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TASK 2 – Pilot Project: Update Stream Classifications in High Resolution NHD

COOPERATIVE AGREEMENT NO. G10AC00432

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Introduction:

The perennial or intermittent classification of a stream is important for both scientific study and regulatory requirements. A stream's classification may determine if it will be included or excluded in regulatory procedures. For example, perennial streams are treated differently within some Idaho Water Quality Standards including Total Maximum Daily Load (TMDL) requirements. The National Hydrography Database (NHD) uses the FCODE attribute to classify River/Stream NHDFlowlines as perennial, intermittent or ephemeral. While the classification of perennial and intermittent within the NHD is accurate for many parts of Idaho, some areas are classified incorrectly or not classified at all in the NHD. Therefore, stream classification in Idaho on the statewide or regional scale is not consistent and is difficult to use for applications. The Idaho Department of Water Resources (IDWR) explored updating stream classification on a selected Subbasin that appeared to have errors in stream classification. Subbasin (SB) 17010303 (Coeur D'Alene Lake) was selected as a pilot area since 99% of the streams in this Subbasin are classified as perennial in the NHD even though many at the 1:100,000 scale are classified as intermittent.

Figure 1: Coeur D'Alene Lake Subbasin
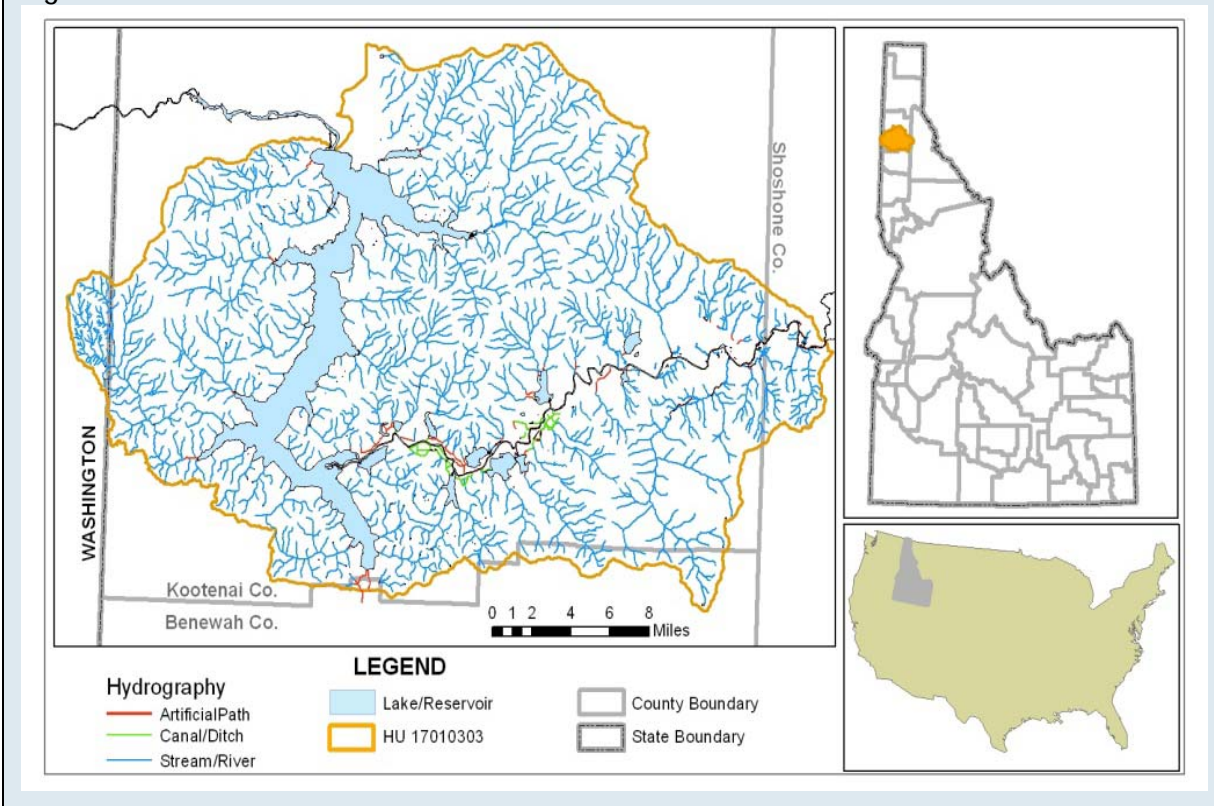
Area of Analysis – Subbasin (SB) 17010303 Coeur D'Alene Lake:

The SB 17010303, located in Northern Idaho, is approximately 400,000 acres. This SB's primary feature is Coeur D'Alene Lake which covers approximately 5% of the SB area. The Coeur D'Alene and Saint Joe Rivers are the lake's major inflows and the Spokane River is its outflow. The majority of the SB is contained within Kootenai County with some sections within Benewah and Shoshone Counties (Figure 1). The headwaters of Lake Creek in the westernmost portion of the SB are within Washington State.[i]

The vegetation of SB 17010303 consists mainly of evergreen forest with scattered shrubland. There is some agriculture, primarily wheat, lentils, clover, grass, alfalfa and other hays, concentrated around the southern portion of the SB near Coeur D'Alene Lake.[ii] The majority of the population in the SB is concentrated in the northern portion of the SB near the outflow of Coeur D'Alene Lake within the City of Coeur D'Alene (pop. 44,137). Other towns within the SB include Harrison (pop. 203), Rockford Bay (pop. 184), and Conkling Park (pop. 43).[iii] Ownership in the SB is primarily private and USFS (Idaho Panhandle National Forest).[iv] The Coeur D'Alene Indian Reservation dominates the southern portion of the SB (approximately 18% of SB's area). The SB ranges in elevation from approximately 2200 ft. in the City of Coeur D'Alene to approximately 6000 ft. near Crystal Lake.[v]

SB 17010303 Coeur D'Alene Lake in relation to other SBs in the State of Idaho

The SB 17010303 is one of the smaller SB's in Idaho. Only one other SB in Idaho is more dominated by a water feature (SB 17010214 with Pend Oreille Lake). The City of Coeur D'Alene is the 7th most populous city in Idaho and the largest city in the 10 northern Idaho counties. The Coeur D'Alene Lake SB is similar to many of Idaho's more mountainous SBs where the primary industries are or were forest products and mining.

