8.6 Riparian Instream Flow Study

8.6.1 General Description of the Proposed Study

8.6.1.1 Riparian IFS Goal and Objectives

The goal of the 2013-2014 Riparian Instream Flow Study (IFS) is to provide a physical and vegetation process modeling approach to predicting potential impacts to downstream riparian floodplain vegetation from Project operational flow modification of natural Susitna River flow, sediment, and ice processes regimes. To meet this goal, first, existing Susitna River groundwater and surface water flow, sediment and ice process regimes will be modeled relative to floodplain plant community establishment, recruitment and maintenance requirements. Second, predictive models will be developed to assess potential Project operational impacts to floodplain plant communities and provide operational guidance to minimize these impacts.

The Riparian IFS approach and format has been written to address, and to parallel, the study format proposed in the USFW Riparian IFS Request (May 31, 2012).

Riparian IFS objectives are:

1. Synthesize historic physical and biological data for Susitna River floodplain vegetation, including: 1980s studies; studies of hydro project impacts on downstream floodplain plant communities; and studies of un-impacted floodplain plant community successional processes.
2. Select Focus Areas – Delineate Riparian Process Domains.
3. Characterize seed dispersal and seedling establishment groundwater and surface water hydroregime requirements. Develop predictive model of potential Project operational impacts to seed dispersal and seedling establishment.
4. Characterize the role of river ice in the establishment and recruitment of dominant floodplain vegetation. Develop predictive model of potential Project operational impacts to ice processes and dominant floodplain vegetation establishment and recruitment.
5. Characterize the role of erosion and sediment deposition in the formation of floodplain surfaces, soils and vegetation. Develop a predictive model of Project operations changes to erosion and sediment deposition patterns and associated floodplain vegetation.
6. Characterize natural floodplain vegetation groundwater and surface water maintenance hydroregime. Develop a predictive model to assess potential changes to natural hydroregime and potential floodplain vegetation change.
7. Map and characterize Focus Area floodplain plant communities in support of developing floodplain vegetation-GW/SW regime functional groups, and forest succession models, in coordination with the Riparian Botanical Survey study.

8.6.1.2 Riparian IFS Analytical Framework and Study Interdependencies

Figure 8.5-11 depicts the overall analytical framework of the Instream Flow Studies commencing with the Reservoir Operations Model (ROM) that will be used to generate alternative operational scenarios under different hydroregimes. The ROM will provide the input data that will be used to predict hourly flow and water surface elevation data at multiple points downstream, taking into account accretion and flow attenuation. A series of biological and riverine process studies will be completed (other studies) to supplement the information collected in the 1980s as necessary to define relationships between mainstem flow and riverine processes and biological resources. This will result in development of a series of flow sensitive models (e.g., models of selected anadromous and resident fish habitats by species and life stage, models to describe invertebrate habitats, temperature model, ice model, sediment transport model, turbidity model, large woody debris (LWD) recruitment model, riparian vegetation, others) that will be able to translate effects of alternative Project operations on the respective processes and biological resources. These resource and process effects will be location and habitat specific (e.g., responses are expected to be different in side sloughs versus mainstem versus side channel versus tributary delta versus riparian habitats) but there will also be a cumulative effect that translates throughout the entire length of the Susitna River. Different Project operations will likely affect different habitats and processes differently, both spatially and temporally. The habitat and process models will therefore be spatially discrete (e.g., by site, reach) and yet able to be integrated to allow for a holistic evaluation of each alternative operational scenario. This will allow for an Integrated Resource Analysis of separate operational scenarios that includes each resource element, the results of which can serve in a feedback capacity leading to new or, modifications of, existing scenarios.

The Riparian IFS is an interdependent effort coordinated with a range of other study disciplines and these interdependencies are depicted in Figure 8.6-1. Studies providing input to the Riparian IFS include: Instream Flow Fish and Aquatic Section 8.5, Groundwater Study Section 7.5, Ice Processes Study Section 7.6, Fluvial Geomorphology Study Section 6.6, and Riparian Botanical Study Section 11.6. The Riparian IFS will provide data and results to: Geomorphology Study Section 6.0, Ice Processes Study Section 7.6, Wildlife Studies Section 10.0, River Productivity Study Section 9.8, Riparian Botanical Study Section 11.6 and to Project operational flow design. The Riparian IFS is a modeling effort designed to evaluate potential Project operations effects on down river floodplain plant communities. The modeling design incorporates both floodplain plant community succession models and physical process models (fluvial geomorphology, sediment transport, ice processes, groundwater / surface water interaction). Together the vegetation and physical models comprise a hydrogeomorphic approach to modeling the physical floodplain boundary conditions controlling the establishment, recruitment and maintenance of characteristic riparian floodplain plant communities (Figure 8.6-1 and Figure 8.6-2). These vegetation and physical models represent the core tools that will be used for assessing changes in riparian floodplain vegetation habitat and riparian plant community composition, succession and spatial distribution, under alternative Project operational scenarios.

8.6.1.3 Existing Information and Need for Additional Information

Information for the study area includes, but is not limited to, recent and historic aerial photography; riparian vegetation surveys and characterizations from recent and early 1980s studies; and riparian vegetation succession conceptual models developed from the 1980s data as part of the original Susitna Hydroelectric Project (SHP) Phase I vegetation mapping studies conducted along the Susitna River from the downstream end of Devils Canyon to Talkeetna, and vegetation succession studies conducted in the Susitna River floodplain between Gold Creek, and the Deshka River (McKendrick et al. 1982, UAFAFES 1985). The riparian sites visited in the 1980s studies were re-sampled in 1992–1993 (Collins and Helm 1997, Helm and Collins 1997). Of primary importance to the Riparian IFS is the previous vegetation mapping and successional dynamics studies by McKendrick et al. (1982), Collins and Helm (1997), and Helm and Collins (1997). These previous works will serve as a baseline for developing a stratified sampling protocol for both the Riparian IFS and Botanical Riparian Study vegetation surveys. The riparian study modeling efforts will build upon the Collins and Helm (1997) riparian vegetation succession conceptual model (Figure 8.6-2).

Although substantial data and information concerning riparian vegetation were collected in the 1980s, those data are approximately 30 years old and therefore additional information needs to be collected to provide a contemporary understanding of the baseline riparian conditions existing in the Susitna River. Moreover, the previous studies (McKendrick et al. 1982; Collins and Helm 1997; Helm and Collins1997) were largely descriptive of riparian vegetation composition, structure and forest succession, and as such, they do not provide an analytical framework sufficient for assessing potential impacts to riparian vegetation that may result from Watana Dam operations, nor do they provide the ability to model and develop alternative flow scenarios. In addition, the configuration and proposed operations of the Project have changed and must be evaluated within the context of the existing environmental setting. This includes consideration of potential load following effects on riparian ecosystems downstream of the Watana Dam site (including the Lower River segment, as appropriate). Therefore, additional riparian studies are necessary to adequately address the effects of potential Project operations on the riparian floodplain plant communities.

8.6.2 Study Area

The study area includes the Susitna River active floodplain that would be affected by the operation of the Project downstream of Watana Dam. The active floodplain is the valley bottom flooded under the current climate. The longitudinal extent of the formal Riparian IFS study area currently extends to River Mile 75. The final Project Area delineation will be determined by the 2012 flow routing modeling assessment of the hydraulic extent of Project operational influence from the Watana Dam site down river.

During the 1980s studies, the Susitna River was characterized into three segments extending above and below the two proposed dam sites. After researching potential Project configurations, AEA is proposing a single dam configuration at the Watana Dam site at RM 184. The proposed study characterizes the Susitna River as three segments (Figure 8.5-8). The Upper River segment represents that portion of the watershed above the Watana Dam site at RM 184; the Middle River segment (extending from RM 184 downstream to the Three River Confluence at RM 98.5) and the Lower River segment (extending from the confluence of Chulitna and Talkeetna rivers (three rivers) to Cook Inlet (RM 0). Potential Project effects to the Upper River segment above the Watana Dam site are addressed in Section 9: Fish and Aquatics, Section 10: Wildlife, Section 11: Botanical, and other studies. Potential Project effects to the Upper River segment will not be addressed in the Instream Flow Study. The Study Area of the Instream Flow Study is focused on the two lower segments of the river, the Middle River segment and the Lower River segment.

The Middle River segment encompasses approximately 85 miles between the proposed Watana Dam site (at RM 184) and the Three Rivers Confluence, located at RM 98.5. The river flows from Watana Canyon into Devils Canyon, the narrowest and steepest gradient reach on the Susitna River. In Devils Canyon, constriction creates extreme hydraulic conditions including deep plunge pools, drops, and high velocities. The Devils Canyon rapids appear to present a partial barrier hindering upstream passage at some flow conditions to the migration of anadromous fish; only a few adult Chinook salmon have been observed upstream of Devils Canyon. Downstream of Devils Canyon, the middle Susitna River widens but remains essentially a single channel with stable islands, occasional side channels, and sloughs. For purposes of the PSP the Middle River segment was further divided into three segments corresponding to Above Devils Canyon, Within Devils Canyon, and Below Devils Canyon.

The Lower River segment consists of an approximate 98-mile section between the Chulitna River confluence and Cook Inlet (RM 0). An abrupt change in channel form occurs where the Chulitna River joins the Susitna River near the town of Talkeetna. The Chulitna River drains a smaller area than the Middle River segment at the confluence, but drains higher elevations (including Denali and Mount Foraker) and many more glaciers. The annual flow of the Chulitna River is approximately the same as the Susitna River at the confluence, though the Chulitna contributes much more sediment than the Susitna. For several miles downstream of the confluence, the Susitna River becomes braided, characterized by unstable, shifting gravel bars and shallow subchannels. For the remainder of its course to Cook Inlet, the Susitna River alternates between single channel, braided, and meandering planforms with multiple side channels and sloughs. Major tributaries drain the western Talkeetna Mountains (the Talkeetna River, Montana Creek, Willow Creek, Kashwitna River), the Susitna lowlands (Deshka River), and the Alaska Range (Yentna River). The Yentna River is the largest tributary in the Lower River segment, supplying about 40 percent of the mean annual flow at the mouth.

Further refinements to the classification system being applied to the Susitna River have been made since the PSP but the major divisions associated with the middle and lower segments have been retained. However, these are now incorporated into a more refined hierarchical classification system which scales from relatively broad to more narrowly defined categories as follows:

> Segment → Geomorphic Reach → Mainstem Habitat Type → Mesohabitat Types (Main channel only) → Off-channel Habitat Types.

The highest level category is termed **Segment** and refers to the Middle River segment and the Lower River segment.

The **Geomorphic Reach level** is next and consists of eight categories *(MR-1 through MR-8)* for the Middle Segment and four categories *(LR-1 through LR-4)* for the Lower Segment. The geomorphic reach breaks were based in part on the following five factors: 1) Planform type (single channel, island/side channel, braided); 2) Confinement (approximate extent of floodplain, off channel features); 3) Gradient; 4) Bed material / geology; and 5) Major river confluences.

This is followed by **Mainstem Habitat Types** which include the same categories applied during the 1980s studies – *Main Channel, Side Channel, Side Slough, Upland Slough, Tributary Mouth, and Tributary.*

The next level in the hierarchy is **Mesohabitat Type** which at this time is reserved for classifying main channel habitats into categories of *Riffle, Pool, Run, and Glide*.

The last level in the hierarchy is referred to as **Lateral Habitats** consisting of a number of descriptive categories and quantitative indices including *Turbid/Clear, Beaver Presence (Y/N), Gross Area (Off-channel Habitats), Shoreline Length (includes both Main Channel and Off-Channel Habitats).* These are more fully described in Table 8.5-xxx (table not created – placeholder) and illustrated in Figure 8.5-10, with further information provided in both the Geomorphic Study Plan (cite to it) and the Habitat Characterization Study Plan.

8.6.3 Study Methods

The Riparian IFS will first develop a process-based model of riparian vegetation succession and dynamics driven by riverine hydrogeomorphic processes. The modeling approach will use geomorphic, hydraulic, ice process and groundwater /surface water interaction models coupled with riparian vegetation succession models based upon riparian vegetation surveys and previous Susitna River riparian forest research (Helm and Collins 1997). Objectives of the modeling approach are to:

1. measure and model riparian vegetation physical process relationships under the natural flow, sediment and ice regimes,
2. model potential impacts to riparian vegetation resulting from proposed Project operational changes to natural flow, sediment and ice regimes, and
3. provide guidance for Project operation scenarios to minimize potential riparian vegetation impacts.

The Riparian IFS methods section is presented in the following format addressing each of the seven project components and objectives. First, each study component and objective are described. Second, study methods, with appropriate literature citations, are presented. Third, Data Input to the Riparian IFS from other Project studies, and Data Output from Riparian IFS to other Project studies are detailed. Fourth, expected work products are presented. The Riparian IFS project schedule is presented in Section 8.6.9 (Table 8.6-1) and a glossary of relevant terms is presented in Section 8.6.7.

8.6.3.1 Synthesize Historic Physical and Biologic Data for Susitna River Floodplain Vegetation, Including: 1980s Studies, Studies of Hydro Project Impacts on Downstream Floodplain Plant Communities; and Studies of Un-impacted Floodplain Plant Community Successional Processes

The goal of this study objective is to critically review and synthesize historic Susitna River riparian vegetation studies within the context of physical process investigations conducted in the 1980s including ice processes, sediment transport, surface water / groundwater and herbivory. Other North American hydro project studies of downriver floodplain vegetation response to hydroregulation will be incorporated into the review to develop a current state-of-the-science analysis of potential Project operational flow effects to Susitna River riparian floodplain vegetation. Additionally, studies of un-impacted temperate and boreal floodplain plant community successional processes will be incorporated into the study as appropriate.

The objectives of this study task are to:

1. Conduct a critical review of previous Susitna River 1980s floodplain vegetation studies;
2. Place potential Susitna River Project operational effects within context of other studied hydroregulated rivers in North America; and
3. Review, and include relevant findings of, current research concerning temperate and boreal floodplain forest succession and dynamics under natural flow regimes.

8.6.3.1.1 Methods

A critical literature review of all appropriate Susitna 1980s studies; historic and current hydro project floodplain effects studies and temperate and boreal floodplain forest scientific literature will be conducted. The synthesis of findings will focus on elements relevant to evaluating potential Project operation effects on downstream floodplain vegetation. An annotated, searchable bibliography will be developed.

8.6.3.1.2 Data Input From Other Studies

1980s Susitna River floodplain study literature, hydro project studies of downstream floodplain vegetation and studies of un-impacted temperate and boreal floodplain plant community succession.

