WRIA 55 (Little Spokane River) Ground-Water Inventory and Mapping Project

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Prepared for:

WRIA 55/57
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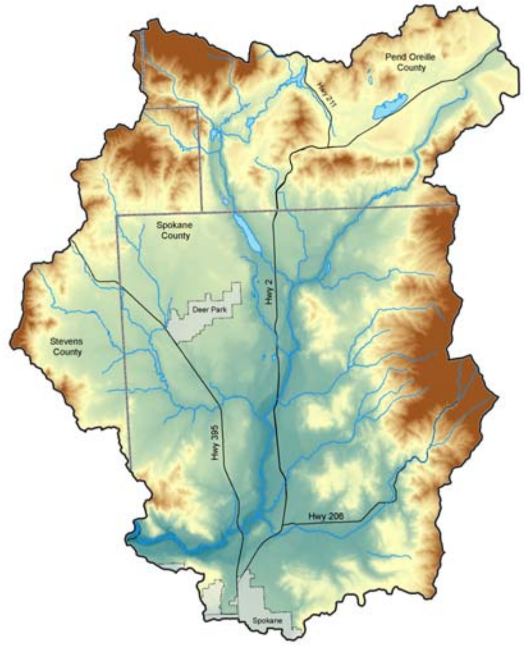
Introduction

This report presents the objectives, methodologies, description of data products, and preliminary analysis for the Little Spokane Ground Water Inventory and Mapping Project. This project was an element of the Water Resource Inventory Area (WRIA) 55/57 watershed plan implementation activities conducted during 2008 and 2009. Funding was provided by the Washington State Department of Ecology (Ecology) through Watershed Implementation Grant G0700149.

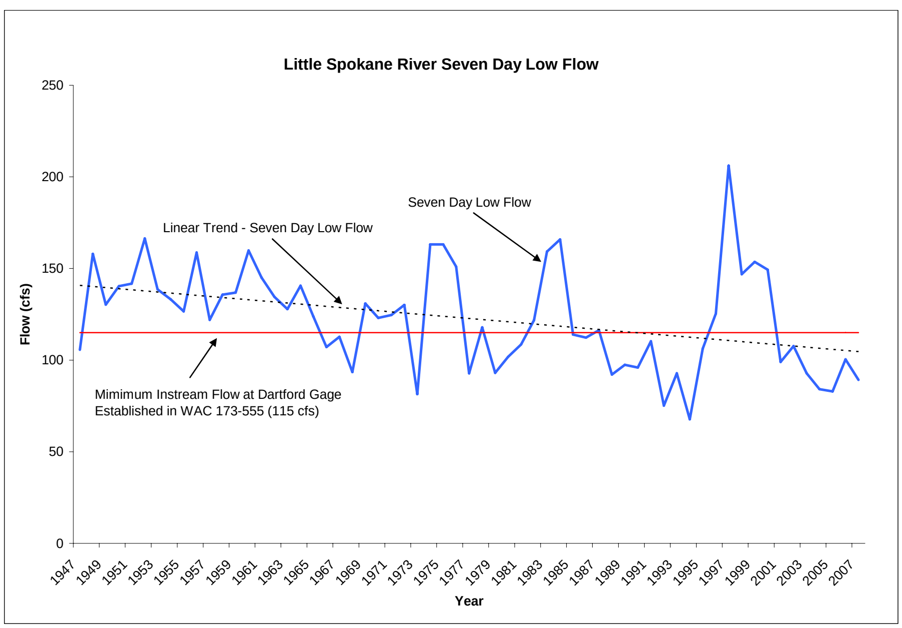


WRIA 55 – Little Spokane River Basin

Background

This project was designed and implemented to fulfill certain recommendations and actions described in the WRIA 55/57 Detailed Implementation Plan (DIP). The DIP was prepared by the WRIA 55/57 Watershed Implementation Team (WIT) and approved on February 20, 2008. The DIP includes recommendations and specific actions to implement the WRIA 55/57 Watershed Management Plan that was adopted on January 31, 2006.

One of the issues addressed in the DIP is domestic exempt well use in the Little Spokane Basin (WRIA 55). The main goal of the recommendations and actions is to address impacts of domestic exempt wells on overall water availability including instream and out of stream uses. Water availability in the basin has been a concern dating back more than 30 years. In 1976 an instream flow rule (WAC 173-555) was established that closed most of WRIA 55 to new surface water appropriations and only allowed interruptible rights to be issued in the remainder. The rule did not officially close WRIA 55 to new groundwater withdrawals, though applications for permits dating back to 1987 have not been processed. However, since 1976 8,900 permit exempt wells have been drilled to supply water for rural residential development.



In 21 of the last 32 years junior water rights have been interrupted. Another cause for concern is the trend of the seven day low flow. Analysis of flow data from the USGS gage at Dartford shows that the seven day low flow exhibits a decreasing trend. Due to the continuing increase in the number of permit exempt wells and the apparent declining low flow the WIT determined it was a priority to study the impacts of permit exempt wells on the surface and groundwater resources of WRIA 55. Several specific actions detailed in the DIP relate to work conducted for this project.

Recommendation	Action
R.IV.A.03.a, R.V.B.01.a	WIT members will assist in updating an existing database of domestic exempt well owners for the West Branch Little Spokane River.
R.IV.A.03.a	Spokane County will establish and maintain a database of addresses of domestic exempt well owners in the Little Spokane Watershed.
R.IV.A.01.f	Spokane County, in coordination with water purveyors, DOH and Ecology, will identify areas of limited water availability, particularly examining rural areas and growth areas under the GMA.
R.IV.A.01.e	Using purveyors' input from the summit on water availability, Spokane County will conduct a data gap analysis to examine well logs, purveyor information, and the DOH complaint data base to identify areas of water availability concern.
R.IV.A.03.a	The WIT, with Spokane County as lead, and support from other counties, cities, water purveyors, and others, will identify owners of domestic exempt wells and issue a press release or send them a letter in mid-summer (when NOAA stream flow predictions fall below minimum instream flows) requesting that they voluntarily conserve water.

At the outset of this project the objective was to address recommendation R.IV.A01. by implementing a project that would identify areas of limited water availability, particularly in rural areas. It became apparent that the tools and dataset to accomplish the objective did not exist and the focus of the project shifted to development of a database of existing ground and surface water information for the Little Spokane River Basin in tabular, GIS, and geologic database formats to further understand:

- Spatial distribution and growth of permit exempt wells;
- Well yield, total depth, and static water levels;
- Potential areas of limited water availability;
- Future growth and its impact on water resources.

