7.6 Sanitation Strategy

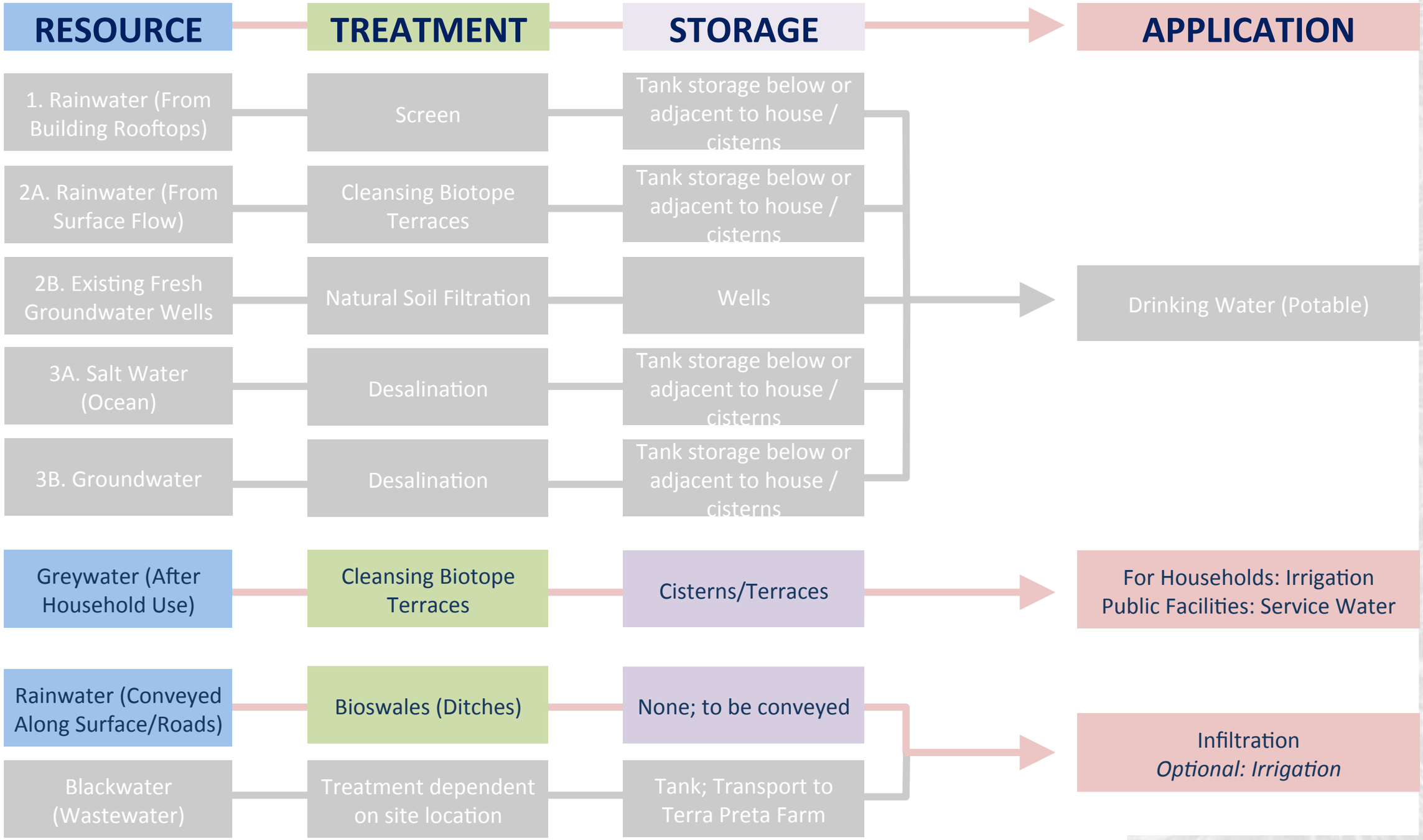
The primary goals for Tanjung Ringgit's integrated sanitation strategy are to:

- **Reduce consumption of potable water**
- **Create a holistic sanitation strategy**
  - **Greywater reused as irrigation and service water source**
  - **Blackwater collected, transported to Terra Preta Farm area, and used as source for Terra Preta soil production**
- **Integration with the water strategy**

The focus of the sanitation concept is the reduction of the consumption of drinkable water, re-use of on-site water sources and sustainable wastewater management. Innovative solutions in treating and reusing wastewater improves sanitation and introduces a waste product as a valuable resource.

The sanitation strategy is comprehensive design solution that requires specialist knowledge of low-tech yet cutting edge, integrated, and contextually appropriate solutions.