8.6.3.1.3 Data Output to Other Studies

Geomorphology and Ice Processes studies: literature review findings concerning Susitna River riparian vegetation and physical process, identification of critical issues from hydro project floodplain vegetation impact analyses, and relevant findings from natural flow regime floodplain vegetation research.

The results of this study will provide project operational design guidance.

8.6.3.1.4 Work Products

1. Report chapter or white paper with an annotated, searchable, bibliographic= appendix.

Product deliverable date: Q4, 2013.

8.6.3.2 Focus Area Selection−Riparian Process Domain Delineation

Floodplain plant communities within mountain river corridors are dynamic in that channel and ice processes annually disturb floodplain vegetation resulting in a characteristic patchwork of floodplain vegetation composition, structure and age reflecting time since most recent vegetation disturbance (Naiman et al. 1998). Vegetation disturbance can be defined as those processes that remove or impact plant communities and soils. Floodplain vegetation disturbance types found within the Susitna River Project Area corridor include: channel migration (erosion and depositional processes), ice processes (shearing impacts, flooding and freezing), herbivory (beaver, moose, and hare), wind, and, to an infrequent extent, fire. Floodplain disturbance types and regimes vary systematically throughout river networks and their geographic distribution mapped (Montgomery 1999).

Process domains define specific geographic areas in which various geomorphic processes govern habitat attributes and dynamics (Montgomery 1999). Within the mountain river network, temporal and spatial variability of channel, ice and sediment disturbance processes can be classified and mapped allowing characterization of specific riparian process domains with similar suites of floodplain disturbance types. Riparian Focus Areas will be selected that represent the suite of geomorphic and ice processes identified to occur within specific riverine riparian process domains. Together with the 2012 geomorphology study, ice process study and riparian botanical survey, we will develop a riparian process domain characterization which will be used to locate and select Focus Areas to subsample all identified riparian process domains. The hierarchical riparian process domain approach facilitates both representative sampling design and the 'scaling-up' of modeling results from Focus Area to process domain.

The issue of pseudoreplication (Hurlbert 1984), and number of adequate sample sites necessary to perform robust statistical analyses, is addressed in the hierarchical riparian process domain sampling design and integration of Riparian Botanical Survey design. The Focus Area sites will be representative of specific riparian process domains and their channel / floodplain characteristics (ice process domains, channel plan form, channel slope, channel confinement). The number of Focus Areas per riparian process domain necessary to capture the range of domain variability, in terms of channel and process characteristics, will be determined by assessing process domain channel, floodplain and process variability. Focus Area physical and vegetation processes will be modeled and floodplain vegetation-flow response relationships statistically described in probabilistic models (Rains et al. 2004). The Riparian Botanical Survey is designed to provide Project Area wide representative sample replicates of floodplain vegetation, soils and alluvial terrain relationships. Furthermore, the surface water flood regime for the Project Area will be modeled, and mapped, providing flow regime plant community relationship analysis replicates throughout the greater Project Area, in addition to those modeled at each Focus Area. The riparian process domain and Project Area wide sampling of the Riparian Botanical Survey is specifically designed to address the question of pseudoreplication.

The objectives of the Focus Area selection and riparian process domain delineation are to:

1. develop a riparian process domain stratification of the Project Area; and
2. select Focus Areas representative of each riparian process domain for physical process and vegetation modeling.

8.6.3.2.1 Methods

Final riparian process domains will be delineated based upon the results of 2012 Geomorphology and Ice Processes studies, inspection of historic aerial photography used in the Geomorphology Study, and 2012 riparian field studies. The Lower River (RM 0 to RM 98.5), the Middle River (RM 98.5 to RM 184) and the Upper River to the Maclaren River confluence (RM 184 to RM 260) was delineated into large-scale geomorphic river segments (few to many miles) with relatively homogeneous characteristics, including channel width, entrenchment, ratio, sinuosity, slope, geology/bed material, single/multiple channel, braiding index and hydrology (inflow from major tributaries) for the purposes of stratifying the river into study segments (Figure 8.5-12 and Figure 8.5-13). Channel reaches will be further classified based upon both aerial photographic analysis, and results of a geomorphic reach reconnaissance survey. Ice Process domain field studies will be used to further characterize river segments and reaches in which ice processes are directly interacting with floodplain vegetation, such as river reach and segments where ice dam formation is noted to occur. A preliminary tree ice scar survey was begun in October 2012, however due river freeze-up October 12-13, 2012, not completed. The preliminary ice process domain delineation will be completed in Q2 2013 when tree ice scars can be mapped either by snow machine and/or jet boat following ice break up.

Together, the results of the 2012 preliminary Botanical Riparian Survey, geomorphology study channel classification and 2012/2013 tree ice scar mapping, will be used to delineate, refine as additional data becomes available, and finalize delineation of Project Area riparian process domains.

8.6.3.2.2 Data Inputs from Other Studies

The Geomorphology Study has provided the geomorphic reach classification and stratification. Ice Process Study will provide further modeling and observational data for refining riparian process domains.

8.6.3.2.3 Data Output to Other Studies

None.

8.6.3.2.4 Work Products

1. A technical memorandum, or chapter, describing the approach and methodology used to develop the riparian process domain map and Focus Area selection process.
2. Map of Susitna River riparian process domains and Focus Area locations.

Preliminary Proposed Focus Areas have been selected (Figure 8.5-14 through Figure 8.5-23). Final Focus Area selection will be finished in consultation with Technical Working Group in Q2 2013.

8.6.3.3 Characterize Seed Dispersal and Seedling Establishment Groundwater and Surface Water Hydroregime Requirements. Develop Predictive Model of Potential Project Operational Impacts to Seed Dispersal and Seedling Establishment

This study objective has two subtasks: (1) Synchrony of seed dispersal, hydrology and local Susitna River valley climate study, and (2) seedling establishment study.

8.6.3.3.1 Synchrony of Seed Dispersal, Hydrology and Local Susitna River Valley Climate

Susitna River pioneer riparian tree and shrub species in the family *Salicaceae*, Balsam poplar (*Populus balsamifera*) and willows (*Salix* spp), are adapted to seasonal snowmelt driven spring peak flows, in terms of timing of seed dispersal, newly deposited mineral substrates, and concordant near surface floodplain groundwater conditions all necessary conditions for polar and willow seedling establishment and recruitment (Figure 8.6-3; Braatne et al. 1996, Mahoney and Rood 1998, Mouw 2012). The timing of snowmelt spring flows, and tree and shrub seedling release and dispersal, is critical to successful establishment and maintenance of riparian floodplain forests (Figure 8.6-4; Braatne et al. 1996, Mahoney and Rood 1998, Scott et al. 1997). An empirical model, the “Recruitment Box Model” that captures cottonwood and willow seed dispersal flow response and recruitment requirements has been successfully demonstrated on rivers throughout North America (Figure 8.6-4; Mahoney and Rood 1998, Rood et al. 2003). The model characterizes seasonal flow pattern, associated river stage (elevation), and flow ramping necessary for successful cottonwood and willow seedling establishment (Figure 8.6-3 and Figure 8.6-4). We will develop a recruitment box model for balsam poplar and select willow species for the Susitna River. Alterations of peak flows due to dam operations may result in a loss of spring peak flows and associated floodplain groundwater conditions necessary to the dispersal and establishment of riparian trees and shrubs.

Objectives of the seed dispersal, hydrology and climate synchrony study are to:

1. measure cottonwood and select willow species seed dispersal timing,
2. model local Susitna River valley climate, and associated seasonal peak flows, relative to cottonwood and willow seed dispersal.
3. develop a recruitment box model of seed dispersal timing, river flow regime and cottonwood and willow seed dispersal and establishment.

8.6.3.3.1.1 Methods

To evaluate the natural synchrony of balsam poplar, and select willow species, seed release and Susitna River natural flow regime we will: (1) conduct a two year survey of seed release of balsam poplar and select willow species (Q2-3, 2013; Q2-3, 2014), (2) develop a ‘degree-day’ climate model for the onset of seed release relative to local temperature conditions using methods developed by Stella et al. (2006), and (3) analyze the historic climate and Susitna River flow regime relationship. The results of this study will identify flow regime timing conditions necessary to support riparian forest establishment and recruitment on the Susitna River.

Four floodplain sites near existing meteorological stations in the Middle and Lower Susitna (Figure 8.6-5) will be selected for balsam poplar and select willow species seed release surveys. At each site ten to twenty dominant female balsam poplar trees and willow shrubs will be surveyed weekly during the months of June, July and first two weeks of August, 2013-2014. Seed release will be measured during each survey by counting open catkins for each tree or shrub. Floodplain riparian plant community characteristics will be sampled for each floodplain seed dispersal survey site using the riparian botanical survey vegetation sampling techniques. Tree data and seed release timing will be analyzed using protocols developed by Stella et al. (2006). At all field sites local air temperature measurements will be collected from adjacent weather monitoring stations (Figure 8.6-5). A degree-day model using seed release observations and continuous temperature records from the monitoring stations will be developed (Stella et al. 2006).

A recruitment box model (Figure 8.6-4; Mahoney and Rood 1998, Rood et al. 2003) will be developed to evaluate the potential effects of various proposed spring operational flows on cottonwood and willow recruitment and establishment. Cottonwood and willow timing of seed dispersal relative to natural spring peak flows is a critical element necessary for the successful establishment and recruitment of cottonwood and willow on the Susitna River floodplain.

8.6.3.3.1.2 Data Input From Other Studies

The Flow Routing and Geomorphology Studies will provide flow modeling (frequency, duration, seasonal timing) for development of the “recruitment box model” of seed dispersal timing and flood regime.

8.6.3.3.1.3 Data Output to Other Studies

The modeling results of the Synchrony study will be used to guide Project operations design such that operations flow regime support cottonwood and willow seeding germination and establishment requirements.

8.6.3.3.1.4 Work Products

1. Degree-day model of peak seed release window using seed release observations and continuous temperature records from each floodplain sample site.
2. Recruitment box model of cottonwood and select willow species.
3. Model of peak runoff / seed release temporal synchrony for operational flow guidelines.
4. Model of critical summer flow regime necessary to support seedling germination and establishment.

The seed dispersal study field work will be conducted in Q2 & Q3 during both 2013 & 2014. Model development will be conducted during Q1-4, 2014.

8.6.3.3.2 Seedling Establishment and Recruitment Study

Riparian vegetation in mountain river networks is adapted to a dynamic physical disturbance regime including flooding, summer desiccation, erosion, sediment burial, ice shearing and freezing, wind, herbivory and, infrequently, fire (Naiman et al. 1998). Seedling establishment, survival and recruitment are critical phases in the development of floodplain plant communities within this dynamic physical environment (Karrenberg et al. 2002; Muow et al. 2009, 2012; Rood et al. 2007). The goal of the seedling establishment and recruitment study is to identify, measure and model potential impacts of Project operational changes to the groundwater, surface water, sediment, and ice regimes, and to assess the effects on seedling establishment and recruitment within the active channel margin / floodplain environment.

Identifying the spatial locations, and groundwater, surface water and sediment requirements under which new cohorts of dominant riparian plant seedlings establish, survive and recruit on the Susitna River floodplain, is a critical element in evaluating potential floodplain vegetation effects of Project operational alterations of the natural flow and sediment regimes. River ice seedling interactions, an additional critical physical disturbance factor, will be investigated in the ice process modeling study (Section 8.6.3.4.2).

Seedling recruitment in the Susitna floodplain occurs not only on new flood deposited sediments along channel and floodplain margins, the primary sites of balsam poplar, willow, thinleaf alder (*Alnus tenuifolia)*, and Sitka alder (*Alnus sinuata)* colonization, but also on sediment deposits within the developing and mature floodplain forest (Helm and Collins 1997). Helm and Collins (1997) noted that within the floodplain forest interior white spruce (*Picea glauca*), paper birch (*Betula papyrifera*), seedlings were found to establish, and recruit, on mineral soils associated with both floodplain surface sediment deposits, ice influenced sediment deposits and tree wind throw mound soils within the floodplain forest interior. Also, during our 2012 Riparian Botanical Survey we observed white spruce and paper birch seedlings growing on mounds of gravel and sand apparently pushed on to the floodplain interior by ice flows. Therefore, seedling establishment and recruitment within the floodplain forest will also be investigated in this study.

Objectives of the seedling recruitment study are to:

1. Map the spatial locations of seedlings throughout the Focus Area, and Riparian Botanical Study sites, active channel margins and floodplain.
2. Use a stratified random sampling approach, with variable plot sizes (Mueller-Dombois and Ellenburg 1974), to sample mapped seedling polygons,
3. Identify seedlings to species, and measure seedling heights and density.
4. Describe and measure seedling site soil characteristics.
5. Measure and model seedling site groundwater and surface water hydroregimes.
6. Investigate ice process seedling site interactions through empirical observations and ice process modeling.
7. Develop a probabilistic model of seedling hydrologic, sediment and ice regime model.

8.6.3.3.2.1 Methods

The dominant riparian woody species will be sampled in this study, including: balsam poplar, white spruce, paper birch, thinleaf and Sitka alder, feltleaf willow (*Salix alaxensis*), and other willow species (*S. novae-angliae, arbusculoides, and barclayi)*. In addition to the target woody seedlings, all herbaceous seedlings within the woody species seedling plot will be identified and measured.

Seedlings are defined as those plants established within the current year of sampling, and all plants with stems < 1m in height. Seedling patches will be mapped throughout the Focus Areas, and at Riparian Botanical Survey sites, and a stratified random sampling protocol applied to each mapped polygon to obtain statistically representative sample (Mueller-Dombois and Ellenberg 1974).

The survey sampling approach is as follows. First, a reconnaissance level survey of the Focus Area, or study site reach, will be conducted and seedling polygons mapped, using GPS, within various plant community successional stages (e.g., willow stage, alder stage, poplar stage, spruce stage, etc.). Second, seedling patches will be sampled using a stratified random approach for plot locations within each seedling polygon patch. Seedling composition, abundance (density) and height will be sampled using variable plot size and shapes (Mueller-Dombois and Ellenberg 1974). At each plot two to three seedlings, of each species, will be excavated and rooting depth measured. Woody seedlings will be aged at the root collar in the laboratory and annual rings measured to provide seedling age. Substrate texture and depth to cobbles will be described and measured by excavating to one meter in depth or to cobble refusal layer. Results of seedling mapping and characterization will be used to assess both groundwater, surface water and ice regime relationships using 1-D / 2-D, MODLFOW and ice process modeling results from the Groundwater, Geomorphology and Ice Process studies.

