Network Design – Hydrological Assets

Includes reservoirs, lakes, streams, rivers, wetlands, aquifer recharge/discharge areas, drinking water source protection zones, water-related conservation easements, canals, land cover data, and Watershed Restoration Areas.

Project Goals for the Wasatch Front Regional Hydrology Green Infrastructure:

A. Protect and enhance the water resources of the Wasatch Front, including our watersheds, wetlands, groundwater and source water areas, to protect water quality and provide a continually safe and abundant water supply for our communities.

B. Promote a healthy hydrological system which encourages efficient flood control and water conveyance while providing clean water, wildlife habitat, and recreational uses.

HYDROLOGICAL NETWORK CRITERIA		
CORES	**SIGNIFICANCE/EXPLANATION**	**FURTHER RESEARCH**
1. Protected lands with hydrological assets within them	Permanently protected lands have a higher likelihood of providing permanent GI services. Inclusion of protect lands is well-documented[1].	*Need to determine if a minimum size or buffer area is needed for these protected lands.*
2. High quality water bodies - includes reservoirs, streams, lakes, rivers	See exclusion factors below, e.g., impaired waters (303d) are removed from core areas; Buffers are incorporated as hubs (see below). All GIS data from AGRC.	
3. Important wetlands within the Wasatch Front	As wetlands within Utah only consist of 0.2% of the entire state, all of the wetlands are critical to water quality and quantity (USFS National Wetland Inventory data).	*Research into minimum size of wetlands to support a suite of wetland species within the Wasatch Front.*
4. Floodplains, where available	Incorporated in multiple green infrastructure planning efforts, including, but not limited to, the Maryland GI Plan (2003), the Travis County Greenprint for Growth Plan (2006), Cecil County, MD GI Plan (2007). Floodplain data for Salt Lake & Weber Counties and the Great Salt Lake are from AGRC and FEMA.	*Identify floodplain data for all counties (currently only have Weber, Salt Lake, the Great Salt Lake and minimal data for Morgan).*
5. Restored landscapes within the Wasatch Front	Areas where counties and municipalities have actively restored hydrological assets (data from Salt Lake Co Flood Control & Water Quality Division); polylines were buffered by 50 ft as per discussion with SL County staff.	*Data for these core areas only exist within Salt Lake County at this time.*
Exclusion Factors:		
A. Remove 303(d) listed waters	303(d) listed waters are considered impaired by federal standards, and thus, would not provide a high level of services to the region's GI network. Data from AGRC.	

B. Impervious areas greater than 10% (would include roads, highways, and heavily urbanized areas)	Arnold and Gibbons 1996; Schueler 1994; Schueler, Fraley-McNeal and Cappiella 2009 all list impervious areas greater than 10% as being impacted. Data derived from the National Land Cover Dataset (AGRC).	*Future research should amend percentages based on proximity to stream and positions within the watershed (Brabec 2009); the Wasatch Front, similar to the Front Range, may be affected by "multiple interacting stressors" (Sprague et al. 2006, 4) that may require a less simplistic number for finer scale analyses*
HUBS	**SIGNIFICANCE/EXPLANATION**	**FURTHER RESEARCH**
1. Watershed Restoration Areas	These areas could be considered core areas when restoration is complete. Data from AGRC.	
2. Groundwater discharge areas, aquifers, & drinking water source protection zones	Incorporated in multiple green infrastructure planning efforts, including, but not limited to, the Maryland GI Plan (2003), the Travis County Greenprint for Growth Plan (2006). Aquifer discharge & recharge area data from AGRC; drinking water source protection zone data from UDWQ.	
3. Buffers around streams a. in urban areas - min. buffer of 50' on either side; expand width to include adjacent wetlands, land covers, etc. b. In nonurban areas - recommendation of 100-300' for species biodiversity; c. Cutthroat trout streams 30.5 m buffers d. Major Rivers – 150’	a. Brown (2000) suggests this minimum width, see also Heraty (1993); b. ELI (2003); c. Hickman and Raleigh (1982), see Castelle et al. (1994) d. Morgan County standards for Weber River	*Cities’ and counties’ individual ordinances should be examined to tailor buffers to community requirements*
4. Buffers around wetlands: a. In urban areas - min. buffer of 50’ for water quality; b. In nonurban areas - min. of 100-300' for species diversity	a. Standards within Morgan & Salt Lake County (for planned developments) require 50’ buffers around wetlands. According to the ELI (2008), a min. of 30’ is needed for water quality (phosphorous and sediments). For nitrogen, a min. of 100’ is needed. b. ELI (2008)	*Consider a more detailed matrix and slope adjustments as per ELI 2008*
5. Hydric soils or areas with shallow groundwater (0’)	Hydric soils (a component of wetlands) & shallow groundwater areas support groundwater/surface water interactions and could support the region's hydro assets. Data from AGRC.	

