MUNICIPALITY OF ANCHORAGE STREAM MAPPING STANDARDS, Ver. 1.03

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Municipality of Anchorage Stream Mapping Standards, Ver. 1.02

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Introduction

Mapping locations of hydrographic features for the Municipality of Anchorage (MOA) and the State of Alaska Department of Transportation and Public Facilities (DOT&PF) NPDES storm water permit program will be performed to standard protocols developed specifically for the permit program. To the extent possible within the constraints of permit business functions, these protocols have been developed to match existing national and state standards. In this context, standards have been developed specifically for mapping streams, including criteria for distinguishing these hydrographic features, and for establishing mapping methodology, scale and accuracy. In addition, basic metadata for NPDES stream mapping projects have been identified. These standards will be expanded to encompass other hydrographic features (for example, lakes, wetlands and marine features) as these features are incorporated into the Municipality's hydrologic features mapping program. Performance standards for mapping stream locations are described in the following text.

Hydrography

A hydrographic model has been developed to support the watershed mapping required by the Municipality's NPDES storm water permit (EPA NPDES Permit No. AKS05255-8). The model is based on professionally accepted technical and legal definitions of hydrologic features. Definitions and criteria for use in identifying a feature as a "stream" or some other hydrologic feature are described in the Watershed Management document "Municipal Stream Classification: Anchorage, Alaska" (document number WMP APg04001, revised from an earlier version). For NPDES mapping, this document will be used as a standard in distinguishing and classifying stream features.

Mapping Methodology

Standard methods for mapping Municipal stream features are necessary to ensure mapping efficiency and consistent data quality and to allow users to select and apply comparable data. Because mapping is required at different accuracies and resolutions, methodologies have been developed to support a hierarchy of mapping "levels". Five qualified mapping levels and one unqualified mapping level are supported under the Municipality's NPDES hydrography mapping program:

Unqualified Mapping (null field value)

1. Photo Interpretive Mapping
2. Reconnaissance Mapping
3. Base Map Survey
4. Low-Resolution Controlled GPS Survey
5. High Resolution Controlled Land Survey

In general, the MOA will perform new hydrographic mapping to provide systematic improvement in stream geographic and attribute information for whole streams. However, different levels of mapping accuracy will inevitably result along individual streams. Some segments of streams are already mapped at a high level of accuracy. Investigators may also perform higher resolution mapping along discrete segments of streams where more detailed information is later required, independent of the mapping resolution of the rest of the stream. Therefore, the accuracy ("level") of mapped information for watercourses is a quality attribute that will be assigned to segments of hydrologic features and not to whole streams. At all mapping, levels, stream map accuracy is assessed with respect to the true ground position of the stream centerline. Each of the five major mapping levels is described in detail in the following text.

Unqualified: Legacy and Other Map Sources

As computer and survey technologies have improved, means to inexpensively and accurately locate and represent geographic features has expanded. Increased data storage capacity has allowed mappers to attach metadata (data about mapping methods and sources) to the geographic data itself. As these technologies and mapping resources become available, old mapping is supplanted by new map data and its metadata. However, until new mapping can be performed, in some areas old mapping will be used to provide basic geographic information. Unfortunately, though source information is usually available for this mapping, other information about the map data quality or mapping criteria often is not. Where the Municipality has incorporated hydrographic data into its datasets with incomplete or unknown data quality, no mapping level will be assigned and mapping level will be left as a null value. Thus Municipal map data with an unqualified map level is of unknown accuracy or quality and, in fact, data may have either high or low accuracy. For substantial (usually headwater) reaches of streams that have not been mapped by the Municipality, the Municipality maintains a 'legacy' stream coverage ("LStreams") as a separate dataset that can be used in conjunction with Municipal stream mapping coverage ("MStreams") to show complete stream networks.