A probabilistic model of seedling and groundwater / surface water, sediment and ice regime will be developed using techniques and methods described in Franz and Bazzaz (1977), Rains et al. (2004), Henszey et al. (2004), Baird and Maddock (2005) and Maddock et al. (2012).

[Additional methodological details will be provided in the December 2012 IFS RSP submitted to FERC and in the Riparian Physical Process Model Technical Memorandum (Q4 2012)].

The results of the Focus Area modeling will be scaled-up to the riparian process domains. The goal is to model both natural riparian flow-response functional groups and natural Susitna River physical process regimes as well as to evaluate Project operational impacts to floodplain vegetation and riparian ecosystem processes throughout the entire Project study area. Recent developments in GIS, LiDAR driven digital terrain models (DEMs), and geo-spatial analytical tools (ARCMAP, ESRI) has provided modelers the capacity to use the results of reach scale analyses to scale-up to larger geospatially defined areas or domains. Modeling riparian vegetation response, over a 185 mile Susitna River valley, to alterations of natural flow regimes, is inherently a geospatial analytical problem. Current state-of-the-art and science practice will be utilized to integrate modeling of physical processes (HEC-RAS, MODFLOW), riparian vegetation-flow response functional groups with GIS geospatial analysis and display (ARCMAP, HEC-GEORAS).

The objectives of the Focus Area scaling model are to:

1. scale-up Focus Area modeling results to riverine / riparian process domains;

2. assess potential impacts of Project operational flows on down river floodplain plant communities and ecosystem processes; and
3. provide input to Project operations.

[Further details will be provided in the December FERC Study Plan submittal.]

8.6.3.3.2.2 Data Input from Other Studies

Groundwater, surface water and sediment regime characteristics of seedling sites developed in the Groundwater, Section 7.5, and Fluvial Geomorphology, Section 6.6, studies. The Ice Processes Study, Section 7.6, will provide modeled ice influence vertical and horizontal zones.

8.6.3.3.2.3 Data Output to Other Studies

Groundwater, surface water and sediment regime seedling requirements to the Project operations design.

8.6.3.3.2.4 Work Products

1. Probabilistic seedling hydrologic, sediment and ice regime model.
2. Technical memorandum or chapter detailing study objectives, methods, results and operational recommendations.

The seedling establishment and recruitment study field work will be conducted in Q2 and Q3 during both 2013 and 2014. Results analysis and technical memorandum, or chapter, will be conducted during Q1-4, 2014.

8.6.3.4 Characterize the role of river ice in the establishment and recruitment of dominant floodplain vegetation. Develop predictive model of potential Project operational impacts to ice processes and dominant floodplain vegetation establishment and recruitment.

Although the role of fluvial disturbance (erosion and sediment deposition) in the development of floodplain vegetation has been well investigated (Naiman et al. 1998; Rood et al. 2007), the consequences of river ice have seen little study (Engstrom et al. 2011; Prouse and Beltaos 2002; Prouse and Culp 2003; Rood et al. 2007). The results of river ice disturbance of floodplain vegetation have been observed in the Susitna River, and reported anecdotally, in Helm and Collins (1997). The 2012 Riparian Botanical Survey Team observed extensive evidence of ice disturbance to floodplain trees, and soils, in the form of: tree ice scars, mechanically disturbed soil stratigraphy, and floodplain gravel deposits, throughout the Middle and Lower Susitna River surveys (Figure 8.6-6, Figure 8.6-7, and Figure 8.6-8).

Impacts of ice-related processes to riparian habitat typically occur during breakup when ice scours channel and floodplain surfaces (Prowse and Culp 2003). During breakup, ice accumulation in meander bends can create ice dams elevating back water surfaces forcing meltwater to bypass the bend, scour a new meander cutoff, generating new side channels (Prowse and Culp 2003). Elevated backwater, resulting from ice dams, may also float ice blocks onto and through vegetated floodplain surfaces causing mechanical shearing effects including: tree ice scarring and abrasion, removal of floodplain vegetation, and disturbance of floodplain soils (Engstrom et al. 2022; Rood et al. 2007; Prowse and Culp 2003).

8.6.3.4.1 Empirical Studies of River Ice and Floodplain Vegetation

Given the paucity of studies concerning river ice and floodplain vegetation interactions, we will use multiple lines of evidence to inform a final research study design to address the question of vegetation response to ice shearing influence on Susitna River floodplain. First, we will observe, map and age (using dendrochronologic techniques) ice vegetation impacts (tree ice scars), and map gravel floodplain deposits throughout the project area to develop a Project Area map of river ice floodplain vegetation interaction domains. We have begun preliminary tree ice scar mapping during the 2012 Riparian Botanical Survey, and early October 2012 Focus Area reconnaissance. We will continue mapping in Q2 2013, and throughout the 2013 and 2014 riparian field seasons. Second, we will interview local residents (for example Mike Wood who lives across from Whiskers Slough) concerning their knowledge of spatial locations of historic ice dams, years of significant ice occurrence, and other anecdotal historical information concerning Susitna River river ice. From these two sources of information, we will build a map of Susitna River ice process domains to guide floodplain vegetation surveys to quantitatively measure (stratified random sampling of ice shear process zones), and statistically describe and compare, vegetation characteristics associated with floodplains experiencing ice shear events and floodplain vegetation without observed ice influence. Our vegetation study design will build on the design and results of Engstrom et al. (2011) where they studied and assessed the effects of anchor ice on riparian vegetation. They found species richness was higher at sites affected by anchor ice than at sites where anchor ice was absent, suggesting that ice disturbance plays a role in enhancing plant species richness (Engstrom et al. 2011). The final study design will be completed in Q2-3 2013, as additional tree ice scar field data becomes available.

8.6.3.4.2 Ice Process Modeling Studies

The ice process study will develop and calibrate a dynamic thermal and ice processes model. The model will provide maps of ice cover progression and decay, ice cover extent and thickness, and effects of Project operational flow fluctuation on ice cover development and stability. Additionally the model will provide flow routing capability. Ice and flow routing effects on floodplain vegetation and channel morphology will be assessed. The ice process study will also provide videography of ice formation and ice break up at a number of locations throughout the Project study area. The ice process modeling study will provide the riparian ice vegetation study with horizontal and vertical zones of ice formation, ice thickness and floodplain impact zones. This model output will be used in conjunction with the empirical survey data to: (1) confirm model output with mapped riparian domains of ice floodplain vegetation interaction, and (2) model changes in locations and types of ice formation processes due to Project operational flow regime. Together, the empirical mapped ice influence zones, empirical studies of vegetation / ice interactions, and (3) modeling confirmation and prediction will be used to understand and predict the influence of Project operational flows on ice an floodplain vegetation interactions.

The objectives of the ice processes floodplain vegetation interaction and modeling study are to:

1. develop an integrated model of ice process interactions with floodplain vegetation;
2. conduct primary research to identify the effects of ice on floodplain vegetation within mapped Susitna River ice floodplain impact zones; and
3. provide Project operational guidance on potential effects of operations flow on ice formation and floodplain vegetation development.

8.6.3.4.2.1 Methods

1. Mapping of ice vegetation interactions and soil disturbance throughout the Project Area.
2. Interviews of local Susitna River residents concerning knowledge of ice dam locations and ice process effects.
3. Comparative quantitative vegetation study of ice effects on identified ice floodplain impact and un-impacted zones. Methods will build on those presented in Engstrom et al. (2011).
4. [Final ice vegetation field sampling methodology will be developed in Q2, Q3 2013 as tree ice scar field data becomes available.]
5. Integration of ice process modeling results with empirical ice vegetation mapping and ice vegetation interaction studies.

The results of the Focus Area modeling will be scaled-up to the riparian process domains. The goal is to model both natural riparian flow-response functional groups and natural Susitna River physical process regimes as well as to evaluate Project operational impacts to floodplain vegetation and riparian ecosystem processes throughout the entire Project study area. Recent developments in GIS, LiDAR driven digital terrain models (DEMs), and geo-spatial analytical tools (ARCMAP, ESRI) has provided modelers the capacity to use the results of reach scale analyses to scale-up to larger geospatially defined areas or domains. Modeling riparian vegetation response, over a 185 mile Susitna River valley, to alterations of natural flow regimes, is inherently a geospatial analytical problem. Current state-of-the-art and science practice will be utilized to integrate modeling of physical processes (HEC-RAS, MODFLOW), riparian vegetation-flow response functional groups with GIS geospatial analysis and display (ARCMAP, HEC-GEORAS).

The objectives of the Focus Area scaling model are to:

1. scale-up Focus Area modeling results to riverine / riparian process domains;

2. assess potential impacts of Project operational flows on down river floodplain plant communities and ecosystem processes; and
3. provide input to Project operations.

[Further details will be provided in the December FERC Study Plan submittal.]

8.6.3.4.2.2 Data Input From Other Studies

Ice process modeling results concerning spatial location of ice, vertical extent of ice, potential ice dam locations will be available beginning Q4 2013 extending through Q4 2014.

8.6.3.4.2.3 Data Output to Other Studies

Project operation guidance on minimizing effects to floodplain vegetation.

8.6.3.4.2.4 Work Products

1. Technical memorandum, or chapter, summarizing study design, methods, results and Project operations guidance.

The river ice seedling establishment and recruitment study field work will be conducted in Q2 and Q3 during both 2013 and 2014. Results analysis and technical memorandum, or chapter, will be conducted during Q1-4, 2014.

8.6.3.5 Characterize the role of erosion and sediment deposition in the formation of floodplain surfaces, soils and vegetation. Develop a predictive model of Project operations changes to erosion and sediment deposition pattern and associated floodplain vegetation.

The dynamics of channel migration, sediment transport, and resulting floodplain erosion and depositional patterns, is a critical physical process directly effecting floodplain soil development and vegetation establishment, recruitment and spatial location throughout alluvial segments of the river network (Richards et al. 2002). The life history strategies, and establishment requirements, of floodplain plant species are adapted to natural flow and sediment regimes (Braatne et al. 1996; Naiman et al. 1998; Karrenberg et al. 2002). As such, alterations of natural hydrologic and sediment regime seasonal timing, magnitude, frequency and duration may have effects on plant species establishment, survival and recruitment (Braatne et al. 1996). The goal of this study is to characterize the role of erosion and sediment deposition in: evolution of floodplain plan form, soil development, and trajectory of plant community succession. This study will investigate the geomorphic evolution of Susitna River Project Area floodplain stratigraphy, and soils, and associated plant community succession. A focus of the investigation will be measurement of historic sediment deposition rates throughout the Project Area and assessment of river network variation in floodplain forming processes. Finally, a predictive model will be developed to assess Project operational effects on hydrologic and sediment regimes, and soil and floodplain plant community development.

Project impacts to this physical process will be assessed using surface water flow routing during ice-free conditions provided by the geomorphology study based on current channel morphology. The Project also has the potential to alter the downstream longitudinal profile of channel bed elevation (scour or deposition), and to alter the channel and floodplain dimensions (width and depth). These potential changes will be assessed in the geomorphology study, and provided to the Riparian Instream Flow Study.

In a river that meanders through a wide valley, erosion on one side of the channel will be balanced by deposition on the other side as the river migrates laterally. Disturbance to riparian habitat on the eroding bank will be balanced by opportunities for recruitment on the point bar. This type of geomorphic process maintains the characteristic range of floodplain surface elevations and vegetation age classes contributing to the diversity of floodplain vegetation composition and structure (Naiman et al. 1998). The rate of channel migration may be impacted by Project operations with additional potential impacts on the riparian community. Potential Project effects on lateral channel migration and reworking of the floodplain will be provided by the geomorphology study.

Development of the study design, modeling, and methods is coordinated closely with Geomorphology, Ice Processes, and Botanical Riparian studies (Figure 8.6-1). The fluvial geomorphology modeling approach is based upon: (1) 1-D / 2-D modeling of river discharge and stage, (3) 1-D / 2-D sediment transport model, and (4) geomorphic reach analyses (historic channel change analysis).

The objectives of the study are:

1. Measure the rates of channel migration, and associated floodplain vegetation successional stages, throughout the Project Area.
2. Measure the rates of sediment deposition, and floodplain development, throughout the Project area.
3. Assess / model how Project operations will effect changes in the natural sediment regime, floodplain depositional patterns, and soil development throughout the Project Area.
4. Assess / model how Project operations changes in sediment transport and soil development will affect floodplain plant community succession.

8.6.3.5.1 Methods

1. Floodplain soils and stratigraphy will be sampled throughout the Project Area using a stratified random approach, including pits located in all Focus Areas.
2. Floodplain soil pits will be excavated from the surface to gravel / cobble layer (historic channel bed) and soil stratigraphy will be described and measured using standard NRCS field techniques (Schoeneberger et al. 2002). Standard sediment grain size sieve analysis will be conducted on the entire sediment profile.

3. Direct dating of fluvial sediments will be conducted using isotopic techniques, including, but not limited to, ^{137}Cs and ^{210}Pb measurements as described in Stokes and Walling (2003).
4. Dendrochronologic techniques will be used to age trees and current floodplain surfaces at each soil pit (Fritts 1976).

The results of the Focus Area modeling will be scaled-up to the riparian process domains. The goal is to model both natural riparian flow-response functional groups and natural Susitna River physical process regimes as well as to evaluate Project operational impacts to floodplain vegetation and riparian ecosystem processes throughout the entire Project study area. Recent developments in GIS, LiDAR driven digital terrain models (DEMs), and geo-spatial analytical tools (ARCMAP, ESRI) has provided modelers the capacity to use the results of reach scale analyses to scale-up to larger geospatially defined areas or domains. Modeling riparian vegetation response, over a 185 mile Susitna River valley, to alterations of natural flow regimes, is inherently a geospatial analytical problem. Current state-of-the-art and science practice will be utilized to integrate modeling of physical processes (HEC-RAS, MODFLOW), riparian vegetation-flow response functional groups with GIS geospatial analysis and display (ARCMAP, HEC-GEORAS).

The objectives of the Focus Area scaling model are to:

1. scale-up Focus Area modeling results to riverine / riparian process domains;
2. assess potential impacts of Project operational flows on down river floodplain plant communities and ecosystem processes; and
3. provide input to Project operations.

Further details will be provided in the December FERC Study Plan submittal.

8.6.3.5.2 Data Input From Other Studies

Geomorphology Study: historic channel migration rates, floodplain vegetation disturbance return interval, flood frequency and flow duration, sediment supply regime and sediment depositional spatial patterns.

