Kachemak Bay and Kenai Peninsula

CLIMATE RESILIENCE WORKSHOP

SCENARIO PLANNING AND
PATHWAYS TO SUCCESSFUL ADAPTATION

October 4th-5th, 2016

Alaska Islands and Ocean Visitor Center | Homer, Alaska

Workshop Summary Report

Kachemak Bay National Estuarine Research Reserve
Alaska Center for Conservation Science
University of Alaska Anchorage

National Estuarine Research Reserve System Science Collaborative

Susanne Moser Research & Consulting

Tijuana River National Estuarine Research Reserve

Workshop Partners

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For more information go to:

Kachemak Bay National Estuarine Research Reserve
http://accs.uaa.alaska.edu/kbnerr/climate-resilience/

Tijuana River National Estuarine Research Reserve
http://trnerr.org/climate-scenario-planning-alaska/

NERR Science Collaborative Successful Adaptation Indicators and Metrics Project
http://graham.umich.edu/water/nerrs/resources/climate

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Participants

NAME		ORGANIZATION
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Steve	Baird	KBNERR
Ed	Berg	UAA Kachemak Bay Campus
Mandy	Bernard	Kachemak Heritage Land Trust
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Julie	Engebretsen	City of Homer
Chris	Guo	KBNERR
Bryr	Harris	Kenai Peninsula Borough
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Dawn	Magness	Kenai National Wildlife Refuge
Jenny	Martin	Alaska Legislature
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Agenda

SCENARIO PLANNING AND PATHWAYS TO SUCCESSFUL ADAPTATION

October 4th, 8:30 am - 5:00 pm
October 5th, 8:30 am - 12:30 pm

Alaska Islands and Ocean Visitor Center
95 Sterling Hwy, Homer AK

DAY 1: OCTOBER 4, 2016

8:30 am	**Registration -** Light breakfast available
9:00 am	**Welcome and introductions** Workshop intent and goals • Participant and facilitator introductions
9:30 am	**Envisioning the community we want** Workshop participants brainstorm and refine a vision for the community: What does Homer look like in 2050? How is its economy thriving? What does a socially, culturally thriving community look like? What defines the community?
10:30 am	Break
10:45 am	**Climate change and community vision of a desirable future** Outline climate scenarios that describe how the community may be affected by key drivers of change • Explore how climate and environmental changes may affect the possibility of Homer's desired future to be realized
12:30 pm	Lunch
1:30pm	**Outlining climate-resilient and socio-economically robust pathways to the future** Identify specific strategies and actions needed to implement adaptation pathways to the for the resilient Homer of 2050 • Identify barriers that may be encountered along the pathways and think creatively about solutions
3:00 pm	Break
3:15 pm	**Climate-resilient pathways: Turning points and decision points** Explore adaptive pathways, even under growing pressures from climate change • Identify relevant thresholds, warning signals

4:30 pm	**Summary of Day 1, outlook to Day 2**
5:00 pm	Adjourn for the day

DAY 2: OCTOBER 5, 2016

8:30 am	**Arrival -** Light breakfast available
9:00 am	**Welcome and panel of leaders reflecting on Day 1** Welcome to yesterday's and any new participants • State, Borough and City leaders reflect on what they heard and identify near-term opportunities (at their respective governance levels) to begin working on adaptation strategies
10:00 am	**From vision and pathways to real world planning and action** Link the adaptive actions and strategies developed on Day 1 to local work, planning efforts and decisions
11:00 am	Break
11:15 am	**Looking ahead: The work this winter** Report out from previous session, discuss opportunities, identify support needs to move adaptation planning forward in Homer and surrounding areas
12:00 am	**Summary and next steps** Synthesis • Commitments of KBNERR to working with community • Outlook to workshop next spring (measuring progress and success) • Evaluation of workshop
12:30pm	Adjourn and optional networking lunch

Workshop Overview

Purpose

Climate change impacts in Alaska are much more pronounced than in other regions of the United States. Outside of the high-arctic, the impacts of recent climate change have been better documented on the Kenai Peninsula than elsewhere in Alaska; however, none of these efforts have resulted in tangible recommendations or a long-term strategy for adaptation when faced with uncertainty about forecasted futures as a result of rapid climate change. To address local issues, this project aims to enhance regional capacity of coastal communities on the Kenai Peninsula to adapt and prepare for a changing climate.

Goals

Building on workshop participants' experience and expertise, as well as on the foundational climate adaptation for coastal communities training and synthesis of local climate science delivered by Kachemak Bay National Estuarine Research Reserve (KBNERR) and the National Oceanic and Atmospheric Administration Office for Coastal Management (NOAA OCM) in March 2016, workshop participants took the next steps in thinking about Homer's and the surrounding areas' and communities' efforts to prepare for, adapt to, and work together towards a climate-resilient future. In this workshop participants:

1. Identified a desirable future for Homer and surrounding areas, considering diverse community goals, climate change, and other opportunities and stressors;
2. Developed feasible, climate-resilient pathway from the present state to the desired future state;
3. Linked the work accomplished during the workshop (on a vision of a desirable future and adaptive pathways) to their daily work, planning efforts and decisions.

Workshop Design

These goals were accomplished by leveraging and integrating both the existing partnerships within the National Estuarine Research Reserve System (NERRS) and local partnerships and efforts on the Kenai Peninsula, establishing a process and developing products that will increase understanding of regional and community-level vulnerabilities and opportunities. We worked with regional leaders and community stakeholders to collaboratively develop a vision of our communities' future, and plausible climate scenarios based on a wide range of environmental and management responses. This workshop's target audience included: local and regional government staff, tribal and community leaders, staff of environmental organizations, and land and resource managers. Three training partners from the NERR system collaborated on this workshop:

- Kachemak Bay National Estuarine Research Reserve has established itself as a nexus for partnerships through the Coastal Training Program (CTP), and regional leader in climate science, with a place-based research and monitoring program.
- Tijuana River NERR brings extensive experience in climate scenario development and adaptation planning through the Climate Understanding and Resilience in the River Valley (CURRV) project. Their expertise in community-based collaborative planning as well as lessons-learned from their efforts to strengthen the efficacy of local climate planning was applied.
- The NERRS Science Collaborative Successful Adaptation Indicators and Metrics (SAIM) project supports participating reserves and nearby coastal communities in developing indicators and metrics of successful adaptation. Their expertise in tracking adaptation success as well as related work on indicators of vulnerability, sustainability, ecological health, and other areas informs the process, and contributes to meaningful and tangible adaptation strategies and pathways.