The database can also provide information for the development of a hydrogeologic conceptual model, design of a field investigation program and eventual development of a numerical model. Preliminary analysis of the data was conducted as budget allowed to further understand the usability of the database to achieve the goal of addressing impacts of domestic exempt wells on overall water availability.

Project Scope of Work

This project was comprised of seven tasks:

1. Collection and processing of data for all water well logs available for the basin;
2. Collection and processing of well depth, yield and water level data for the basin;
3. Development of an exempt well location and address database;
4. Development of a hydrogeologic database;
5. Collection of stream flow data for the basin;

6. Evaluation of existing monitoring infrastructure; and
7. Evaluation of development potential within the basin.

Preliminary analysis was conducted as part of each task. The analysis was not intended to be comprehensive; the purpose was to demonstrate how the data and tools can be used in future work to better understand the hydrogeology of the basin. Presented below are the data sources, methodologies, discussion of analysis, and description of the data products for each task.

Task 1 – Collection and processing of data for all water well logs available for the basin

The objective of this task was to collect information for water well logs including approximate location, date of installation, and whether or not the well was deepened or hydrofractured - a technique utilized to increase the yield of a well completed in bedrock. This data can be utilized to analyze the spatial and temporal trends of exempt well installation and deepening of wells.

The main data source for this task was the Department of Ecology (Ecology) Well Log database. The State of Washington has been receiving well logs since the 1930s. Since 1971 management of well logs has been the responsibility of Ecology. Well logs are available for download based on a variety of criteria, one of which is the WRIA in which the well is located. A collection of well logs and a text file that includes basic information for each well in the collection can be downloaded. At the time the data was collected there were 10,370 well logs available for WRIA 55. A portable document format (PDF) copy of each well log for WRIA 55 along with one text file that included the approximate location and date of installation for each log was downloaded. The text file was imported into an excel spreadsheet to facilitate analysis. Once downloaded each well log was visually inspected to determine if the well was a record of a well deepening or hydrofracture. That information was then recorded in the spread sheet. The spread sheet included coordinates for each record which was utilized to create a GIS coverage.

Figure 1-1 presents the number of wells drilled in WRIA 55 each year. The number of wells represented for the years between 1947 and 1973 is not considered accurate for two reasons: 1. the practice of well drillers completing and submitting a well log to the State was not common; and, 2. management of well log data changed agencies and was not the responsibility of Ecology until 1971. Data from 1974 to 2007 is a better representation of the number of wells installed each year in WRIA 55. Figure 1-2 shows the number of wells installed in each county that has jurisdiction in WRIA 55. The map shown in Figure 1-3 shows both the spatial and temporal distribution of exempt well development in WRIA 55.

Each well log shows whether the work performed was for a new well, deepening an existing well or reconditioning and existing well. The rational for collecting this data was that it could provide insight into specific areas with limited water availability. While collecting the data it was found that deepened wells were in two categories, a well that was drilled deeper or a well that was hydrofractured. These activities are distinct and have different implications. Drilling a well deeper is likely done because the static water level has dropped below the bottom of the well. Hydrofracturing a well is likely done because the well was completed in competent bedrock and creating fractures could increase the well yield.

