HIGH LINE CANAL

CONSERVANCY

Connecting Communities – Connecting Nature
From the Foothills to the Plains
A Landmark of Our Agricultural History
Preserved as a Legacy Greenway
HAND DUG IN 1883
ACQUIRED BY DENVER WATER IN 1924
OPENED TO RECREATION IN 1970
LAST CENTURY’S INFRASTRUCTURE
THIS CENTURY’S OPEN SPACE NETWORK
OUR STRATEGY: PARTNERSHIPS

High Line Canal Working Group
- Adams County
- Arapahoe County
- Arapahoe County OSTAB
- City of Aurora
- Aurora Open Space Advisory Board
- Centennial
- Cherry Hills Village
- City and County of Denver
- Denver
- Douglas County
- Greenwood Village
- Highlands Ranch Metro District
- Littleton
- South Suburban Parks and Rec. District
- High Line Canal Conservancy
- HLC Preservation Association
- South Metro Land Conservancy
- Cherry Hills Land Preserve

High Line Canal Core Team
- Arapahoe County
- City of Aurora
- City and County of Denver
- Denver Water
- Douglas County
- High Line Canal Conservancy

High Line Canal Conservancy
PRESERVE, PROTECT AND ENHANCE THE 71-MILE-LONG CANAL IN PARTNERSHIP WITH THE PUBLIC
ACCESS AND SIGNAGE

- 71 new mile markers
- 51 new wayfinding signs
- 5 new trail heads
- 7 improved access points
SAFETY AND CROSSING ENHANCEMENTS

- 4 new underpasses
- 20 improved crossings
- 5 trail gaps connected
NEIGHBORHOOD IMPROVEMENTS

- **89 new benches**
- **4 new picnic areas**
- **15+ new community spaces**
LANDSCAPE AND TREE CARE

caring for 24,000 mature trees

450 plant species identified
STORMWATER MANAGEMENT

The Canal’s Watersheds

The Canal is on the downhill side of significant watershed areas and provides an opportunity to manage this stormwater runoff to the benefit of the region.

40% cleaner water with stormwater management

Canal will be wet 100 more days per year
IMPLEMENTING THE PLAN

Projects included in The Plan

- Amenities - $1,404,544
- Access - $8,443,250
- Activation - $805,000
- Connectivity - $55,795,000
- Stormwater Enhancement - $12,480,000
- Landscape Enhancement - $19,190,000
- Signage - $967,500

Total $99,085,294
PROJECTS TO DATE:
$30M INVESTMENT 2014-2020

- Parker & Mississippi Underpass
- Long’s Pine Grove Open Space
- Yale Crossing Enhancement
- Yale Underpass
- Tunnel Art
- Denver Stormwater Project
- Greenwood Village Stormwater Project
- Sumac Hill Farm Overlook
- Franklin Street Bridge
- Milliken Park Restroom
- Bannock Street Bridge
- Trail Enhancement
- I-70 Underpass
- Triple Creek Trailhead
- Chesapeake Pond Stormwater Project
- Florida Crossing Enhancement
- Quebec Way Trailhead
- Trail Enhancement
- Bible Park Bridges
- Hampden & Colorado Underpass
- Orchard Road Trailhead Restroom
- Ice Arena Bridge
dekOevend Parking Lot Bridge
- Crossing Connection to Centennial Link Trail
- Elati Street Trailhead
- Santa Fe Underpass
- Mirabelle Stormwater Project

Legend:
- 3 Crossing Enhancements
- 5 Underpasses
- 2 Trail Enhancements
- 3 Bridges / Bridge Replacement
- 2 Restrooms
- 1 Open Space
- 1 Tunnel Art
- 1 Overlook
- 4 Stormwater Projects (Concept Only)
Little’s Creek and Big Dry Creek Area Spills

Example Solution

- Sta. 2371+50: Raise low point in embankment by 1.7’ for a length of 200’.
- Sta. 2382+00: Raise low point in embankment by 1.7’ for a length of 100’.
- Sta. 2365+40: 100 LF constructed overflow with crest set 5.7’ above canal invert and 300 LF formalized channel through recreation area between buildings. Q100 = 170 cfs.
- Sta. 2233+50: 70 LF constructed overflow with crest set 5.0’ above canal invert and 820 LF formalized channel to Big Dry Creek. Q100 = 230 cfs.
- Sta. 2278+00: Raise low point in embankment by 1.1’ for a length of 50’.
- Sta. 2251+00: Raise low point in embankment by 1.7’ for a length of 270’.