Level 1: Photo Interpretive Mapping

At this mapping level all watercourse or other mapped features are interpreted through use of existing ("legacy") mapping and aerial photography. This mapping method represents a level of effort that focuses on initial, fast, economical characterization and location of hydrographic features. No field verification or other quality assurance testing is performed. However mappers include features at this mapping level only where sufficient photo indicators or existing field information or mapping substantiate the presence of a stream feature. This means that unknown smaller stream features (typically with bank-full widths of one meter or less) may not be identified in mapping performed at this level.

The method includes four essential steps:

1. compiling legacy and ortho-photomaps into common map projections
2. "snapping" existing mapped features to specified ortho-photomaps
3. applying photointerpretive techniques to confirm, refine and update legacy mapping
4. assigning basic segmentation and identification to mapped features.

As a first step, existing (legacy) stream maps and orthophoto maps are identified and converted to a common map projection. Source maps are compiled from any suitable planimetric map source (including hard copies) along with any available metadata (mapping method, source, date and base map projection). Ortho-photomaps are orthographic map projections of geographic features presented in a photographic format and prepared from any appropriately controlled telemetry that has been processed to correct for displacement errors resulting from tilt and relief. Ortho-photomaps may be prepared from aerial photography or from satellite imagery.

After the legacy maps have been digitally compiled and overlaid on orthophoto maps, stream centerlines of existing (legacy) maps are "snapped" (translated in the horizontal plane) to coincide with the same features observed on selected ortho-imagery. "Snapping" is manually performed while viewing the ortho-photomaps at scales of about 1:2400.

After existing mapping has been transferred and "snapped" to match ortho-photomap features, the resulting digital maps are corrected for gross location and transfer errors through photo-interpretation of recent aerial photography. It is at this point that photo-interpreters will apply Municipal hydrographic definitions and criteria to distinguish "stream" features from other types of hydrologic features (especially "drainageways"). Mappers will remove from the final mapping product those initially snapped features that cannot be located or determined to meet Municipal hydrographic criteria.

Because field checks are typically not done at the "photo interpretive" level of mapping, identifications of stream features are based substantially on the local knowledge and professional judgment and expertise of the interpreter. Typically identification and location of mapped features is determined by knowledge of the local area and by observation of photographic indicators including tonal and textural signatures, morphology (as viewed in a stereoscopic model), and presence of correlated features. Because quality of final map information is in large part dependent upon the capabilities of interpreters, these interpreters must be proficient in geologic and hydrologic sciences and in analysis of stereo aerial photography and other imagery, and have some knowledge of local geography.

Source photography or other source mapping used by interpreters must also provide sufficient detail to allow general identification and differentiation of target features to two meters or less in smallest dimension. Features not indicated through inspection of magnified stereo inspection of aerial photographic contact prints flown at a scale of 1:12000 or smaller (typically streams less than about one meter wide) may not be mapped. In general, final photo-corrected locations will be compiled so as to achieve *estimated* correct location of 95% of mapped features to within ±25 meters of their true ground position.

Finally, unique stream features identified on the completed "snapped" and photo-truthed digital maps are segmented into "reaches" and assigned identification codes. Reaches are stream management units that reflect common *contributing watershed* characteristics, *riparian terrain* and *channel slope*. The beginning and ending points of a reach are also commonly selected so as to ease their location on the ground. Sub-reaches are not typically identified during "photo interpretive"-level mapping.

Reaches are numbered consecutively starting at the downstream end of each discrete stream feature and continuing to the end of that stream feature. Identification codes assigned to unique stream features (main stems and their tributaries) must conform to standard Municipal practices (see Appendix A). Coding of Municipal streams provides a unique tabular identification for these features and provides a means of indexing stream features and segments to a number of different variables. It provides a means of deriving some stream feature characteristics (for example, stream "order"). Coding also provides a means of indexing stream segments (reaches and sub-reaches) to specific stream features, and streams and stream segments to watersheds. In a similar fashion, it provides a means of indexing stream and stream segment attribute data to many other important watershed geographic features (e.g., drainageways, outfalls, outfall basins, etc.) and their attributes. Finally, Municipal stream identifications will also incorporate, or be keyed to, available U.S. Geological Survey Hydrographic Data Model (NHD) stream coding.

