs whether the older Quaternary deposits are interbedded with silt and partly sorted deposits, or whether these are primarily gravels with silt in the matrix. Split spoon samples taken down the hollow stem auger rig, which drilled the deepest well on Blackwell Island to 90.8 ft were apparently all refused, suggesting mostly large sized, hard cobbles. A density and lithology contrast was noted at 75 ft below the surface in this well (test boring #6, 2006). This may be the contact between Q5 (Gravels of Coeur d'Alene) and a larger grain size in the top of Q4 (see B-B' and above point).

- Whereas sediments in Area E continue to show the regional coarsening-upward trend, the gross local trend here suggest finer overall Quaternary sediments than seen in cross-sections further west. In cross-section 28, the 2003 City of Coeur d'Alene well (12 BCD1) and Idaho Water Company wells (12 CBA1, 12 CBB1,) encountered sandy gravel, very thick clay (over 50 ft thick) and sandy clay below 1900 ft. Nearby the 1966 Idaho Water Company well (12 CCB1) encounters 6 ft of basalt at about 1960 ft elevation. These data are difficult to reconcile, and we concur with the interpretation shown in Kahle and Bartolino (2007; Plate 2, e.g., cross section I-I'), which includes a relict paleorelief of Miocene basalt and Latah Formation surrounded by abundant Quaternary units. The latter show clay interbeds (up to 18 ft thick) and sands with nodules, clay inderbeds, clayey sands, gravelly sands, silty gravel and thin interbeds of coarse less than 3 inch cobble beds (e.g., 1994 Demming well further north, and abundant fine-grained material seen in the 2000 City of Coeur d'Alene well, cross-section 26). These units suggest glacial lake deposits and or subaqueous deposited coarse/fine turbidities (*c.f.* Rigby, 1982). Alternatively, the well that terminates in basalt may be interpreted as a large clast, yet such clasts are often associated with relatively nearby basalt bed rock (see cross-sections in Segment D).

- Transect I-I' in Plate 2 of Kahle and Bartolino (2007) shows wells 51N 04W 35 BBA and 35 DDA - these have been added to cross-sections 26 and 28 to show that geological surfaces encountered in these wells closely match (and therefore support) the contacts, lithofacies, and paleorelief shown in these cross-sections.(i.e., well 35 DDA encountered "Glacial Lake deposits" between 2000 ft and 1900 ft and basalt just below ~1800 ft).

- Water table levels after (Figure 42, Hsieh et al., 2007) suggest highest levels near the lake shore at 2080 ft, dropping to 2040 ft in the northern part of these cross-sections.

AREA F

Cross-Sections 30, 32 and 34

- Cross-section 32 shows faint dotted lines that show the basement traces of cross-section 30, 32 and 34. Given the paleorelief shown here (with Tubbs Hill and other gneissic outcrops forming a major barrier between the SVRP aquifer sediments and Coeur d'Alene lake), and given the evidence shown in cross-section 32 for abundant cut, and back-filled Miocene deposits, there is reason to draw attention to a deep, scalloped, erosional feature here termed the "Fernan Channel" (Plate 1). While it may not be a channel associated with Missoula Floods per se, it is at least a major erosional feature, an area that was first cut and then filled by fairly coarse, clean sand and gravel (see well 2003 City of Coeur d'Alene, 13 DDA1). The GTE well in cross-section 30 (PLS Section 13) and the Marrow and Nelson wells in cross-section 34 (PLS sections 19 and 7, respectively), and abundant nearby outcrops (see strip map in cross-section 34), make it clear that relict basalt and thick Latah Formation occur around the edges of this erosional feature. Moving towards Lake Fernan, the channel feature appears to recede in size (see Washington Power well in cross-section 34), having perhaps formed partly as area that back-washed following initial flooding of the area. The Washington Power well shows good contacts with both brown clay correlation (known to occur in the Latah Formation in other wells in the area), and with Proterozoic rocks (at ~1900 ft).

- If Fernan Lake contributes to the SVRP aquifer water budget, it does so through the Fernan Channel (like many of the other Missoula Flood gravel dammed lakes on the edges of the greater SVRP valley).

- Geology in this part of the study area is dominated by the Purcell Trench detachment fault, a major steep extensional structure running down the Purcell Trench along the Selkirk Mountains near Sandpoint, down past Round Mountain and along the east side of the Rathdrum Prairie, through the study area and along the east side of the Lake Coeur d'Alene. This fault drops younger (or less metamorphosed) rocks on the east side against amphibolite-grade metamorphic rocks of the Priest River complex and the Spokane Dome mylonite zone (Miller et al., 1999). In the study area, at Tubbs Hill on the west side of the fault, pegmatitic highly deformed gneiss with top to the east structures occur, whereas on the other side of the fault occur much less deformed metasediments (e.g., argillite, siltite and quartzite) of the Prichard Formation (Belt Supergroup, outcropping for example at Best Hill). This fault is thought to have been active in the Early Cenozoic (Eocene?) associated with the unroofing of the Priest River Metamorphic Core complex (these rocks and associated Cretaceous intrusive rocks include all the crystalline basement in the rest of the study area).

- The Anderson well on Potlatch Hill on the edge of the study area shows a 500+ foot thick accumulation of Miocene Columbia River Basalts and interbedded Latah Formation. Likewise the Dennis well shows a similar stack of rocks, with the basal Latah Formation below the lowest Basalt flows reaching a thickness of 250 ft. Although this is regionally a fairly thin accumulation of Latah Formation sediments, note that gravel is generally a minor facies in this primarily(?) lacustrine unit. This basal Miocene sedimentary unit, when and if present without basalt flow may play an important role in the eastern part of the study area – for example although the sediment/crystalline basement may appear at depth in geophysical studies, much of the actual Quaternary aquifer thickness may be masked by thick Latah Formation. On the other hand, once the basalt flows were cut away by flood waters, the clay units might have been more easily eroded (unless some sort of clay armoring processes can be invoked).

- Water table in Area F occurs between 2080 ft and 2040 ft.