DAY 1: OCTOBER 4, 2016

VISION

Welcome and introductions
KBNERR Reserve Manager, Jessica Shepherd, welcomed participants and Coastal Training Program Coordinator, Syverine Abrahamson, outlined the workshop background, intent and goals. Participants introduced themselves, coming from a broad range of decision-makers and stakeholders on the Kenai Peninsula, sometimes representing multiple organizations or entities. Many attendees expressed that the group benefited from participation of planning departments and elected officials from the municipal, borough and state level.

Presentation: Envisioning the community we want
Dr. Susi Moser reviewed the local history of change through photos, from glaciers receding, to the 1964 earthquake, and population increases on the Southern Kenai Peninsula. Participants became comfortable with the idea of ongoing change, even radical change, and thinking outside the box for the future. Moser ended the presentation by asking:

- *What does Homer look like in 2050?*
- *How is its economy thriving?*
- *What does a socially, culturally thriving community look like?*
- *What defines the community?*

Group Activity: Identifying elements of a successful future
Workshop participants identified what they hope will be true about Homer and surrounding areas/communities in 2050. Facilitators reminded them to think of the best things they want to see preserved, but also the things they want to see improved or enhanced or even created, if they don't exist now. A "resilient Homer" can mean or include a wide range of components or aspects of living here – ecological, social, physical, cultural, political, psychological, and economic- related to daily life and particular events. Strong themes emerged around:

1. Natural Resources: elements included access to clean water and recreation, abundance of wild foods, maintaining diverse and healthy wilderness, habitats and salmon streams.
2. Development: elements included long term planning, smart growth, and consideration for housing and energy changes.
3. Economy: elements included a secure economy that was controlled locally, is diverse and sustainable.
4. Culture: elements included healthy people and food systems, equitable access to public services and education, a community with diverse perspectives but a shared cultural identity including a stewardship land ethic. The community has a participatory local government; freedoms are intact and we are prepared for population changes.

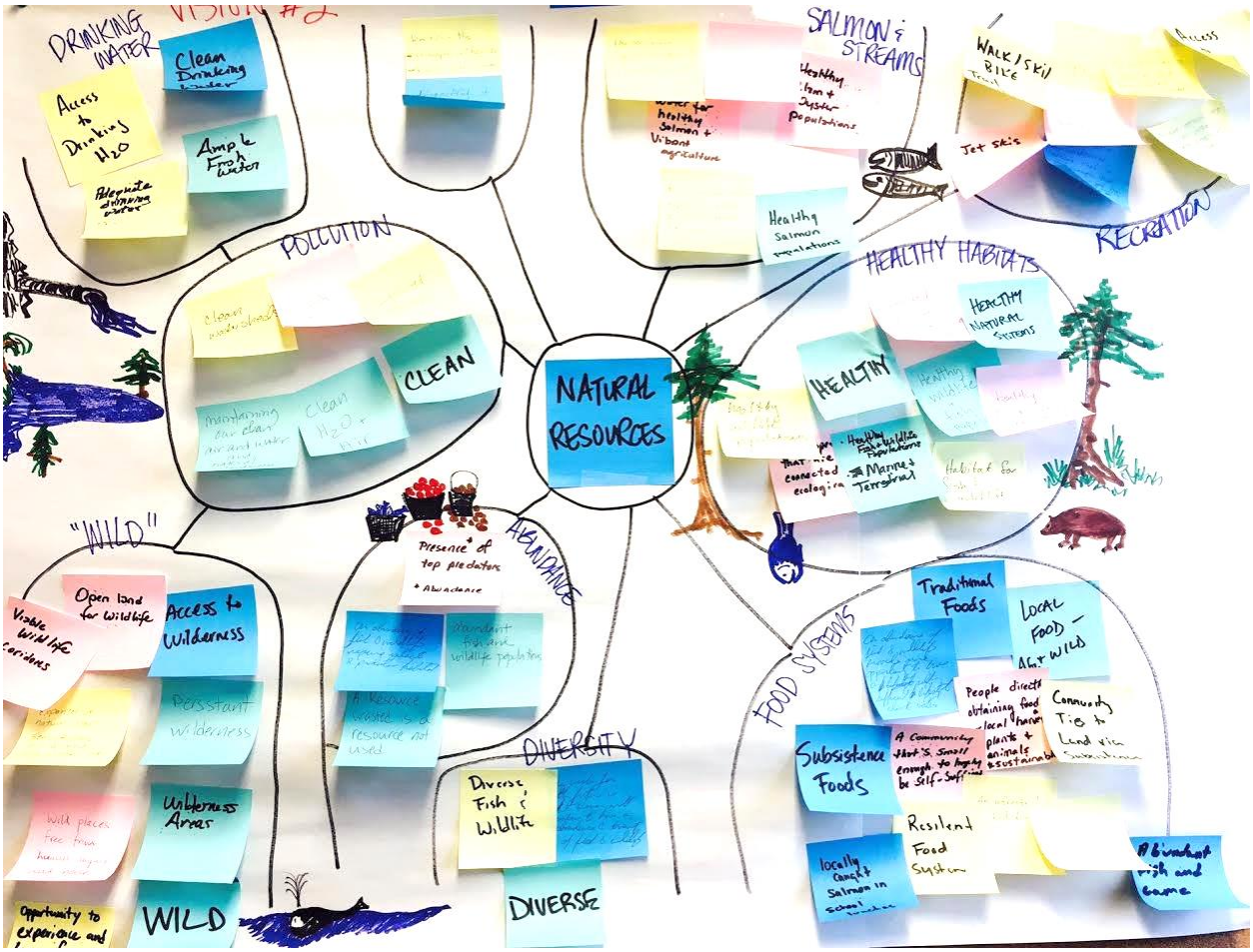

Figure 1: The participant's vision for a healthy, thriving, and resilient future.

Discussion: Vision

Moser reviewed the vision, shared common threads and ideas, as well as outliers. Attendees commented that the vision sounds like the place that we live in. Participants were asked to refine the collective vision for the community and add additional elements. They identified the following when asked- *Is there anything even better in our future?*

- Freedom from fear: confidence that the community could cope with anything and acceptance that change causes you to be better off than you were before. Resilience.
- Process and governance system: enables one to work out how to grow from conflicting values and diverse perspectives.
- Population change and growth: Learn ways to invite people in and help them mesh values with this place. Identifying cultural values.
- Independence: Preserve access to public lands and promote stewardship of private property.

The group was reminded that we have an opportunity to keep bringing people into a joint vision and that the vision is an anchor, a beacon that you can hold onto.