Greywater Schematic



Note: *Greywater from larger buildings (hotels, hostels, clubhouses) applied firstly as building service water*

Goal 3: Create a Holistic Sanitation Strategy

GREYWATER

GREYWATER DEFINED:

- Water not polluted by fecal matter or sewage
- Source can come from multiple areas (sinks, showers, laundry water)
- Provides constant resource independent of local weather conditions

Cleansing and Treatment

- Cleansing biotope terraces (similar structure to constructed wetlands)

Application

- Primarily for irrigation
- In optional cases can be applied as service-process water
- For larger buildings, such as hotels, hostels, spa, all grey water shall be reused again within the building due to size of facility
- Secondary use can be for irrigation

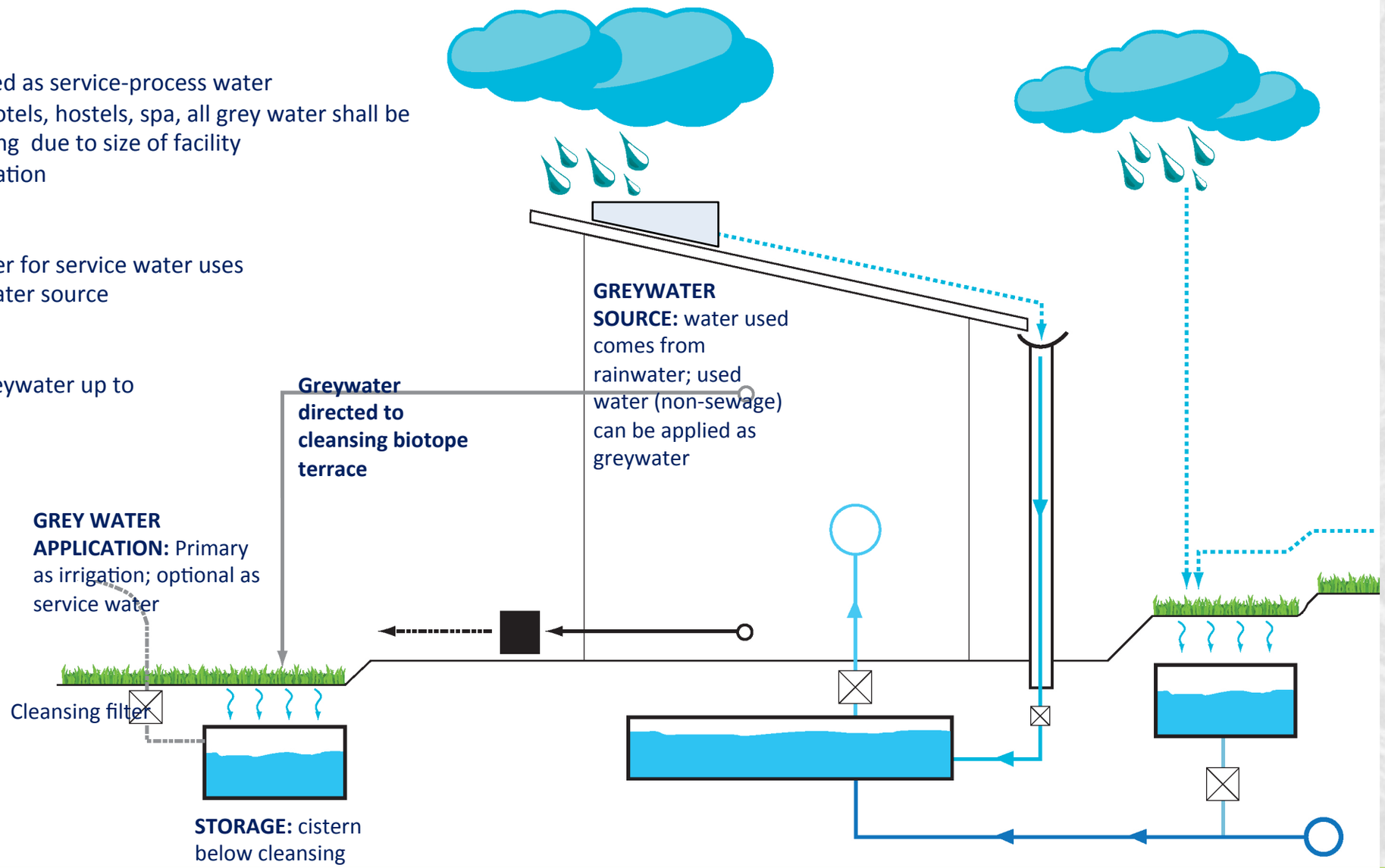
Advantages

- Eliminates use of potable water for service water uses
- Can be applied as irrigation water source