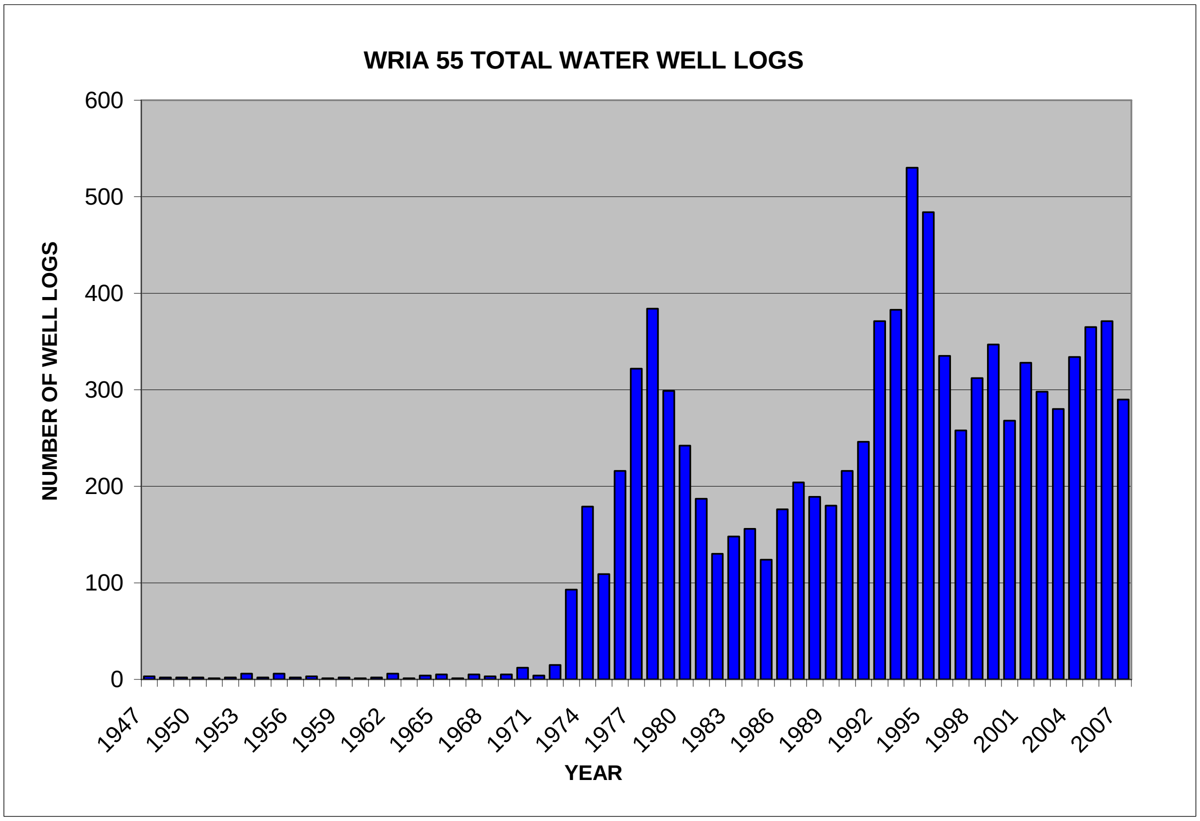


Figure 1-1

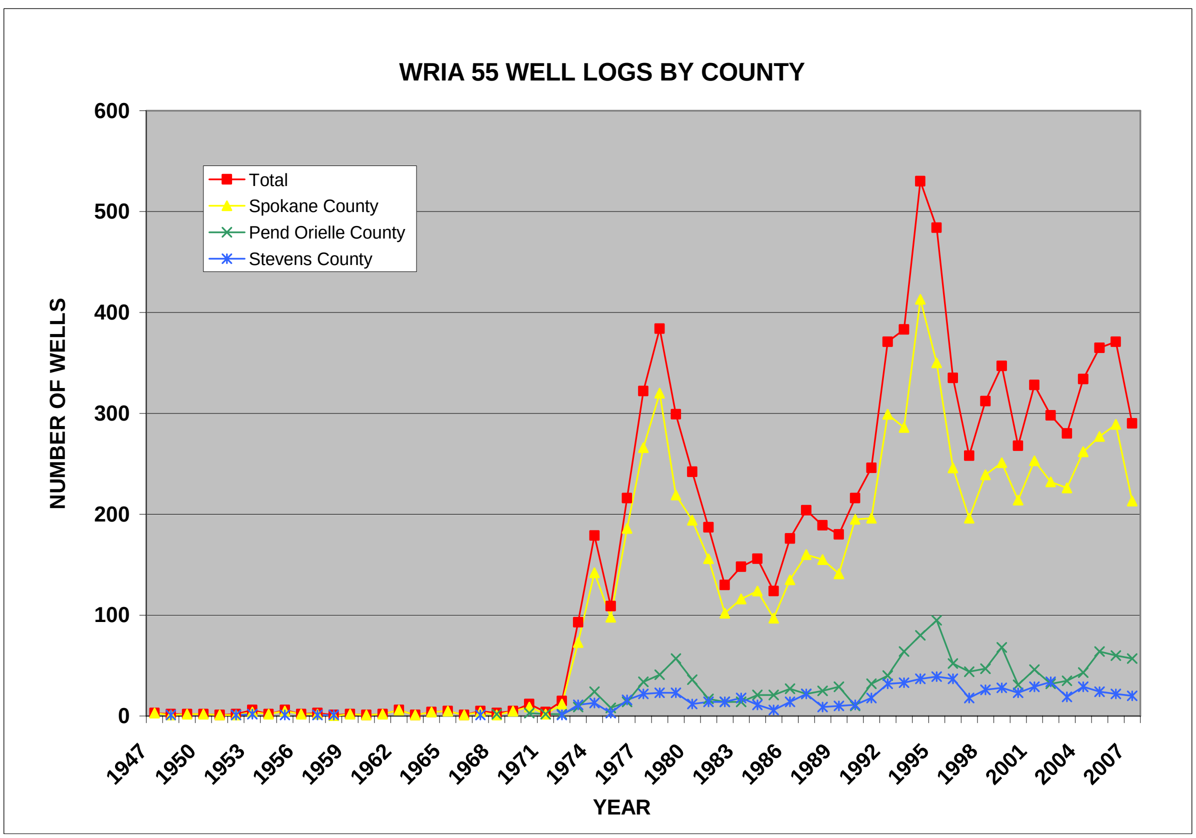


Figure 1-2

Hydrofracturing is often done shortly after the original well is completed, while well deepening is often done years later. Figure 1-4 shows the number of deepened wells per year and the map in Figure 1-5 shows the location of the deepened or hydrofractured well.

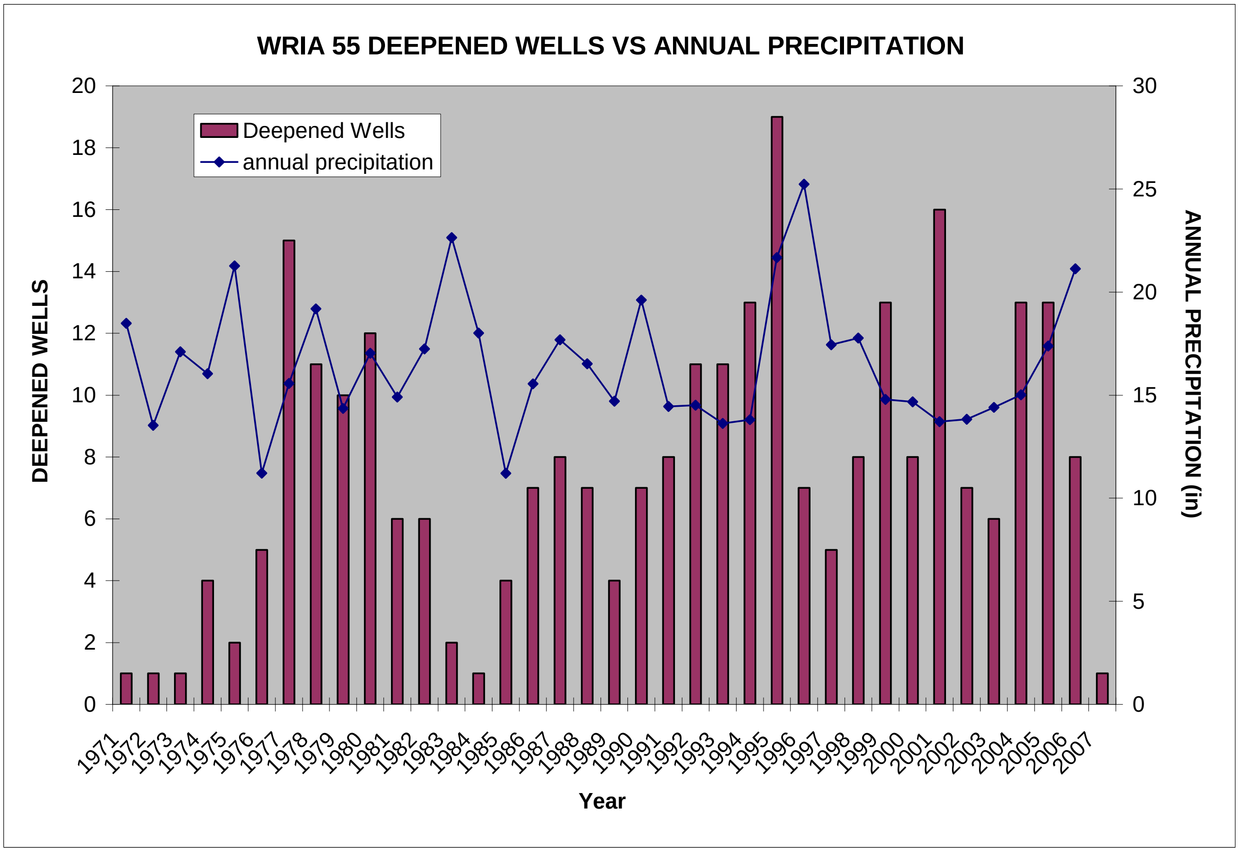


Figure 1-4

The goal of collecting the deepened/hydrofractured well data was to determine if there was a pattern that offered insight into limitations of water availability. Review of the locations did not reveal any particular geographic concentration of deepened/hydrofractured wells. Two potential patterns, though, were identified.

