WILDFIRES AND FOREST HEALTH - COLORADO-BIG THOMPSON PROJECT

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ABSTRACT

The Colorado-Big Thompson Project (C-BT) and the associated Windy Gap Project deliver over 230,000 acre-feet of water annually to supplement municipal, agricultural and industrial water supplies for 860,000 people and 640,000 acres of irrigated land in Northern Colorado. Water is diverted from the Colorado River Basin to the South Platte Basin through a system of 12 reservoirs with a total storage capacity of nearly 1 million acre-feet, 35 miles of tunnels, 95 miles of canals, three pumping plants and six hydroelectric power plants with an installed capacity of 216 megawatts. The Northern Colorado Water Conservancy District (Northern Water) was created in 1937 to contract with the U.S. Bureau of Reclamation (Reclamation) for construction and repayment of project facilities, and jointly operates and maintains C-BT with Reclamation.

C-BT water supplies are nearly entirely dependent upon snowmelt from high elevation watersheds along the Continental Divide in Northern Colorado. Forest health and fires within these watersheds can have dramatic effects on the quality of watershed runoff and the ability of C-BT water supplies to meet municipal, industrial and agricultural water uses. Catastrophic wildfires that occurred in Northern Colorado during 2012-2013 drought conditions highlighted the risk that C-BT water supplies face given deteriorated forest health conditions, drought, and urbanization at the wildland-urban interface. Northern Water, in conjunction with its partner local, State and Federal agencies are taking a pro-active approach to addressing these conditions, including actions to protect water supplies from recent wildfires, as well as initiating the C-BT Headwaters Partnership, which will develop a plan and program to address forest health conditions in C-BT watersheds and pre-plan post-wildfire response in preparation for potential future wildfires.

INTRODUCTION AND BACKGROUND

C-BT is Colorado’s largest transmountain diversion project. The project was authorized as a federal reclamation project by Congress on June 24, 1937 with the approval of Senate Document 80 (Reclamation, 1937). The project was built from 1938 to 1957 with a final construction cost of $164 million, and provides supplemental water to 32 cities and towns and more than 100 ditch and reservoir systems. C-BT is designed to collect and deliver up to 310,000 acre-feet of water annually from the Upper Colorado River Basin. It transports up to

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550 cubic feet per second (cfs) of water to the Front Range via the 13.1-mile Alva B. Adams tunnel beneath the Continental Divide. Total storage of the C-BT system (not including Green Mountain Reservoir, which is used for water and power obligations on the West Slope) is approximately 845,000 acre-feet. The largest reservoirs are Lake Granby (540,000 acre-feet), Horsetooth Reservoir (157,000 acre-feet) and Carter Lake (112,000 acre-feet).

The Windy Gap Project consists of a diversion dam on the Colorado River, a 445-acre-foot reservoir, a pumping plant, and a six-mile pipeline to Lake Granby. Windy Gap water is pumped and stored in Lake Granby before it is delivered to water users via the Colorado-Big Thompson Project’s East Slope distribution system.

Northern Water is a public agency created in 1937 under Colorado’s Water Conservancy Act (Colorado Revised Statutes § 37-45-101 et seq.). The boundaries encompass nearly 1.5 million acres in portions of Boulder, Broomfield, Larimer, Logan, Morgan, Sedgwick, Washington and Weld counties (Figure 1). Water assessments and ad valorem taxes form Northern Water’s primary revenue base. The Municipal Subdistrict is a separate and independent conservancy district that constructed and operates the Windy Gap Project. The Municipal Subdistrict Board directors are the same as the Northern Water Board.

West Slope Watersheds

Snowmelt from the watersheds of the West Slope Collection System comprises more than 80 percent of the water supply yield for the C-BT and Windy Gap projects. Watersheds range in elevation from nearly 13,600 feet along the continental divide to the east and north, to 8,100
feet at Willow Creek Reservoir and 7,800 feet at Windy Gap Reservoir. Unlike many large water supply agencies, neither Northern Water nor Reclamation own significant portions of the C-BT watersheds. Approximately ¼ of the West Slope watersheds are within Rocky Mountain National Park, and ½ are within the Arapaho National Forest (Figure 2). Northern Water and the Municipal Sub-District own approximately 3,300 acres (less than one percent of the West Slope watersheds) around Willow Creek Reservoir and Windy Gap facilities, while Reclamation owns land immediately surrounding its facilities.