Level 2: Reconnaissance Base Mapping

Reconnaissance mapping includes all elements of "photo interpretive" mapping but improves mapping resolution and accuracy through additional iterative photo interpretive and field reconnaissance efforts. At this mapping level, limited field reconnaissance is performed after initial photo interpretive corrections are made. Field reconnaissance focuses on resolving small-scale features (streams with bank full widths less than one meter wide) and in providing some confirmation and refinement of photo-interpreted locations. Level 2 mapping also commonly includes collection of reach and subreach locations using map-grade GPS technology (these data points are archived in a separate data set). However, field inspections at this mapping level are performed only with the purpose of ensuring that feature identities, locations and assigned attributes are representative and generally within stated accuracy limits. Quality control procedures do not include statistical analysis or other quantitative testing to confirm that stream centerline locations are within stated accuracy limits.

Because of the discontinuous nature of the field reconnaissance, identifications and locations of stream features remain substantially based on the professional judgment and local knowledge of the interpreter. Nevertheless, feature location accuracy and resolution is improved at this mapping level as a result of ground truthing and periodic map-grade GPS data collection. This mapping level also targets all known stream features for mapping. Though no quantitative confirmation is made of target location accuracies, final photo-corrected locations will be compiled so as to achieve *estimated* correct location of 95% of mapped stream features to within ±12 meters or better of their true ground position. Level 2 Municipal stream mapping will generally provide base map information that will conform with horizontal accuracy standards at larger map scales as specified by the Federal Emergency Management Agency (FEMA) in its "Guidelines and Specifications for Flood Hazard Mapping Partners" (April, 2003).

At this mapping level sub-reaches as well as reaches are usually identified. Sub-reaches are segments of reaches that reflect common *stream habitat*, *channel morphology*, and *stream modification* characteristics. 'Extended' stream attribute data may also be collected during reconnaissance-level mapping efforts (Table1).

Level 3: Certified Map-Grade Survey

Municipal base map stream surveys are tested and certified to conform with specific horizontal accuracy standards at select map scales as specified by the Federal Emergency Management Agency (FEMA) in its

"Guidelines and Specifications for Flood Hazard Mapping Partners" (April, 2003). Reported horizontal locations of mapped features will have a certified positional accuracy with respect to true ground position that is equal to or better than 30 feet (about 10 meters), as confirmed at the 95% confidence level.