Figure 2: Coeur D'Alene Lake Area
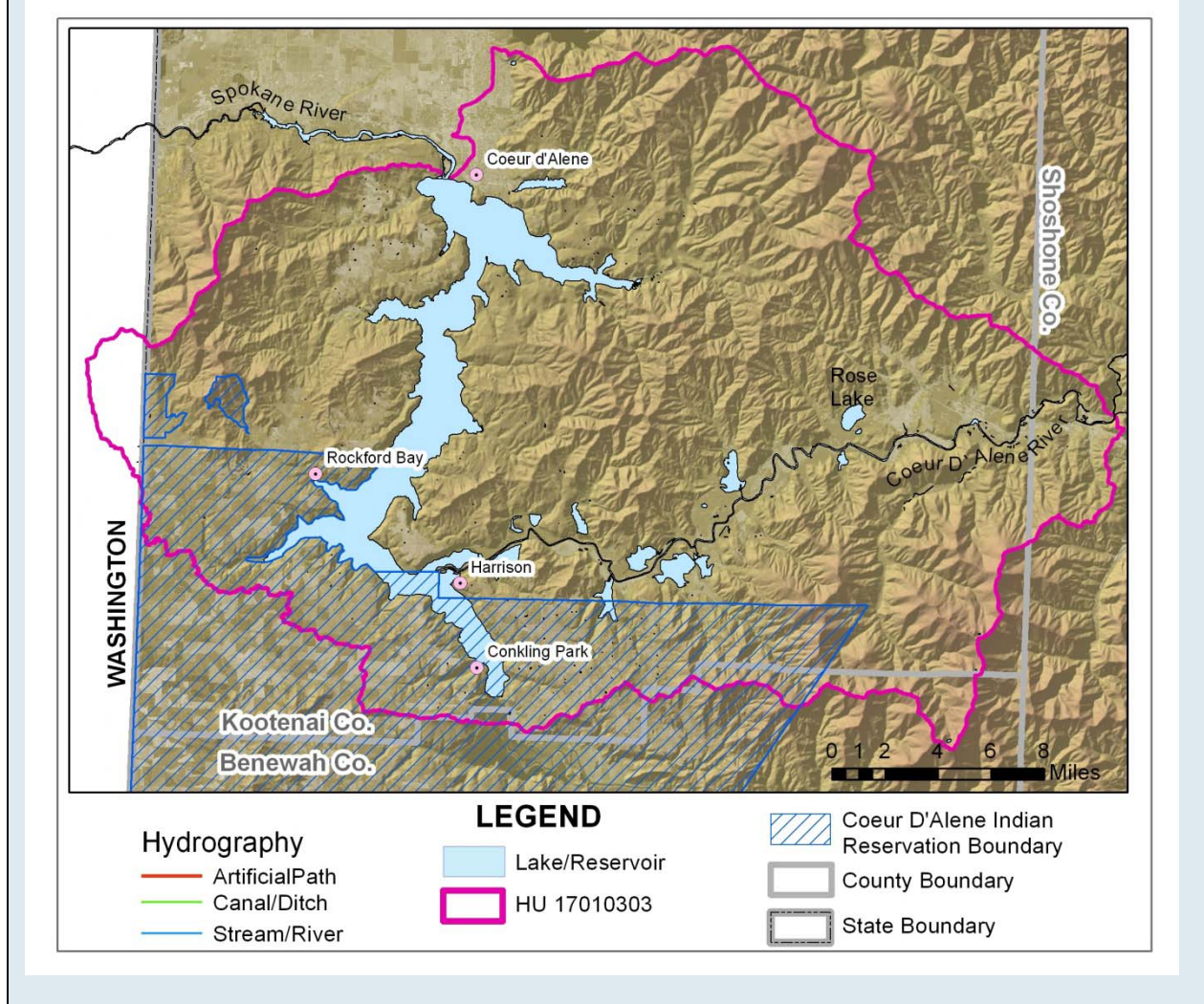
Methods and Results:

The original NHD Subbasin (SB 17010303) was downloaded as an ESRI Geodatabase from the NHD website.[vi] Analyses conducted in this project were prepared with the ESRI ArcGIS 10.0 suite of products unless otherwise noted. This analysis focused on the NHDFlowlines with the FType stream/river as these are the only linear features that maintain the intermittent/perennial attribution. There are 2766 total NHDFlowline segments in SB 17010303, 2140 segments with FType = 460 (stream/river). Of the 1937 stream/river segments that are completely in Idaho, nearly 99% are classified perennial in the NHD download (Table 1).

| Table 1: FCode Summary of FType = 460 in SB 17010303			
FCODE	DESCRIPTION	# SEGMENTS	NOTES
46000	Stream River, unclassified	1	Rose Lake Quads
46007	Stream River Ephemeral	0	
46003	Stream River Intermittent	14	Quads: CDA, Fernan Lake, Harrison, Black Lake
46003	Stream River Intermittent	161	Quad: Mica Peak (WA + ID)
46006	Stream River Perennial	1922	All in Idaho
46006	Stream River Perennial	42	Quad: Mica Peak (WA + ID)

Not all of the NHDFlowline segments split at the state boundary between Washington and Idaho. This became important as there were 203 overlapping arcs in the Washington portion of the SB. IDWR will need to work with the Washington State NHD Steward to address the linework issues before conducting an analysis of the flowline attribution in Washington. Both USGS and the Washington State NHD Steward were contacted regarding this discrepancy.

Topographic Map Comparison

USGS topographic maps provide a uniform map series that include hydrologic features and cover the contiguous United States at a large scale. These maps show the perennial or intermittent status of specific streams based on field information collected when the maps were created. The FCode of the NHDFlowlines for SB 1701303 were compared with the stream classifications on the USGS 7.5 minute (1:24,000 scale) topographic maps.

The NHDFlowline feature class was exported into a separate ESRI geodatabase. The attribute DRG_Classification was added to the geodatabase attribute table. Each flowline was compared with the stream type seen on the corresponding topographic map and attributed accordingly. Flowlines classified as artificial paths were not reviewed. A summary of the classification results is provided in Table 2. While doing the classification, 90 segments were split because the classification break on the topographic map used didn't match the NHDFlowline segment. Of the 2032 stream/river segments that are completely in Idaho, nearly 34% are classified perennial per the 1:24,000 topographic maps.