SCENARIOS

Presentation: Climate Scenarios
Dani Boudreau of the Tijuana River National Estuarine Research Reserve (TRNERR) outlined climate scenarios as a tool to describe how the community may be affected by key drivers of change. Boudreau explained that a scenario is a plausible, internally consistent description of a possible future state of the world. Scenarios are not forecasts or predictions; rather, each scenario is one alternative representation of how the future may unfold. Scenario planning embraces uncertainty, helping decision-makers generate creative approaches by thinking about a range of possible climate futures, and how we can be resilient and achieve our community vision. By integrating history, experiences, and science, we can identify what segments of the ecosystem management decisions we can influence in preparation to prepare for future challenges with increased speed and confidence. Benefits of scenario planning as a decision support tool, include:

- Embracing uncertainty
- Informed by experience and best available science
- Multiple variables are considered
- Begins dialogue within the community
- Applicable to existing decision-making frameworks

For a more in depth discussion of what scenario planning entails visit: http://trnerr.org/currv_reports/

Presentation: Local Drivers of Change
Syverine Abrahamson of KBNERR presented priority impacts of climate change based on stakeholder interviews, community conversations and data from previous trainings. High on the list of issues were:

- Infrastructure protection
- Drinking water
- Water quality
- Flood management
- Fire management
- Agriculture development
- Habitat conservation.

The scenario planning process is based on drivers of change with centrality to these issues and had the framework was developed considering the following qualities:

1. Considered how multiple variables interacted, instead of considering climate change impacts in isolation.
2. Uncertainties explored are affected by climate, environmental, and management changes, providing an opportunity discuss both physical and biological processes as well as broader socio-ecological decisions.
3. The drivers of change have associated uncertainty but provide a framework from which the direction of change (e.g., increased vs. decreased precipitation) can be analyzed, while allowing for a wide range of magnitudes of change to be explored.

Given these considerations, drivers of change were identified for the scenario process that focused on hydrology and how water relates to so many aspects of climate change in our region. Climate change impacts local hydrology through: temperature increases, changing precipitation rates, vegetation changes, and sea level rise. Additionally, management practices impact hydrology through including:

water use, development of impervious surfaces, and alteration of wetlands impacting water distribution on the landscape. Two drivers of change that capture these effects are:

- Extreme surface flow events; and
- Groundwater recharge.

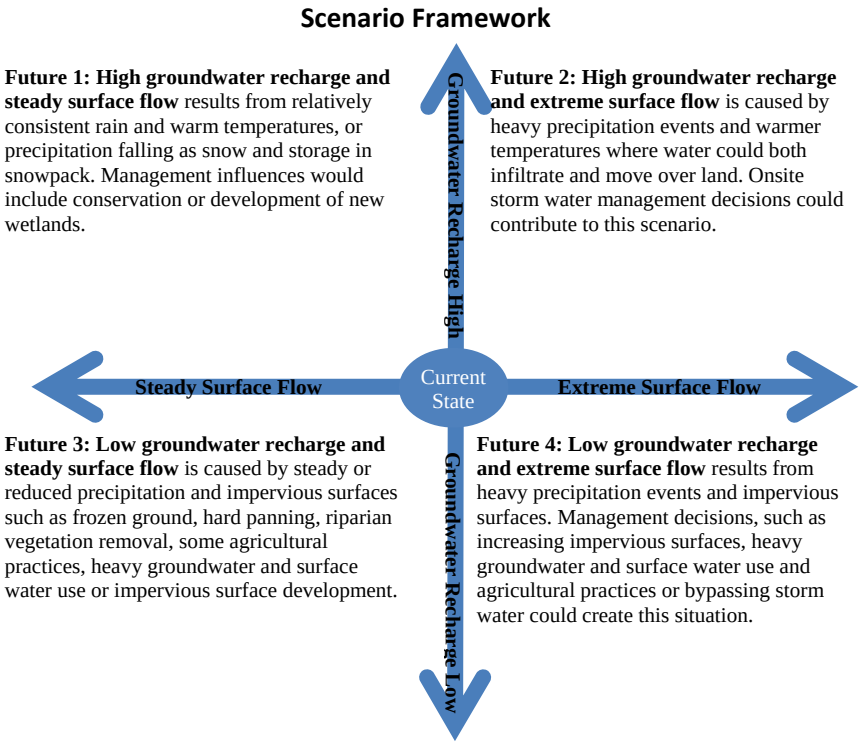

Figure 2: Scenario planning framework used to develop four future scenarios.

Breakout Group Activity: Developing Climate Scenarios

Participants split up into 4 groups to explore one of the 4 climate scenarios (Refer to Figure 2) and develop narratives to describe a plausible future landscape. Groups described each future considering:

- Physical and biological characteristics or management responses,
- Identified vulnerabilities and information gaps;
- Created 3 news headlines (near term and long term) characterizing what the future may have in store; and
- Titled each future to quickly capture the expected outcomes of the future.

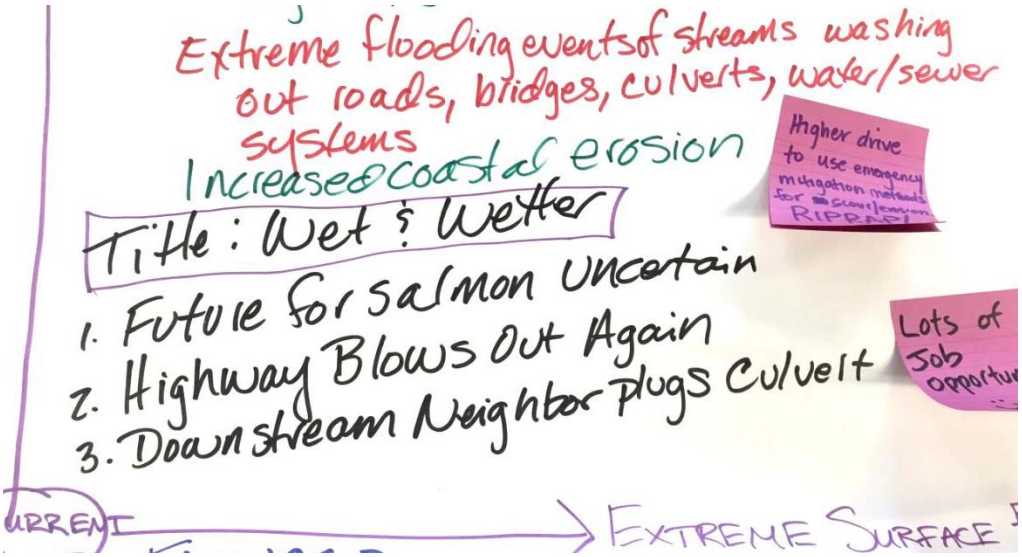

Figure 3: One group's description of the future through 3 news headlines and title.