The first pattern is the relationship of deepened wells to geology. In addition to deepened/hydrofractured well locations the map in Figure 1-5 shows surficial geology. Geologic units were grouped into three categories unconsolidated material, basalt and crystalline basement. Table 1-1 below shows the number of deepened/hydrofractured wells for each surface geologic group

Table 1-1

Geologic Group	Deepened Wells	Hydrofractured Wells
Basalt	10	3
Crystalline Basement	58	41
Unconsolidated	194	54

The majority of deepened wells are found in areas of unconsolidated surface material. The hydrofractured well vs. surface geologic unit data was not as conclusive. Hydrofractured wells usually occur in competent bedrock, but the majority of hydrofractured wells are found in areas where unconsolidated material is present at the surface. This is most likely attributed to those wells that did not encounter water in the unconsolidated material and are drilled into underlying bedrock.

The second pattern is temporal in nature. In addition to the number of deepened wells per year, Figure 1-4 shows annual precipitation as recorded at the Spokane Airport. In general a year with low precipitation is followed by an increase in well deepenings the next year. These two patterns demonstrate that wells that withdraw water from unconsolidated aquifers are subject to water level fluctuations that can have significant impacts on water supplies.

Task 2 - Collection and processing of well depth, yield and water level data for the basin

The objective of task 2 was to collect well yield, total well depth, and static water level data for the basin which could be used to analyze the spatial distribution of these variables. This database contains information for a subset of wells that are in the database completed for Task 1. Two data sources were used: 1. Ecology's Notice of Intent (NOI) Database, and 2. A well log database created for an Eastern Washington University (EWU) Geology Masters Thesis (Boese and Buchanan, 1996).

The NOI database is part of the Ecology Well Construction and Licensing System. It contains information collected when a well driller submits documentation prior to drilling a well and any report made to Ecology after the well has been drilled. The difference between this database and the database utilized in Task 1 is that the well depth, yield, and water level are in an electronic format as opposed to just being shown on the PDF copy of the well log. Many of the records for the NOI database also include the tax parcel ID. This coupled with GIS data available from each county allows for more accurate location information to be associated with each record. Since all of this is in an electronic format it allows the user to integrate this data with other data sources, create spatial datasets, and analyze the data.

The second data source for this task was unique to WRIA 55. A database of over 1500 well logs selected from Ecology well logs before June 1995 including location, well depth, well yield, static water level, and lithologic description was created for the *Aquifer Delineation and Baseline Groundwater Quality Investigation of a Portion of North Spokane County, Washington* prepared by Reanette M. Boese and John P. Buchanan, 1996, EWU Geology Department. This database covers only the southern portion of WRIA 55

Records from each database were combined to create a database of 2,688 records. Date ranges for the data from each data set were chosen to ensure that the final database did not include duplicate records. The charts in Figures 2-1 and 2-2 show the distribution of well yield and total well depth values for the entire basin.