Table 2: FCode Summary after Topographic Map Classification Review			
FCODE	DRG CLASSIFICATION	# SEGMENTS	NOTES
In Idaho			
46000	Stream River, unclassified	0	
46003	Stream River Intermittent	1347	
46006	Stream River Perennial	685	
46007	Stream River Ephemeral	0	
In Washington			
46000	Stream River, unclassified	77	Not on the original DRG. All in WA
46003	Stream River Intermittent	71	WA – potential overlap
46006	Stream River Perennial	50	WA – potential overlap
46007	Stream River Ephemeral	0	

Figure 3. Topographic Map Classification
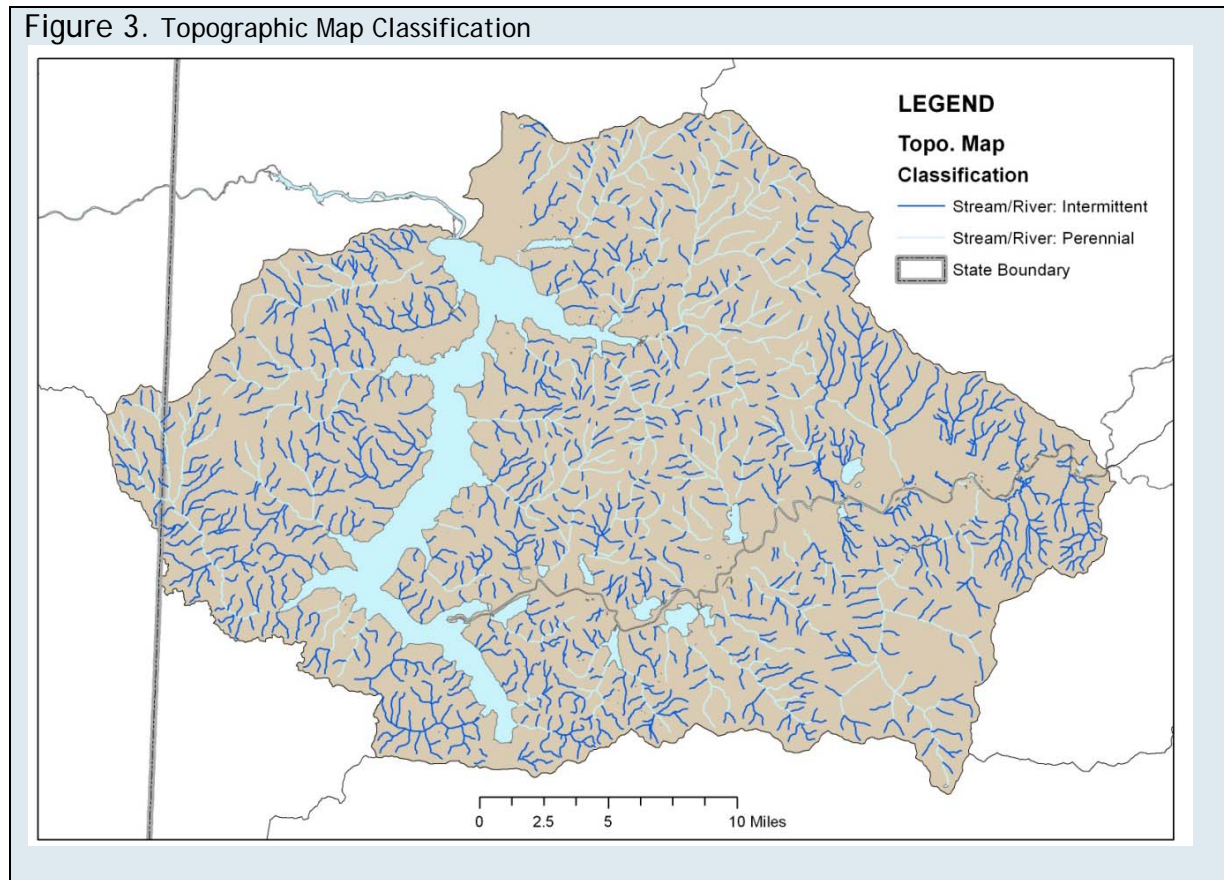
Because of technological and terrain changes over time, the cartographic representation of perennial/intermittent status of streams on USGS topographic maps is not always consistent from one adjacent map to another, nor from one edition to another.[vii] A list of the specific quadrangles used in this analysis is provided in Table

3. The 7.5-minute, 1:24,000 scale quadrangle series was officially completed in 1992, and the program has recently been replaced by The National Map.[viii]

Table 3: 1:24,000 Quads Used					
QUAD INDEX	QUAD NAME	Q100K	PHOTO YEAR	FIELD CHECK DATE	PUBLICATION EDITION DATE
F53	Rockford Bay	Coeur D' Alene	1975	1976	1981
F54	Mica Bay	Coeur D' Alene	1975	1976	1981
F55	Mount Coeur D'Alene	Coeur D' Alene	1975	1976	1981
F56	Lane	Coeur D' Alene	1975	1976	1981
F57	Rose Lake	Coeur D ' Alene	1977	1980	1985
F58	Cataldo	Coeur D' Alene	1977	1980	1985
F52	Mica Peak	Spokane	1972	1973	1973
G2	Setters	Rosalia	1975	1976	1980
G3	Worley	Saint Maries	1975	1976	1981
G4	Harrison	Saint Maries	1975	1976	1981
G5	Black Lake	Saint Maries	1975	1976	1981
G6	Medimont	Saint Maries	1975	1976	1981
G7	Rochat Peak	Saint Maries	1947	1950	1952
G8	Twin Crags	Saint Maries	1948	1950	1952
F3	Post Falls	Coeur D' Alene	1975	1977	1981
F4	Coeur d'Alene	Coeur D' Alene	1975	1977	1981
F5	Fernan Lake	Coeur D' Alene	1975	1976	1981
F6	Wolf Lodge	Coeur D' Alene	1975	1976	1982
F7	Skitwish Peak	Coeur D' Alene	1977	1980	1985

Comparison of USGS Estimated Perennial Streams

IDAPA 58.01.02.010.51 defines Intermittent Waters as "A stream, reach, or water body which naturally has a period of zero (0) flow for at least one (1) week during most of the year. Where flow records are available, a stream with a 7-day, 2-year annual ($7Q_2$) hydrologically based unregulated flow of less than one-tenth (0.1) cubic feet per second (cfs) is considered intermittent. Streams with natural perennial pools containing significant aquatic life uses are not intermittent."[ix] Using regression equations in conjunction with a GIS technique known as weighted flow accumulation that allows for estimation of $7Q_2$ stream flow along a stream, an attributed synthetic stream line dataset based on 10M National Elevation Dataset (NED) data was created

by USGS scientists. The USGS publication "Estimated Perennial Steams of Idaho and Related Datasets: USGS Data Series 412" (Data Series 412) included a synthetic stream line dataset of perennial streams in Idaho created by this methodology.[x] The Synthetic Stream Dataset only indicated perennial streams. If a stream segment is not in the dataset, it is assumed not to be perennial but intermittent or ephemeral.