West Slope watersheds are characterized by alpine and sub-alpine vegetation zones (Lugo et al. 1999), with large expanses of even-aged lodgepole pine at the lower elevations of the sub-alpine zone surrounding and immediately upstream of C-BT facilities (Table 1). Forest health has been severely affected by the mountain pine beetle epidemic, resulting in mortality of approximately 90 percent of mature lodgepole pine (Grand County, 2008). The epidemic began on the West Slope in the late 1990’s, with most tree mortality occurring between 2000 and 2009 (U.S. Forest Service 1997-2012). Most of the lodgepole pine forests on the West Slope are in the gray stage, which occurs about 2 to 3 years after initial infestation once needles fall off the trees, but before the time when trees begin falling to the forest floor. The grey stage is expected to last 4 to 10 years (Schoennagel 2012), and presents the optimum time to perform forest health treatments as there can be some value left in the lumber, and access and logging activities have not been affected by downed timber.
Table 1. Vegetation Types in C-BT Watersheds

<table>
<thead>
<tr>
<th>Vegetation Type</th>
<th>West Slope</th>
<th>East Slope</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(acres)</td>
<td>(%)</td>
<td>(acres)</td>
</tr>
<tr>
<td>Lodgepole</td>
<td>128,000</td>
<td>36%</td>
<td>51,000</td>
</tr>
<tr>
<td>Ponderosa</td>
<td>9,000</td>
<td>3%</td>
<td>90,000</td>
</tr>
<tr>
<td>Spruce-Fir</td>
<td>90,000</td>
<td>25%</td>
<td>28,000</td>
</tr>
<tr>
<td>Other Forested</td>
<td>12,000</td>
<td>3%</td>
<td>21,000</td>
</tr>
<tr>
<td>Alpine</td>
<td>42,000</td>
<td>12%</td>
<td>29,000</td>
</tr>
<tr>
<td>Other</td>
<td>74,000</td>
<td>21%</td>
<td>81,000</td>
</tr>
<tr>
<td>Total</td>
<td>355,000</td>
<td></td>
<td>300,000</td>
</tr>
</tbody>
</table>

East Slope Watersheds

Although East Slope water supplies only constitute a small amount of the overall C-BT yield, these watersheds are extremely important to C-BT because these streams intermingle with C-BT water, primarily at Lake Estes, Dille Tunnel diversions in the lower Big Thompson Basin, and from watersheds that surround terminal reservoir facilities. Watersheds range in elevation from 14,250 feet on Long’s Peak near Estes Park to about 5,400 feet at Horsetooth Reservoir. As on the West Slope, Northern Water and Reclamation do not own appreciable land in the East Slope watersheds. Approximately \( \frac{1}{3} \) of East Slope watersheds are within Rocky Mountain National Park, and \( \frac{1}{4} \) are within the Roosevelt National Forest (Figure 2).

Because of larger variability in elevation and precipitation, East Slope watersheds are characterized by alpine, sub-alpine, upper montane, lower montane, and lower ecotone vegetation zones, with associated variability in vegetation types (Kaufmann et al. 2006). The dominant forest type is ponderosa pine (Table 1) and occurs throughout the elevation range surrounding and immediately upstream of C-BT facilities. Forest health has also been severely affected by the mountain pine beetle epidemic. However, since the epidemic generally proceeded from west to east through Northern Colorado forests, the epidemic is younger and still on-going within the East Slope watersheds (Colorado State Forest Service 2012). A similar level of tree mortality in East Slope lodgepole pine forests is expected as on the West Slope; it is possible that ponderosa pine mortality may be less severe. Beetle-impacted forests on the East Slope are a mix between the initial, red stage within the foothills areas to the early grey stages at higher elevations.