Further consideration

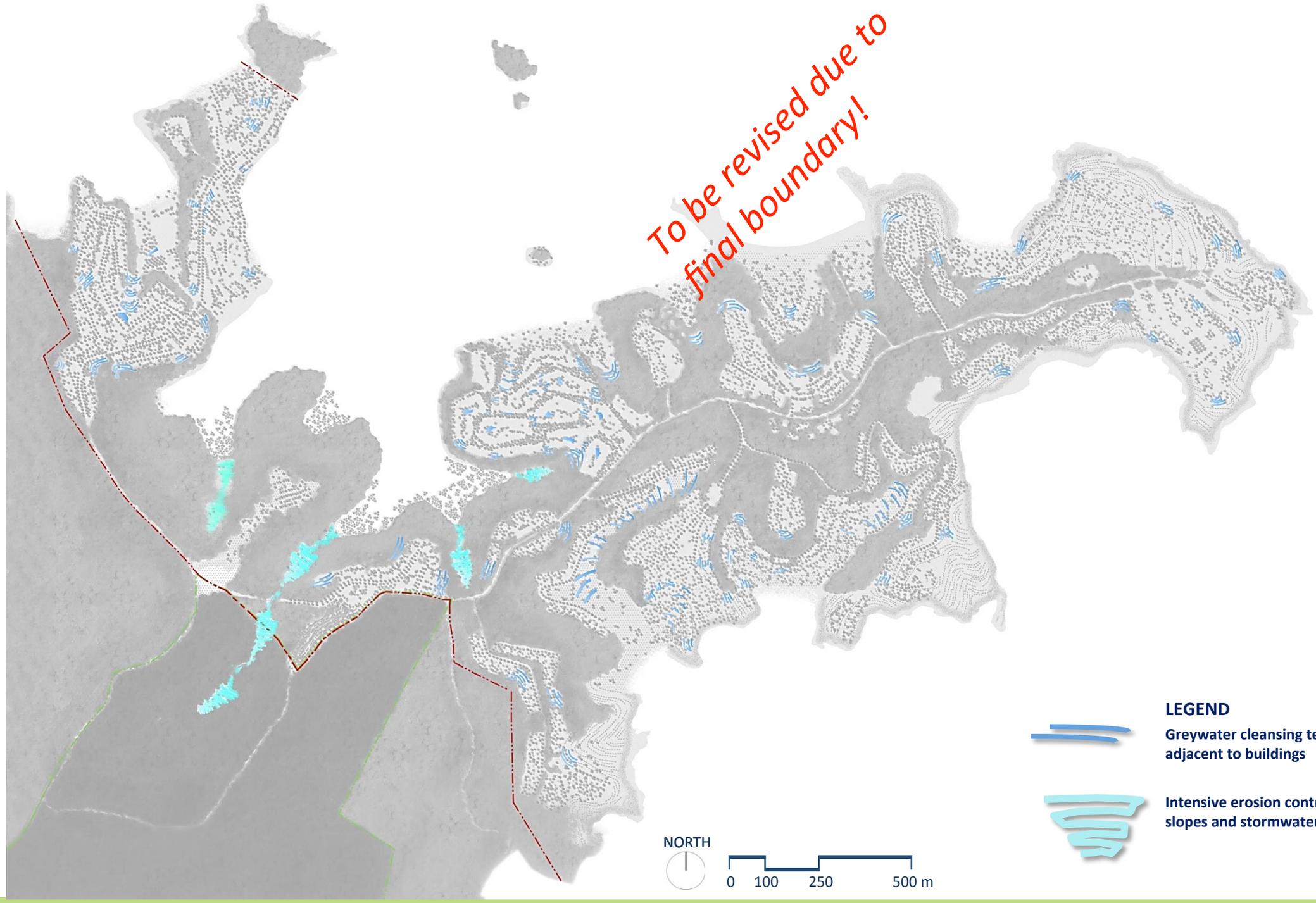
- Technology exists to purify greywater up to potable water standards

Note: Graphic shown representatively and not to scale; roof areas dimensions to be based upon plan layout



Goal 3: Create a Holistic Sanitation Strategy

GREYWATER CLEANSING TERRACES



Goal 3: Create a Holistic Sanitation Strategy

APPLICATION:
IRRIGATION FOR REFORESTATION OF ~1.20 HA OVER 3 YEAR PERIOD:
Note: calculations are assumptions only and will change based upon shifts in land area estimates

Irrigation to come from household greywater (surface stormwater to be used primarily as secondary potable water supply; excess can then be used for necessary irrigation or service water needs)

General guidelines for irrigation

- Xeri-scaping and drip irrigation provide efficient, sustainable applications
- Develop irrigation service and management plan as part of design development
- Select plants that require less water to reduce the amount needed for irrigation
- Water on an efficient managed schedule
- Use no potable water for irrigation purposes

Area to be irrigated	(Approximately) **1.2**	**hectares**
Number plants	1	per m^2
Irrigation rate	5	liter / plant / event
Irrigation events	1	event / week
Number weeks to irrigate	30	weeks / year
Irrigation volume	1.800	m^3 / year
Period	3	years
Total irrigation volume	5.400	m^3 / 3 years
Volume per week	84	m^3

Drip Irrigation: *highly efficient but slow; adaptable to sloping terrain of site*

Drip Irrigation: *must be differentiated by purple piping due to use of wastewater for irrigation*

Lay piping within ditches to revegetate bare forest

Goal 3: Create a Holistic Sanitation Strategy

GREYWATER

CLEANSING AND TREATMENT, OPTIONS FOR TREATMENT IN TERRACES:

Though names may differ, the treatment train process for cleansing water seeks to replicate the natural processes of wetlands with such uses as:

- Treating runoff from hardscapes such as roads or plazas
- Purifying the effluent from agriculture, fishing, or farming
- Offering habitats for animals and plants to revitalize the wildlife population and biodiversity

Three particular 'terraced' options for constructed wetlands, each intended for various application

- The most effective and efficient greywater cleansing system for the site is a mix of the three with constant circulation; a hybrid solution is especially relevant in warm, tropical climates