Riparian Botanical Survey: will conduct the sediment and soils field work including stratigraphic description and strata measurements, and floodplain sediment dating throughout the Project Area.

8.6.3.5.3 Data Output to Other Studies

To Geomorphology Study: floodplain stratigraphic descriptions, grain size analyses and fluvial sediment dating. Dendrochronologic dating of floodplain surfaces.

8.6.3.5.4 Work Products

1. Technical memorandum, or chapter, summarizing study design, methods, results and Project operations guidance.

The seedling establishment and recruitment study field work will be conducted in Q2 and Q3 during both 2013 and 2014. Results analysis and technical memorandum, or chapter, will be conducted during Q1-4, 2014.

8.6.3.6 Characterize natural floodplain vegetation groundwater and surface water maintenance hydroregime. Develop a predictive model to assess potential Project operational changes to natural hydroregime and floodplain vegetation.

Riparian floodplain vegetation relies to a large extent on groundwater as a water source (Naiman et al. 1998). Floodplain groundwater depths have been demonstrated to control floodplain plant community composition, species richness and structure (Henszey et al. 2004; Baird et al. 2005; Mouw et al. 2009; Naiman et al. 1998). Project operations will alter, on a seasonal basis, the flows in the Susitna River, and on a shorter time scale, flows associated with potential load-following operations.

The goal of the floodplain vegetation groundwater and surface water interaction modeling effort is to characterize the relationship between floodplain ground water and surface water hydroregime and associated floodplain plant communities and to use this model to predict Project operation effects on floodplain vegetation. This investigation will develop both groundwater / surface water and floodplain vegetation-flow response models. The results of this study will be scaled-up from the Focus Areas, to their respective riparian process domains, to provide a model of the entire Project area.

8.6.3.6.1 Groundwater and Surface Water Interaction Modeling

A physical model of groundwater/surface water interactions will be developed for all Focus Area sites to model groundwater/surface water relationships (GW/SW) with floodplain plant communities. Developing conceptual model and numerical representations of the GW/SW interactions, coupled with important processes in the unsaturated zone will help evaluate natural variability in the Susitna River riparian floodplain plant communities, and assesses how various Project operations may potentially result in alterations of floodplain plant community types, as well as improve the understanding of what controlled fluctuations of flow conditions would result in minimal riparian changes.

Regional and local groundwater flow systems are important to floodplain riparian vegetation (Figure 8.6-9). Seasonal river stage fluctuations generate transient groundwater and surface-water (GW/SW) interactions at a local scale under and adjacent to the river, including side channels, side sloughs and upland sloughs (Figure 8.6-9 and Figure 8.6-10). A typical system representing several types of surface-water features is shown in the Whiskers Slough candidate Focus Area (Figure 8.6-11). This plan view shows both the potential orientation of mainstem and side channel surface water features, along with typical riparian floodplain plant community types found in the Middle River segments of the Susitna River. A schematic cross-section of a typical profile across the river floodplain from main channel through floodplain, secondary channel and adjacent hillslope is shown in Figure 8.6-10. This figure depicts the relative relationships between surface-water stage levels, groundwater levels, land-surface elevations, and riparian floodplain plant community types.

Developing conceptual model and numerical representations of the GW/SW interactions, coupled with important processes in the unsaturated zone will help evaluate natural variability in the Susitna River riparian zones, and how various Project operations would potentially result in alterations of floodplain plant community types, as well as improve the understanding of what Project operational fluctuations of flow conditions would result in minimal riparian changes.

8.6.3.6.2 Floodplain Vegetation-GW/SW Regime Functional Groups

Metrics and indices will be developed for quantitatively describing the relationship between floodplain plant communities and the varying groundwater and surface water hydroregime. Probabilistic response curves will be developed for select plant species and all riparian plant community types using techniques described in Rains et al. (2004) and Henszey et al. (2004). The results of the response curve analyses will be used to develop floodplain vegetation-GW/SW regime functional groups (Merritt et al. 2010; Rains et al. 2004). These techniques and analyses will form the basis for development of a statistically modeled relationship between individual riparian species, floodplain plant community types and natural groundwater and surface water hydroregime that will be used to predict potential effects of Project operations on Susitna River floodplain plant communities. These floodplain vegetation-GW/SW regime statistical relationships will provide a defensible basis for recommended flow prescriptions necessary to protect riparian vegetation establishment, recruitment and maintenance of floodplain plant communities throughout the Project study area.

We will integrate the physical modeling and spatial mapping of riparian vegetation conducted in the Botanical Riparian Study to predict the extent and characteristics of riparian vegetation change under various simulated operational flows (Pearlstine et al. 1985).

8.6.3.6.3 Methodology

We will use MODFLOW (USGS 2005), the most widely used groundwater model in the U.S. and worldwide. Additionally, we will utilize RIP-ET (riparian−evapotranspiration MODFLOW package; Maddock et al. 2012) developed to help better represent plant transpiration processes in the unsaturated zone to more accurately calculate evapotranspiration, separating out plant transpiration from evaporation processes.

The data collection period will begin early July 2013 and continue through September 2014. This will include the fall 2013 winter transition period, winter 2013/14 conditions, spring 2014 and summer 2014. Physical weather and climate conditions are not the same from year to year, so data collected during summer 2013 cannot be combined with data from 2014.

We will collect field data on riparian plant communities in coordination with Botanical Riparian Studies. Riparian floodplain plant community characterization and mapping at each intensive study reach will overlap in design with the Botanical Riparian Survey of the entire project study area. Some additional more intensive riparian plant community measurements concerning dendrochronology, soils and effective plant community rooting zones will be done in support of the riparian vegetation GW/SW interaction analyses.

The riparian vegetation GW/SW interactions study approach and design will be integrated with the findings of the riparian plant community succession and geomorphology, ice processes physical processes modeling to characterize physical processes and riparian plant community relationships. The results of these studies will be used to assess (1) changes to physical processes due to dam operations, and (2) response of riparian plant communities to operations alterations of natural flow and ice processes regimes.

The results of the Focus Area modeling will be scaled-up to the riparian process domains. The goal is to model both natural riparian flow-response functional groups and natural Susitna River physical process regimes as well as to evaluate Project operational impacts to floodplain vegetation and riparian ecosystem processes throughout the entire Project study area. Recent developments in GIS, LiDAR driven digital terrain models (DEMs), and geo-spatial analytical tools (ARCMAP, ESRI) has provided modelers the capacity to use the results of reach scale analyses to scale-up to larger geospatially defined areas or domains. Modeling riparian vegetation response, over a 185 mile Susitna River valley, to alterations of natural flow regimes, is inherently a geospatial analytical problem. Current state-of-the-art and science practice will be utilized to integrate modeling of physical processes (HEC-RAS, MODFLOW), riparian vegetation-flow response functional groups with GIS geospatial analysis and display (ARCMAP, HEC-GEORAS).

The objectives of the Focus Area scaling model are to:

1. scale-up Focus Area modeling results to riverine / riparian process domains;
2. assess potential impacts of Project operational flows on down river floodplain plant communities and ecosystem processes; and
3. provide input to Project operations.

Detailed GW/SW interaction study approach and methods are presented in the Groundwater Study Plan Section 7.5

[Further details will be provided in the December FERC Study Plan submittal.]

8.6.3.6.4 Data Input from Other Studies

Groundwater Study Section 7.5 will provide GW SW interaction modeling results including a variety groundwater and surface water regime seasonal statistics. Groundwater monitoring data will be provided to the Riparian IFS in real time throughout Q3, Q4, 2013 and Q1-Q4, 2014. MODFLOW results and report will be provided in Q3 and Q4 2014.

8.6.3.6.5 Data Output to Other Studies

The floodplain vegetation groundwater / surface water study field work will be conducted Q2-Q4, 2013 and Q2-Q4, 2014. Modeling, results analysis and technical memorandum, or chapter, will be developed in Q2 through Q4, 2014.

8.6.3.6.6 Work Products

Temporal and spatial seedling recruitment patterns will be characterized, mapped and modeled relative to groundwater / surface water.

8.6.3.7 Map and characterize Focus Area floodplain plant communities in support of developing floodplain vegetation-GW/SW regime functional groups and forest succession models in coordination with the Riparian Botanical Survey study.

8.6.3.7.1 Methods

The objectives of the Focus Area riparian vegetation mapping and survey are to:

1. characterize and map riparian floodplain plant community types relative to underlying alluvial terrain;
2. measure plant community composition, abundance, structure, and age;
3. provide data for development of riparian vegetation –flow response and riparian vegetation succession models.

The riparian instream flow vegetation mapping and measurement approach builds upon those measures developed for the Botanical Riparian Study Section 11.6.

8.6.3.7.2 Habitat Plots

Focus Area riparian vegetation mapping and sampling will follow protocols developed in coordination with the Botanical Riparian Study plan. Riparian habitats in this study will be mapped to the Level IV of the Alaska Vegetation Classification (Viereck et al. 1992) with adjustments, as needed, for early successional riparian stages following Helm and Collins (1997). An Integrated Terrain Unit (ITU) mapping approach will be used. The ITU approach is based on methodology developed for various Ecological Land Surveys (ELS) done throughout the state of Alaska over the past 15 years (e.g., Jorgenson et al. 2003). All sampling will occur in the growing season months of June, July, and August.

Field sampling locations will be stratified across the study area using a gradient-directed sampling scheme to sample the range of ecological conditions across the sites. Intensive sampling will be conducted along toposequences (transects) placed across the floodplain surface. We will use high-resolution aerial or satellite imagery to pre-determine transect locations in the office. Along each transect, 7-10 plots will be sampled, each in a distinct vegetation type or spectral signature identifiable on aerial photographs. Sample plot locations will be intuitively controlled by the field crew leader, be placed in homogenous patches of vegetation (approximately 1.2-acre [0.5-hectare], minimum area), and ecotones will be avoided. Plots will be spaced adequately to cover the entire transect and to avoid "pseudoreplication" of plots within a single transect (i.e., sampling the same or very similar vegetation and soils within the same transect). Plot locations will be pinpricked on aerial photographs/satellite imagery, and coordinates (including approximate elevations) will be obtained with Global Positioning System (GPS) receivers (accuracy plus or minus 16.4 feet [5 meters]). At each plot (approximately 33-foot [10-meter] radius), geology, hydrology, soil stratigraphy, soil chemistry and vegetation structure and cover will be described or measured (see below). Digital photos will be taken at plot locations, including landscape and ground cover view, and photos of the soil pit face. All field data will be collected on a handheld tablet PC for easy digital upload upon return to the office.

Geologic and surface-form variables that will be recorded include physiography, geomorphic unit, slope, aspect, surface form, and height of microrelief. Sample plot elevations will be surveyed relative to the active channel (unvegetated channel) / active floodplain (vegetated floodplain surface) and water surface at the time of the survey. Hydrologic variables measured include depth of water above or below ground surface, depth to saturated soil, pH, and electrical conductivity (EC). Ground surface variables include percent frost boils and surface fragments. Water-quality measurements (pH and EC) will be made using portable meters that are calibrated daily with standard solutions.

General soils data will be collected from shallow soil plugs/pits (approximately 16-20 inches [40-50 centimeters] deep) or cut banks at each plot. When frozen ground is encountered at less than or equal to 20 inches (50 centimeters deep), we will continue to dig for approximately 4 inches (10 centimeters) into the frozen ground to confirm the presence of ice structure or other evidence of permafrost. General soils data collected at each plot will include depth of surface organic matter, cumulative thickness of all organic horizons, percent coarse fragments, cumulative thickness of loess, depth to upper boundary of coarse fragments (greater than 15 percent by volume), temperature (°C) at 20 inches (50 centimeters), presence of cryoturbation, presence of effervescence using a dilute acid solution, and depth of thaw. When water is not present, EC and pH will be measured from a saturated soil paste. Soil texture will be assessed by hand texturing, using a 2 millimeter (0.1 inch) mesh sieve to remove coarse fragments. A single simplified texture (i.e., loamy, sandy, ashy, organic) will be assigned to characterize the dominant texture in the top 16 inches (40 centimeters) at each plot for ecotype classification.

Vegetation composition and structure data will be measured semi-quantitatively for all vascular and dominant non-vascular plant species, and several categories of non-vascular plants, including percent *Spagnum* species; percent feathermoss, and percent combined *Cladonia*/*Cladina* species. If cover is less than 10 percent or more than 90 percent, then cover of each species or category will be visually estimated to the nearest 1 percent; for cover of 10-90 percent, cover will be estimated to the nearest 5 percent. Isolated individuals or species with very low cover will be assigned a cover value of 0.1 percent. In forested stands, DBH, age (using increment borer or thin cross-section), and height will be recorded for one to two representative dominant trees in each plot. Total cover of each plant growth form (e.g., tall shrub, dwarf shrub, lichens) will be estimated independently of the cover estimates for individual species. Data will be cross-checked to ensure that the summed cover of individual species within a growth form category was comparable to the total cover estimated for that growth form.

Ice process floodplain vegetation interactions will be mapped and characterized at each intensive study reach. Measurements will include type of evidence (soil disturbance, tree / shrub abrasion, whole scale plant community removal due to scour), and elevation surveyed. Mapped ice impact locations and elevation will be utilized in ice processes modeling of spatial extent and elevational zone characterization of ice / vegetation interactions at each study reach.

8.6.3.7.2.1 Sediment Aging

The Riparian Botanical surveys will conduct the field stratigraphic descriptions and collect soil samples for use in quantifying rates of sedimentation on the Susitna River floodplain. Sedimentation aging will occur in soil pits dug down to the original gravel/cobble surface at all intensive plots and at a subset of ITU plots selected using a stratified, random sampling design.

General methods are as follows: Floodplain soil pits will be excavated from the surface to gravel / cobble layer (historic channel bed) and soil stratigraphy will be described and measured using standard NRCS field techniques (Schoeneberger et al. 2002). Standard sediment grain size sieve analysis will be conducted on the entire sediment profile.

Direct dating of fluvial sediments will be conducted using isotopic techniques, including, but not limited to, 137Cs and 210Pb measurements as described in Stokes and Walling (2003).

The Riparian IFS will use dendrochronologic techniques to age trees and current floodplain surfaces at each soil pit as described by Fritts (1976). The results of the dendrochronology study will be used to corroborate the results obtained from sediment aging.