IMMEDIATE CONCERNS: WILDFIRE IN C-BT WATERSHEDS

As a result of extreme weather conditions and declining forest health, 2012 produced a devastating wildfire season throughout Colorado. In Northern Colorado, the 2012 fire season included the second largest wildfire in Colorado’s recorded history (at the time), as well as a rare late-season high-elevation wildfire in Rocky Mountain National Park. The 2013 wildfire season didn’t start much better, with a quick-moving wildfire during March and another high-elevation early-season fire in Rocky Mountain National Park. The lessons learned about the landscape’s physical response to these fires as well as the actions and coordination needed during and after these fires has shaped development of Northern Water and the C-BT Headwaters Partnership wildfire plan and program.
Recent Fires

Fires have always been a part of the landscape within the low and high-elevation watersheds of the C-BT system. However, as with the rest of Colorado, there has been an increase in both the number and size of fires over the last two decades. Figure 3 presents a summary of the number of fires and acreage burned on state and private land in Colorado since 1960 (Colorado State Forest Service 2013, Edwards 2013). Although this data does not include federal land, the trends are indicative of overall fire behavior within the state.

The reasons for increases in wildfire starts and size are reflected by changes in the three dominant factors that influence fire (vegetation characteristics, fire weather climatology, and ignition patterns), all of which vary in importance spatially and temporally (Moritz et al. 2012). The single most important factor affecting wildfire, especially at higher elevations, is weather and climate (Veblen et al. 2012). Colorado has been in an extended drought since the early 2000’s, and indeed, the most destructive statewide fires occurred in the severe drought years of 2002 and 2012. Increased tree densities (resulting not only from fire exclusion policies, but also early 20th century logging, grazing and timber practices), especially in lower elevation ponderosa pine forests where many of the larger recent fires occurred, have increased fuel loads beyond natural levels (Kaufmann et al. 2006). Ignitions include both natural and man-made causes, and the number of fires in Figure 3 is well correlated with increases in Colorado population and associated wildland urban interface population.

Several fires have burned within or adjacent to critical C-BT watersheds (i.e. watersheds that are direct water supplies for the project, or watersheds immediately upstream of key...
reservoirs) within recent years (Figure 4). The following describes the major fires that have affected C-BT watersheds:

- **High Park Fire.** The High Park Fire burned more than 87,200 acres in Larimer County during summer 2012, killing one person and destroying 259 homes. The fire burned approximately 410 acres within the Horsetooth Reservoir watershed – the remainder of the fire was adjacent to main C-BT water supply watersheds (approximately 8,465 acres burned in the Redstone Creek watershed, which is considered a C-BT watershed but is not a main water supply watershed). The fire burned primarily in upper and lower montane forests, with predominantly mature lodgepole pine and a relatively closed canopy at mid and higher elevations, and mixed-conifer forests containing lodgepole pine, ponderosa pine, and Douglas-fir at lower elevations. Nearly 50 percent of the area burned at moderate or high intensity (U.S. Forest Service 2012).

- **Fern Lake Fire.** The Fern Lake Fire began in October 2012 in the higher elevations of Rocky Mountain National Park in the Big Thompson watershed. Under a full-suppression strategy since it began, the fire remained in inaccessible terrain until late November, when 70-mile-per-hour winds pushed the fire east into Moraine Park, more than doubling its size. The fire burned about 3,498 acres, and is located in the sub-alpine lodgepole and mixed conifer forests of the Lake Estes watershed.

![Figure 4. Recent Major Fires In and Near C-BT Watersheds](image-url)
• **Galena Fire.** In March 2013, the Galena Fire burned about 1,348 acres directly west of Horsetooth Reservoir in Lory State Park and Horsetooth Mountain Park. This fire was immediately south of the southeast corner of the High Park Fire, and located in the lower montane ponderosa pine forests and grasslands of the Horsetooth Reservoir watershed. The fire burned down to the reservoir high water line in several places.

• **Big Meadows Fire.** The Big Meadows fire is currently burning in Rocky Mountain National Park. The fire began in June 2013 and has burned slightly more than 600 acres at the time of this paper. The fire is located in the Grand Lake watershed on the West Slope.