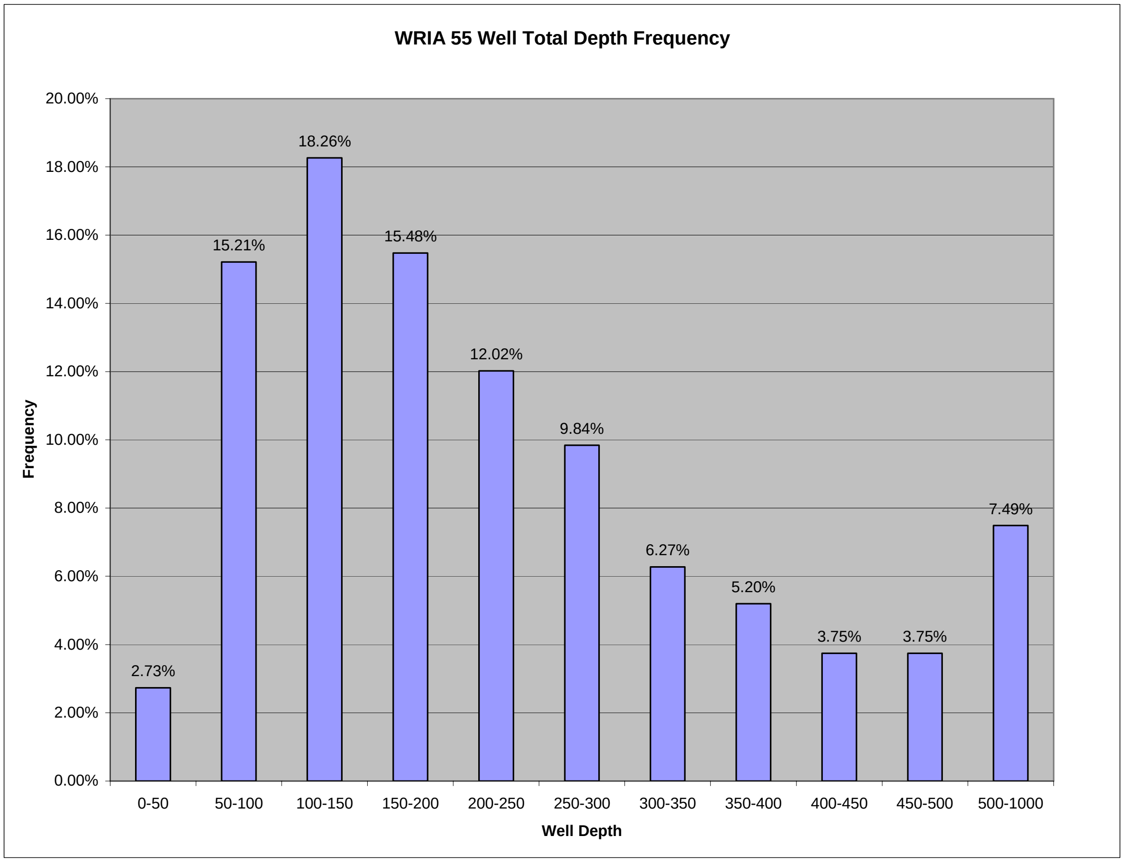


Figure 2-1

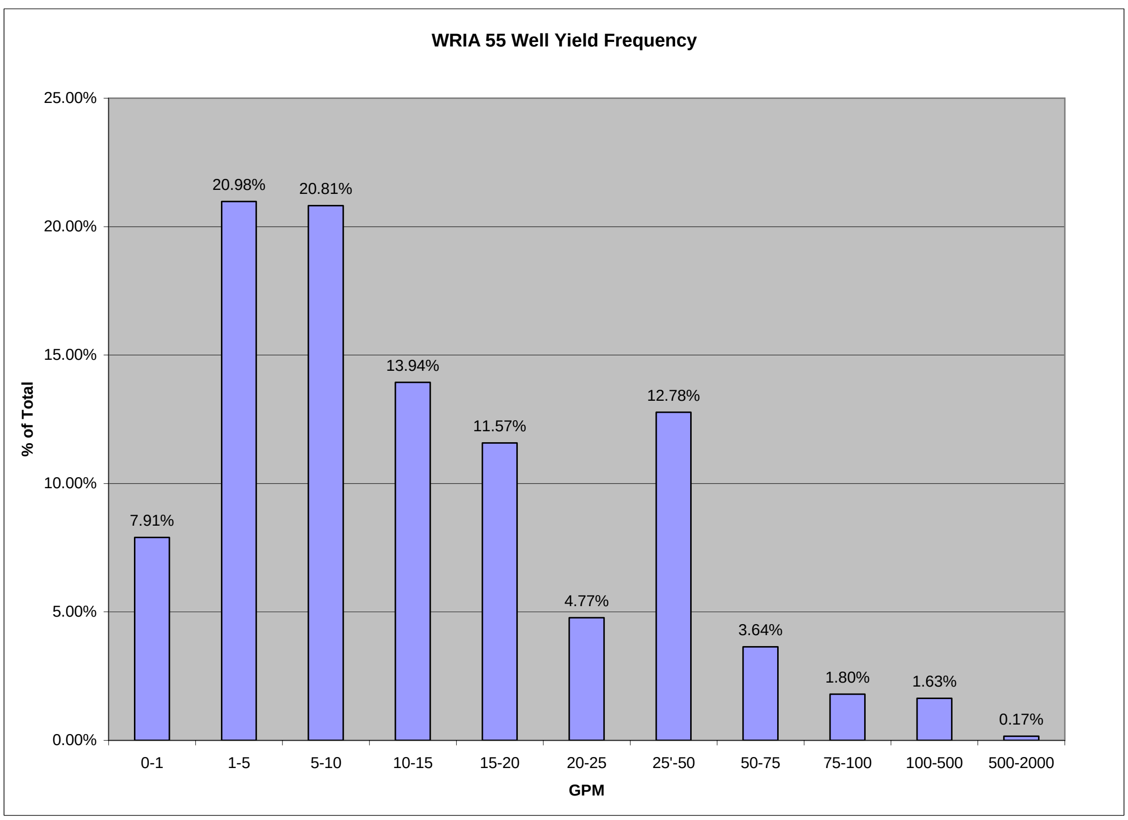


Figure 2-2

The main objective of Task 2 was to analyze the spatial distribution of well yield, static water level, and total well depth. In essence this involved estimating a three dimensional surface from scattered data points. To accomplish this task several methods are available including triangulation, inverse distance weighted, distance to point, multiple linear regression, natural neighbor, kriging, and hybrid approaches. Kriging, a geostatistical technique often used in soil science and geology, was chosen because it is best suited for data that is spatially correlated and has a directional bias. Maps included in Figures 2-3, 2-4, and 2-5 show the results of the analysis of well yield, total well depth, and static water level.

When utilizing data collected by others the quality of that data is a concern. In this study a parameter of particular concern was well yield. Anecdotal evidence suggests that the reported well yield is not always accurate. This could be due to a number of factors. The reported yield is often determined by an air test, a method of using compressed air to force water out of the well, which is not considered as accurate as a pump test. The air test is usually conducted over a shorter amount of time than a traditional pump test, and there may be an incentive for well drillers to over estimate the well yield.

To test the accuracy of the reported well yield a comparison of well yield reported on the well log vs. well yield determined from a 4 hour pump test was done. Records that include the water well log and a 4 hour pump test are available for many properties in Spokane County. As part of the building permit process information on water supply must be submitted to the Spokane Regional Health District. The information includes both the well log and a 4 hour pump test completed by a certified service provider. The 4 hour pump test is considered more accurate than the yield reported on the well log.

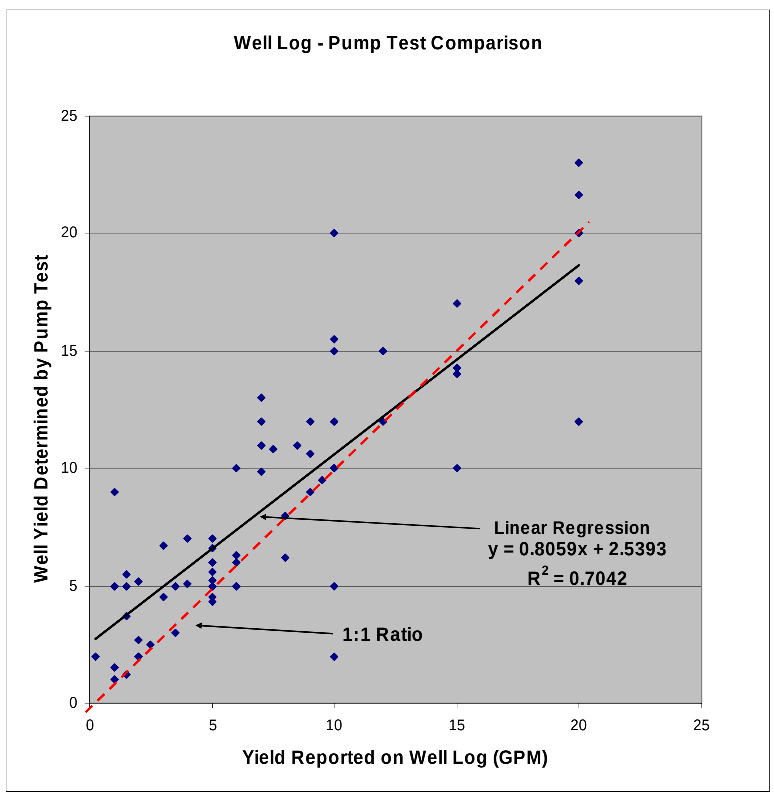


Figure 2-6

Ninety one records were compared. The well log yield values ranged from 0.25 gallons per minute (GPM) to 75 GPM. The average difference between the well log yield and pump test yield was 5.06 and the relative percent difference was 39.61%. When records above 20 GPM are excluded (17 records) the average difference was 2.24 GPM and the relative percent difference was 35.18%. Figure 2-6 shows the results of the comparison of values 20 GPM and less. A linear regression equation, represented by the solid black line, was calculated from the observed data points. The red dashed line represents a 1:1 ratio, or perfect agreement between the pump test and well log yield values.   In general the yield reported on the well log is a good estimation of the actual well yield. Additionally the linear regression line shows that for values below 13 GPM the well log yield slightly under represents the well yield as determined by the pump test and above 13 GPM the well log value slightly over represents the yield as determined by the pump test.