Group Discussion: Scenarios

Once the groups filled in their quadrants, they shared the plausible climatic scenarios, descriptions and headlines. These descriptions were discussed in the frame of how climate and environmental changes may affect the possibility of Homer's desired future to be realized. Participants were asked:

- *How does the scenario modify your vision of the future?*
- *Are there certain physical/ biological changes in our environment that would indicate you are moving towards a certain scenario?*
- *Are there certain clues within your organization or community indicating a change is taking place?*

Headlines written for each scenario helped us identify thresholds, turning points or signals for decision-making. Thematic areas for discussion on strategies and pathways were also identified: food systems, local economy, land development and conservation of the wild.

STRATEGIES

Discussion: Climate-resilient and socio-economically robust pathways to the future
Susi Moser introduced the next session focused on developing specific adaptation strategies and actions needed to implement adaptation pathways to the vision of Homer in 2050. She explained the need for robust strategies that will work under different circumstances, so they are resilient in the face of the climate future scenarios outlined in the previous discussion. Participants were tasked to think creatively about solutions and identify barriers that may be encountered along the pathways in the four groups focused on **food, economy, development, and the wild**.

Breakout Group Activity: Identify key strategies and actions to create a path to the future
Within the identified focal areas, each group was asked to consider the following:

1. *What's working right now?*
2. *What do we need to do better?*
3. *What new or additional things should we be doing?*
4. *Do these strategies need to be adjusted to adapt to the different scenarios?*

Food (subsistence, food security, and managed agriculture): New or better practices for agriculture that account for changes in water availability and temperature, reducing food waste, and conserving healthy wild food sources were priorities to explore further. Additional things to be doing were to examine tradeoffs between managed and wild food sources, and create a policy for water usage and infrastructure, and increasing interagency/cross boundary cooperation.

Development (smart growth, land management and recreation): Major pluses in our current strategies were agency coordination, identifying conservation opportunities instead of waiting until restoration is needed, the quantity of public lands set aside, and local stewardship ethic. We could increase land use regulations on the borough level to consider "watershed scale" or cumulative effects of development. Long term planning and public education to reach under-engaged segments of the population was also highlighted as a need. Climate scenarios would help identify robust but flexible additions to regulations and code.

The wild (ecosystem integrity, biodiversity, abundance of species): Public lands set aside and intact ecosystems are both currently working in favor for conservation of "the wild". Agencies and non-profits can work better on education and incentives to improve stewardship among private landowners. Historical land and resource use from native culture and perspectives should be integrated into our whole community. Important corridors for habitat conservation may shift depending on climate scenarios, and adaptive management would be necessary.

Local economy (diversity, sustainability, and infrastructure): Human resources were highlighted in this discussion, with creative entrepreneurs, diverse small businesses and non-profits. The high quality of life is balanced with high costs of living, and unknowns about what a "livable wage" is in Homer. Since the group viewed the population as economically adaptive, there were not climate scenario specific adjustments. Additional things we should be doing were networking businesses, increasing investment in local workforce education, and changing our expectations for high paying jobs and government services.

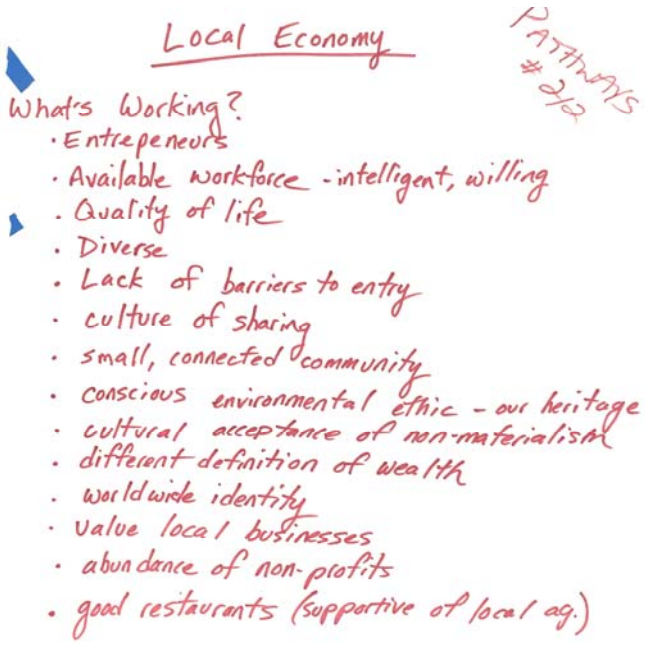

Figure 4: The *local economy* group's brainstorming.

PATHWAYS

Presentation: Decision Points and Turning Points
James Arnott presented the idea of identifying relevant thresholds and warning signals that would warn us to change our adaptation strategies. He emphasized finding socially-relevant triggers/tipping points that can drive responses at different stages over time, where they might originate and what we can do to prepare. In a full group discussion participants imagined and discussed potential major disruptions, windfalls and what could be the next "big one", including:

- Privatization of public lands
- Earthquakes, tsunamis
- Ocean Acidification (OA) altering entire ocean food web
- Natural gas development
- Major influx of people
- Economic downturn

Breakout Group Activity
Rotating groups tested the sectors (Economy, Land Development, Food and the Wild) with 3 different key events or state changes that affect social values or societally important systems that could lead to major turning points in the community and likely spur some form of response (for better or worse). For each of these tipping points, groups provide justification for them, connect them to overarching environmental scenarios, and estimate a time frame in which they might occur. Participants explored how to avoid damage from bad events, and to take advantage of potential opportunities. The groups were asked to consider:

- *What are the critical turning points or events?*
- *How would it affect the community/ region?*
- *How would it impact the pathway to the desired future?*
- *What can you do to start preparing?*

The turning points identified and discussed amongst each group are outlined below:

Food (subsistence, food security, and managed agriculture) turning points:

- Drought
- Mild Winters
- Population Increase

Development (smart growth, land management and recreation) turning points:

- Privatization of public lands
- Increased shipping and access to arctic
- Climate change becomes top political issue

The wild (ecosystem integrity, biodiversity, abundance of species) turning points:

- Ocean acidification
- Human population growth
- Shift to warm winters and dry springs

Local economy (diversity, sustainability, infrastructure) turning points:

- National economic collapse
- Influx of wealthy climate refugees
- Political imperative for local energy

DAY 2: OCTOBER 5, 2016

REFLECTIONS

Welcome and panel of leaders reflecting on Day 1

Jessica Shepherd welcomed participants and introduced local government staff and elected officials at the Borough and City level to reflect on the first day of the workshop and identify near-term opportunities (at their respective governance levels) to begin working on adaptation strategies. Each panelist was asked: *How this might help you in your policy making or planning process?*

City Planning - Julie Engebretsen

- Currently updating city comprehensive plan in-house.
- There is common ground in the recently updated hazard mitigation plan and the sense of resilience.
- Challenge is to put words on paper that speaks to a broad group of people.
    - Both those who want to consider climate change and those who don't.
- We need to be thinking for a longer timeframe (tend to plan to the near term).