Legend
- 100-Year Existing Canal Spill
- Wastegate
- High Line Canal
- Formalized Channel
- Constructed Overflow
- Proposed WQ Berm
Wooded Landscape
Without Stormwater

UPLAND PLANTING
Low Water Use
Trees
Shrubs
Seed Mix
Wildflower Mix

TRAIL

UPLAND PLANTING
Low Water Use
Trees
Shrubs
Seed Mix
Wildflower Mix

DRY Canal BED
Low Water Use
Shrubs

UPLAND PLANTING
Low Water Use
Trees
Shrubs
Seed Mix
Wildflower Mix
Prairie Landscape
Without Stormwater

- Upland Planting: Seed Mix, Wildflower Mix
- Trail: Seed Mix, Wildflower Mix
- Upland Planting: Seed Mix
- Dry Canal Bed: Seed Mix
- Upland Planting: Seed Mix, Wildflower Mix
Prairie Landscape With Stormwater

UPLAND PLANTING
- Seed Mix
- Wildflower Mix

TRAIL
- Low / Medium Water Use
- Trees
- Shrubs
- Seed Mix
- Wildflower Mix

UPLAND PLANTING
- Medium / High Water Use
- Trees
- Shrubs

RIPARIAN PLANTING
- Low Water Use
- Trees
- Shrubs
- Seed Mix
- Wildflower Mix

UPLAND PLANTING
STEP TECHNICAL LEADERSHIP TEAM

Multi-disciplinary Stakeholder Team

• Technical Leadership Team (12 members)
  o Cities of Aurora, Cherry Hills Village, Greenwood Village and Littleton
  o City & County of Denver
  o Denver Water
  o Douglas County
  o Highlands Ranch Metro District
  o Mile High Flood District
  o RESPEC Engineering
  o SEMSWA
Stormwater Projects

1. Douglas County (Solstice Development)
   Project Type: Conveyance

2. Littleton
   Project Type: Conveyance

3. Greenwood Village
   Project Type: Flood Mitigation

4. Denver
   Project Type: Water Quality
Multi-layered Benefits of Green Infrastructure

- **Adaptive and Innovative Reuse**
  - Canal could be wet 100 more days per year

- **Vibrant Canopy**
  - Improves air quality
  - Sequesters carbon
  - Mitigates heat island effect

- **Environmental Health**
  - Stormwater 72-hour hold provides 40% cleaner water
  - Improves habitat
  - Improves community health

- **$30 Million in Potential Savings (Green vs. Gray)**
  - Cost for High Line Canal stormwater system is ~$45m
  - Cost for traditional infrastructure is ~$75m
Stacked Benefits Analysis

Ecosystem Services
What Nature provides us for free

Supporting
- Soil Formation
- Photosynthesis
- Biodiversity
- Habitat
- Stewardship
- Aesthetic
- Recreation

Provisioning
- Clean Water
- Fish
- Wood
- Pollination
- Control Flooding
- Purify Water