Task 3 - Development of a permit exempt well location and address database

The objective of Task 3 was to develop a database of well locations and addresses for all permit exempt wells currently in use in the basin. This database will be used for public outreach efforts to those that use permit exempt wells in the basin, estimates of water use, and to show the spatial distribution of permit exempt wells.

The databases developed in Task 1 and 2 do not represent permit exempt wells in current use. The database developed in Task 1 represents all wells installed in the basin according to Ecology records. These records include multiple wells drilled on a single parcel, wells that have been deepened, and wells that were installed and subsequently decommissioned. Also, these records do not include many wells that were installed before submission of well logs to the State was common or required practice. The database developed in Task 2 is a subset of Task 1 and therefore does not represent all wells.

In lieu of actual records, parcel improvement value recorded by each county assessor was used to indicate use of a parcel that would require a water source. Additionally parcels served by a water purveyor were identified. Parcels that require a water source, but are not served by water purveyor, were assumed to use a permit exempt well. The criteria used to identify use of a parcel requiring a water source was $20,000 or more of improvements as recorded by the county assessor. Based on this methodology the estimated total number of permit exempt wells currently in use in the basin is 8,467. The distribution by county is 6,654 in Spokane County, 888 in Pend Oreille County, and 925 in Stevens County. The map shown in Figure 3-1 shows the locations of the wells. The number of addresses associated with a permit exempt well is less than the total due to property records with no address, incomplete address and multiple parcels associated with one owner.

Task 4 - Development of a hydrogeologic database

The objective of Task 4 was to create a database of hydrogeologic data that can be used to develop conceptual models on a basin and subbasin level. Conceptual models are important tool to understanding groundwater systems including recharge, groundwater/surface water interaction, and impacts from withdrawals. The database also provides a framework to which data can be added as additional studies are conducted in the basin, and overtime a robust data set will be available for analysis.

RockWorks by RockWare Inc., a software package for geological data management, analysis, and visualization, was chosen for this project. RockWorks is comprised of two main components, Borehole Manager, and RockWorks Utilities. The Borehole Manager allows for storage of many types of data. Data pertinent to this project include a well's location, elevation, total depth, lithologic data, stratigraphic data, water level measurements, and well construction. Once stored in the Borehole Manager, RockWorks Utilities can be used to develop three dimensional lithologic and stratigraphic models, groundwater elevation maps, geologic cross sections, fence diagrams, and many other types of analysis.

The Borehole Manager is a relational database in which data is stored in a Microsoft Access Database format (MDB). The database requires parameters to be entered in particular formats, i.e. numbers, dates, text. In addition to those formats specific lithologic types and stratigraphic types require a definition. Without definition the analysis tools do not function. Rockworks does not provide standard definitions for these data types so they must be defined for each project. The following are the lithologic data types defined for this project: 1. basalt, 2. clay, 3. clay and basalt, 4. clay and sand, 5. clay with gravel, 6. existing well, 7. granite, 8. gravel, 9. previous, 10. sand, 11. sand and gravel, 12. shale, 13. soil, 14. something, 15. topsoil. Items 6, 9, and 14 are not typical lithologic types, but were added to accurately describe some well log entries. Three stratigraphic types were defined for this project: 1. unconsolidated, 2. basalt, and 3. granite.

At the completion of this Task 4 the hydrogeologic database contained 1,753 records. Data was gathered from three sources; 1. The EWU Masters Thesis (Boese and Buchanan, 1996) utilized for Task 2 (1,453 records) 2. Ecology's Well Log Database (201 records), and 3. The Colbert Landfill Remedial Investigation, Design, and Action (87 records). The collection and analysis of geologic data is complicated by several factors. Well log data is collected by a many drillers over many years. Lithologic descriptions are varied in detail and nomenclature. Well location data is often only accurate to the ¼ ¼ section and many times misrepresented. Water level data is collected shortly after the well is completed and may be impacted by slow recovery. Water level data also spans many years and is collected during different seasons. Below is a summary of the data selection, processing and representation.

The majority of records that comprise the database were from the EWU Masters Thesis (Boese and Buchanan, 1996). This data existed in a tabular format that included the location, elevation, water level, and lithologic descriptions. Location information is accurate to the ¼ ¼ section, or 1,320 feet. Elevation was determined from USGS 7.5 min topographic maps with 10 foot contours. Lithologic descriptions were in a uniform format similar to the lithologic type definitions for the project. The data was formatted and imported into RockWorks. The ability to import the data facilitated the addition of significant amount of data in a short time. Data from this source only covered the southern portion of the basin.

The second source of data was the Ecology Well Log database which provided data for areas not covered by the EWU Masters Thesis (Boese and Buchanan, 1996). The well logs are available for download from Ecology's website in a PDF format which requires hand entry of data into the RockWorks database. A density of at least one well log for each section within the basin was achieved. While a higher density is desirable budget constraints allowed for this amount of data collection. Two criteria were used in selecting well logs: 1. depth - well logs were chosen that were at least 100 feet in depth and most were greater than 200 feet, and 2.

location data – well logs were chosen that had data, such as a tax parcel ID or an address, which allowed location of the well beyond ¼ ¼ section accuracy. Once selected, the location information - either tax parcel ID or address - was used in conjunction with an aerial photo to determine the latitude and longitude of the well. Wells were assumed to be in close proximity to the residence on the parcel, and while this is not always the case it is a reasonable assumption given that it is preferred to have a well near the place of use to minimize the amount of infrastructure needed to deliver the water. Elevation was determined from the USGS National Elevation Dataset. Well log lithologic entries vary greatly from one well log to another, but as discussed above RockWorks requires standard entries. As lithology data was entered into RockWorks each well log entry had to be categorized as one of the defined lithologic types. In addition to the standard entries, the actual verbatim well log entry was recorded in the comment section of each lithology record so that the further examination of the data could be conducted at a later time if necessary.

The third data source was data collected in support of the Colbert Landfill Remedial Investigation, Design, and Action. The data is groundwater elevation measurements and did not include lithology. Groundwater elevation measurements in support of this project date back as far as 1986 and in some locations provide measurements as frequent as 1 month intervals.

In addition to lithologic, location, elevation, and groundwater elevation data, stratigraphic data was added to many, but not all records. Stratigraphic data is different than the other types of data. Instead of direct entry from a data source stratigraphic data is interpreted from lithologic data. Stratigraphy is essentially lithologic groups that describe interpreted geologic formations. Entry of stratigraphic data required evaluation of the lithologic descriptions to determine the depth intervals of each stratigraphic unit. Given the complexity of lithologic data and the inherent data discrepancies, visualizing stratigraphic data is useful, especially at the basin scale.