City Council - Donna Aderhold

- If going to make headway on climate resilience everyone needs to be engaged in public process.
- Need to have some level of cooperation between the City and the Borough that doesn't exist currently- how can we work together at those boundaries?
- If the City needs to do something to improve resiliency that costs money- how do we pay for it?
- If our populations are going to increase on the Kenai Peninsula then I think we're going to need to think about how to strategically accommodate population increases.

Borough Assembly - Willy Dunne

- People don't want to spend money yet still want services.
- Glad to hear that the scenario that Tijuana River said would never happen happened- to show us we need to prepare for the unexpected.
- Borough has positive things going for it, including the 50ft buffer between development back from anadromous streams.
- Looking forward to working on these pathways and integrating into the comprehensive plan, it is incredibly important for many people to be involved.
- Still living the frontier attitude today- we're going to do what we want to do…need to gradually change that.

Borough Planning - Bruce Wall

- Borough is very large, very diverse opinions and values.
- The borough will reach out to a variety of organizations for comprehensive plan renewal.
- By the time we get the new one adopted it will be year 13/14 (overdue for 10 year date).
- Added in some language to incorporate climate change for contractor- then removed with hope that it will come out in public meetings.
- A lot of community support to plan for climate change and resilience.

ACTIONS

Presentation: From vision and pathways to real world planning and action
Susi Moser helped participants link the adaptive actions and strategies developed on Day 1 to entry points into local work, planning efforts and decisions. She acknowledged the difficulty of going from a workshop like this back to work and integrating the workshop's tools and discussions to existing workloads. Moser posed the following questions to participants to explore in breakout groups:

1. Entry point: *What do you see as the best, earliest opportunity to get started on some aspect of the adaptation pathway in your area of joint responsibility? When is it? How much time do you have to get ready?*
2. Opportunity/goal: *What is the opportunity here? What actually can be done? Why is that important? How far can the ball be kicked down the field? What would be the goal? How can this set you up to be well positioned for the next step?*
3. Foreseeable challenges: *What are some challenges you can foresee that could come up (e.g., lack of interest, political resistance, no money, competing demands on time)? What else?*
4. Partners: *Who is needed (absolutely necessary and helpful reinforcement) to bring to the table? What skills/expertise/access is needed? Who - if you not directly – can reach them? Who should do what?*
5. Resources: *What resources (information, money, time, staff etc.) are needed to prepare ahead of and at the time of that entry point/opportunity? Are they available? If not, where can you find them?*
6. Lead and task assignments: *Who will take the lead? Who will take the next steps? Who will take on what tasks? How will you ensure this gets done?*

Breakout Group Activity: Exploring key action mechanisms and engagement processes
This breakout activity was based on similar or related work responsibilities, people who work together in a particular institution, at the same level of government, or who are logically aligned to realize a political opportunity outlined in morning panel. Groups self-selected, huddled and explored 5 areas of engagement:

Group 1: **Wildlife Corridor Planning: Cross boundary management**
Infuse habitat connectivity/ cold water refugia concepts into planning processes. Partnership exists with the mountains to sea project, NRCS, USFWS and Land Trusts. Create outreach materials including a GIS story map to tell the story about cold water refugia.

Group 2: **Comprehensive and Climate Action Planning**
Land use or economic chapters of City Comprehensive Plan would be a good entry point. Promote public participation in the plan update, including real estate developers and planning commission. Incorporate Climate Action Plan concepts into comprehensive plan, and work on funding and resources to renew 10-year old Climate Action Plan.

Group 3: **Watershed Planning**
Habitat Focus Area NOAA grant an opportunity to develop watershed scale habitat protection. Develop tools and best practices materials for permitting and planning to incorporate landscape processes into decision making. People making decisions need to have information communicated to them, need funding to centralize data and build networks and communication tools.

Group 4: **Sentinel Site Planning for Seldovia**

Engage more communities in Kachemak Bay and develop NERR sentinel sites. Develop capacity and funding to transfer methods and information from NERR sites to Seldovia. Partner with schools, community volunteers and increase community support. Stewardship and Research team at the NERR will seek funding, Seldovia Village Tribe will report on tribal issues summary, NERR community monitoring program will help with education next steps and Alaska Sea Week.

Group 5: **Communication Efforts**
Many resources and options for increasing communication efforts (individual) and refining messaging (workgroup) around climate change. Goals are to identify storylines that effect behavior change. A challenge is making abstract concepts relatable, use specific events or local phenomena. Use social marketing concepts and science to develop community of practice on climate communication, and a peninsula wide communication plan with messages about science, impacts and adaptation.

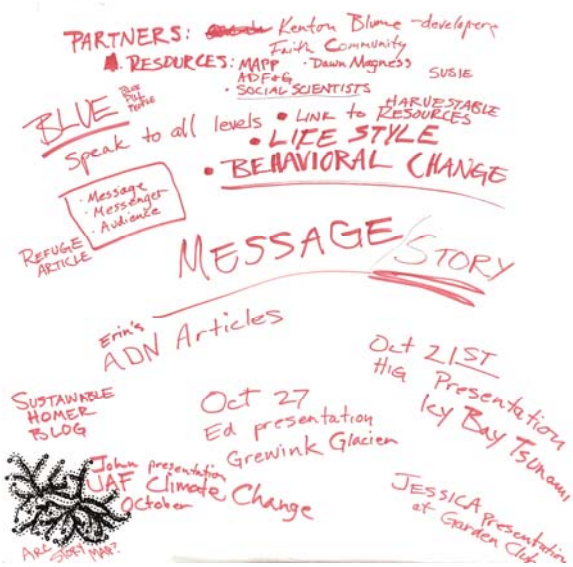

Figure 5: Communication group's brainstorming.