Table 1
MOA STREAM ATTRIBUTES AND VALUES

Feature	Attribute	Values	Description
Reach	Reach Slope	0.nnnn (dimensionless)	Ratio of reach endpoint elevation change and reach length
Subreach	Flow Type	Perennial or intermittent	Spatial or temporal continuity of flow
	Routing Type	source, stem, outlet, continuity	Stream connectivity identity
	Profile Type	1-pool/riffle, 2-estuarine, 3-run, 4-braided, 5-step pool, 6-cascade, 7-bog, 8-multi-channel, 9-flat, 10-piped, 11-continuity	Stream longitudinal profile character
	Maximum Bankfull Depth	nn.n feet	Channel depth from bankfull stage at thalweg
	Mean Bankfull Depth	nn.n feet	Mean bed surface to bankfull stage
	Bankfull Width	Nnn.n feet	Mean stream width at bankfull stage
	Width/Depth Ratio	nn.n feet	Ratio of bankfull width to mean bankfull depth
	Floodprone Width	Nnn.n feet	Flood surface width at 2x maximum bankfull depth
	Entrenchment	n.n (dimensionless)	Ratio of floodprone width to bankfull width
	Sinuosity	1-s<1.2, 2-1.2≤s≤1.4, 3-s>1.4	Ratio of stream centerline length to down-valley length
	Bed Material	1-d<100μ, 2-100μ≤d<420μ, 3-420μ≤d<25mm, 4-25mm≤d <150mm, 5-150mm≤d, 6-peat/root, 7-bedrock/cemented, 8-armored	Stream bed material
	Bank Material	same as Bed Material	'In-place' bank material exposed to flow between channel bottom and bankfull stage
	Roughness	0.nnn (dimensionless)	Manning's n
	CEM Class	1-dynamic equilibrium, 2-vertical erosion, 3-lateral erosion and bed aggradation, 4-aggradation	Channel evolutionary stage
	Channel Modification	1-unmodified, 2-slightly modified, 3-moderately modified, 4-highly modified	Degree of human modification to stream channel
	Undercut Bank	1-uc≤10%, 2-10%<uc≤30%, 3-30%<uc≤50%, 4-50%<uc≤75%, 5-75%<uc	Overarching bank structure with overhang >0.5 feet; 100%=both banks
	Canopy	Same as Undercut Bank	Overarching vegetation cover over bankfull width
	Fish Habitat	Whole no. 1 to 9 (dimensionless)	Fish habitat index
	Invertebrate Habitat	Whole no. 1 to 6 (dimensionless)	Invertebrate habitat index

Level 4: Continuous Map-Grade Survey

Low-resolution controlled (map-grade) GPS surveys systematically employ GPS technology in the field to accurately locate stream features. In general, map-grade GPS data collection can be a useful means of quantitatively testing the quality of other mapping methods, where periodic point measurements may be used to test and confirm interpreted stream locations. However, at this mapping level, GPS location data are used to *continuously* map entire features. That is, map-grade GPS techniques are used to accurately locate a series of points sufficient, when connected to form a series of arcs, to accurately represent the location of part or all of a stream centerline.

In this method, "arcs" used to map stream locations are made up of a series of GPS-located points connected by straight-line segments which, taken as a whole, generally describe the *centerline* of the stream. The centerline of a stream is the line connecting the midpoints of all surface water cross sections measured at the bankfull stage. For this method reported horizontal location of the stream centerline shall have a positional accuracy with respect to true ground position that is equal to or smaller than a distance of 20% of the stream's bankfull width or 3.0 meter, whichever is larger, at a 95% confidence level.

Map-grade GPS methods used to map vertices on the centerline arcs shall control for a minimum horizontal accuracy of vertex locations of ±two (2.0) meters at a 95% confidence. Because different map-grade GPS instrument brands vary in control settings and parameters, operation protocols designed to achieve this accuracy are not readily standardized. The Municipality has developed suggested standard operational procedures based on GPS mapping-grade receivers manufactured by Trimble Navigation Limited. The following summarizes suggested SOPs that will generally support desired accuracy levels when used with this level of GPS mapping equipment .

Data Points:

• Coordinate system	lat/long, NAD83 datum (post-2004 data)
• Minimum observable satellites	≥4 satellites
• Minimum satellite elevation	$\geq 15^0$
• Minimum point occupation time	≥10 seconds @ 1sec logging interval
• Maximum point dilution of precision (PDOP)	<8 PDOP
• Minimum signal to noise ratio (SNR)	≥6 SNR

Geodetic Control Points:

• Minimum control points/project	≥2 controls
• Maximum control point spacing	≤10 kilometers
• Minimum control point occupation time	≥3 minutes @ 5sec logging interval
• Minimum control point re-occupation	≥2 times per day, each control point
• Minimum re-occupation separation time	≥2 hours

Base Station:

• Minimum satellite elevation	$\geq 10^0$
• Maximum point dilution of precision (PDOP)	≤6 PDOP
• Maximum base station/rover separation	500 kilometers

Project Management:

- List survey equipment and certify calibration once per project
- Confirm minimum 8 hour field crew training on listed equipment
- Identify telemetry signal source(s) for real time differential or base station correction
- Submit project schedule based on ephemeris charts and estimated SV elevations
- Identify, catalog and display map positions of project control points
- Perform data download at minimum of once per field day
- Submit GPS correction and control points error logs and summarize data completeness
- Export point and attribute data to ArcInfo/ArcView/*.dbf compatible formats
- Plot and link data points to show arc features and overlay on Municipal ortho-photomap

Level 5: High-Resolution Controlled Land Survey

"Controlled survey" mapping incorporates photo interpretive mapping with standardized land surveying techniques (including high-resolution GPS survey methods) to acquire accurate horizontal locations of stream features in the field. Similar to low-resolution GPS mapping, controlled survey mapping may be used to accurately locate either relatively discrete point features along a stream, or associated series of points representing the linear stream feature itself.

Mapping at this level is performed so as to meet nationally established land survey standards. Municipal Rights-of-Way officers select, review and establish acceptable Municipal survey standards. For stream location mapping, however, the method of representation of linear stream features using surveyed points must meet additional representational requirements similar to those described for "low-resolution GPS" mapping.

Useful Map Scale

Municipal stream mapping will be appropriate for viewing at different map scales, depending upon the initial feature mapping accuracy (Municipal 'mapping level'). Level 1 mapping can provide good feature location representations at map scales of 1:24000 or smaller, while Level 2 mapping will accurately depict feature locations at map scales of 1:12000 or smaller. However, often Level 2 Municipal mapping can provides useful graphic map content at a map scale as large as 1:3600. Dependent upon the selected mapping level, either all stream features will be resolved (Level 2 or better), or all stream features with a bank-full width greater than 1 meter will be resolved (Level 1). Stream attributes will be resolved as representative characteristics of whole streams or of segments of streams ("reaches" and "sub-reaches").

Accuracy

Accuracy has been discussed as an element of each of the methodologies described above. The following table summarizes accuracy standards for each of the five mapping levels.

Table 2: Municipal Stream Mapping Accuracy

LEVEL	METHODOLOGY	CONF.	ACCURACY	FEATURE	MAP SCALE
	Unqualified		Unknown	Stream	1:25000
1	**Photo Interpretive Map**	Est.	±25 meters	Stream ≥1meter	1:12000
2	**Reconnaissance Base Map**	95% @	±12 meters	Stream C/L	1:6000
3	**Certified Map-Grade Survey**	95% @	±10 meters	Stream C/L	1:6000
4	**Continuous Map-Grade Survey**	95% @	±20%BFW or ±3.0 meter	Stream C/L	1:3600
			±2.0 meter	CL vertex	
5	**Controlled Land Survey**	95% @	±20%BFW or ±1.0 meter	Stream C/L	1:1200