8.6.3.7.2.2 Floodplain Plant Root Zone Characterization

It is critical to measure the depth of the root zone of dominant floodplain plants for modeling availability of groundwater, and capillary fringe, to floodplain plant communities. The rooting depth of dominant floodplain plants will be measured through excavation of trenches within each floodplain plant community type. Depth and width of dominant plant root systems will be measured and photographed. Additionally, a river bank survey will be conducted to utilize recently exposed root systems for measurement of tree root systems. The river bank survey will provide a much greater sample size then through trench excavations alone.

8.6.3.7.3 Dendrochronology

Each mapped woody species plant community, including seedlings, will be aged to determine year of origin to be used in historic analysis of vegetation recruitment hydroregime characteristics and to model floodplain turnover / disturbance rates using standard dendrochronologic techniques (Fritts 1977).

Tree and shrub dendrochronologic samples will be taken with either an increment borer or by cutting the shrub or sapling stem and taking a section for laboratory analysis. Increment cores (two per tree) will be collected from each tree. For each tree, floodplain sediment will be excavated to uncover the stem root collar and depth of sediment aggradation will be measured for further age estimation. A sample of tree seedlings for each dominant species will be excavated, heights measured, stems sectioned at the rood collar and annual rings measured under a dissecting microscope. A regression analysis will be conducted to assess the relationship between stem diameter and seedling height. The results will be used to add additional years to trees to account for height of core sample above the root collar.

Cores will be taken as close to the ground surface as possible, generally 12 inches (30 centimeters) above ground surface. Total height of tree core sample above the root collar will be calculated and used to estimate additional years to estimate tree year of origin. Twenty cottonwood seedlings were excavated from floodplain seedling plots and sectioned to determine height / age relationship for seedlings up to one meter in height. This relationship was used to add additional years to each tree core sample based upon core height above root collar and seedling height age relationship.

Increment cores will be mounted on pieces of 1 inch by 2 inch wood and sanded with variable grades of sand paper following standard methods described in Fritts 1976. Ring width measurements will be made, and annual years counted, for both the tree cores and stump sections using a dissecting microscope. Individual trees will be cross-dated, if possible, using standard methods (Fritts 1976).

8.6.3.7.4 Riparian Floodplain Vegetation Succession Models

Riparian floodplain vegetation succession model development will build upon previous studies of riparian plant community succession conducted in the Susitna and Talkeetna Rivers (Helm and Collins 1997, Mouw et al. 2009). The number of riparian successional models to be developed will depend upon the final riparian Project area delineation as defined by the results of hydrologic assessment of the extent of operational flow changes throughout the Project study area from the Dam site to Cook Inlet. For example, the Helm and Collins (1997) model of riparian vegetation succession focused upon the Middle River section and Three Rivers Confluence segments of the Susitna (Figure 8.5-8). Once the extent of potential hydroregime change throughout the study area is assessed, and riparian Project area defined, the number of vegetation succession models incorporating the range of riparian vegetation types seen from the estuarine environment to the Dam site will be determined. For example, Sitka spruce (*Picea sitchensis)* and black cottonwood (*Populus balsamifera* ssp. *trichocarpa*) occur within the lower estuarine reaches of the Susitna river, but these tree species do not extend geographically up river to the Middle River segments. Therefore, riparian vegetation successional dynamics will vary throughout the Project study area and additional vegetation models will be developed to capture this variability once the extent of operational hydroregime influence is determined.

8.6.3.7.5 Work Products

Technical memorandum will be developed summarizing Focus Area riparian floodplain plant community sampling results. Detailed descriptions of riparian floodplain species composition, abundance, structure, age and environmental parameters will be presented in figures and tables.

The Focus Area floodplain vegetation study field work will be conducted Q2-Q4, 2013 and Q2-Q4, 2014. Modeling, results analysis and technical memorandum, or chapter, will be developed in Q2 through Q4, 2014.

8.6.4 Consistency with Generally Accepted Scientific Practice

The proposed Riparian IFS, including methodologies for data collection, analysis, modeling, field schedules, and study durations, is consistent with generally accepted practice in the scientific community. The Riparian IFS is consistent with common approaches used for other FERC proceedings and references specific protocols and survey methodologies, as appropriate. Specifically, riparian vegetation mapping and measurement, the classification of riparian plant communities, and dendrochronologic techniques will follow standard methods generally accepted by the scientific community. A potential suite of groundwater and surface water models have been identified for integration with ice processes models that are widely used throughout the discipline (Baird and Maddock 2005; Maddock et al. 2012; Franz and Bazzaz 1977; Rains et al. 2004).

Current state-of-the-art and science practice will be utilized to integrate modeling of physical processes and riparian vegetation-flow response guilds with GIS geospatial analysis and display (Van de Rijit et al. 1996).

8.6.5 Schedule

The schedule for completing all components of the Riparian IFS is provided in Table 8.6-1. Licensing participants will have opportunities for study coordination through regularly scheduled meetings, reports and, as needed, technical subcommittee meetings. Reports will be prepared at the end of 2013 (Initial Study Report) and 2014 (Updated Study Report) for each of the study components. Licensing participants will have the opportunity to review and comment on these reports. Workgroup meetings are planned to occur on at least a quarterly basis, and workgroup subcommittees will meet or have teleconferences as needed.

8.6.6 Level of Effort and Cost

The Instream Flow Riparian Study is planned as a 2+ year effort, with field sampling conducted spring through summers and fall of 2013-2014. Initial Study Report will be delivered in late 2013 and updated in early 2015.

Riparian ISF Study elements and their estimated levels of effort include:

1. Spring/Summer 2013 field work investigating up to six intensive study reaches. Field effort will involve approximately a team of three ecologists one to two week per Focus Area to map and sample riparian vegetation.
    - $310,000

2. Spring/Summer 2014 field work field work investigating up to six intensive Focus Areas. Field effort will involve approximately a team of three ecologists one to two week per study site to map and sample riparian vegetation.
   - $310,000
3. Modeling forest succession and physical processes (groundwater / surface water, hydraulic, ice processes, operational flow simulations).
   - $440,000
4. Statistical analyses and report development; meetings, presentations.
   - $440,000
5. Groundwater/surface water interaction study.
   - Costs provided in Groundwater Study Section 7.5.

Total approximate effort/cost: $1.5 million (not including costs for riparian groundwater/surface water interaction study instrumentation, field installation and monitoring, and MODFLOW modeling). Details and level of field effort will be based upon approved overall study objectives and design. Field surveys would be conducted for 40 to 50 days in each year, depending on the needs for additional ground-verification data. The Riparian IFS Study will involve extensive, office-based activities including remote sensing interpretation, physical modeling, vegetation modeling, statistical modeling, geospatial analyses and study report preparation.

The final types and level of physical process modeling will be determined in coordination with the Instream Flow, Geomorphology, Ice Processes, Botanical Riparian, and Groundwater Study teams. Estimated study costs are subject to review and revision as additional details are developed.

8.6.7 Draft Glossary

Note: to be completed in December 2012 Final Study Plan submittal to FERC.

Active floodplain

Riparian process domain

Floodplain vegetation functional group

Process domain

Focus Area

Dendrochronology

Disturbance regime

Isotopic dating

Floodplain

Radiogenic dating

Riparian

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8.6.9 Tables

Table 8.6-1 Schedule for implementation of the Riparian Instream Flow Study.

Activity	2012				2013				2014				2015	
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q
Refine and Finalize Study Plan		——	——	——										
Focus Area Study Site Selection			——	——	——			------	------	--				
Critical review of 1980s Susitna River data; current scientific research concerning hydro project floodplain vegetation effects; and unimpacted, natural floodplain vegetation research					——	——	——	——						
Finalize Riparian Groundwater / Surface Water Field Design					——			------	------	---				
Implement Riparian Groundwater / Surface Water Installation and Sampling						——	——	——	——	——	——	——		
Riparian Vegetation: Field data collection		——	——			——	——	——		——	——			
Seed dispersal study		——	——			——	——	——		——	——			
Tree ice scar mapping		——	——			——	——	——		——	——			
Focus Area vegetation mapping and sampling		——	——			——	——	——		——	——			
Dendrochronology sampling		——	——			——	——	——		——	——			
Soil sampling		——	——			——	——	——		——	——			
Sediment Dating: Sampling and Analysis						——	——	——		——	——	——		
Develop groundwater / surface water models					——	——	——	——	——	——	——	——		
Develop vegetation flow-response models						——	——	——	——	——	——	——		
Develop riparian scaling model: reach to riparian process domain								——	——	——	——	——		
Develop vegetation Project operational flow-response model											——	——	——	——▶
Riparian vegetation impact analyses											——	——	——	——▶
Alternative operational scenarios												——	——	——▶
Reporting									Δ				▲	

Legend:

—— Planned Activity
----- Follow up activity (as needed)
Δ Initial Study Report
▲ Updated Study Report

8.6.10 Figures

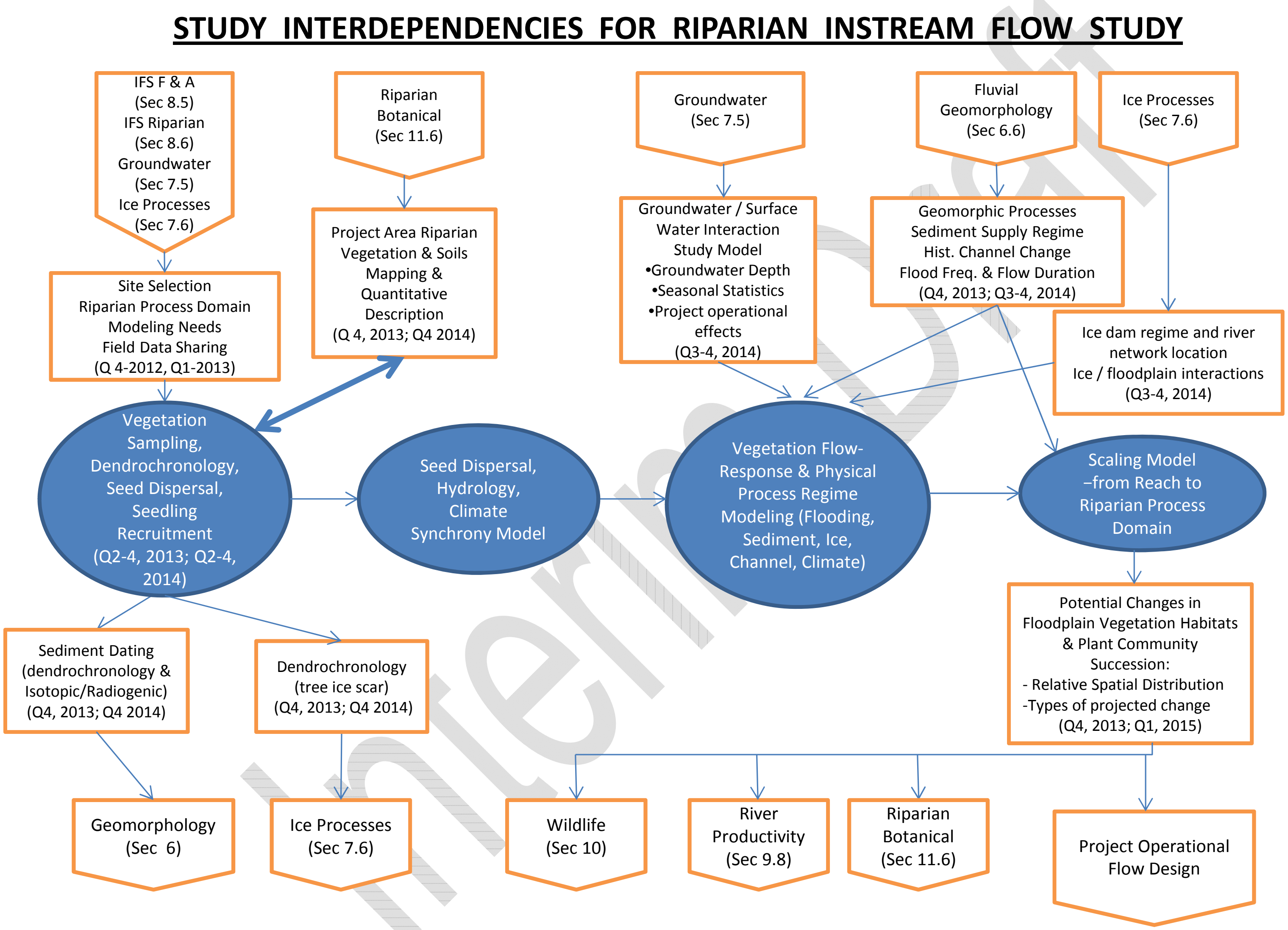
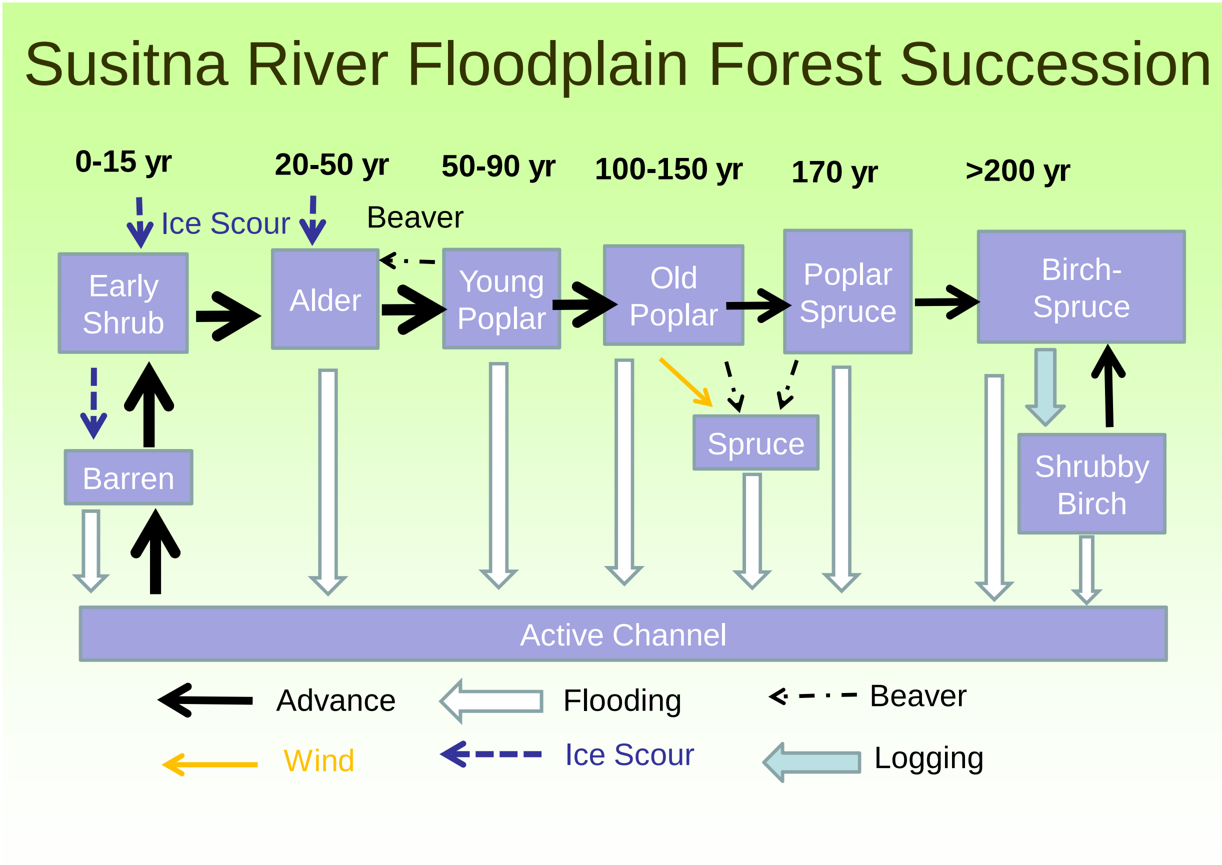


Figure 8.6-1 Study interdependencies for Riparian Instream Flow Study.