The attribution indicating perennial streams consists of three PerCode values which specify error ranges. A PerCode of "1" for the error range of less than 0.1 ft^3/s, PerCode of "2" for the error range greater than 0.1 ft^3/s, and PerCode of "3" for $7Q_2$ values greater than the error ranges.[xi] The smaller the error range, the more likely a segment is a transitional reach. The attributes of the synthetic stream line dataset have been transferred to the medium resolution NHD (1:100,000 scale) for Idaho, but have not been associated with the high resolution NHD (1:24,000 scale). During this stage of the project, the synthetic stream line dataset was associated with the high resolution NHD of SB 17010303 using linear referencing tools.
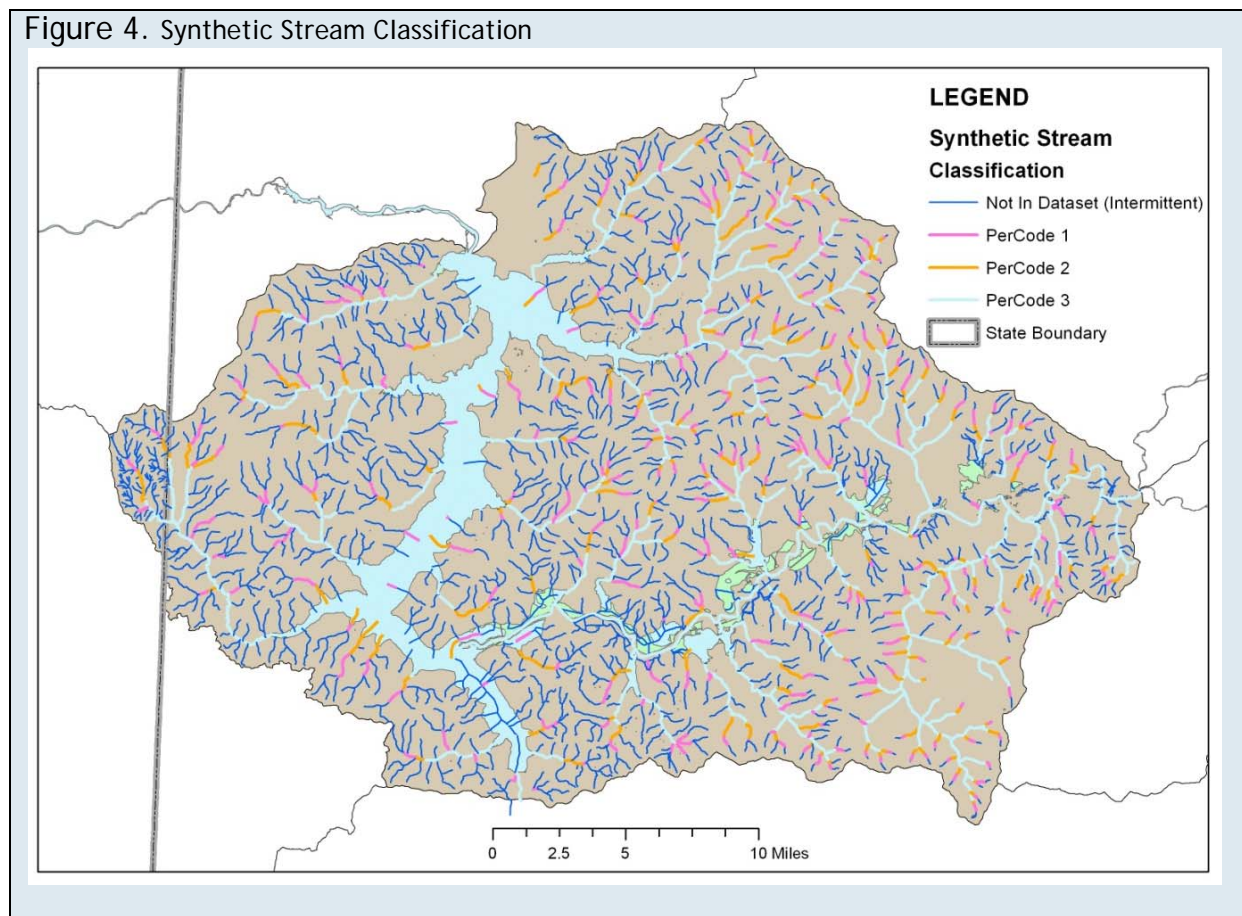
Event Methodology