Free-Water Surface Constructed Wetlands FWSCF: several ponds of descending depths that can remove suspended solids and pollutant substances

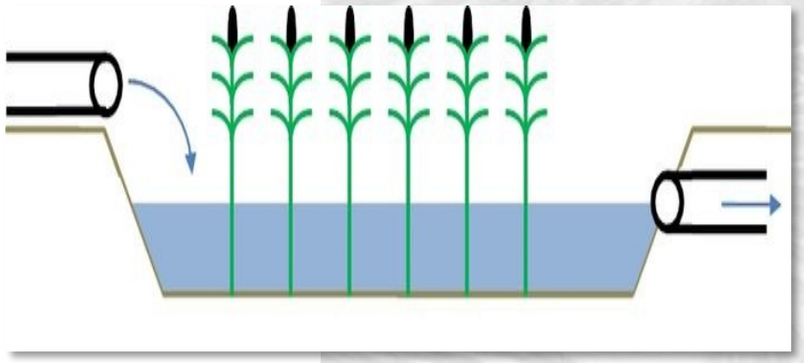
- Requires more land and time for pollutants to filter through with appearance of natural wetlands

Horizontal Subsurface Flow Wetland HSFW: anaerobic process where large lagoon is filled with gravel and sand and planted with aquatic vegetation; no sewage on surface; no risk to humans

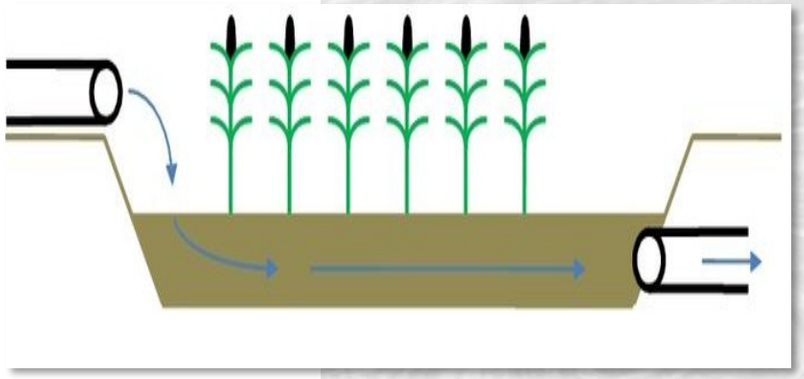
- Polluted water flows horizontally while plants filter particles /microorganisms degrade organics

Vertical Subsurface Flow Wetland VSFW: combined with waterproof underground layer and effluent collection, allows water to process through different stages of aerobic and anaerobic conditions

- Suggested for sloped areas but does require trained maintenance staff for service



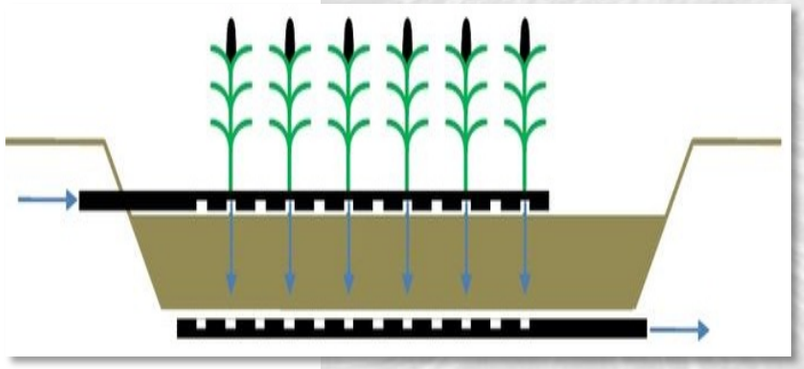
FWSCF: for larger ponds that can represent natural cleansing wetland conditions and aesthetic appearances



HSFW: best with an even inlet water flow as purification occurs below surface to outlet pipe

Constructed wetland suitable for shallower terraces

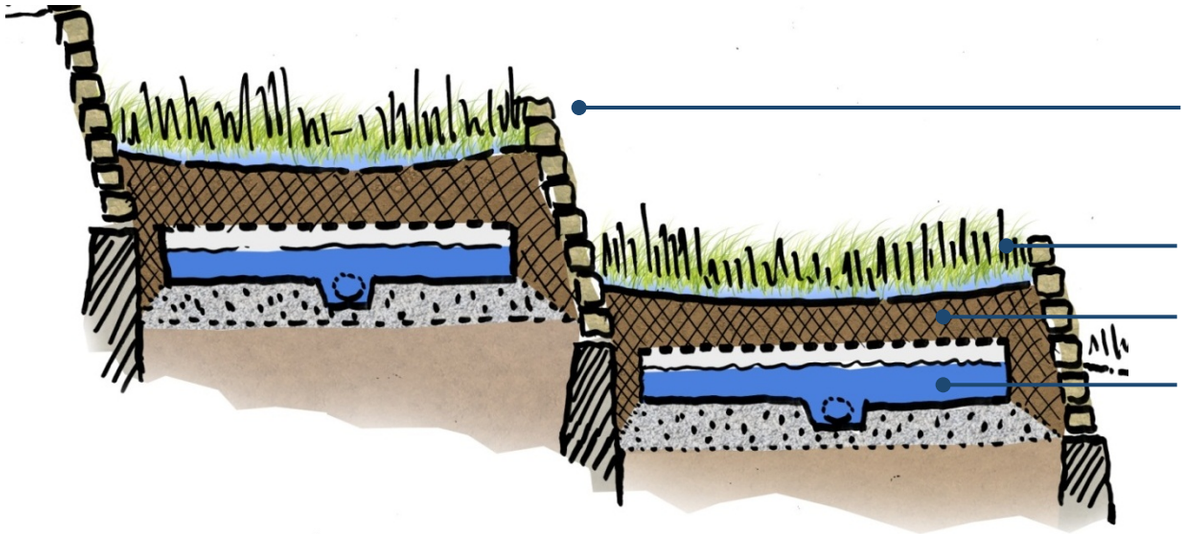
Constructed wetland suitable for steep terraces