The Hewlett Gulch fire, located at the northeast boundary of the High Park fire, burned approximately 7,685 acres during the spring of 2012. Although this fire had significant effects on other municipal water supplies in the Poudre River Basin, including those for the cities of Fort Collins and Greeley, it did not have a direct impact on C-BT water supplies.

**Fire Response**

Northern Water’s responses to the recent fires were focused in three main areas: direct mitigation of land and facilities affected by the fires, water quality monitoring, and evaluating opportunities for operational changes to address potential poor quality runoff.

• **Direct Mitigation:** funded seeding and mulching efforts to revegetate and reduce erosion; installed and maintain temporary wattles in tributary channels, and constructed sediment basins to capture sediment and debris in drainages upstream of reservoirs; cleaned sediment from facilities; and, planned for installation of floating debris booms in reservoirs and tributary channels to capture and remove larger floating debris from reservoirs.

• **Water Quality Monitoring:** Coordinated and installed water quality monitoring to provide real-time information on water quality conditions, primarily turbidity, to water users through a web-based application; and, developed baseline water quality sampling in conjunction with the USGS and municipalities to study rainfall and runoff processes as a result of the fires.

• **Operational Investigations:** Considered options to reduce or restrict imports of water from the West Slope to the East Slope for short durations following events that cause short-term adverse water quality conditions.

Because of its limited impact on C-BT water supplies, the mitigation efforts by Northern Water were only a small part of the overall mitigation efforts for the High Park and Hewlett Gulch fires. Numerous federal, state and local public agencies, non-profit organizations and land owners are investing millions of dollars and volunteer hours to address the long-term recovery of the High Park burn area. Mitigation efforts include reseeding, aerial and hand placement of straw and wood mulch, replanting of trees, directional felling of logs in
drainages, sedimentation basins, culvert replacement, increased water quality monitoring and
general debris cleanup.

**Effects of Fires**

The primary effects of fires on water supply systems are changes in post-fire hydrology and
water quality. Post-fire hydrology varies by fire severity, and is characterized by loss of
protective surface cover and surface roughness; hydrophobic (water repellent) soil
conditions; a shift from sub-surface to overland flow, and increases in runoff and erosion
rates. Post-fire water quality is characterized by increased stream turbidity and suspended
sediments, increased total organic carbon, volatilization of nitrogen, large phosphorous flux
from soil erosion and sediment transport, and oxidation of heavy metals in soils and plants
(Stednick 2013).

Of the numerous fires, the High Park Fire has had the most significant effects on regional
water supplies. Normal-intensity rainfall events and spring runoff conditions have flushed
sediment and fire debris into the Poudre River, a major source of drinking water for the cities
of Fort Collins and Greeley and surrounding areas. The water suppliers become nearly
entirely dependent on Horsetooth Reservoir water supplies immediately following these
types of events, including for several months following the fire. It is expected that over the
next several years until the watershed fully recovers, these types of events will continue to
result in periods of highly turbid runoff resulting in increased reliance on Horsetooth
Reservoir and C-BT water supplies.

Irrigators were also affected by the fire, primarily from ash, sediment and debris at diversions
and in canals. The Munroe Gravity Canal diversion, a part of the C-BT project that delivers
irrigation water to the North Poudre Irrigation Company, was completely clogged with
sediment and debris following a rainstorm over parts of the High Park Burn area in 2013 (one
year following the fire; Figure 5). This event interrupted deliveries through the Munroe
Gravity Canal for approximately 10 days. Fortunately, in-system reservoir storage was
available to supply most irrigators canal during the outage. Northern Water assisted the North
Poudre Irrigation Company in the excavation of about 1,000 cubic yards of debris from the
diversion structure and downstream tunnel, and further structural repairs may be required.

Additionally, reports were received regarding clogging of center-pivot sprinkler nozzles and
clogging/interruption of irrigation siphon tubes (Gertig 2013), and there are many locations
where tributary drainages flowing are passed over or under irrigation ditches and canals that
could be adversely impacted by increases in runoff (U.S. Forest Service 2012).