6. Appropriate land covers that can serve as riparian vegetation for the high priority riparian areas	Appropriate land covers would include non-urbanized land covers (e.g., forests, grasslands, shrub/scrub, etc.) within 300 m of the surrounding core areas to reduce edge effects (ELI 2003). Data derived from the National Land Cover Dataset.	
Exclusion Factors:		
B. Impervious areas greater than 25%	Schueler, Fraley-McNeal and Cappiella (2009) list impervious areas greater than 25% as being nonsupporting of urban drainage. Data derived from the National Land Cover Dataset.	*Original figures suggested 30% impervious percentages (Schueler 1994; Arnold and Gibbons 1996). Research within the Wasatch Front would be useful to further refine these numbers.*
CORRIDORS	**SIGNIFICANCE/EXPLANATION**	**FURTHER RESEARCH**
1. High quality streams and rivers - from core analysis above	The hydrological system identified in the core and hub areas will be used as corridors, given the linear nature of the systems.	
2. Canals	Serve as conduits for hydrological systems within the Wasatch Front	*Irrigation canals may or may not add to region's water quality.*
Suitability Factors	**Significance/explanation**	**Further research**
1. Impaired water bodies would be rated less than higher quality water bodies	303(d) listed waters are considered impaired by federal standards, and thus, would not provide a high level of services to the region's GI network.	

[1]See Utah DFFSL 2010 Statewide Assessment document available at http://www.ffsl.utah.gov/stateassessment.php.

References:

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Heraty, M. (1993). Riparian Buffer Programs: A Guide to Developing and Implementing a Riparian Buffer Program as an Urban Stormwater Best Management Practice. Metropolitan Washington Council of Governments. Produced for US EPA Office of Wetlands, Oceans, and Watershed. Washington, DC.
Hickman, T. and Raleigh, R.F. 1982. Habitat suitability index models: Cutthroat trout. FWS/OBS-82/10.5. U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC.
Schueler, Thomas R. 1994. The importance of imperviousness. Watershed Protection Techniques 1:100-111.
Schueler, Thomas R., Lisa Fraley-McNeal, and Karen Cappiella. 2009. Is Impervious Cover Still Important? Review of Recent Research. Journal of Hydrologic Engineering 14 (4):309-315.