Regulating
- Clean Air
- Store Carbon
- Cool Temperatures

Cultural
- Education
- Recreation

US EPA
## Stacked Benefits Analysis: Inputs

<table>
<thead>
<tr>
<th>Category</th>
<th>Attribute</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Study Framework</strong></td>
<td>Design Reach</td>
</tr>
<tr>
<td></td>
<td>Length</td>
</tr>
<tr>
<td></td>
<td>Tributary Area</td>
</tr>
<tr>
<td></td>
<td>Jurisdiction (Location)</td>
</tr>
<tr>
<td></td>
<td>Mile marker</td>
</tr>
<tr>
<td></td>
<td>Ecological zone</td>
</tr>
<tr>
<td></td>
<td>Character Zone</td>
</tr>
<tr>
<td></td>
<td>HUC12</td>
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<tr>
<td><strong>Water-- Quality &amp; Flood Management</strong></td>
<td>Existing Inflow</td>
</tr>
<tr>
<td></td>
<td>Future inflow</td>
</tr>
<tr>
<td></td>
<td>Excess Capacity</td>
</tr>
<tr>
<td></td>
<td>Capacity Shortage</td>
</tr>
<tr>
<td></td>
<td>Impervious surface</td>
</tr>
<tr>
<td></td>
<td>Impaired Water Proximity bonus .5 pt?TBD</td>
</tr>
<tr>
<td></td>
<td>WQ Benefit Type</td>
</tr>
<tr>
<td></td>
<td>WQ Benefit Value (0-4)</td>
</tr>
<tr>
<td></td>
<td>Existing Freeboard</td>
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<tr>
<td></td>
<td>Overflow Risk (L/M/H)</td>
</tr>
<tr>
<td></td>
<td>Constructed overflow locations</td>
</tr>
<tr>
<td></td>
<td>Flood Mgmt Benefit Value Rank (0-3)</td>
</tr>
<tr>
<td><strong>Landscape Natural Environment</strong></td>
<td>communities (CPW wetlands/riparian polys, landuse)</td>
</tr>
<tr>
<td></td>
<td>Native plant diversity--Floristic index?</td>
</tr>
<tr>
<td></td>
<td>immediate or 1/4 mile buffer IPAC survey?</td>
</tr>
<tr>
<td></td>
<td>sensitivity) native/total with all nonnative and urban communities or open water within 1/4 mi</td>
</tr>
<tr>
<td></td>
<td>1-3 / 1-5, weighting?</td>
</tr>
<tr>
<td><strong>Resiliency</strong></td>
<td>Current heat island area impacted acres</td>
</tr>
<tr>
<td></td>
<td>Tree Canopy supported?</td>
</tr>
<tr>
<td></td>
<td>Resiliency benefit rank (H/M/L?= 1-3?)</td>
</tr>
<tr>
<td><strong>Community Health &amp; Livability</strong></td>
<td>Acres of public open space Canal + immediate buffer</td>
</tr>
<tr>
<td></td>
<td>Acres of nearby public open space 1/4-mibuffer</td>
</tr>
<tr>
<td></td>
<td>TPL Population w/in 10-min walk minute analysis</td>
</tr>
<tr>
<td></td>
<td>Trail (Lft) in immediate buffer</td>
</tr>
<tr>
<td></td>
<td>Trail (Lft) w/in 1/4-mi</td>
</tr>
<tr>
<td></td>
<td>Community Survey data</td>
</tr>
<tr>
<td></td>
<td>location</td>
</tr>
<tr>
<td></td>
<td>mi</td>
</tr>
<tr>
<td></td>
<td>Community benefit rank (H/M/L?= 1-3?)</td>
</tr>
<tr>
<td><strong>Costs</strong></td>
<td>CIP &amp; Maintence Costs in FS 2018: + Maintenance in Op Plan; compare to UDFCD costs?</td>
</tr>
<tr>
<td></td>
<td>Grey infrastructure costs</td>
</tr>
<tr>
<td></td>
<td>Offset Costs</td>
</tr>
<tr>
<td><strong>Scenarios</strong></td>
<td>Future reduced benefit?</td>
</tr>
</tbody>
</table>

**Biohabitats**
Riparian Habitat and Connectivity

Example mapping of riparian vegetation

Includes Prairie, grasslands, natural ground cover, tree canopy and water

737 acres in 75 ft buffer

Potential connectivity to 27 acres protected parkland in ¼ mile buffer

DRCOG Land Use Land Cover Data
Land Surface Temperatures

MODIS 5-year Average
Land Surface Temperature
($^\circ$F)

Value
High : 112.436
Low : 64.4143

Sources: Esri, HERE, Garmin, Intermap, increment P Corp.
IGN, Kadaster NL, Ordnance Survey, ESRI Japan, METI, Esri
OpenStreetMap contributors and the GIS User Community

High Line Canal Conservancy
Water Quality Benefits

Design Reaches - Water Quality

WQ_RANKV2

- 4
- 3
- 2
- 1
- 0
Water Quality Benefits and Riparian Quality
Water Quality Benefits and Riparian Quality in Vulnerable Communities
Prioritizing Stacked Benefits

- **Protect high quality riparian** areas by providing supporting stormwater
- **Improve poor quality riparian** areas by providing stormwater and planting
- **Reduce risk of uncontrolled canal overflows** by providing waste gate structures in reaches with little to no freeboard
- **Reduce risk of local flooding** by directing additional stormwater to reaches with moderate to high available freeboard
- **Support the resiliency of vulnerable communities**
## Stacked Benefits Analysis: Scenario Testing

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
</table>
| **Water-- Quality & Flood Management** | Existing inflow  
Current available/excess capacity  
Allowable Additional *Peak flow* into canal cfs  
Added avoided flood risk  
Proposed water quality features  
  - Capital cost  
  - O&M w stormwater (includes greenway)  
  - O&M without stormwater (includes greenway)  
  Water quality treatment value (based on Parkland + Capital) |
| **Landscape Natural Environment** | **Existing Trees & Vegetation**  
  - Trees asset value - CO2, energy, Air quality, rainfall interception, prop values  
  - Low quality Prairie/Grassland/Natural Ground Cover  
  - Increased O&M for tree loss/removal |
| **Proposed Trees and Vegetation:** |  
  - Trees  
  - Shrubs  
  - Herbaceous/seeding cost  
  - Tree value (present value)  
  - Improved Prairie/Grassland/Natural Ground Cover |
| **Community Health**             | Health value - improved physical condition of nearby residents |
| **TOTAL CO-BENEFIT**             | 50 year period (present day dollars)  
Annual |

### 1. No Stormwater Project
- Offsite infrastructure  
- Loss of trees and native veg  
- Park value decline/loss

### 2. Water Quality Treatment Only

### 3. Full Concept Project
- Water Quality  
- Additional trees and veg  
- Social amenities
Stacked Benefits Analysis: Eisenhower Park