The most significant regional effect of the High Park Fire on irrigators may be changes in
temporary water supply availability from municipalities. Typically, municipalities execute
annual rentals with irrigators for C-BT and other water supplies that are in excess of what
they can use in a given year. However, partially due to uncertainties regarding Poudre River
runoff as a result of the High Park Fire and partially due to current drought conditions, most
cities will not have excess water available to rent in 2013. Coupled with the drought
conditions, late season water supplies are expected to be lower than normal in 2013, and have
affected cropping and irrigation patterns throughout Northern Water boundaries.
Initial assessments by the National Park Service indicate that both the Fern Lake Fire and the Big Meadows fire burned at low intensity, and that natural filtering of runoff through large meadows downstream of each fire will help reduce sediment and debris in the water. Further evaluation is currently being completed by the National Park Service.

The Galena Fire occurred during a time of year that allowed substantial vegetative recovery prior to summer thunderstorm events. Wattles and sediment basins installed by Northern Water were effective in reducing ash and sediment runoff into Horsetooth Reservoir during spring snowmelt runoff and lighter precipitation events in the early summer.

**LOOKING AHEAD: C-BT HEADWATERS PARTNERSHIP**

The 2012 fire season was a wakeup call to water supply entities in Northern Colorado that watershed health is paramount to delivering clean usable water supplies to water users in Northern Colorado. This, along with other Colorado water suppliers’ and agency experiences in responding to wildfire and forest health planning, led to establishment of the C-BT Headwaters Partnership. The partnership was created in 2012 through a Memorandum of Understanding between the U.S. Forest Service, Colorado State Forest Service, Reclamation and Northern Water. The goal of the partnership is to proactively restore forest and watershed health, and to pre-plan post-wildfire response to protect C-BT infrastructure and water supplies through the following efforts to be conducted by the partnership:
- Conduct forest and watershed health treatments, and pre-plan post-wildfire response
- Develop a 5-year operating plan specifying treatment zones and activities
- Support creation and refinement of watershed assessments
- Coordinate to provide education, technical and financial incentives
- Engage other partners
- Develop a shared communications and media campaign

As the C-BT Headwaters Partnership is in its infancy, the remainder of this section will discuss on-going planning activities and targeted treatment areas for the early stages of the program, including watershed assessments, opportunities and constraints analysis, and funding. In addition to the initial planning-level work, a monitoring plan will be developed for both forest health treatments and post-wildfire activities to ensure that all activities will have a meaningful effect on forest health, water quality, and wildfire mitigation.

**Watershed Assessment**

The primary planning document being developed under the partnership is a wildfire watershed assessment and post-wildfire plan. The plan will update and build upon the Upper Colorado Headwaters Watershed Assessment (JW Associates 2013) and the Big Thompson Wildfire/Watershed Assessment (JW Associates 2011). The watershed assessments are “designed to identify and prioritize sixth level [USGS] watersheds based upon their hazards of generating flooding, debris flows and increased sediment yields following wildfires that could have impacts on water supplies” (JW Associates 2011). The wildfire watershed assessment and post-wildfire plan follow procedures outlined in the Colorado Watershed Protection Data Refinement Work Group (2009). The watershed assessments include a stakeholder process that includes representatives from water providers; federal, state and local land management agencies; counties; towns and other interested groups.

The C-BT wildfire watershed assessment considers four components in evaluating watershed conditions, including wildfire hazard, flooding or debris flow hazard, soil erodibility and water supply. The following describes the general ranking process for these components. Some variance from these procedures was necessary to account for special situations that fall outside of the general bounds used to develop the methods.

- **Wildfire Hazard.** Wildfire hazard was developed using the Fire Behavior Assessment Tool, which is an interface between ArcMap and FlamMap (U.S. Forest Service, 2013). Certain input spatial data sets were updated and adjusted based on mountain pine beetle mortality conditions as described in 2002-2012 aerial detection surveys (USGS, 1997-2012). The flame length results were divided into five categories of wildfire hazard, with a formula based on the percent of watershed in the highest flame length categories used to develop the final wildfire hazard ranking.