The first step was to clip the synthetic stream line dataset from Data Series 412 to the boundary of SB 17010303. Then an Event Table using the ArcGIS *Locate Features Along Routes Tool* was created. (For Tool Parameters, see Table 4.) A 10 meter XY tolerance was used. Tolerances of 25 m and 50 m were also tested but did not provide significantly better results than at 10 m. The ArcGIS *Make Route Event Layer Tool* was used to create a feature layer of the Event Table. The resulting layer was then exported to a shapefile. Events could have been created using the USGS Hydrography Event Management (HEM) tool. The HEM tool was not used in this pilot as the intent is to use ArcGIS Model Builder to automate the process for other possible SB's in the State.
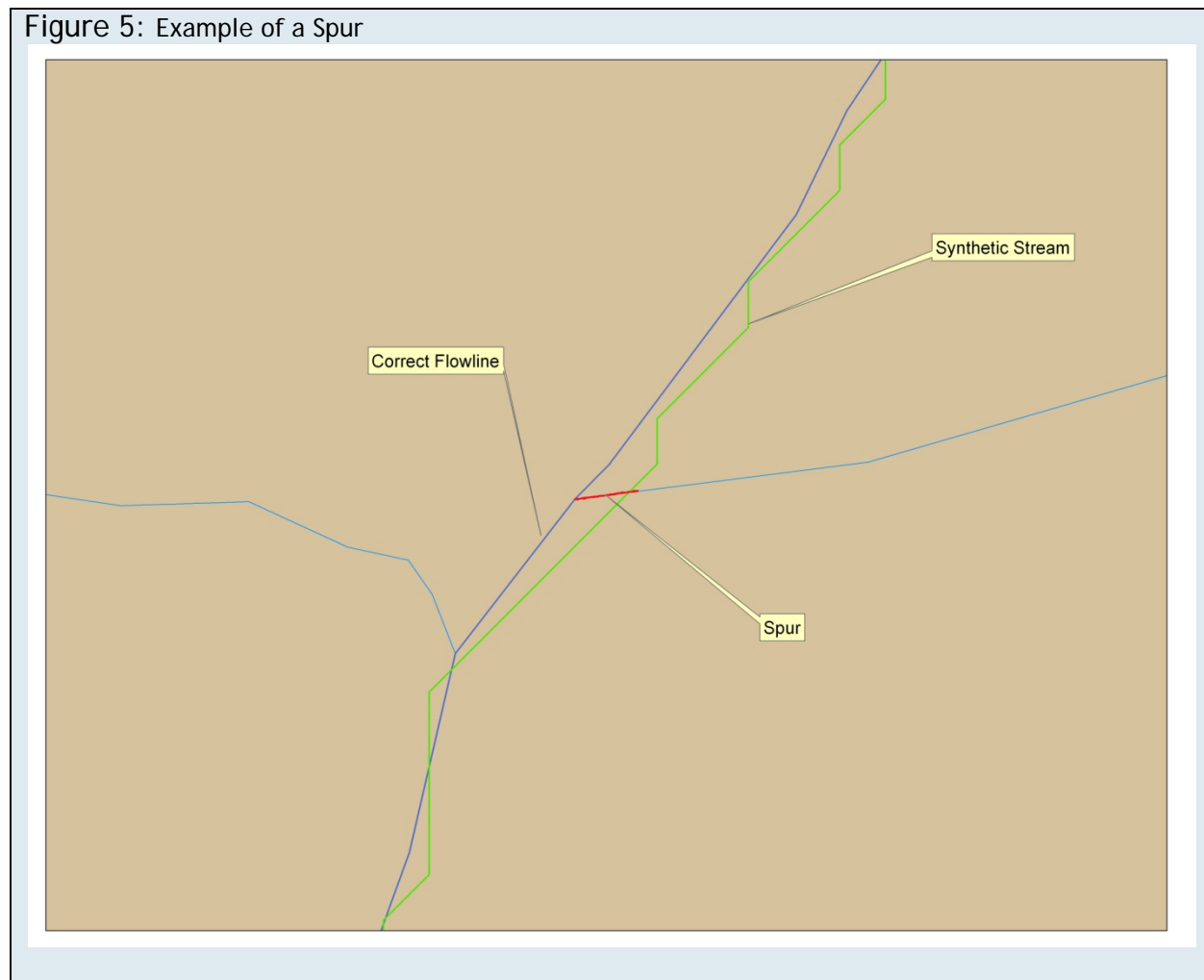
Table 4: Locate Features Along Route Tool Parameters
o **Input Features: clipped Synthetic Stream Dataset**   o **Input Route Features: NHDFlowline**   o **Route Identifier Field: ReachCode**   o **XY Tolerance: 10 meters**   o **Output Event Table: <Table Name>.dbf**   o **Route Identifier Field: RID**   o **Event Type: Line**   o **From-Measure Field: FMEAS**   o **To-Measure Field: TMEAS**   o **Checked: Include all fields from input and Use M Direction Offsetting**

The next step was to transfer the attribution from the synthetic streams (through the events shapefile) to the NHDFlowlines. Since the segments of the synthetic streams rarely encompassed complete segments in the NHDFlowlines feature class, the NHD flowlines were split based on the synthetic stream's events. This was accomplished by using the Split Lines at Points Tool on the NHDFlowlines with a zero search distance based on the first and last nodes of each line segment in the synthetic stream event shapefile. The nodes of the synthetic stream events shapefile were created using python code that is available in Appendix B. The attributes of the synthetic stream shapefile were transferred to the NHDFlowlines by selecting flowlines that share a line segment (ArcGIS *Select by Location Tool*) with the synthetic stream shapefile and calculating the attributes. Synthetic stream attributes of PerCode 1, 2 or 3 were transferred to the event classification attribute. Because the process described in Data Series 412 resulted in streams classified as perennial, if the NHDflowline was not associated with an event from the Synthetic Stream Dataset, it was classified as intermittent.

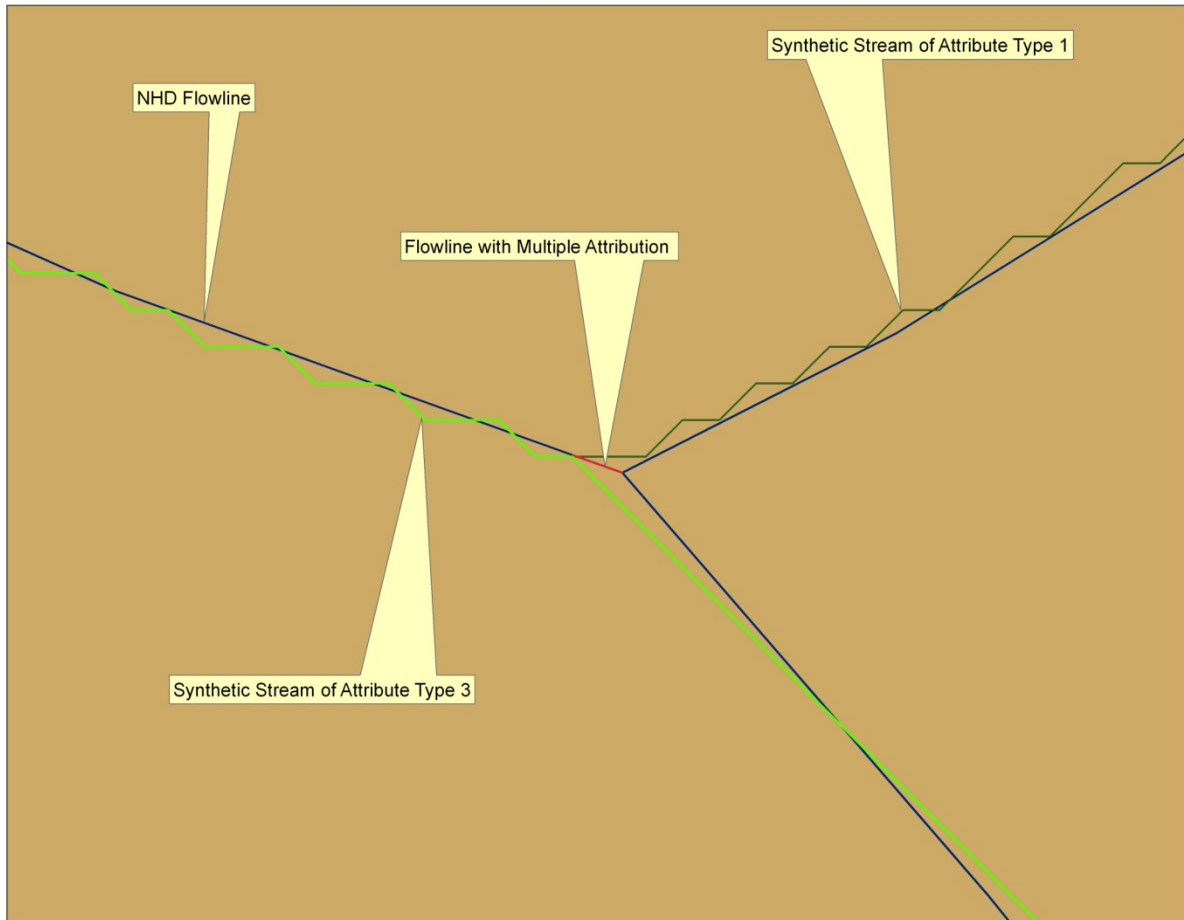Figure 4. Synthetic Stream Classification