NEXT STEPS

Looking ahead: Summary and next steps

Reflecting on the previous session, the group discussed opportunities, and identified support needs to move adaptation planning forward in Homer and surrounding areas. KBNERR has a continued commitment to working with community, and participants suggested the following ideas for products and tools that would help them:

- Dry paper report isn't effective- think creatively for outreach and in-reach with this group
- Songs to reach beyond the "choir" of people
- Children's stories off of the scenario narratives, movie of the scenarios coming to life
- Artist-in-residence or artist in the schools
- Animation or cartooning (compelling fun, way of getting great information)
- Science/ art collaborative (creating a show by the science that artists learn)
- Climate change poetry

In the outlook to the workshop in Spring 2017, participants brainstormed ideas for indicators and metrics that can help track progress and successful adaptation:

- Measure of political will (tracking tool of where we are in that spectrum)
- Social network analysis (to see what new connections have been made)
- Social ecological hotspots- documented shifts within past 10 years
- How do we know we're growing our choir- reach people not in this room now
- Change in people reaching out to you about permitting
- How do the sums of all plans/ projects come together? If they contradict each other and are successful at what they do, then you could have the sum total of nothing
- Not all success will be comfortable- increased outrage means that we are out there
- One-on-one conversations and individual experiences (not easy to track with statistics

APPENDIX A:

Climate Science of Kachemak Bay and the Kenai Peninsula[1]

Local science to inform local decisions

Coastal communities on the Kenai Peninsula are already coping with a variety of challenges related to a changing environment, particularly because communities depend on coastal resources for their economic and cultural livelihood. The effects of a warming climate in this region are dramatic and forecasted to become even more so in future years. Agencies, small businesses, and communities on the Kenai Peninsula have responded to these signs of rapid climate change in varying ways; however, these efforts to date have not resulted in many tangible recommendations or a long-term strategy for adaptation.

Increased awareness and understanding of climate change science and vulnerabilities among decision-makers would help these communities adapt and increase resilience to environmental change. To start address this issue, Kachemak Bay National Estuarine Research Reserve (KBNERR) collaborates with researchers to synthesize and distribute the best available science around climate change impacts projected for the Kenai Peninsula.

Climate Science and Impacts

Local Climate

Temperatures will increase, especially in the winter.

Alaska is warming at twice the rate of Lower 48, with winters warming more than summers and nights have warmed more than days. Since 2014, KBNERR System Wide Monitoring Program has measured temperature anomalies in Kachemak Bay air and estuary water temperatures that have been above normal. Warmer air temperatures influence freshwater inputs to the estuary by changes in precipitation patterns and the rapid melting of overwinter snow pack and coastal glaciers.

Precipitation will increase overall, with more precipitation falling as rain rather than snow.

One of the most difficult to forecast trends on the Kenai Peninsula is the form, timing, and magnitude of increasing precipitation. Scenarios Network for Alaska and Arctic Planning predictions indicate a shift in precipitation from snow to rain, which impacts water storage capacity and surface water availability. Impacts include changes in storm water runoff, groundwater infiltration and water storage. Snow may increase at higher elevations but decrease along coast.

Many locations will be dryer in the summer as evaporation rates increase.

Research by Kenai National Wildlife Refuge documents wetland drying and encroachment of woody vegetation into peatlands. KBNERR has found that these peatlands are important sources of organic carbon, vital for stream productivity, and support on anadromous fish. The Western Kenai has warmed and dried in last 50 years with respect to available water (60% loss since 1968), wetlands (6 – 11% per decade), and glaciers (5% surface area, 21 m elevation). Glacial systems provide cold water during warm months but at higher stream flow and will likely contribute to increased turbidity.

Coastal & Marine

Storm intensities and frequency will increase.

Sea level rise is likely to be offset by land level rise from glacial rebound and tectonic uplift according to a joint study between KBNERR and UAF Geophysical Institute. Oceanographic monitoring in Kachemak Bay and lower Cook Inlet done collaboratively with KBNERR and Kasitsna Bay Lab indicates a lack of ocean cooling in the winter is important. Wave height, period, and direction are important factors in sediment transport; wave dynamics are being monitored with an IOOS wave buoy supported by KBNERR and KBL in outer Kachemak Bay. A 2016 study by KBNERR indicates erosion rates on Eastern shores of Cook Inlet are 1 foot per year, and 2.3 feet per year on the western Homer area.

Oceans will become warmer and more acidic.

Increase in carbon in the atmosphere will affect ocean carbonate chemistry, leading to ocean acidification. Shell formation of important zooplankton is most at risk and a source of food for many harvested fish stocks in the region. Ocean

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[1] KBNERR hosted a Climate Adaptation for Coastal Communities workshop in March 2016 in Homer, AK. The climate science and impacts summarized in this document are a result of the presentations and discussions during this workshop. NOAA Office for Coastal Management trainers presented basic influences on the climate system, as well as climate's impact on coastal communities and the natural environment. Regional experts presented local data and monitoring, impacts on coastal and watershed resources, and landscape level vegetation and wildlife change. Through facilitated discussion, regional environmental experts, coastal decision-makers, and community members were able to understand synergistic and land-scape level impacts that are occurring on the land and in the estuary. Coastal and community impacts were identified utilizing local research and monitoring, and observations from our network of partners, including the National Estuarine Research Reserve System's (NERRS) System-Wide Monitoring System (SWMP). Presentations:

- *Regional Data, Trends, and Impacts*, Jessica Shepherd, Kachemak Bay NERR
- *Alaska's Salmon Streams in a Changing Climate*, Sue Mauger, Cook Inletkeeper
- *Early Responses of Kenai's Wildlife and Vegetation to Rapid Climate Change*, John Morton, USFWS Kenai National Wildlife Refuge

acidification will damage vital nurseries for many fish stocks. Alutiiq Pride Shellfish Hatchery tests water samples from numerous communities near coastal villages and communities in south-central Alaska to assess vulnerability with the emphasis on shellfish health. NOAA Kachemak Bay Habitat Focus Area research is currently being conducted to promote native shellfish population recovery through pH monitoring, habitat modeling and clam spawning sanctuaries.

Wildfires

Wildland fire season will shift in timing and vegetation types.
Official fire season is now April 1 instead of May 1. In the aftermath of spruce bark beetle-induced deforestation, grassland fires have burned in April on the southern part of the Peninsula in recent years. Lightning caused the 2005 Irish Channel fire that burned 1,100 acres of mountain hemlock, an event so rare in this forest type that charcoal evidence of a historic fire regime has not been detected.

Agriculture & Fisheries

Length of growing season will increase.
Homer's growing season has increased from 100 days to 130 in the past 30 years. Homer has jumped 2 USDA plant zones, and season extension and mechanisms that improve plant health and vigor (high tunnels) has increased local agriculture opportunities. Southern Kenai Peninsula NRCS offices are the highest grantor of Equip grants in the nation.

Salmon stream viability will be stressed.
Several of our Kenai Lowlands streams have been measured by Cook Inletkeeper that fall into temperature categories that put salmon at risk. Warmer temperatures will cause reduced survivorship of salmon egg and fry, reduced growth rates due to increased rates of respiration and metabolism. Premature smolting and shifts in emigration timing reduce marine survival and some organic chemicals and metals, including mercury, can increase in toxicity with temperature, causing greater vulnerability. Juvenile salmon may respond positively to increased stream temps as long as their habitat and food sources are intact.