- **Flooding or Debris Flow Hazard.** Flooding and debris flow hazard was calculated as the road density ranking plus twice the ruggedness ranking. Watershed ruggedness, calculated as the product of basin height and the inverse square root of basin area, is an indicator of the relative sensitivity to debris flow (Cannon and Reneau 2000), with
higher more rugged watersheds having a higher sensitivity to debris flow (Melton 1957). Road density, in miles of road per square mile of watershed area, was used as an indicator of the tendency for roads to convert subsurface runoff to surface runoff and route the surface to stream channels, increasing peak flows (Megan and Kidd 1972, Ice 1985 and Swanson et al. 1987).

- **Soil Erodibility**: High severity wildfires can dramatically change runoff and erosion processes in watersheds. Water and sediment yields may increase as more of the forest floor is consumed (Wells et al. 1979, Robichaud and Waldrop 1994, Soto et al. 1994, Neary et al. 2005, and Moody et al. 2008) and soil properties are altered by soil heating (Hungerford et al. 1991). As a measure of soil susceptibility to erosion, standard K factors from U.S. Department of Agriculture STATSGO and SSURGCO data sets and land slope derived from USGS 30-meter digital elevation models were combined with a slope grid using Natural Resources Conservation Service (1997) slope-soil relationships to create erosion hazard ranking.

- **Water Supply**: For purposes of C-BT watersheds, the location and importance of water supply and power infrastructure is an important aspect in the overall watershed ranking. Water supply and power infrastructure was prioritized based on its operational importance and flexibility. For instance, systems such as the Windy Gap Project and Willow Creek Reservoir and Pump Canal were ranked lower because these systems can be temporarily shut down with little effect on water supply yield. In-line reservoirs and terminal reservoirs were ranked higher, as there is little ability to temporarily disrupt operations without having effects on yield. A similar approach was used for power generation and transmission facilities.

The final step in watershed prioritization was developing zones-of-concern for the C-BT and Windy Gap systems. The zones-of-concern recognize that the immediate watersheds above important surface water intakes, upstream diversion points and reservoirs have higher potential to contribute significant sediment or debris following wildfire events. Based on Colorado Revised Statute § 31-15-707 et seq., which allows municipal water providers to enact ordinances within five miles upstream of water intakes to protect water supplies, 14 primary zones-of-concern were developed 5 miles upstream of water sources total nearly 156,000 acres. Based on experiences with previous fires and subsequent flooding events in the Upper South Platte, several zones-of-concern were extended to 11 miles upstream of water sources (or where they encounter watershed divides) for an additional 159,000 acres.

The C-BT Headwaters Partnership is now developing a small-scale watershed prioritization that will guide watershed protection projects. The highest priority watersheds are anticipated to generally lie upstream of Grand Lake, Shadow Mountain Reservoir and Lake Granby on the West Slope, and upstream of Lake Estes on the East Slope. A map showing the C-BT watershed zones-of-concern and preliminary watershed prioritization is presented in Figure 6. Preliminary prioritizations are subject to change as the study continues moving forward.
Opportunities and Constraints

The opportunities and constraints analysis identifies potential opportunities for specific watershed treatments in all of the zones-of-concern developed in the watershed assessment phase. Four major constraints limit the ability to reasonably conduct forest treatments, including land ownership, land management, access and slopes.

- **Land Ownership:** Much of the high priority watershed areas lie within Rocky Mountain National Park, and will be treated according to the Long-Term Fuels Treatment Plan for Rocky Mountain National Park (National Park Service 2012). This plan generally identifies fuels treatments projects “due to their proximity to values at risk”. The plan identifies approximately 28,000 acres of treatments primarily located along the eastern park boundary surrounding Estes Park, and the western park boundary near Grand Lake and the North Fork of the Colorado River.