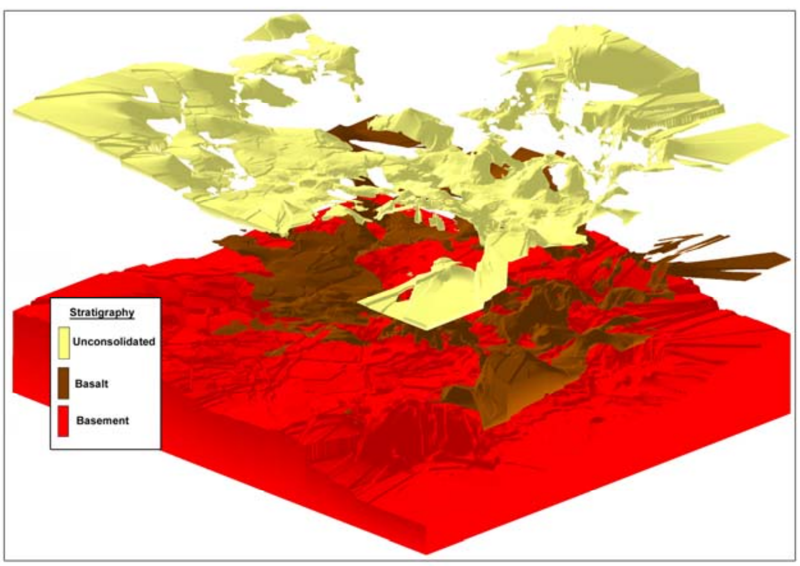


Figure 4-1

The compilation of all three data sources in RockWorks provides a comprehensive data set for analysis and development of conceptual models. Figure 4-2 shows a three dimensional representation of the data. While not the objective of this project, some initial analysis of the data was completed. The database was utilized to develop a three dimensional stratigraphic model shown in Figure 4-1. Visualizing the stratigraphy in three dimensions is useful for getting a general sense of the basin geology, but the model is especially useful by taking slices of the model to create geologic cross sections. Figure 4-3 shows four cross sections correlated with well yield. Two observations derived from this figure are: 1. high yield areas that are intersected by cross section C and cross section D occur in areas of basalt, and 2. the Little Spokane River is underlain by granite, or other crystalline basement rock, in the northern portion of the basin and unconsolidated material in the southern portion which likely impacts the connection of groundwater and surface water. This preliminary analysis demonstrates the utility of the tools developed in this project to create conceptual models of groundwater systems in the basin.

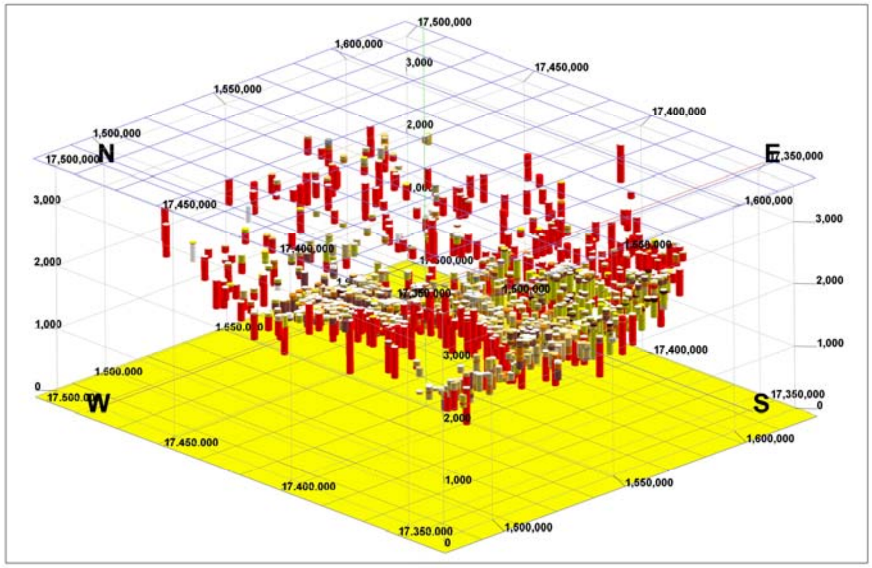


Figure 4-2

Task 5 - Collection of stream flow data for the basin

The objective of Task 5 was to collect available steam flow data for the basin and assemble it into a format that can be readily used with the hydrogeologic data complied for this project. Stream flow data was compiled from both long term gage sites and data generated for project specific purposes, often water quality studies which use stream flow data to calculate pollutant loading. Fifty five measurement locations, shown in Figure 5-1, were identified for this project. The chart provided in Figure 5-2 shows the time periods for which data is available at a measurement location. A spread sheet work book was developed that contains all data. The work book contains a separate worksheet for each location and one worksheet that is a consolidation of all data. The consolidated worksheet has one common column for the measurement date so that measurements taken on the same day or within a range of dates can be identified.

Task 6 - Evaluation of existing monitoring infrastructure

The objective of Task 6 was to identify any existing infrastructure, i.e. wells, that could be utilized for future groundwater elevation monitoring programs. Two considerations make utilizing existing infrastructure desirable; 1. the cost of installing new monitoring well is significant, and 2. historical data is often available for existing wells. For this project wells that could be used for continuous monitoring and wells that could be used for periodic measurement were identified.

Seven wells, shown in figure 6-1, are available for continuous monitoring. These wells are owned by either Whitworth Water District, Spokane County Water District 3 or Department of Ecology. The wells are located in the southern half of the basin and four are in close proximity to the Little Spokane River. Below is a short description of each well.

- Whitworth Water Location 1- Located south of Little Spokane Drive on Shady Slope Road. It is a production well on emergency standby status and is used on a limited basis. Currently the Department of Ecology has a data logger installed in this well.

- Whitworth Water Location 2-This well was owned and operated by the North Glen Water Association until it was discovered that the well was contaminated. Whitworth Water District now serves the area and owns the well. The well is located approximately 2.5 miles south of Chattaroy and is in close proximity to the Spokane River.

- Whitworth Water Location 3 – This well was owned and operated by the ______ water system until __. Whitworth water now serves the area and owns the well. The well is not currently used. It is approximately 2.5 miles north of the Dartford Gage.

- Water District 3 Location 1 – This well is located at 28411 N. River Estates Drive, approximately 2 miles north of Chattaroy near the Little Spokane River. The well is located approximately 10 feet away from a production well and would be influenced during pumping.

- Water District 3 Location 2 – This well is located approximately ½ mile north east of the Dartford Gage. The well is currently used to irrigate a park but could be dedicated for monitoring and park irrigation supplied from a different well. This well is also located near a production well and would be influenced during pumping.