Habitats, Wildlife, & Plants

Land cover types will change.
Temperature and precipitation regimes indicate we are in the edge of three biomes- boreal forest, temperate rainforest and grassland savanna. Kenai National Wildlife Refuge has detected woody shrub encroachment into 8000 year-old Sphagnum peatlands, and conversion of spruce forests to savannah. Eastern Kenai Peninsula is predicted to undergo afforestation in alpine (hemlock) and coastal (Sitka spruce) areas, while the Western side will undergo deforestation (white and black spruce), expanding grasslands.

Animals, insect species, and plant communities will shift their ranges.
Changing bird migration windows and birds that are more common in winter have been documented through E-bird. In the marine environment, changes in food web dynamics likely influenced mortality events for large whales in the Gulf of Alaska and common murres. COASST Citizen Scientists recorded the die-off of thousands of common murres in fall, 2015. Sea otter strandings increased to record numbers for Kachemak Bay during 2015 according to the Marine Mammal Stranding Network. Baseline vegetation mapping in four salt marshes (Beluga Slough, Fox River Flats, Sadie and China Poot) has been done through KBNERR to measure plant community dynamics in response to sea level change.

Changing conditions will enhance the likelihood of invasive and harmful species.
KBNERR Harmful Species Program works with oyster growers and community volunteers for early detection of harmful algal blooms and invasive species. A toxic *Pseudo-nitzschia* bloom in Kachemak Bay was seen September 2015 and a Kachemak Bay oyster farm tested positive for saxitoxins, which can cause Paralytic Shellfish poisoning from *Alexandrium*. As marine water temperatures increase, Southcentral Alaska is vulnerable to invasions from marine invasives, including European Green Crab and Invasive Tunicates. Alaska Center for Conservation Science tracks all non-native plants known to occur in Alaska. Spruce forests have been hit by eruptive species such as Spruce Bark Beetles, and more recently Spruce Aphids, causing defoliation around Kachemak Bay in 2016.

Where can I learn more?

- Kachemak Bay NERR Long Term Monitoring and Research Programs
  http://accs.uaa.alaska.edu/kbnerr/research-program/
- Alaska's Climate Change Strategy: Addressing Impacts in Alaska
  https://climatechange.alaska.gov/aag/docs/aag_all_rpt_27jan10.pdf
- Climate Change Impacts in the United States: Alaska Chapter
  https://www.epa.gov/climate-impacts/climate-impacts-alaska

APPENDIX B:

Climate Adaptation for Kachemak Bay and the Kenai Peninsula

Community priorities and needs to inform scenario decision-support tools

To create a foundation for a climate scenario planning process on the Kenai Peninsula, Kachemak Bay National Estuarine Research Reserve (KBNERR) collected stakeholder information to gain insight into community priorities related to climate adaptation. Regional climate observations, risk perceptions, preparedness, and perceptions of successful community adaptation were gleaned from input by a broad range of stakeholders.

Purpose

KBNERR is not a land manager, and the focus of our projects are to serve the land and resource managers in our ecoregion. However, this work will closely connect our research and monitoring priorities to community needs, and should inspire new directions and revisions to our management plan.

Identifying community priorities and needs

Responses were used from a Climate Adaptation for Coastal Communities workshop held in 2016, as well as informal informational interviews once workshop results and local climate science was synthesized. Stakeholder responses helped to identify needs, barriers and primary climate change uncertainties that are central to decision-making and the scenario planning framework development was informed by the kinds of adaptation measures stakeholders identified as possibilities.

Priority areas of concern were identified from climate stressors and assets:

- Infrastructure protection
- Fresh water conservation
- Flood management
- Fisheries management
- Shellfish restoration
- Fire management
- Agriculture development

Assets

Guiding assumptions grounded in climate science

A synthesis of local climate science was used to outline a few assumptions or predictions that aided in narrowing the focus of decision tool development:

- Air and water temperatures will rise
- Precipitation will fall as rain instead of snow
- Growing season will lengthen
- Winter storms will increase in frequency and intensity
- Local land level rise will outpace sea level rise for the near future

Barriers

Identifying the primary drivers of change

Given these community priorities, and lessons from climate science, it was clear that **primary drivers of change that shape the landscape were inextricably linked to water**. Understanding how water moves is the basis for looking at how climate may impact current functionality and inform coastal planning and management decisions.

Barriers

Adaptation Measures

The drivers of change for these local issues were identified as variables for scenario framework development using the following criteria:

- Have associated uncertainty: Decided direction of change but a range of magnitude
- Interact with each other: Consider how multiple variables interact, instead of considering climate change impacts in isolation
- Driven by both climate and management: Capture uncertainties related to broader socio-ecological drivers of change

This process ensures the final decision-support products meet local needs, allowing room for the consideration of both climatic and non-climatic stressors on the biophysical and socioeconomic characteristics of the communities. Several possible water-related variable pairs were identified by stakeholders:

1. Hydrology
    - Extreme surface flow and Groundwater recharge
2. Coastline
    - Frequency of extreme river discharge and Changes in coastal sediment supply
3. Watershed Habitat
    - Increase in fire frequency and intensity and Changes in available freshwater
4. Marine Habitat
    - Ocean Acidification and Ocean Temperature

Given these potential possibilities two primary drivers of change were chosen for the scenario process, with feedback from local scientists and researchers, which focused on hydrology drivers and how water relates to so many aspects of climate change in our region. Two drivers of change that capture these effects are **extreme surface flow events** and increasing or decreasing **groundwater recharge**.

Local freshwater is distributed unevenly across the landscape, throughout the seasons, and from year to year. Climate change impacts local hydrology through temperature increases, changing precipitation rates, vegetation changes and sea level rise. Management practices including water use, development of impervious surfaces and alteration of wetlands can also impact water distribution on the landscape.

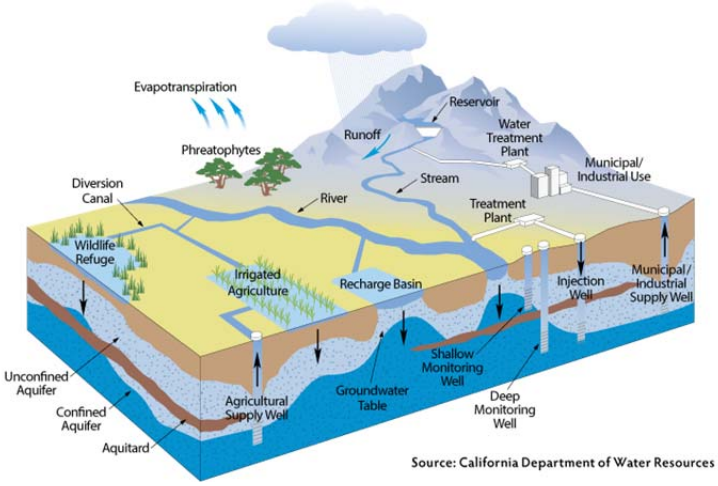
Next steps

This scenario framework was the basis for a series of workshops in 2016-2017 in collaboration with Tijuana River NERR and the NERR Science Collaborative Successful Adaptation Indicators and Metrics project.