- **Land Management:** Treatment activities are limited within wilderness areas, Upper Tier roadless areas and U.S. Forest Service special protection areas due to law and agency policies.
Access: Access to specific areas within a watershed is a key factor in determining the opportunities for mitigation wildfire hazards or the ability to install, operate and maintain erosion and sediment control structures. Traditional logging and thinning operations are best suited within ¼ to ½ miles of roads. Specialized logging equipment can be used to move logs and other products as far as 2 miles or more depending upon terrain. If products do not require removal to meet treatment requirements and can be masticated, equipment can be moved from further distances.

Slopes: Land slopes are a major constraint when considering the locations and types of treatments that can be conducted. Although some equipment exists to perform treatments on nearly all slopes (including tracked mastication equipment and helicopters), a slope of 40 percent was used to identify reasonable maximum slope for which treatments would be targeted.

As previously discussed, several factors influence the potential for wildfires to occur and have adverse effects on water supplies, including vegetation type, physical characteristics and health; ground slope, aspect and soil types and the potential for erosion; and weather conditions. The primary means for influencing fire behavior is modifying the vegetation conditions that fuel wildfires. It is not the intention of this influence to completely prevent wildfires, but rather to influence the size, intensity and movement of these wildfires, especially in areas that have physical characteristics that could have detrimental effects to water quality should they burn intensely.

To guide opportunities for vegetation modification, it is important to understand the nature of the different forest types within the watersheds.

Ponderosa Pine - Lower elevation ponderosa pine forests, the dominant forest type in the lower montane zones of the East Slope watersheds, are the most vulnerable parts of the forest due to their naturally short fire return interval (sometimes less than 30 years), greater impacts from human use, settlement and historical fire exclusion. These types of forests provide the best opportunity to improve forest sustainability by performing treatments that return and emphasize characteristics of pre-settlement conditions.

Aspen – Aspen occurs throughout the montane and sub-alpine zones. It is an aggressive invader to disturbed areas, and is more resistant to fire because crown fires will seldom carry through this forest type except for extreme drought combined with windy conditions, primarily during fall periods. For these reasons, Aspen is considered a good species to maintain or promote within the landscape (JWA 2011).

Lodgepole Pine - Lodgepole pine, the dominant forest type in the sub-alpine zones in the West Slope watersheds, are found in dense, continuous stands. Lodgepole pine has a longer natural fire interval (150-300 years), and fires that do occur are typically large scale stand replacing fires. The dense forest types are not a substantial departure from pre-settlement conditions (Veblen et al., 2012). However, as the mature trees begin to fall as a result of mountain pine beetle or other diseases, they create large
fuel loads on the forest floor, which could result in hot, fast moving crown fires that are difficult to contain. Treatments in these areas do not target broad-scale fuel treatments, but rather a more focused response of hazard tree removal, fuels reduction near the wildland-urban interface and infrastructure, and creation of diversity at the stand and landscape levels by clear-cutting, patch cutting, permanent openings, or converting areas to aspen (JWA 2011).

- **Spruce-Fir** – Spruce-fir, a mixture of Engelmann Spruce, Colorado blue spruce, subalpine fire, and other minor species, occurs in the sub-alpine zones, especially within the West Slope watersheds. Spruce-fir has a very long natural fire interval (up to 500 to 700 years). However, when it does burn, fires can be intense and cause severe erosion and sedimentation problems. Spruce-fir is difficult to thin within a short period sufficiently to develop enough diversity to reduce wildfire hazards.

Given these opportunities and constraints, approximately 112,000 acres were identified as potential targets for long-term forest treatments as part of the C-BT Headwaters Partnership. Although the ponderosa pine in the montane zones present a higher risk of wildfire during any given year, the effects on C-BT infrastructure from these watersheds is substantially less than the higher subalpine watersheds on the West Slope and East Slope above Lake Estes. Given the vulnerability of West Slope infrastructure and the limited opportunities due to land ownership above Lake Estes, treatments are focused primarily on West Slope watersheds within lodgepole pine forests. Specific treatment locations and types have yet to be defined, and will vary based on land-owner willingness to participate, environmental considerations, economic considerations, and other factors.