(after Helm and Collins 1997)

Figure 8.6-2 Helm and Collins (1997) Susitna River floodplain forest succession. Note: model depicts typical floodplain forests found in the Susitna River Middle River and Three Rivers Confluence segments.

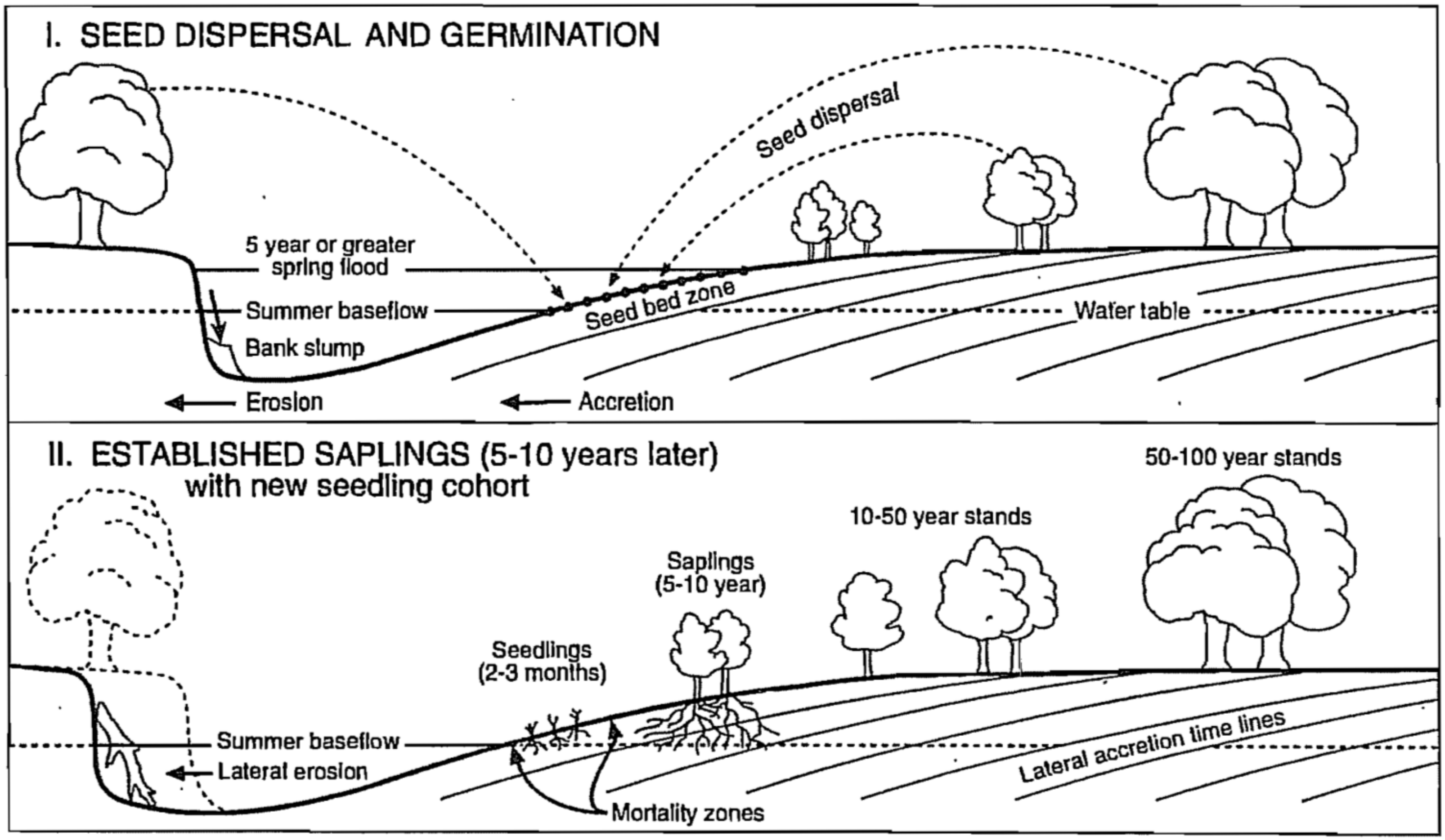


Figure 8.6-3 Cottonwood (Populus) life history stages: seed dispersal and germination, sapling to tree establishment. Cottonwood typically germinates on newly created bare mineral soils associate with lateral active channel margins and gravel bars. Note proximity of summer baseflow and floodplain water table (Braatne et al. 1996).

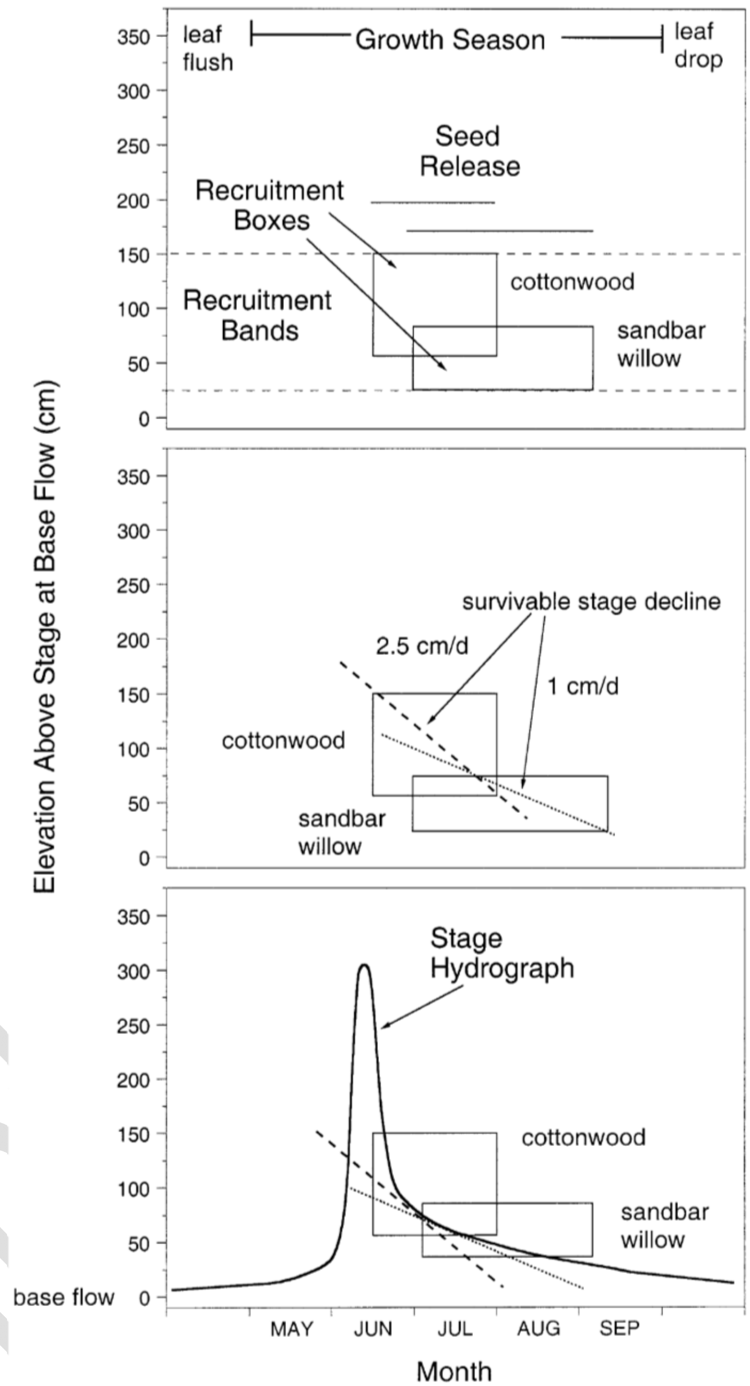


Figure 8.6-4 The riparian "Recruitment Box Model" describing seasonal flow pattern, associated river stage (elevation), and flow ramping necessary for successful cottonwood and willow seedling establishment (from Amlin and Rood 2002; Rood et al., 2005). Cottonwood species (*Populus deltoides*), willow species (*Salix exigua*). Stage hydrograph and seed release timing will vary by region, watershed, and plant species.

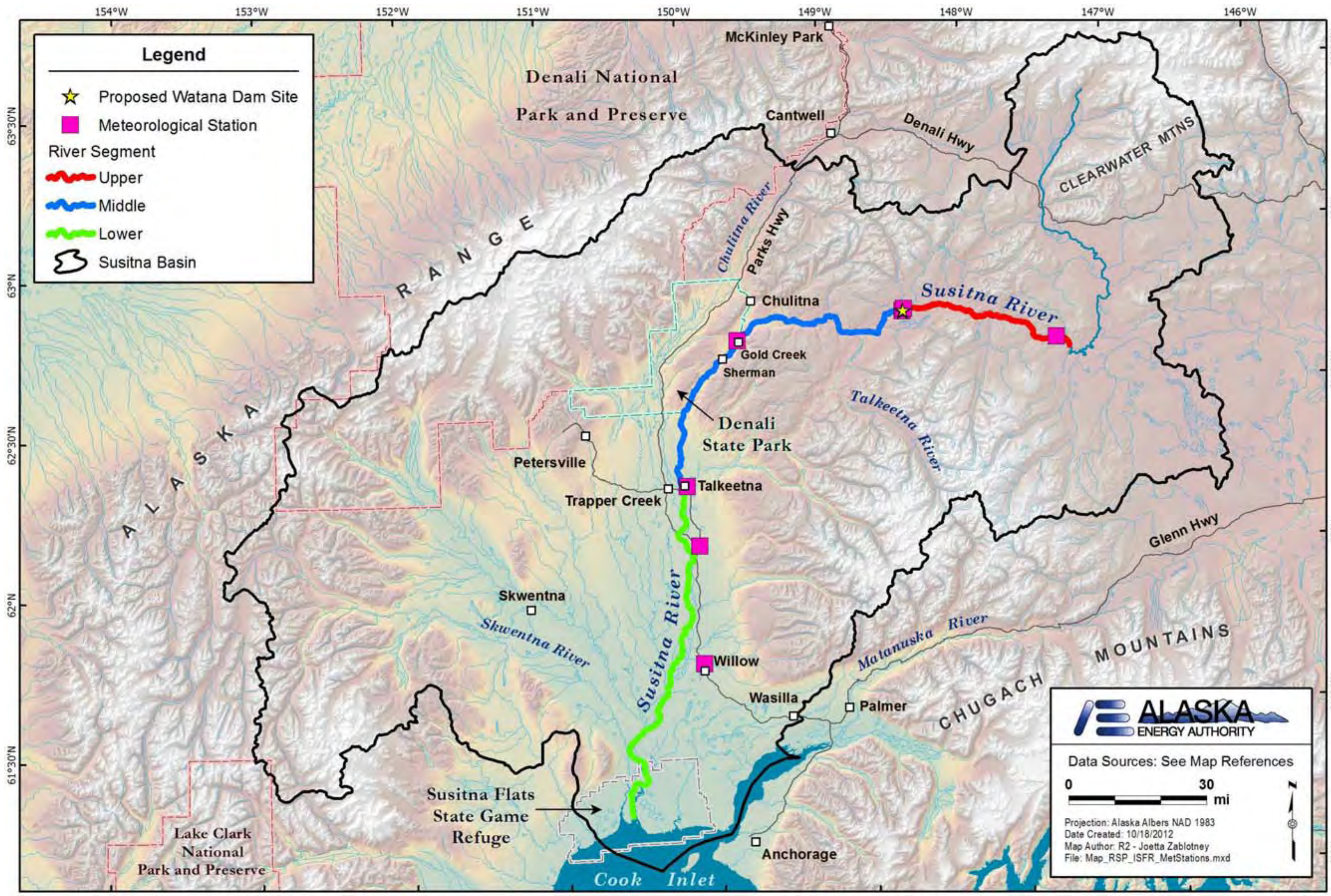


Figure 8.6-5 Susitna project area meteorological station locations.

Figure 8.6-6 Cottonwood tree ice scar. Floodplain located immediately above Three Rivers.

Figure 8.6-7 Cottonwood forest tree ice scars. Floodplain located immediately above Three Rivers.

Figure 8.6-8 Floodplain ice deposited gravel piles. Floodplain in braided reach below Three Rivers.