- Department of Ecology Chattaroy Well – This well is located approximately 2.75 miles north west of the Little Spokane River. It is on Perry Road ¾ of a mile north of Owens Rd. The well is currently equipped with a Department of Ecology data logger.

- Department of Ecology Deer Park Well – This well is located just north of Deer Park. The well is not currently equipped with a data logger.

There are two opportunities for periodic water level measurement that would build on historical data. The Deer Park Ground Water Characterization Study Hydrogeologic Summary Report (1992) completed by Emcon contains water level measurements taken in 1991 and 1992 for 55 wells. There is sufficient information to determine the owner and location of 21 wells. The EWU Master Thesis (Boese and Buchanan, 1996) discussed previously contains water level measurements taken in 1996 for 36 wells. There is sufficient information to determine the owner and location of all 36 wells. Periodic water level measurement at these wells could provide insight on long term ground water elevation trends.

Task 7 - Evaluation of development potential within the basin

The objective of Task 7 was to assess the number of potential new residential units that could be built in the basin given the allowable density according to the latest comprehensive plan and zoning for each county. This is often called a build out analysis.

The data pertinent to the build out analysis was available in a GIS format which enabled analysis at the parcel level. The analysis encompassed the following steps:

1. Identify all parcels within WRIA 55;
2. Identify parcels not served by a water purveyor. The corporate boundaries on file with the Boundary Review Board were used to identify parcels not served by a water purveyor. In some cases water service is provided outside of this boundary, but determination of those parcels was outside the scope of this project and is likely small in comparison to the total number of parcels analyzed.
3. For each parcel outside a water service area 6 pieces of information were determined
    1) Total acreage;
    2) Allowable density according to the comprehensive plan;
    3) Acreage of critical areas that reduce the buildable acreage of a parcel including wetlands, 100 year flood plain, and geologic hazards; (Critical area GIS data was not available for Stevens or Pend Oreille County)
    4) Value of improvements associated with the parcel;
    5) Effective acreage (total acreage – acreage of critical areas); and
    6) Utilization (effective parcel size/minimum allowable density).
4. Parcels were placed in five groups:
    1) Parcels with an effective size at or below the minimum allowable density (utilization less than 2) and have greater than $5,000 worth of improvements,
    2) Parcels with utilization less than 2 and have less than $5,000 worth of improvements,
    3) Parcels with utilization greater than 2 and greater than $5,000 of improvements, and
    4) Parcels with utilization greater than 2 and less than $5,000 of improvements, and
    5) State lands and transportation routes.
5. The final calculation was:

Potential Residential Units = (Type 2 parcels) + (Type 3 parcel utilization – 1) + (Type 4 parcels utilization)

Table 7-1 presents the build out analysis results. In addition to the analysis discussed above two other factors were analyzed: 1. how many residential units are derived from forest lands owned by timber companies, and 2. how many residential units are outside the Boundary Review Board boundary but inside the future water service areas as identified in the Spokane County Coordinated Water System Plan. The build out analysis was also coupled with the estimated spatial distribution of well yield to analyze the number of potential residential units in areas of limited water availability (Table 7-2).

Table 7-1 Build Out Analysis

Parcel Type	Potential Residential Units			
	Spokane County		Stevens County	Pend Oreille County
	Within CWSP	Outside CWSP		
Undeveloped parcels without further subdivision potential	3,080	1,705	1,052	1,964
Undeveloped parcels that can be subdivided	2,395	1,597	114	2,635 (1263 RU2.5)
Developed parcels that can be subdivided further	829	921	12	733
Forest land owned by Timber Companies	0	589	Included in other parcel types	1,416
Subtotal	6,304	4,812	1,178	6,748
Total	11,116			
WRIA 55 Total	19,042			

Table 7-2 Potential Residential Units and Estimated Well Yield

Estimated Well Yield (GPM)	Potential Residential Units			
	Spokane County		Stevens County	Pend Oreille County
	Within CWSP	Outside CWSP		
0-5	431	1278	281	429
5-10	1392	2,276	358	2,239
10-15	926	1,497	113	1,988
15-20	720	1,139	80	6,41
20-25	359	588	35	2,20
25-30	107	361	17	23
30-35	53	111	9	3
35-40	67	152	38	-
40-50	52	75	11	-
50-70	18	122	-	-

Project Data Products

<u>Tabular:</u>

1. WRIA 55 All Well Logs-Date Installed & Deepened.xls *(Task 1)*
2. WRIA 55 Depth-Static-Yield.xls *(Task 2)*
3. Analysis-NOI & Well Log Data.xls *(Task 1 & 2)*
4. LSR Stream Flow-Consolidated List.xls *(Task 5)*
5. LSR Flow Data Summary-Time Distribution.xls *(Task 5)*

<u>GIS:</u>

Shape Files

1. WRIA55_All_Well_Logs.shp Task *(Task 1)*
2. WRIA55_Depth_Static_Yield.shp *(Task 2)*
3. Stream_Flow_Locations.shp *(Task 1)*
4. Rockworks_Borehole_Locations.shp *(Task 4)*
5. Water_Level_Sites_Emcon_Study.shp *(Task 6)*

6. Water_Level_Sites_Masters_Thesis.shp *(Task 6)*
7. Current_Exempt_Well_Estimate.shp *(Task 3)*
8. Potential_Well_Monitoring_Sites.shp *(Task 6)*

Raster Files-

1. WRIA55_Well_Yield *(Task 2)*
2. WRIA55_Static_Water_Level *(Task 2)*
3. WRIA55_Total_Well_Depth *(Task 2)*

Rockworks:

1. LSR.mdb *(Task 4)*

Next Steps

As stated in the introduction, it is a priority of the WRIA 55/57 WIT to investigate the impact of permit exempt wells on aquifers and stream flows within WRIA 55. This project was the first step. Through this project data sets and tools were developed to better understand the hydrogeology of the basin, the spatial distribution and growth of permit exempt wells, spatial distribution of well characteristics (total depth, static water level, and well yield), potential areas of limited water availability, and future growth and its impact on water resources.

The following are recommendations for future study that build upon the efforts of this project:

1. Conduct seepage runs on the Little Spokane River to determine the location and magnitude of groundwater contributions;
2. Continued development of the stream flow database;
3. Implement groundwater level monitoring at locations described in Task 7.
4. Evaluate domestic water demand patterns;
5. Continue development of the hydrogeologic database. Additions could include more wells in the northern portion of the WRIA and inclusion of screened interval on all records;
6. Evaluation of existing water rights within the basin to meet the needs of areas identified as future water service areas; and
7. Evaluation of rural residential water demand.