Hydrological Asset Network Criteria – Design Process

Hydrological Cores

1. Create a new toolbox in ArcCatalog for Hydrology modeling - HydroAssets
2. Create Cores
   A. #1 Core Criteria – protected lands with hydrological assets within them
      i. Merge vector files H20ConvEasementst, Easements_hydrology and SaltLakeprotectedarea together → hydro_protected_lands
      ii. Convert to raster → hyd_protland
      iii. Reclassify to 0 and 1 for analysis → ***rc_hydprotect***
   B. #2 Core Criteria – high quality water bodies, including reservoirs, lakes, streams and rivers
      i. Add lakes from National Hydrological Dataset (includes reservoirs), manually remove tailings ponds sound of the Great Salt Lake (lakes), convert to raster → lakes2, reclassify → rc_lakes1
      ii. Add major rivers (majorrivers), convert to raster → majorriver3, reclassify → reclass_majorriv2
      iii. Add permanent and intermittent streams, convert to raster → streams_perm1, streams_int1, reclassify → reclass_stre1, reclass_stre_int
      iv. Using single output map algebra, add the above 4 reclassified rasters together →all_hydro5
      v. Reclassify all values greater than 1 as 1 → ***rc_allhydro1***
   C. #3 Core Criteria – important wetlands
      i. Add wetlands as defined by the USFWS in the National Wetlands Inventory, clip to 10km project boundary → NWI_wetlands_clip
      ii. Convert to raster → NWI_wetlands
      iii. Reclassify → ***rc_NWIwetland***
   D. #4 Core Criteria – floodplains
      i. Merge together floodplains for counties with accessible data (Floodplains_SaltLakeCty, Floodplains_Weber, Davis_Floodplains, Floodplains_GSLclip) → Floodplains_All1
      ii. Convert to raster → floodplains1
      iii. Reclassify → ***rcfloodplain1***
   E. #5 Core Criteria – restored hydrological landscapes
      i. Add Restoration_SLCty_completed to map
      ii. Convert to raster and reclassify to 0 and 1 for analysis → ***rcslrestor***
3. Merge cores together
   A. Using single output map algebra, add together the above 6 reclassified rasters → hydro_cores35
   B. Reclassify all values above 1 as 1 and NoData as 0 → rchydrocores4
4. Merge core exclusion factors
   A. Merge exclusion layers – impervious surfaces (imp_grt10pct) & 303(d) impaired waters (impair_h20) → ***hydro_excl***
   B. Reclassify ***hydro_excl*** where 1 values are now no data and nodata values are now 1→ ***rc_hydroexcl***
5. Complete core analysis
   A. Using single output map algebra, multiply the hydro_cores35 layer with the rc_hydroexcl layer → ***hydro_cores36*** – vector file is ***hydrocores5***

Hydrological Hubs

1. Create hubs
   - A. #1 Hub Criteria – Watershed Restoration Areas
     - i. Clip Watershed Restoration Focus Areas (UDWR Watershed Restoration Initiative) to project boundary → watershed_restoration_areas
     - ii. Convert to raster → h20_restor
     - iii. Reclassify → ***rc_h20restor***
   - B. #2 Hub Criteria – groundwater discharge areas, aquifers and drinking water source protection zones
     - i. Clip USGS aquifer file (includes recharge and discharge areas of principle aquifers) to new boundary → aquifer_10km_boundary
     - ii. Add drinking water source protection zones (DWSPzones), select protection zones 1 through 3 (1=100-foot radius from margin of collection area, 2=area within 250-day ground water time of travel to margin of collection area, 3=area within a 3-year ground water time of travel to margin of collection area) → DWSP_Zones1-3
     - iii. Merge together the aquifer_10kmboundary layer and the DWSP_Zones1-3 layer → DWSPzones_aquifer, convert to raster → DWSP_aquifer, reclassify to 0 and 1 for analysis →***rc_DWSP_aquif***
   - B. #3 Hub Criteria – buffered streams
     - i. Transform the streams (permanent and intermittent) into urban and non-urban areas to perform buffer analyses
     - ii. Buffer according to criteria → majorrivers_buffer150ft, streams_perm_urban_Buffer50ft, streams_perm_nonurban2_Buffer100ft, streams_intermittent_nonurban_buffer100ft, streams_intermittent_urban_Buffer_50ft, BCT_streams_100ftbuff
     - iii. Merge the above 6 shapefiles together → all_streams_buffered
     - iv. Convert to raster → allstreamsbuf
     - v. Reclassify to 0 and 1 for analysis → ***rc_buffstream***
   - C. #4 Hub Criteria – buffered wetlands
     - i. Transform wetlands into urban and non-urban areas to perform buffer analyses (using select by location – those wetlands that intersect with developed_land_all1) → NWI_wetlands_UrbanIntersect; NWI_wetlands_nonurban_ByIntersectSwitch
     - ii. Buffer according to criteria → NWI_wetlands_urban_50ftbuff; NWI_wetlands_nonurban_100ftbuff
     - iii. Merge the above 2 shapefiles together → NWI_wetlands_buffered
     - iv. Convert to raster → wetlandsbuff1
     - v. Reclassify to 0 and 1 for analysis → ***rc_wetlanbuf1***
   - D. #5 Hub Criteria – shallow ground water and hydric soils
     - i. Hydric soils with percentage greater than 70% hydric components (as per conversation with NRCS State Soil Scientist) → hydric70pct
     - ii. Use single output map algebra to merge together the hydric70pct layer with the rchydrodist300 layer to select all hydric soils within 300 m of core areas → hydric70pt300
     - iii. Reclassify → rc_hydric300
     - iv. Select ground water at a depth of 0 feet → grndh20_0ft
     - v. Convert to raster → shal_grndh20
     - vi. Reclassify → rc_shalgrh20