Treatments conducted as part of the C-BT Headwaters Partnership will complement thousands of acres already treated within the C-BT zones-of-concern by the U.S. Forest Service, Colorado State Forest Service, National Park Service and private land-owners, and those being conducted by the National Park Service. The partnership is currently developing an overall treatment targets for the forested area within the C-BT zones-of-concern. The amount of treatments actually conducted will primarily be a function of funding available from each partner on an annual basis.

Initial treatments are commencing immediately, with over 100 acres of treatments targeted on lands owned by Northern Water south of Willow Creek Reservoir, and approximately 15-30 acres surrounding critical infrastructure at the West Portal of the Alva B. Adams tunnel along the eastern shores of Grand Lake. The anticipated Willow Creek treatment will consist of the removal of beetle-kill lodgepole pine, and regeneration of aspen. The West Portal treatment will primarily consist of removal of hazardous beetle-kill trees.

**Pre-Planning for Post-Wildfire Response**

Spurned to action by lessons learned in multiple fires within and near C-BT watersheds, pre-planning post-wildfire responses is a key part of the C-BT Headwaters Partnership. Using results of the watershed assessment analysis, key locations for implementation of post-wildfire mitigation are being identified, and discussed with permitting agencies. Post-wildfire activities may include but are not limited to similar activities described as mitigation efforts.
for previous fires. The group is also identifying specifications and suppliers of key materials such as wattles, seed, mulch, floating debris booms, and barge mounted equipment to perform work along reservoirs where land access is not available. Northern Water is procuring some critical materials to have on-hand for emergency situations.

Another key aspect of post-wildfire response is developing communication chains that can be implemented during and after wildfires. The C-BT Headwaters Partnership partners have been able to leverage Northern Water and the Colorado State Forest Service’s extensive connections with local water providers and agencies with federal-level communications through the U.S. Forest Service and Reclamation. Sharing up-to-date and accurate information is critical during and following wildfires, especially given social media, which is a normally helpful tool, but can be problematic if inaccurate information is conveyed.

**Funding**

As with any project of this magnitude carried out over multiple years and multiple agencies, funding becomes a major constraint to implementation of the planning document. At the federal level, this is further complicated by the uncertainties of the annual federal budgeting process. No annual budgets for the implementation program have been developed at this time. Northern Water is currently undertaking a rate study to provide more information on what types of future revenue may be available from its existing revenue sources and assessments, and may be reasonably expected from potential future rate adjustments.

The C-BT Headwaters Partnership has also received a grant through the state-funded Wildfire Risk Reduction Grant program. This program was established by the legislature in Senate Bill 269, and will be administered through the Department of Natural Resources. The program was funded with $9.8 million of general fund dollars, and is focused on projects that reduce the risk for damage to property, infrastructure, and water supplies, and those that limit the likelihood of wildfires spreading into populated areas. The grant includes a monitoring component, which will demonstrate the effectiveness of the treatment projects and the utility of grant resources (Colorado Department of Natural Resources 2013). The C-BT Headwaters Partnership grant award will leverage Northern Water revenue and funding with local treatments on private lands (through hard matches or soft in-kind contributions) to maximize treated acreage within and benefits to C-BT watersheds.

**SUMMARY**

As with most irrigation and municipal water supply systems in the Western United States, protection of Colorado-Big Thompson Project watersheds from the devastating effects of wildfire has gained increased importance over the last decade as the incidence of wildfire has increased. Both municipal and agricultural water users have expressed an interest in taking a pro-active approach to addressing forest health within the watersheds and pre-planning for post-wildfire response. The C-BT Headwaters Partnership was established with these goals in mind, and provides a coordinated program between local, state and federal land managers and water agencies to address plan, fund and execute these activities. Forest treatments within C-BT watersheds, which were heavily affected by the recent mountain pine beetle epidemic, will be implemented over the next 5 to 10 years.
REFERENCES


Colorado Department of Natural Resources (CDNR). 2013. Wildfire Risk Reduction Grant Program Request for Applications (RFA). Available at: http://dnr.state.co.us/Media/Pages/WFRRGrantProgram.aspx.