VSFW: good oxygen transfer capability, nitrification

Goal 3: Create a Holistic Sanitation Strategy

CLEANSING AND TREATMENT, A CONCEPTUAL UNDERSTANDING:

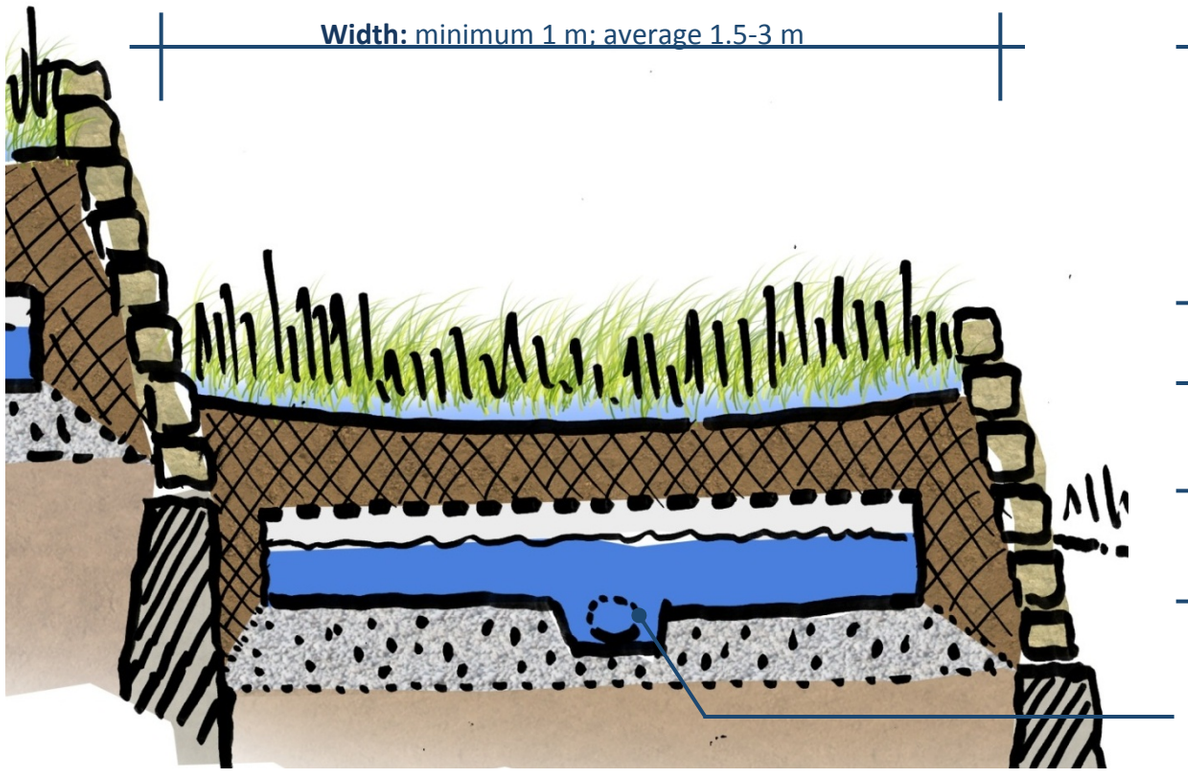


Front Wall: Natural stone, battered; set on retaining wall foundation

Cleansing biotope: small grass and trees; minimum 10 cm water retention depth

Topsoil: Terra Preta Rejuvenated Soil

Storage: polyethylene (PE) tank; perforated top with filter; set on gravel base and compacted sub-grade