vii. Use single output map algebra to add the rc_hydric300 layer and the rc_shalgrh20 layer → hyd_shallow
viii. Reclassify all values above 1 as 1 → ***rc_hydshallow***

E. #6 Hub Criteria – supporting riparian land covers
   i. Select appropriate land covers, including forested (mixed, evergreen, and deciduous), grassland, wetland (herbaceous and woody), and shrub/scrub cover → hydro_landcover
   ii. Use the single part to multipart tool to "undissolve" all of the land cover areas in individual parts (polygons)
   iii. Buffer the hydro_cores layer by 30 m →hydro_cores_30mbuffer
   iv. Select by location all of those areas in the hydrolandcover_multipart that intersect the hydro_cores_30mbuffer (captures all polygons in the adjacent cells) →hydro_landcover_adjacenttocores
   v. Buffer the hydro_cores7 layer by 300 m (total of 300 m) →hydro_cores_300mbuffer;
   vi. Intersect the hydro_landcover_adjacenttocores with the hydro_cores_300mbuffer→hydrocoveradj
   vii. Convert each of the above layers to raster (output = hydrocoveradj and rchydrodist300); perform a single map output algebra to merge together those areas that are overlapping →hydrocovadj300
   viii. Reclassify hydrocovadj300 to include "nodata" values in the analysis (change from NoData to 0)→***rccovadj300***

2. Merge hubs together
   A. Using single output map algebra, add the six reclassified raster riles together → hydro_hubs14
   B. Reclassify all values greater than 1 as 1 → ***rc_hydrohubs2***
3. Create hub exclusion factors
   A. Select impervious surfaces greater than 25% → ImperviousSurfacegrtthan25pct
   B. Convert to raster → imp_grt25pct
   C. Reclassify so all 1 values are 0 and NoData is 1 → ***rc_imperv25_1***
4. Complete hub analysis
   A. Using single output map algebra, multiply the rc_hydrohubs2 layer with the rc_imperv25_1 layer → ***hydro_hubs15***

Hydrological Corridors

Hydrological corridors (streams and canals) are inherent in the core areas and required no additional mapping or design process.

Final Shapefiles for Agencies and Organizations

Merged Cores	Hydrological_Cores
Merged Hubs	Hydrological_Hubs

Note – merged files have been dissolved by layer – data is extremely simplified.

Core #1 – Protected lands with hydrological assets	Protected_Hydro_Lands
Core #2 – High quality streams, rivers, lakes & reservoirs	Streams_Rivers_Lakes
Core #3 – Important wetlands	Wetlands
Core #4 – Floodplains	Floodplains
Core #5 – Restored landscapes	SaltLakeCounty_Restoration
Core Exclusion #1 – 303(d) listed waters	Impaired_Water
Core Exclusion #2 – Impervious areas greater than 10%	Impervious_Surfaces_Over10Percent
Hub #1 – Watershed restoration areas	Watershed_Restoration_Areas
Hub #2 – Aquifers & drinking water source protection zones	DWSP_Zones_Aquifer_Recharge
Hub #3 – Stream buffers	Buffered_Streams
Hub #4 – Wetland buffers	Buffered_Wetlands
Hub #5 (1) – Hydric soils	Hydric_Soils_AdjacentToCores
Hub #5 (2) – Shallow groundwater areas (0’)	Shallow_Groundwater_0ft
Hub #6 – Riparian vegetation buffering core areas	Supporting_Landcover
Hub Exclusion #1 – Impervious areas greater than 25%	Impervious_Surfaces_Over25Percent