Community Health
$301,104 per year in reduced health care costs

Stormwater
Gray infrastructure estimated at $4,077,035
Green infrastructure estimated at $941,575

Operations
Estimated cost of $35,000 per year in O&M

Environment
514 healthy trees are worth $699,000
185 trees that need to be removed @ $92,500

Park
2 miles of trail
36 ac of park land
$1,782,720
## Stacked Benefits Analysis: Canal-Wide Benefits

<table>
<thead>
<tr>
<th>Category</th>
<th>Metric</th>
<th>Canal wide results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water Quality</strong></td>
<td>Acres existing green infrastructure area</td>
<td>51.3 acres</td>
</tr>
<tr>
<td></td>
<td>Acres proposed green infrastructure area</td>
<td>45 acres</td>
</tr>
<tr>
<td><strong>Flood Management</strong></td>
<td>miles/acre(s) of canal currently providing flood control (or current flood storage volume)</td>
<td>12.3mi</td>
</tr>
<tr>
<td></td>
<td>Miles of canal available for future local flood control moderate to high potential (or potential additional volume?)</td>
<td>45.8 mi</td>
</tr>
<tr>
<td><strong>Riparian Habitat</strong></td>
<td>Acres riparian vegetation in entire corridor (75 ft buffer)</td>
<td>737</td>
</tr>
<tr>
<td></td>
<td>No of living trees in entire corridor (75 ft buffer)</td>
<td>19055</td>
</tr>
<tr>
<td></td>
<td>Acres nontree or impermeable riparian vegetation</td>
<td>416</td>
</tr>
<tr>
<td></td>
<td>No. of living native trees</td>
<td>10787</td>
</tr>
<tr>
<td></td>
<td>High quality acres protected in 1/4-mi buffer</td>
<td>27</td>
</tr>
<tr>
<td><strong>Community Health</strong></td>
<td>Vulnerable population benefiting from open space</td>
<td>45,785</td>
</tr>
</tbody>
</table>
## Stacked Benefits Analysis: Canal-Wide Benefit Valuation

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Unit value + or (-), negative is cost</th>
<th>Existing Qty</th>
<th>Existing value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acres riparian vegetation in entire corridor (75 ft buffer)</td>
<td>acres</td>
<td>$34,000</td>
<td>737.2</td>
<td>$25,064,800</td>
</tr>
<tr>
<td>Trees asset value - CO2, energy, Air quality, rainfall interception, prop values</td>
<td>no./tree</td>
<td>$1,361</td>
<td>19,055</td>
<td>$25,933,855</td>
</tr>
<tr>
<td>Replacement cost for native trees</td>
<td>$/tree</td>
<td>$(250)</td>
<td>10,787</td>
<td>$(2,696,750)</td>
</tr>
<tr>
<td>Increased O&amp;M for tree loss/removal (native only)</td>
<td>$/tree</td>
<td>$(500.00)</td>
<td>10,787</td>
<td>$(5,393,500)</td>
</tr>
<tr>
<td>Water quality treatment value (land only)</td>
<td>ac</td>
<td>$34,000</td>
<td>51</td>
<td>$1,744,200.00</td>
</tr>
<tr>
<td>Proposed Water quality treatment value (land only)</td>
<td>cu ft</td>
<td>$34,000</td>
<td>45</td>
<td>$1,530,000.00</td>
</tr>
<tr>
<td>Added avoided flood risk</td>
<td>no.</td>
<td>na</td>
<td>na</td>
<td></td>
</tr>
<tr>
<td>Waste gate</td>
<td>reduced med$/per</td>
<td>$351.00</td>
<td>45800</td>
<td>$16,075,800</td>
</tr>
<tr>
<td>Health value - improved physical condition</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** The table above represents the stacked benefits analysis for the Canal-Wide Benefit Valuation. The values are expressed in dollars ($), and the existing quantity and value are calculated based on the unit values and existing quantities provided.
Stacked Benefits Analysis: Habitat Values

- 737 acres (64%) forest/natural riparian habitat in 75-ft buffer
- $25M price to purchase riparian habitat replacement acres
- 19,055 trees along canal
- $25.9M value of existing trees
- 10,055 high value native trees along canal
- $5.4 M O&M costs deferred by stormwater prevention of tree loss
- $2.7M for tree replacement
Stacked Benefits Analysis: Water Management Values

51 acres existing green infrastructure for water quality

$1.74M avoided costs for land purchase to replace existing green infrastructure

$1.5M avoided costs for land purchase for proposed green infrastructure

45 acres proposed green infrastructure area for water quality (berm area)
Thank you!

Josh Phillips
Director of Planning and Implementation
Josh.P@highlinecanal.org

HIGH LINE CANAL
CONSERVANCY

Connecting Communities – Connecting Nature
From the Foothills to the Plains