Each newly attributed segment in the NHDFlowlines were manually reviewed to identify geography errors and attribution errors. Common geography errors included spur and missing segments. Spurs occur during event creating when a line segment is within the XY tolerance (Figure 5). These are usually small segments and often connections from streams to the artificial path of a lake or double banked stream. Approximately 6% of the attributed segments were spurs. A NHDFlowline segment may not have been matched and hence was missing an event because it was further from the synthetic stream than the XY Tolerance. These segments were often seen as breaks in the downstream flow from one attributed segment to another.

Figure 5: Example of a Spur

A common attribution error occurred when an NHDFlowline segment had two events associated with it. This error occurs most often when two or more, smaller synthetic streams converge into a larger tributary (Figure 6). This results in an NHDFlowline segment being within the XY tolerance of more than one synthetic stream segment. If the overlapping events have the same attribution, the error is not noticeable. If

the overlapping events have different attribution, the correct attribution must be manually selected. Approximately 2% of the attributed segments had multiple attributions.

Figure 6: Example of flowlines with Multiple Attributions

Point-Trace Method

A point-trace methodology was also attempted in order to match the Synthetic Stream Dataset to the NHDFlowlines. The premise of this methodology is to take the first and last nodes of original Synthetic Stream Dataset from Data Series 412, snap the nodes to the nearest NHDFlowline, create flags of the first nodes and barriers of the last nodes, then trace along the NHD Hydro-Net using ArcGIS Utility Analyst

between the first and last nodes of matching segments. This methodology was abandoned for the following reasons:

1) The Utility Network Analyst could only trace a segment one at a time.   This caused this methodology to be extremely time consuming.
2) The trace often selected the segment upstream of the flag (first node).
3) Due to snapping tolerances, barrier nodes near confluences can snap to the opposite fork, effectively placing the barrier upstream of the trace.
4) Rebuilding of the network after the segments were split at nodes required an ArcGIS ArcInfo licensing level.

Comparison to Verification Data

USFS Road Survey Data

The U.S. Forest Service, Panhandle National Forest (USFS) provided 119 locations within the SB where road culvert surveys were conducted. Only 31 of the locations were within 25 meters of an NHDflowline. Those 31 points were overlaid on the 2009 NAIP imagery to confirm that they were on roads that crossed the NHDflowline, and not running parallel to it. The majority of locations greater than 25 meters from an NHDflowline were on roads that did not cross the NHDflowlines and appear to be on culverts of unmapped/smaller draws.

USFS Field Observation Data

The USFS provided 27 field observation locations. Twenty three of the locations were linear reach descriptions (had an upstream and a downstream location description) while 3 had only a single location description and one did not have a lat/long description. One of the linear reach nodes was incorrect therefore it was discarded and the remaining node location was added to the single location file. Of the 22 valid linear reach descriptions, lines were created using the Points to Lines Tool (line field = tributaries). As to be expected, the longer the distance between the upstream and downstream location, the greater the discrepancy between the NHDflowline and the newly created line.
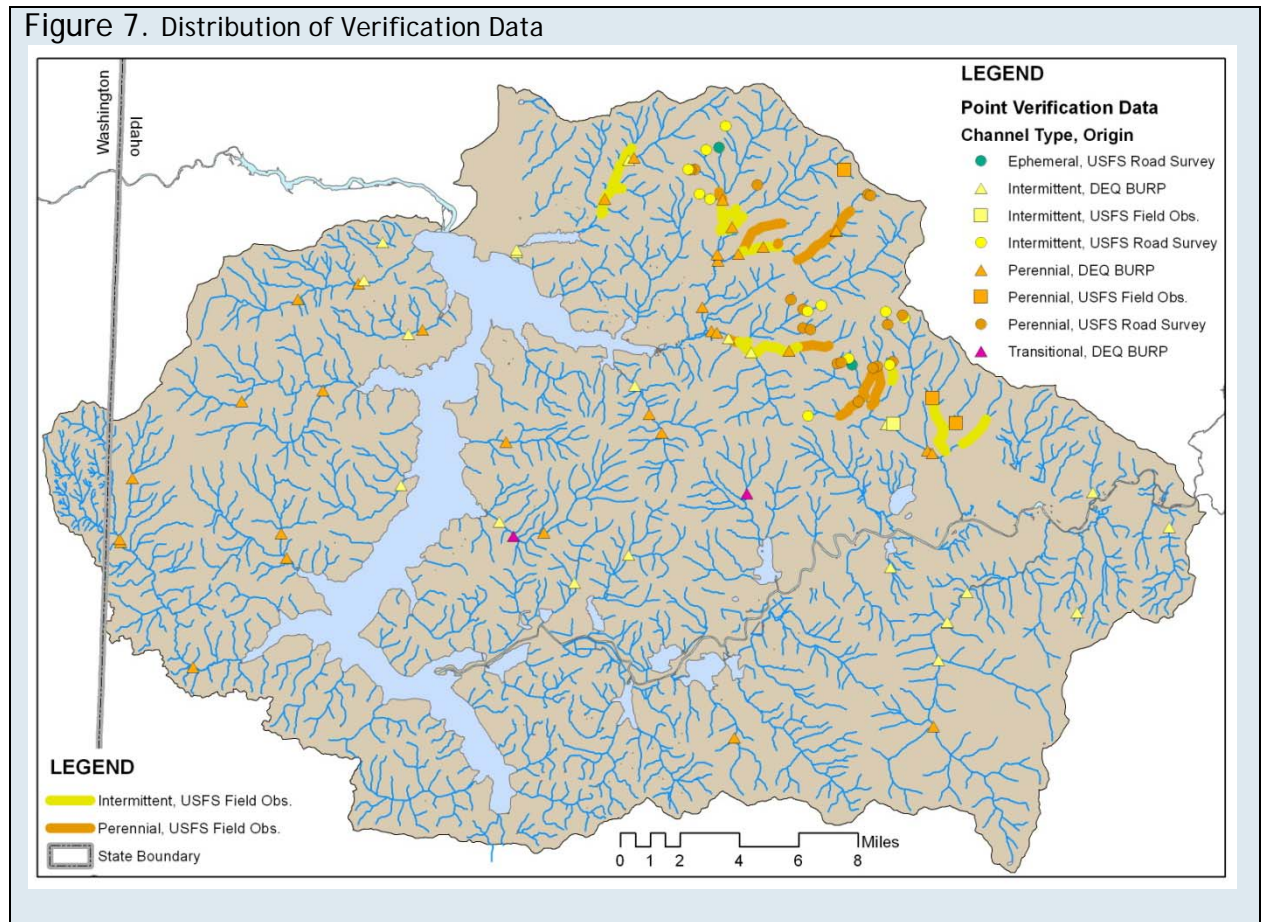
DEQ BURP DATA