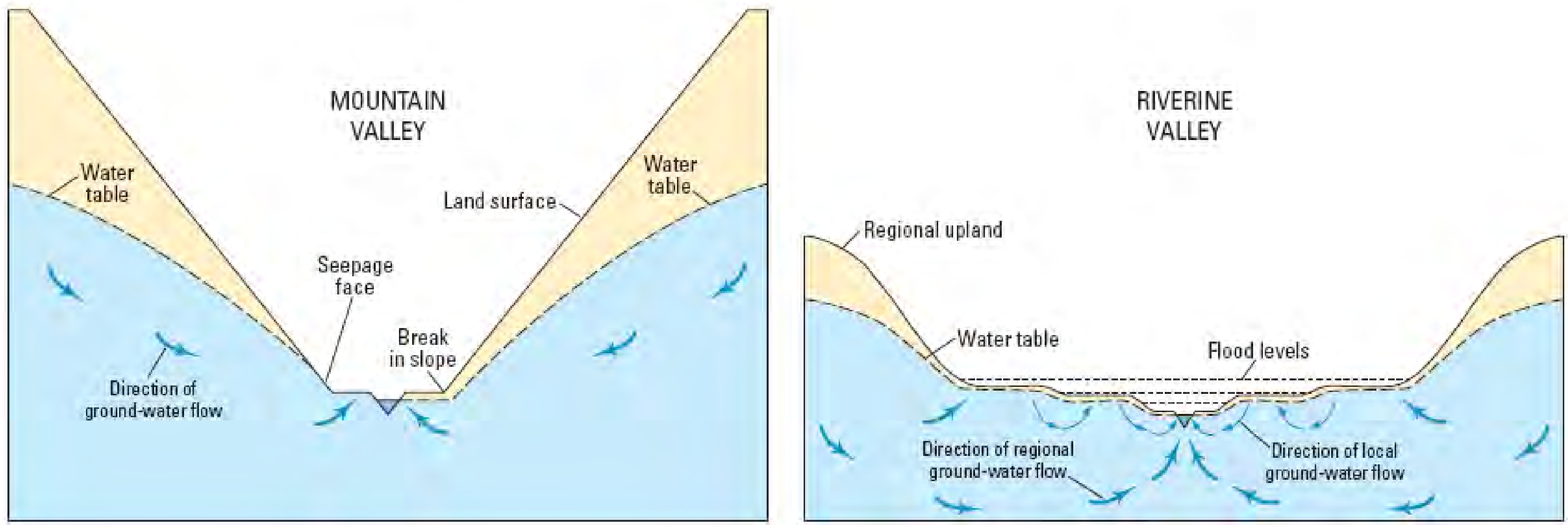
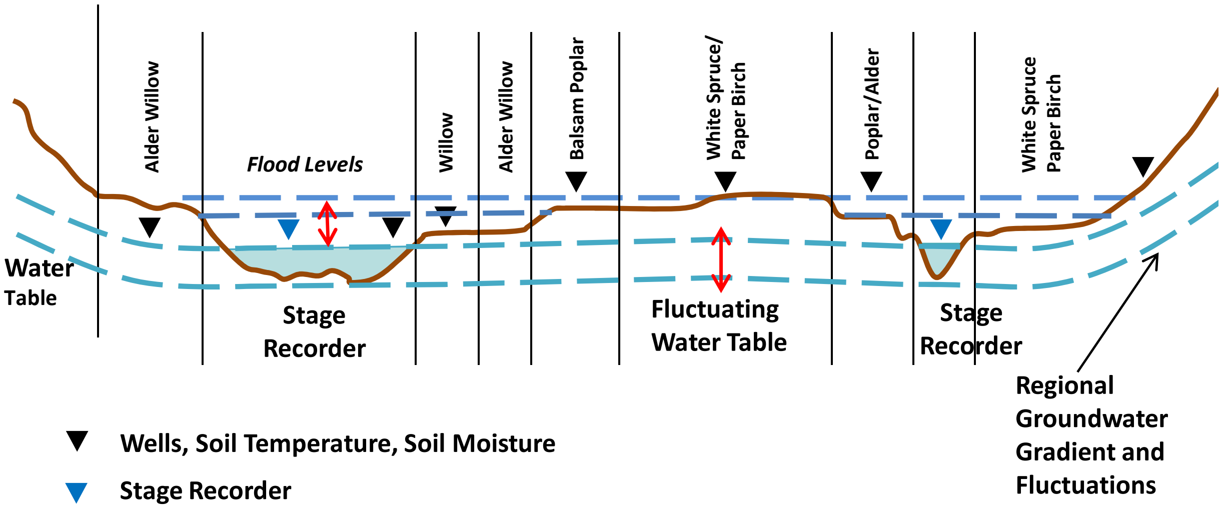


Figure 8.6-9 Riverine hydrologic landscape (Winter 2001).



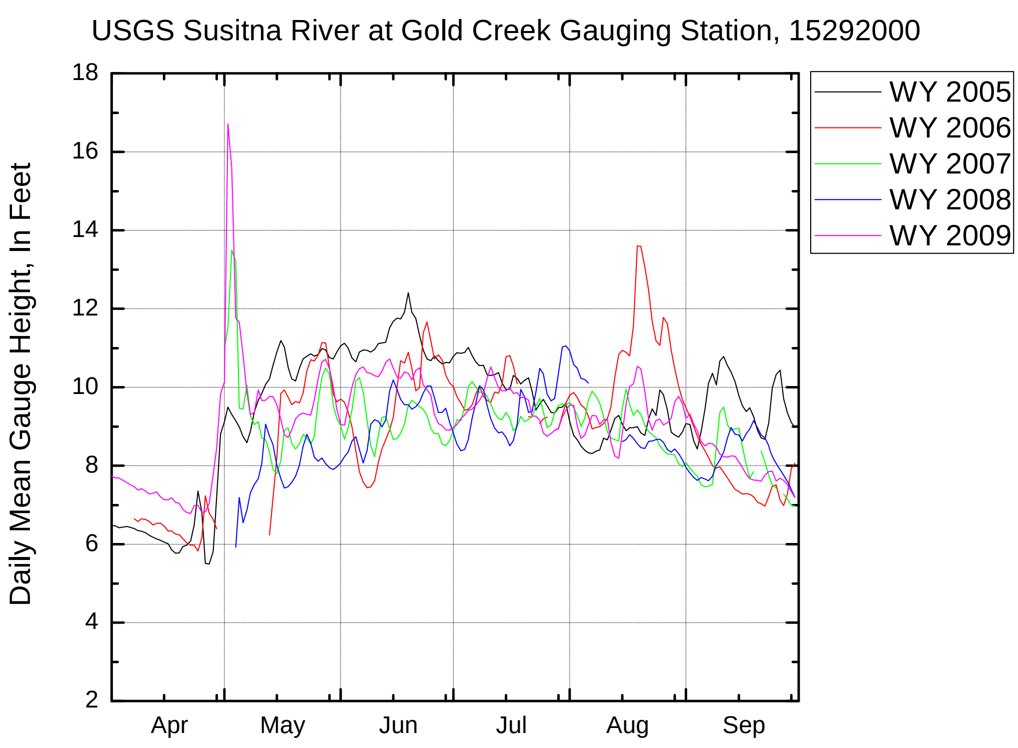


Figure 8.6-10 (A) Transect profile view of typical monitoring well and stage recorder locations looking down river. (B) Gold Creek Gauge Station, Susitna River April through September 2005-2009.

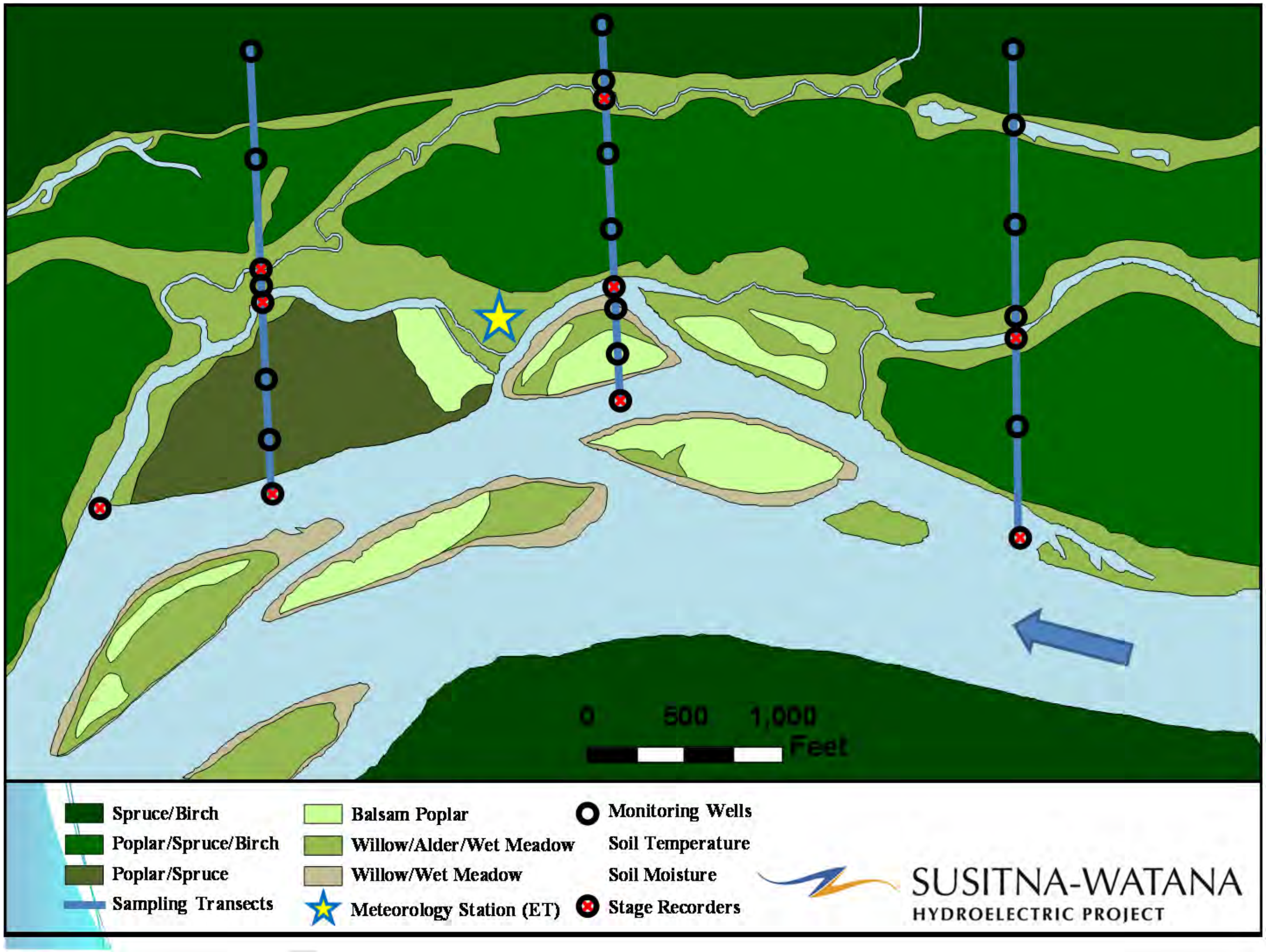


Figure 8.6-11 Whiskers Slough typical Focus Area groundwater / surface water study design illustrating monitoring well and stage recorder transect locations. Typical floodplain plant community types found in middle segment of Susitna River are shown.

ATTACHMENT 8-1. LIST OF TERMS AND DEFINITIONS

Included in this list are definitions obtained from the glossary prepared by the Instream Flow Council (Locke et al. 2008) as well as definitions developed for the Susitna-Watana Hydroelectric Project.

Term	Definition
Accretion	1. Addition of flows to the total discharge of the stream channel, which may come from tributaries, springs, or seeps. 2. Increase of material such as silt, sand, gravel, water.
Adaptive management	A process whereby management decisions can be changed or adjusted based on additional biological, physical or socioeconomic information.
Adfluvial	Fish that spend a part of their life cycle in lakes and return to rivers and streams to spawn.
Adult	Sexually mature individuals of a species.
Age-0 juvenile	The description of an organism that, in its natal year, has developed the anatomical and physical traits characteristically similar to the mature life stage, but without the capability to reproduce.
Aggradation	1. Geologic process in which inorganic materials carried downstream are deposited in streambeds, floodplains, and other water bodies resulting in a rise in elevation in the bottom of the water body. 2. A state of channel disequilibrium, whereby the supply of sediment exceeds the transport capacity of the stream, resulting in deposition and storage of sediment in the active channel.
Anadromous	Fish that mature in seawater but migrate to fresh water to spawn.
Annual flow	The total volume of water passing a given point in one year. Usually expressed as a volume (such as acre-feet) but may be expressed as an equivalent constant discharge over the year, such as cubic feet per second.
Armoring	1. The formation of an erosion-resistant layer of relatively large particles on the surface of a streambed or stream bank that results from removal of finer particles by erosion, and which resists degradation by water currents. 2. The application of materials to reduce erosion. 3. The process of continually winnowing away smaller substrate material and leaving a veneer of larger ones.
Average daily flow	The long-term average annual flow divided by the number of days in the year usually expressed as an equivalent constant discharge such as cubic feet per second. In some settings, the value can be used to represent only the portion of the daily flow values in a defined period such as those that occur within a calendar month.
Bank	The sloping land bordering a stream channel that forms the usual boundaries of a channel. The bank has a steeper slope than the bottom of the channel and is usually steeper than the land surrounding the channel.
Bathymetric	Related to the measurement of water depth within a water body.
Bedload	Material moving on or near the streambed and frequently in contact with it.
Benthic	Associated with the bottom of a body of water.
Benthic macroinvertebrates	Animals without backbones, living in or on the sediments, a size large enough to be seen by the unaided eye, and which can be retained by a U.S. Standard No. 30 sieve (28 openings/inch, 0.595-mm openings). Also referred to as benthos, infauna, or macrobenthos.
Braid	Pattern of two or more interconnected channels typical of alluvial streams.