BFW=Bankfull Width
C/L=Centerline

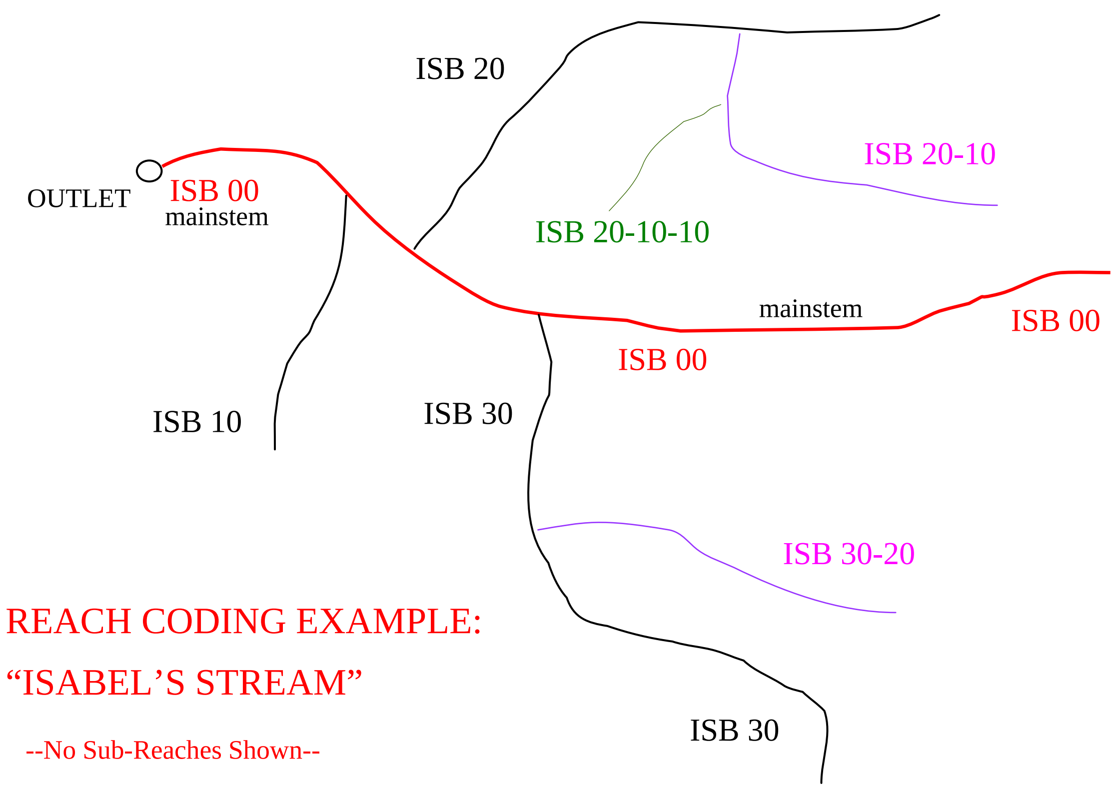
Metadata

Characterization of the quality and nature of Municipal stream mapping data is crucial to the confident and correct application and integration of this information with other data sets, and for planning for future Municipal mapping. Information about the quality and character of data is called metadata. General guidance for the development of spatial metadata has been prepared by the Federal Geographic Data Committee (FGDC, June 8, 1994: "Content Standards for Digital Geospatial Metadata", Section 2.4, *.pdf file download @ http://www.fgdc.gov/standards/documents/standards/). To the extent feasible, or as required to meet other agency requirements, metadata prepared for Municipal stream mapping projects will conform to FGDC standards. However, for ease of use, the Municipality has developed a 4-part metadata structure that provides summary and descriptive information about mapping datasets in addition to standard FGDC metadata.

Appendix A

Municipality of Anchorage Stream Identification Coding

The Municipality has developed conventions for use in assignment of unique identification codes to discrete stream features. In general, all stream features within a stream catchment basin are assigned identification codes in relation to the main stem stream feature within that basin. The main stem is first assigned a three-letter mnemonic code (which reflects the commonly used name of the main stem or the principle branch) and a numeric code, -00, which signifies its identity as the main stem or a primary tributary (i.e., generally a higher order feature in the watershed). The main stem alpha code is then concatenated with a sequence of two-digit numeric codes to create unique identification codes for each tributary to the main stem. Finally, a four place decimal number (nn.nn indicating reach.sub-reach) is assigned to specify reach and sub-reach identities.