The Idaho Department of Environmental Quality (DEQ) provided 70 points from the Beneficial Use Reconnaissance Project (BURP) Monitoring Results Data for use in this project. BURP data reported flow in cubic feet per second (cfs). Based on the IDAPA 58.01.02.010.51 Intermittent Waters definition, any location with a cfs greater than 0.1 was classified as perennial and any location with a cfs less than 0.1 was classified

as intermittent.[xii] If measurement equaled 0.1 the location was classified as transitional.

Twelve points were not used because the BURP locations did not have useable data. Of these twelve points, ten points were not used because no measurements were taken due to lack of access and two points were not used as the location was too deep to monitor using the DEQ protocol. The remaining points were used to estimate perennial/intermittent stream classification.

Figure 7. Distribution of Verification Data

NHDflowline segments were selected using the ArcGIS *Select by Location, Intersect*. A total of 133 segments were associated with verification data from all sources. These segments were given a verification classification of either intermittent or perennial dependent upon the classification of the associated verification data.

Comparison of Classifications

There were 2766 original segments in SB 17010303. After splitting segments to accommodate topographic and synthetic stream classification results, there were a total of 3722 segments. Of the 3722 segments, 2806 segments were classified as stream/river and within the State of Idaho. The remaining segments were artificial paths or in Washington. Of the 2806 stream/river segments, 1888 segments had matching topographic map and synthetic stream attribution but no field verification data, 785 segments did not have matching topographic map and synthetic stream attributes and no field data and 133 segments had field verification data along with topographic map and synthetic stream attributes. These results are summarized in Table 5.

Table 5: Comparison Results Summary			
Classification	Description	% of stream/ river segments	Number of Segments
Intermittent	Topo map = synthetic stream, no field verification	39.8	1116
Perennial	Topo map = synthetic stream, no field verification	27.5	772
Intermittent	Topo map = synthetic stream = field verification	0.2	7
Perennial	Topo map = synthetic stream = field verification	1.5	43
[Unmatched]	Topo map <> synthetic stream, no field verification	28.0	785
[Unmatched]	Topo map, synthetic stream, or field verification did not agree	3.0	83

Forty percent of the segments were classified as intermittent and twenty nine percent of the segments were classified as perennial. For the 69% of segments where a classification was determined, if the existing NHDFlowline classification did not coincide, it was submitted to the Idaho State Steward as updates to the NHD.

For the 133 segments with field verification data, only thirty eight percent had matching topographic map, synthetic stream, and verification data. Of the 83 unmatched segments, eighteen segments were undetermined because the field verification data was either transitional, ephemeral, or there were multiple sources of field verification data that did not agree. These eighteen segments were not classified and the original NHDFlowline classification was not changed.

In SB 17010303 Idaho, 442 segments had the synthetic stream attribute, PerCode of "1". A PerCode of "1" is for the error range of less than 0.1 ft^3/s and is most likely to be a transitional reach in the Synthetic Stream Dataset. Therefore these 442 segments could be classified incorrectly as perennial.

Of the 442 segments with a Percode = "1", one hundred and fifty six segments were classified as perennial. 154 segments did not have field verification data, but were classified as perennial if the topographic classification was perennial. This was accepted because the perennial classification was the primary default classification for the NHDFlowlines in this Subbasin. Two segments had both field verification and topographic classifications as perennial.

282 segments had intermittent topographic classification and no available verification data. One segment had intermittent topographic classification and inconclusive field data. Two segments had an intermittent topographic classification and a perennical field verification classification. Additionally, one segment had both field verification and topographic classifications as intermittent. None of these segments were considered matching although should be considered for further review.

Discussion & Conclusion:

<u>Issues and Challenges</u>

1) Challenges in processing: Spur and segments with multiple attributes are barriers to the automation of this process.
2) Potential Issues with the Synthetic Stream Dataset:
    a. Transitional Areas in the Synthetic Stream Dataset: Segments where PerCode = 1 have the dataset highest error range and could be incorrectly classified as perennial.
    b. Coeur D'Alene Lake Hydrology: Glacier processes significantly impacted the watershed. It is suspected that the flows go subsurface in the lower portions of the streams early. Because of the unique hydrology, the Synthetic Stream Dataset would be expected to be more accurate at higher elevations and less accurate at lower elevations within this SB.[xiii]
3) Need for Additional Field Verification Data: Only 5% of the SB segments had verification data (data from recent field measurements).
4) Disagreement of Verification data: Some of the locations of the topographic map and synthetic stream data matched but the verification data did not. Also, there were areas where multiple measurements or sources of validation data did not match. These inconsistencies could indicate transitional areas,

differences in the seasons the validation data was taken in, or errors in the validation data.

5) Errors within the Data:
   a. Issues with the NHDFlowline: in this SB, there was a "duplication" of lines in Washington; therefore segments in Washington were not modified by this process.

Updates to this SubBasin

During this process, 950 NHDFlowlines were inserted, updated, or deleted (Table 6). There were no NHD Area or NHD Line edits. While most of the edits were made to FCode attribution, there were some additional edits made that were not part of this project. These additional edits were to fix naming and connectivity issues. Edits to SB 17010303 were made using the GeoEdit Tools and updates will be submitted to USGS for incorporation into the NHD. See Figure 8 for a representation of the changes as a result of this project.