APPENDIX C:

Developing Scenario Framework: Groundwater and Surface Water Drivers

A climate scenario framework, targeting the relationship between 2 drivers of change (shallow groundwater and surface water) is explored below. These drivers are chosen because of their strong role in physical and biological processes operating on landscape and their centrality to effective management of many resources and assets. Local freshwater is distributed unevenly across the landscape, throughout the seasons, and from year to year.



1. Extreme stream flow events

Extreme stream events can increase or decrease based on changes in precipitation patterns (e.g., frequency and intensity), water management practices (e.g., dams, channelization of river channels), and / or land use patterns (e.g., increased impervious or denuded surfaces) altering the amount and velocity at which freshwater and sediment enters the system. Climate change is projected to affect weather patterns and storms, so considering **changes in extreme stream flow events** is important. From both natural and human perspectives, extreme river flows can change the landscape and produce hazardous flooding. For example, historically, the most damaging storms in Alaska have been extreme events, particularly storms that occur during the fall and winter, producing intense rains during times of low water absorption by soils and vegetation (frozen ground or plant productivity).

2. Groundwater recharge

Groundwater recharge occurs in areas of the landscape where water moves from surface water to groundwater below. **Increases or decreases in groundwater recharge** will depend in large part on the relationship between precipitation, soil infiltration and local subsurface lithology. The direction that water moves reflects gravity and/or relative water pressure gradients and continuity of permeable ground. Unless blocked by an impermeable surface, water moves from areas of higher water pressure (hydraulic head) to areas of lower water pressure. Management practices impacting recharge include development of infrastructure like roads, parking lots and buildings and other operations that reduce infiltration, and agriculture practices that are water intensive. Climate change is projected to affect timing of freeze/thaw and seasonal recharge. Increased evapotranspiration due to warmer summers means that the landscape will be drier (drying wetlands, less groundwater recharge and stream flow.) Peat bogs, Depressions, Headwater Fens, and Late Snow Plateaus and undisturbed Upland wetlands are most likely to recharge groundwater, at least seasonally. Increased rainfall that saturates the ground on the top of bluffs above the Homer Bench will increase the probability of cataclysmic bluff collapse which could wipe out most of the town in a few minutes. Reduced groundwater will increase the demand for hauled water from the City reservoir, which itself will experience declining stream and groundwater input due to the climatically-reduced available water

With input from local experts, we assessed 4 futures that have different directions and magnitude of groundwater recharge and extreme to steady surface flow. We described how these drivers could be influenced by climate and management decisions, and the physical characteristics of the landscape.

Increased Groundwater Recharge

Future 1: High groundwater recharge and steady surface flow results from relatively consistent rain and warm temperatures, or precipitation falling as snow and storage in snowpack. Management influences would include conservation or development of new wetlands.

Physical Characteristics:
Increased Infiltration
Decreased surface flow
Groundwater maintained base flow
Less erosion and scour
Decreased turbidity in streams
Moderated stream temps in summer
Saturated soils

Future 2: High groundwater recharge and extreme surface flow is caused by heavy precipitation events and warmer temperatures where water could both infiltrate and move over land. Onsite storm water management decisions could contribute to this scenario.

Physical Characteristics:
Flooding during extreme events
Groundwater maintained base flow
High Infiltration
More Erosion and Scour
Increased turbidity in Streams
Saturated soils
Bluff Collapse
Moderated stream temps in summer

Steady Surface Flow

Extreme Surface Flow

Current State

Future 3: Low groundwater recharge and steady surface flow is caused by steady or reduced precipitation and impervious surfaces such as frozen ground, hard panning, riparian vegetation removal, some agricultural practices, heavy groundwater and surface water use or impervious surface development (management decisions).

Physical Characteristics:
Reduced Infiltration
Less Erosion and Scour
Increased evaporation and freezing
Interrupted streamflow
Decrease turbidity in streams
Drying wetlands
Increase depth to water
Higher stream temps in summer

Future 4: Low groundwater recharge and extreme surface flow results from heavy precipitation events and impervious surfaces. Management decisions, such as increasing impervious surfaces, heavy groundwater and surface water use and agricultural practices or bypassing storm water could create this situation.

Physical Characteristics:
Reduced Infiltration
Variable water and sediment input rates to wetlands
More erosion and scour
Increased turbidity in streams
Sediment gravity flows
Higher stream temps in summer

Decreased Groundwater Recharge

Scenario Narrative Development:
Physical Characteristics, Biological Responses and Community Vulnerabilities

In an October 2016 workshop, participants were asked to develop the climate scenarios by describing how changes in groundwater and extreme surface flow events would impact key physical characteristics such as flooding and inundation, water quality, water storage, erosion and sedimentation, and streamflow regimes.

- **Flooding & Inundation**
  Understanding how a system floods, where to expect flooding based on elevations, and what is causing the flooding (e.g., groundwater or surface water) is crucial to effective management of a system. Flooding is not only an important factor for natural systems, but also for managing built infrastructure such as roads, utilities and facilities.
- **Water Storage**
  Natural water storage occurs where inflows from precipitation, surface flow, or subsurface flow are absorbed or held before they flow out. This storage includes both surface and subsurface storage (in the soil).
- **Water Quality**
  Water pressures found in the groundwater zone are high enough to enable water to be pumped out, so recharging groundwater is critical to maintaining the supply of water in wells. Groundwater and surface water interactions determine the distribution of specific habitat types on a landscape through nutrient inputs and temperature buffers.
- **Erosion and Sedimentation**
  Too much sediment can fill-in river channels leading to increased flooding extents. Too little sediment can lead to channel reconfiguration and erosion.
- **Streamflow Regimes**
  Key characteristics of streams include channel shape, streambed material, water quality and temperature, and aquatic and riparian plant communities. Groundwater maintains stream flows during winter—when surface water sources are frozen—and during low flow periods in late spring and summer (after snowmelt and before rainfall).

Each group developed 1 of the 4 climate scenario narratives to describe a plausible future landscape. After they developed ideas of what the physical characteristics of the landscape were in each of the four scenarios, they explored biological responses and vulnerabilities. Keeping the desired vision for the future from the start of the workshop in mind, we explored adaptation strategies and pathways that are resilient in the face of these climate futures. Ultimately, these pictures of the future were used to test whether our community vision is robust, or if we can identify adaptation measures and pathways to achieve our community vision. The future headlines helped us identify thresholds, turning points or signals for decision making.