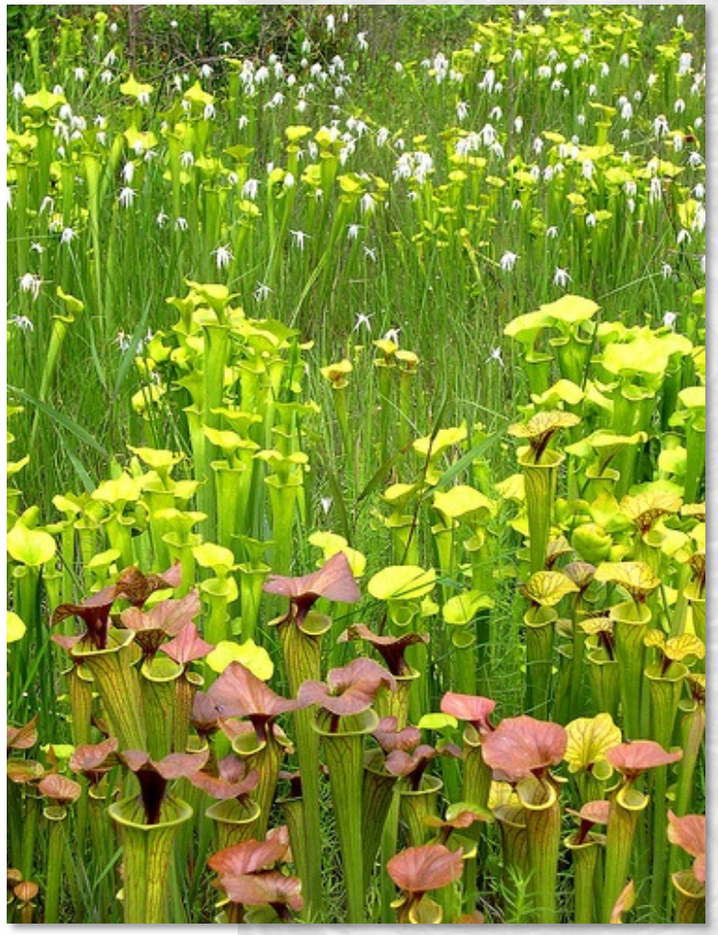
Terrace to Terrace Height: minimum 10 cm; average 20-50 cm

Top of Soil to Top of Wall: 10-30 cm

Top of Tank to Top of Soil: minimum 50 cm

Tank: Size to be determined based on location

Flow: one-side perforated pipe set on gravel base above sub-grade; pipe to connect system of terrace storage units



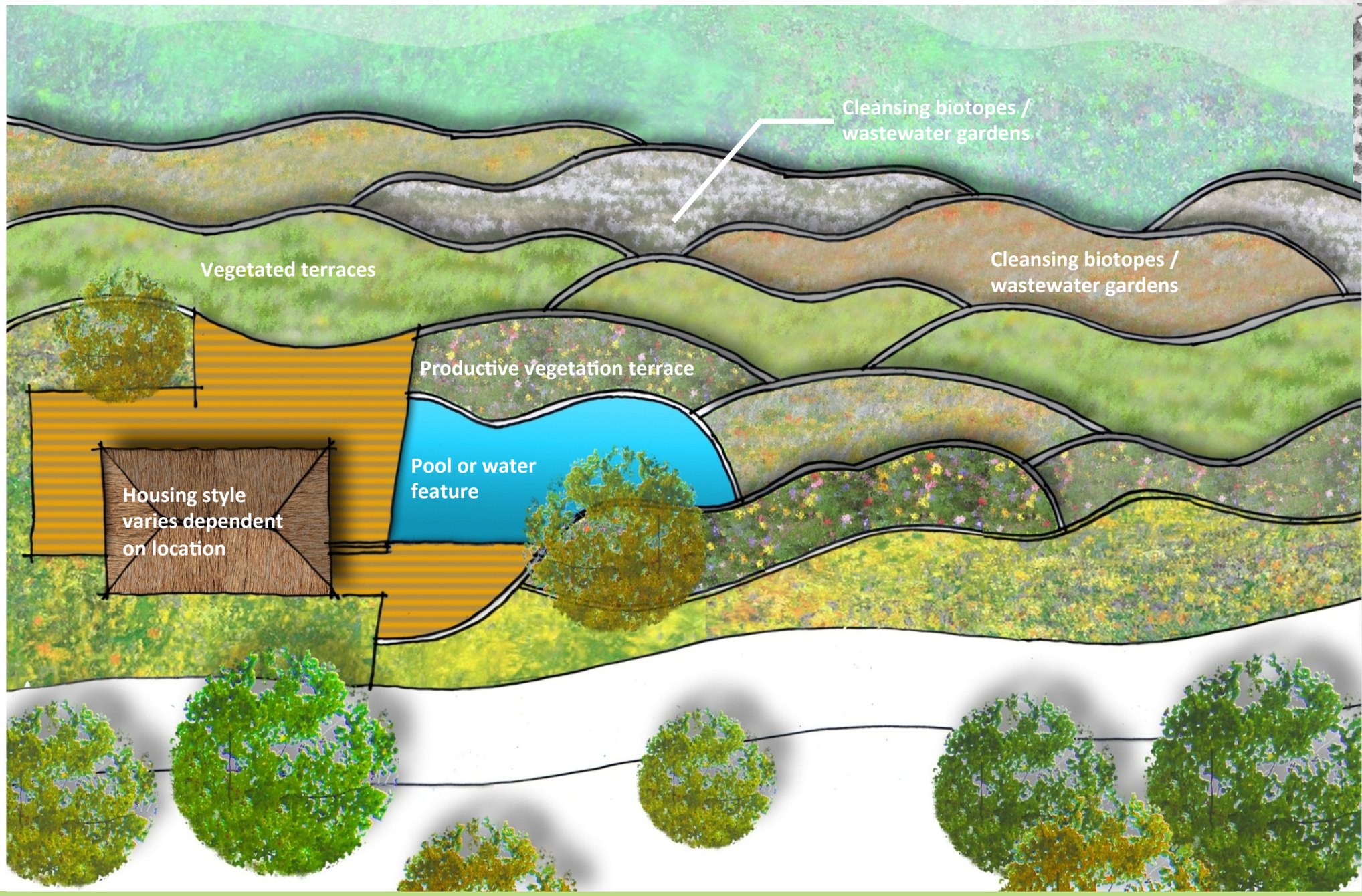
Accent vegetation within cleansing biotopes