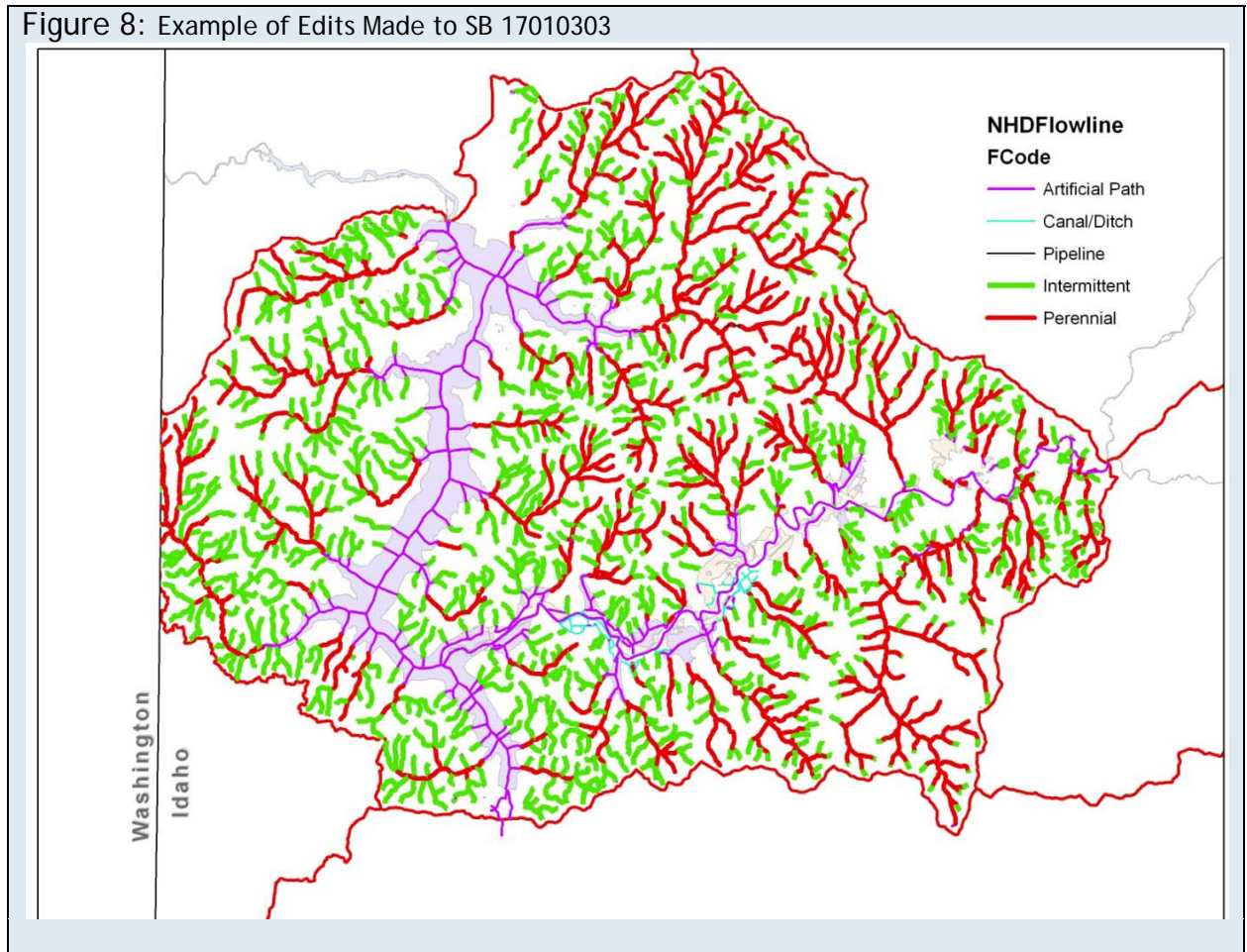Figure 8: Example of Edits Made to SB 17010303

Table 6: Number of edits for this subbasin		
NHDFlowline - FCodes		
From	**To**	**Number of Segments**
Connector (33400)	Stream/River - Intermittent (46003)	1
Stream/River (46000)	Stream/River - Intermittent (46003)	1
Stream/River - Intermittent (46003)	Stream/River - Perennial (46006)	942
Artificial Path (55800)	Canal/Ditch (33600)	1
Artificial Path (55800)	Stream/River - Perennial (46006)	5
	TOTAL	**950**

Conclusion

A Synthetic Stream Dataset with modeled perennial and intermittent flow can be used to improve the classification of streams within the Subbasin or to assist in highlighting areas that need further review. Although the dataset gives a consistent, statewide classification, special hydrologic characteristics highlight the need for field data verification. This Subbasin was unique in that the existing NHDFlowline classification was in dire need of updating.

Estimated Resource Requirement to Update Other Areas in Idaho

Based on this pilot project, a Subbasin may take as long as six weeks to update depending on the size, the amount of change, and the availability of field data in the Subbasin.

Acknowledgements:

Appendix:

A. Rea, Alan, and Skinner, K.D., 2009, Estimated perennial Streams of Idaho and Related Geospatial Datasets – U.S.G.S. Data Series 412:
http://pubs.usgs.gov/ds/412/

B. Python Code Used to Generate First and Last Nodes of a Line Segment
http://www.idwr.idaho.gov/GeographicInfo/NHD/Projects/PDF/Task2_2011_python.pdf

End Notes:

[i] Derived from National Hydrography Database:
http://viewer.nationalmap.gov/viewer/nhd.html?p=nhd
[ii] Derived from 2010 National Agricultural Statistics Service Cropland Data Layer 2010:
http://www.nass.usda.gov/research/Cropland/cdorderform.htm
[iii] Derived from 2010 Census Data: http://www2.census.gov/census_2010/01-Redistricting_File--PL_94-171/Idaho/
[iv] Derived from Surface Management Agency (Land Status) for Idaho:
http://cloud.insideidaho.org/webApps/metadataViewer/default.aspx?path=G%3a%5cdata%5canonymous%5cblm%5cRLTY_SMA_PUB_24K_POLY.shp.xml
[v] Derived from 10m NED 1/3 data: http://seamless.usgs.gov/
[vi] National Hydrography Database:
http://viewer.nationalmap.gov/viewer/nhd.html?p=nhd
[vii] Rea, Alan, and Skinner, K.D., 2009, Estimated Perennial Steams of Idaho and Related Geospatial Datasets: U.S. Geological Survey Data Series 412, p. 1
[viii] http://topomaps.usgs.gov/
[ix] http://adm.idaho.gov/adminrules/rules/idapa58/0102.pdf
[x] Rea, Alan, and Skinner, K.D., 2009, Estimated Perennial Steams of Idaho and Related Geospatial Datasets: U.S. Geological Survey Data Series 412, 32 p.
[xi] Rea, Alan, and Skinner, K.D., 2009, Estimated Perennial Steams of Idaho and Related Geospatial Datasets: U.S. Geological Survey Data Series 412, p. 15
[xii] http://adm.idaho.gov/adminrules/rules/idapa58/0102.pdf
[xiii] Email Communication with Robert Steed, DEQ; March 23, 2010