Term	Definition
Calibration	The validation of specific measurement techniques and equipment, or the comparison between measurements. In the context of PHABSIM, calibration is the process of adjusting input variables to minimize the error between predicted and observed water surface elevations.
Calibration	The process of adjusting selected model parameters within an expected range until the differences between model predictions and field observations are within acceptable criteria for performance.
Cascade	The steepest of riffle habitats. Unlike rapids, which have an even gradient, cascades consist of a series of small steps of alternating small waterfalls and shallow pools.
Catch Per Unit Effort (CPUE)	A metric of abundance expressed as the number of fish captured per unit of effort, which is often measured as time or per unit type of sampling gear (e.g., number per trawl tow).
Channel	A natural or artificial watercourse that continuously or intermittently contains water, with definite bed and banks that confine all but overbank streamflows.
Confidence interval	The computed interval with a given probability that the true value of the statistic – such as a mean, proportion, or rate – is contained within the interval.
Confinement	Ratio of valley width (VW) to channel width (CW). Confined channel VW:CW <2; Moderately confined channel VW:CW 2-4; Unconfined channel VW:CW >4.
Confluence	The junction of two or more streams.
Connectivity	Maintenance of lateral, longitudinal, and vertical pathways for biological, hydrological, and physical processes.
Cover	Structural features (e.g., boulders, log jams) or hydraulic characteristics (e.g., turbulence, depth) that provide shelter from currents, energetically efficient feeding stations, and/or visual isolation from competitors or predators.
Cross section	A plane across a stream channel perpendicular to the direction of water flow.
Cross-sectional area	The area of the stream's vertical cross section, perpendicular to flow.
Cubic feet per second (cfs)	A standard measure of the total amount of water passing by a particular location of a river, canal, pipe or tunnel during a one second interval. One cfs is equal to 7.4805 gallons per second, 28.31369 liters per second, 0.028 cubic meters per second, or 0.6463145 million gallons per day (mgd). Also called second-feet.
Current meter	Instrument used to measure the velocity of water flow in a stream, measured in units of length per unit of time, such as feet per second (fps).
Datum	A geometric plane of known or arbitrary elevation used as a point of reference to determine the elevation, or change of elevation, of another plane (see gage datum).
Degradation	1. A decline in the viability of ecosystem functions and processes. 2. Geologic process by which streambeds and floodplains are lowered in elevation by the removal of material (also see down cutting).
Delta	An alluvial deposit made of rock particles (sediment, and debris) dropped by a stream as it enters a body of water.
Density	Number of individuals per unit area.
Deposition	The settlement or accumulation of material out of the water column and onto the streambed.
Dewater	Remove or drain the water from a stream, pond or aquifer.

Term	Definition
Discharge	The rate of streamflow or the volume of water flowing at a location within a specified time interval. Usually expressed as cubic meters per second (cms) or cubic feet per second (cfs).
Dissolved oxygen (DO)	The amount of gaseous oxygen (O2) dissolved in the water column. Oxygen gets into water by diffusion from the surrounding air, by aeration (rapid movement), and as a waste product of photosynthesis. More than 5 parts oxygen per million parts water is considered healthy; below 3 parts oxygen per million is generally stressful to aquatic organisms.
Drainage area	The total land area draining to any point in a stream. Also called catchment area, watershed, and basin.
Ecosystem	Any complex of living organisms interacting with nonliving chemical and physical components that form and function as a natural environmental unit.
Electrofishing	A biological collection method that uses electric current to facilitate capturing fishes.
Embeddedness	The degree that larger particles (boulders, rubble, or gravel) are surrounded or covered by fine sediment. Usually measured in classes according to percent of coverage.
Emergent vegetation	An emergent plant is one which grows in water but which pierces the surface so that it is partially in air. Collectively, such plants are emergent vegetation.
Euphotic zone	Surface layer of an ocean, lake, or other body of water through which light can penetrate. Also known as the zone of photosynthesis.
FLIR	Forward looking infrared (FLIR) is an imaging technology that senses infrared radiation. Can be used for watershed temperature monitoring.
Flood	Any flow that exceeds the bankfull capacity of a stream or channel and flows out on the floodplain.
Floodplain	1. The area along waterways that is subject to periodic inundation by out-of-bank flows. 2. The area adjoining a water body that becomes inundated during periods of over-bank flooding and that is given rigorous legal definition in regulatory programs. 3. Land beyond a stream channel that forms the perimeter for the maximum probability flood. 4. A relatively flat strip of land bordering a stream that is formed by sediment deposition. 5. A deposit of alluvium that covers a valley flat from lateral erosion of meandering streams and rivers.
Flushing flow	A stream discharge with sufficient power to remove silt and sand from a gravel/cobble substrate but not enough power to remove gravels.
Fry	A recently hatched fish.
Gaging station	A specific site on a stream where systematic observations of streamflow or other hydrologic data are obtained.
Geomorphic reach	(IN PROGRESS)
GIS	Geographic information systems (GIS) or geospatial information systems is a set of tools that captures, stores, analyzes, manages, and presents data that are linked to location(s). In the simplest terms, GIS is the merging of cartography, statistical analysis, and database technology.
Glide	(IN PROGRESS)
Gradient	The rate of change of any characteristic, expressed per unit of length (see Slope). May also apply to longitudinal succession of biological communities.
Groundwater	In general, all subsurface water that is distinct from surface water; specifically, that part which is in the saturated zone of a defined aquifer. Sometimes called underflow.

Term	Definition
Habitat guild	Groups of species that share common characteristics of microhabitat use and selection at various stages in their life histories.
Habitat mapping units and categories	(IN PROGRESS)
Habitat Suitability Curve (HSC)	A graph/mathematical equation describing the suitability for use of areas within a stream channel related to water depth, velocity and substrate by various species/lifestages of fish.
Habitat Suitability Index (HSI)	(IN PROGRESS)
Hydraulic control	A horizontal or vertical constriction in the channel, such as the crest of a riffle, which creates a backwater effect.
Hydraulic head	A measure of energy or pressure, expressed in terms of the vertical height of a column of water that has the same pressure difference.
Hydraulic model	A computer model of a segment of river used to evaluate stream flow characteristics over a range of flows.
Hydrograph	A graph showing the variation in discharge over time.
Hyporheic zone	(MICHAEL LILLY DEFINITION)
IFIM	The Instream Flow Incremental Methodology.
Incised	Lowering of the streambed by erosion that occurs when the energy of the water flowing through a stream reach exceeds that necessary to erode and transport the bed material.
Incremental method	The process of developing an instream flow policy that incorporates multiple or variable rules to establish, through negotiation, flow-window requirements or guidelines to meet the needs of an aquatic ecosystem, given water supply or other constraints. It usually implies the determination of a habitat-discharge relation for comparing streamflow alternatives through time (see Standard setting).
Invertebrate	All animals without a vertebral column; for example, aquatic insects.
Large Woody Debris (LWD)	Pieces of wood larger than 10 feet long and 6 inches in diameter, in a stream channel. Minimum sizes vary according to stream size and region.
Lateral habitat	(IN PROGRESS)
Life stage	An arbitrary age classification of an organism into categories relate to body morphology and reproductive potential, such as spawning, egg incubation, larva or fry, juvenile, and adult.
Macroinvertebrate	An invertebrate animal without a backbone that can be seen without magnification.
Main channel	(IN PROGRESS)
Mainstem	(IN PROGRESS)
Mainstem habitat type	(IN PROGRESS)
Mesohabitat	A discrete area of stream exhibiting relatively similar characteristics of depth, velocity, slope, substrate, and cover, and variances thereof (e.g., pools with maximum depth <5 ft, high gradient rimes, side channel backwaters).
Microhabitat	Small localized areas within a broader habitat type used by organisms for specific purposes or events, typically described by a combination of depth, velocity, substrate, or cover.
Non-native	Not indigenous to or naturally occurring in a given area. Presence is usually attributed to intentional or unintentional introduction by humans. Non-native species are also termed “exotic” species.

Term	Definition
Nose velocity	The velocity at the approximate point vertically in the channel where a fish is located.
Off channel	(IN PROGRESS)
One dimensional (1-D) model	(IN PROGRESS)
Peak load	The greatest of all load demands on an interconnected electric transmission network occurring in a specified period of time.
Period of record	The length of time for which data for an environmental variable have been collected on a regular and continuous basis.
pH	A measure of the acidity or basicity of a solution. Pure water is said to be neutral, with a pH close to 7.0 at 25 °C (77 °F). Solutions with a pH less than 7 are said to be acidic, and solutions with a pH greater than 7 are said to be basic or alkaline.
PHABSIM	(pronounced P-HAB-SIM) The Physical HABitat SIMulation system; a set of software and methods that allows the computation of a relation between streamflow and physical habitat for various life stage of an aquatic organism or a recreational activity.
Physical habitat	Those abiotic factors such as depth, velocity, substrate, cover, temperature, water quality that make up some of an organism's living space.
Pool	Part of a stream with reduced velocity, often with water deeper than the surrounding areas, which is usable by fish for resting and cover.
Powerhouse	A structure that houses the turbines, generators, and associated control equipment.
Q	Hydrological abbreviation for discharge, usually presented as cfs (cubic feet per second) or cms (cubic meters per second).
Radiotelemetry	Involves the capture and placement of radio-tags in adult fish that allow for the remote tracking of movements of individual fish.
Ramping rate	The rate of change in discharge from base flow to generation flow below a peaking hydroelectric facility.
Rapids	A part of a stream with considerable turbulence where the current is moving with much greater velocity than usual and where the water surface is broken by obstructions, but without a sufficient break in slope to form a cascade.
Recruitment	The number of new juvenile fish reaching a certain size/age class; connotes the process whereby juveniles survive and mature into adults.
Refugia	An area protected from disturbance and exposure to adverse environmental conditions where fish or other animals can find shelter from sudden flow surges, adverse water quality, or other short-duration disturbances.
Regime	The general pattern (magnitude and frequency) of flow or temperature events through time at a particular location (such as snowmelt regime, rainfall regime).
Reservoir	A body of water, either natural or artificial, that is used to manipulate flow or store water for future use.
Restoration	To return a stream, river, or lake to its natural, predevelopment form and function. Restoration typically eliminates the human influence that degraded or destroyed riverine processes and characteristics.
Riffle	A relatively shallow reach of stream in which the water flows swiftly and the water surface is broken into waves by obstructions that are completely or partially submerged.
Riparian	Pertaining to anything connected with or adjacent to the bank of a stream or other body of water.

Term	Definition
Riparian vegetation	Vegetation that is dependent upon an excess of moisture during a portion of the growing season on a site that is perceptively more moist than the surrounding area.
Riparian zone	A stream and all the vegetation on its banks that is influenced by the presence of the stream, including surface flow, hyporheic flow and microclimate.
River	A large stream that serves as the natural drainage channel for a relatively large catchment or drainage basin.
River corridor	A perennial, intermittent, or ephemeral stream and adjacent vegetative fringe. The corridor is the area occupied during high water and the land immediately adjacent, including riparian vegetation that shades the stream, provides input of organic debris, and protects banks from excessive erosion.
River mile	The distance of a point on a river measured in miles from the river's mouth along the low-water channel.
Run	A portion of a stream with low surface turbulence that approximates uniform flow, and in which the slope of the water surface is roughly parallel to the overall gradient of a stream reach.
Scour	The localized removal of material from the streambed by flowing water. This is the opposite of fill.
Sediment	Solid material, both mineral and organic, that is in suspension in the current or deposited on the streambed.
Sediment load	A general term that refers to material in suspension and/or in transport. It is not synonymous with either discharge or concentration. (see Bedload).
Segment	(IN PROGRESS)
Side channel	Lateral channel with an axis of flow roughly parallel to the mainstem, which is fed by water from the mainstem; a braid of a river with flow appreciably lower than the main channel. Side channel habitat may exist either in well-defined secondary (overflow) channels, or in poorly-defined watercourses flowing through partially submerged gravel bars and islands along the margins of the mainstem.
Side slough	(IN PROGRESS)
Sinuosity	The ratio of channel length between two points on a channel to the straight-line distance between the same two points. The amount of bending, winding and curving in a stream or river.
Slope	The inclination or gradient from the horizontal of a line or surface. The degree of inclination can be expressed as a ratio, such as 1:25, indicating one unit rise in 25 units of horizontal distance or as 0.04 height per length. Often expressed as a percentage and sometimes also expressed as feet (or inches) per mile.
Smolt	The salmonid or trout developmental life stage between juvenile and adult, when the fish undergoes smoltification to adapt to the marine environment.
Smoltification	The physiological changes anadromous salmonids and trout undergo in freshwater while migrating toward saltwater that allow them to live in the ocean.
Spawning	The depositing and fertilizing of eggs by fish and other aquatic life.
Split channel	A river having numerous islands dividing the flow into two channels. The islands and banks are usually heavily vegetated and stable. The channels tend to be narrower and deeper and the floodplain narrower than for a braided system.
Stage	The distance of the water surface in a river above a known datum.
Stage-discharge relationship	The relation between the water-surface elevation, termed stage (gage height), and the volume of water flowing in a channel per unit time.

Term	Definition
Stranding	(IN PROGRESS)
Streambed	The bottom of the stream channel; may be wet or dry.
Substrate	The material on the bottom of the stream channel, such as rocks or vegetation. Proposed substrate classification system for use in development of HSC/HIS curves for the Susitna-Watana Project. Code — Substrate Type — Size (Inches) — Size (mm) 1 — Silt, Clay, or Organic 2 — Sand — <0.1 — <2.5 3 — Small Gravel — 0.1-0.5 — 2.5-12.7 4 — Medium Gravel — 0.5-1.5 — 12.7-38.1 5 — Large Gravel — 1.5-3.0 — 38.1-76.2 6 — Small Cobble — 3.0-6.0 — 76.2-152.4 7 — Large Cobble — 6.0-12.0 — 152.4-304.8 8 — Boulder — >12.0 — >304.8 9 — Bedrock
Suitability	A generic term used in IFIM to indicate the relative quality of a range of environmental conditions for a target species.
Temporal variability	Pertaining to, or involving the nature of time, occurrence in time, and variability in occurrence over some increment in time (e.g., diurnally, daily, monthly, annually).
Thalweg	A continuous line that defines the deepest channel of a watercourse.
Time step	The interval over which elements in a time series are averaged.
Time-series analysis	Analysis of the pattern (frequency, duration, magnitude, and time) of time-varying events. These events may be discharge, habitat areas, stream temperature, population factors, economic indicators, power generation, and so forth.
Transferability	1. Applicability of a model (e.g., habitat suitability criteria) to settings or conditions that differ from the setting or conditions under which the model was developed. 2. Applicability of data obtained from a remote source (e.g., a meteorological station) for use at a location having different environmental attributes.
Trapping	(IN PROGRESS)
Tributary	A stream feeding, joining, or flowing into a larger stream (at any point along its course or into a lake). Synonyms: feeder stream, side stream.
Tributary mouth	(IN PROGRESS)
Turbidity	A measure of the extent to which light passing through water is reduced due to suspended materials.
Two dimensional (2-D) model	(IN PROGRESS)
Upland slough	(IN PROGRESS)
Velocity	The distance traveled by water in a stream channel divided by the time required to travel that distance.
Vertical	A location along a transect across a river where microhabitat-related data are collected.
Weighted usable area (WUA)	The wetted area of a stream weighted by its suitability for use by aquatic organisms or recreational activity.
Wet year	A water year characterized by above average discharge. Exact measure of deviation from some average, or median value depends on the decision setting.
Wetted perimeter	The length of the wetted contact between a stream of flowing water and the stream bottom in a plane at right angles to the direction of flow.

ATTACHMENT 8-2. [AS NEEDED, FOR INDIVIDUAL STUDY PLANS]

[As needed]