Stepwise guidance for applying stream coding is described in the following text:

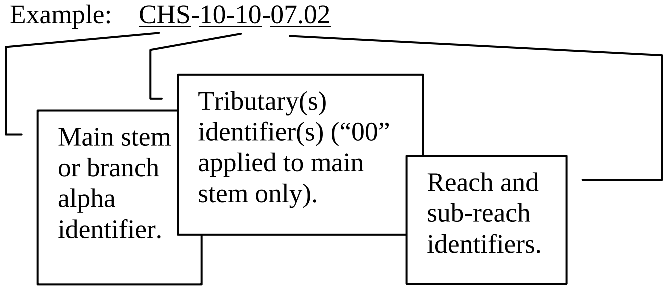
- USGS map comparability:

Compare Municipal mapping and any mapping and segmentation prepared under the U.S. Geological Survey's Hydrographic Data Model (NHD) program. Identify principle NHD network points (tributary confluences) and codification (including NHD "watershed IDs"). Establish representational identities between Municipal features and NHD features. That is, identify the extent and approximate location of features apparently common to both data sets (Municipal locations are not likely to match exact NHD locations because of differences in mapping scale). Identify on the MOA streamline dataset the approximate location of the endpoints of NHD stream features. Code each discrete Municipal stream feature with appropriate NHD identification codes, including at minimum the NHD watershed ID.

- Basic stream codification:

Code all stream reaches with a combination of: (a) a *3-letter alpha string* representing the principle main stem or branch stream, (b) a *series of 2-digit codes* representing one or more tributaries related to the main stem or branch (concatenated with dashes in text form), and (c) a *4-digit code* identifying a reach and a sub-reach respectively (concatenated with a decimal point in text form, nn.nn, with the first two digits the reach and second two the sub-reach).

Example: CHS-10-10-07.02



- Alpha mnemonics conventions for known streams:

Use unique 3-letter mnemonics supplied by the Municipality and use the suffix -"00" with the alpha string to name all main stem or branch streams currently mapped as principal watersheds in the Municipal corporate map set.

> Examples: Chester Creek main stem reach identifications will all begin with CHS-00; North Fork Chester Creek main stem reaches will all begin with NCH-00. Note that the North Fork Chester Creek main stem is prefaced with NCH-00 (by Municipal caveat) even though it is a tributary to the main stem of Chester Creek.

- New main stem identifications:

Where a principal watershed includes a number of streams and tributaries (e.g., Little Campbell Creek), first select as the main stem ("-00" stream) that continuous stream thread that is currently named and generally understood (mapped) as the main stem. In identifying the extent of any unmapped streams and tributaries, select as the main stem that continuous stream thread that receives runoff from the largest contributing area.

- New alpha mnemonic assignments:

For un-mapped or un-named streams, assign new, unique 3-letter alpha prefixes only where the un-mapped stream flows directly into marine waters or into another un-mapped or unnamed stream. For un-mapped or unnamed streams that are tributaries to existing named streams, assign the same 3-letter mnemonic to the tributary as used for the existing named stream.

Assign short alpha names to higher order streams as shown on NPDES map sets, USGS maps, MOA maps or as generally and publicly known.

- Tributary coding conventions:

Assign odd decimal numeric identifiers to tributaries entering a main stem from the right side of the main stem (as determined looking up stream). Assign even decimal numeric identifiers to tributaries entering a main stem from the left side of the main stem (as determined looking up stream). Number those tributaries closer to the outlet of a main stem with lower decimal numerals and those tributaries closer to the source of a main stem with higher decimal numerals. The same numbering convention is applied to tributaries of tributaries.

For example, the first tributary entering a main stem from the left (looking upstream) will be identified as "–20". The first tributary entering a main stem from the right (looking upstream) will be identified as "–10". The second tributary entering a main stem from the right (looking upstream) will be identified as "–30", and so on. If the principal decimal numbers become exhausted, additional unit digits will be used to uniquely identify tributaries.

- Reach/Sub-reach coding conventions:

For each stream feature, assign reach numbers consecutively starting at the outlet of each discrete stream feature. A segmented Municipal stream feature has one (1) or more reaches. For each individual reach, assign sub-reaches consecutively, as necessary, beginning at the downstream end of each reach. Each Municipal stream reach has one (1) or more sub-reaches. The first reach of a stream or tributary is numbered "01". The first (or in cases where only one sub-reach is identified, the only) sub-reach of a reach is numbered "00".

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