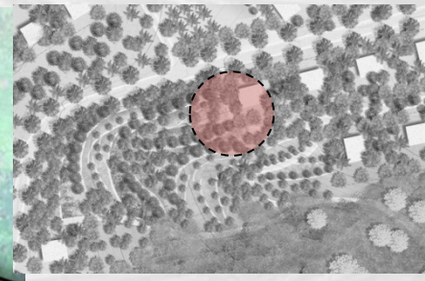
Planting scheme incorporates both water and vegetation

Goal 3: Create a Holistic Sanitation Strategy

CLEANSING AND TREATMENT: CONCEPTUAL PLAN:

- **Note:** Plan shown below as concept only. Actual form of terraces, building style, tree planting to follow from masterplan.



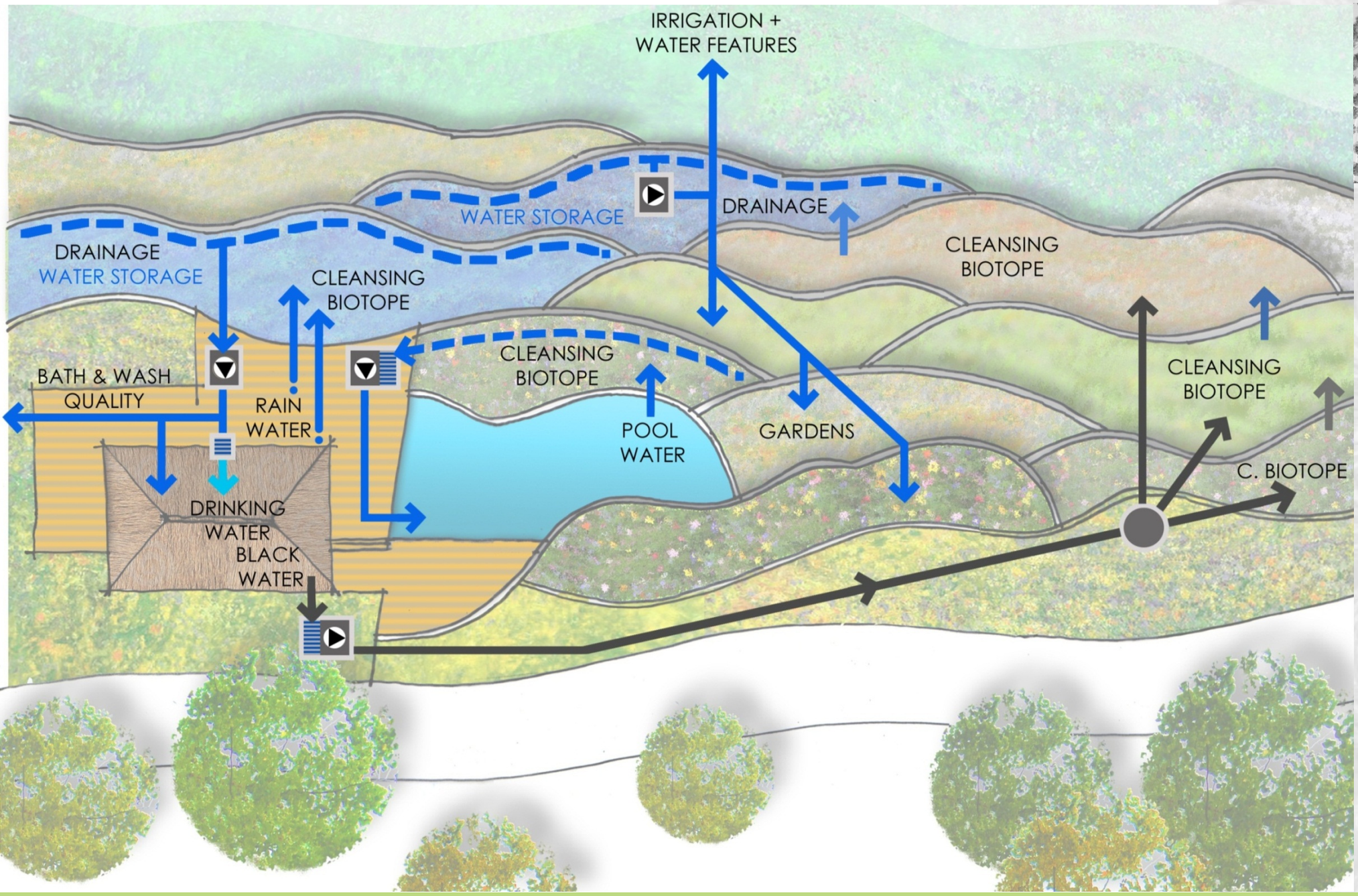


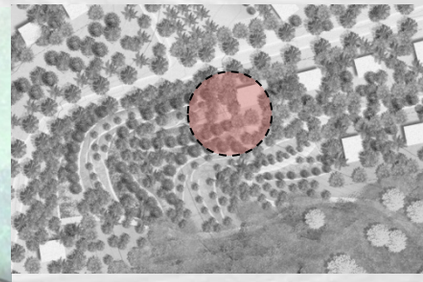
GREYWATER

Goal 3: Create a Holistic Sanitation Strategy

CLEANSING AND TREATMENT: CONCEPTUAL RAINWATER PLAN:

- **Note:** Plan shown below as concept only. Actual form of terraces, building style, tree planting to follow from masterplan.





Goal 3: Create a Holistic Sanitation Strategy

CLEANSING AND TREATMENT, CONCEPTUAL IMAGERY:

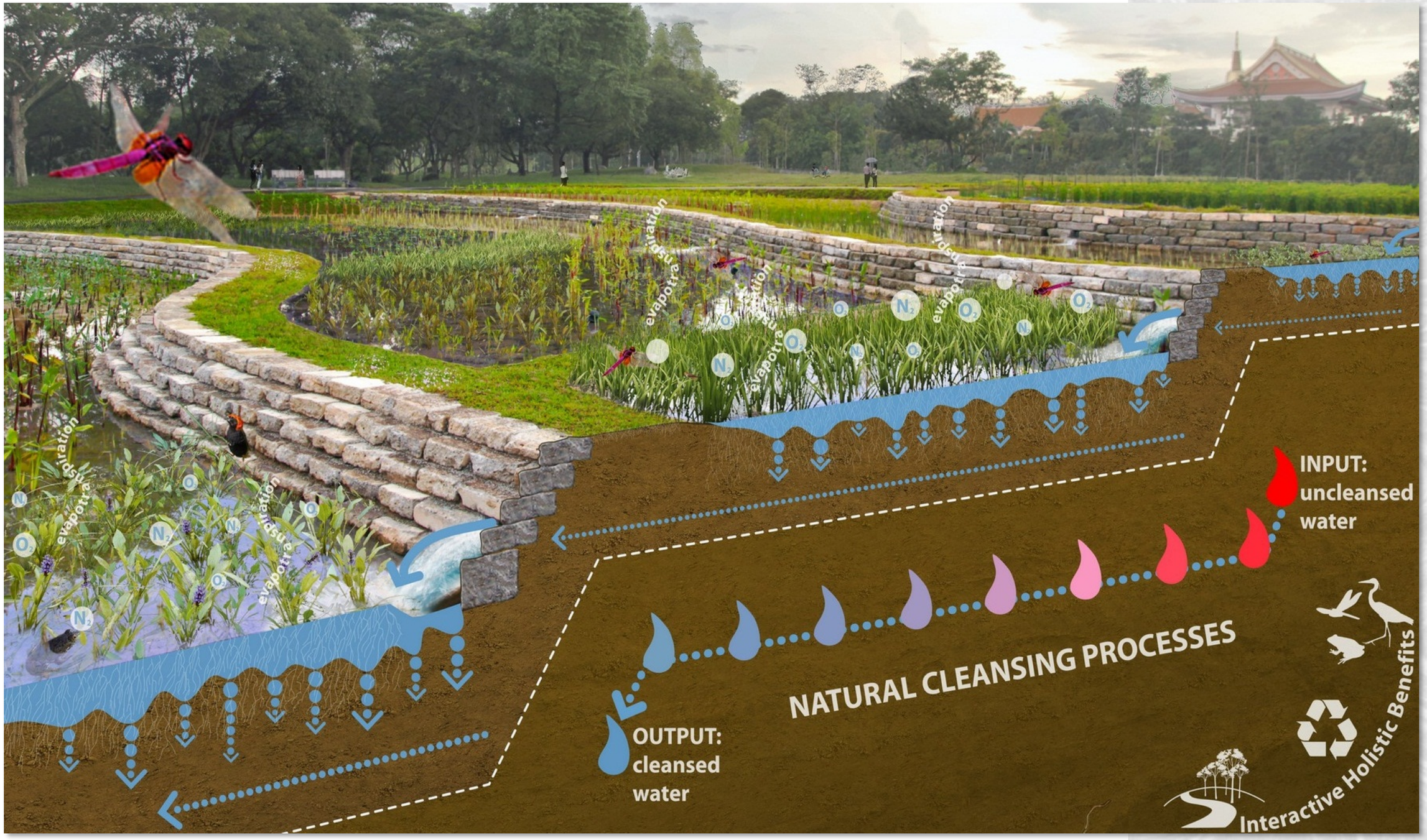
- **Note:** Visualization shown below as concept only. Actual form of terraces, building style, tree planting to follow from masterplan.

After: *implementation of terraces (form to develop in next phase)*

Before: *bare site along sloped terrain*

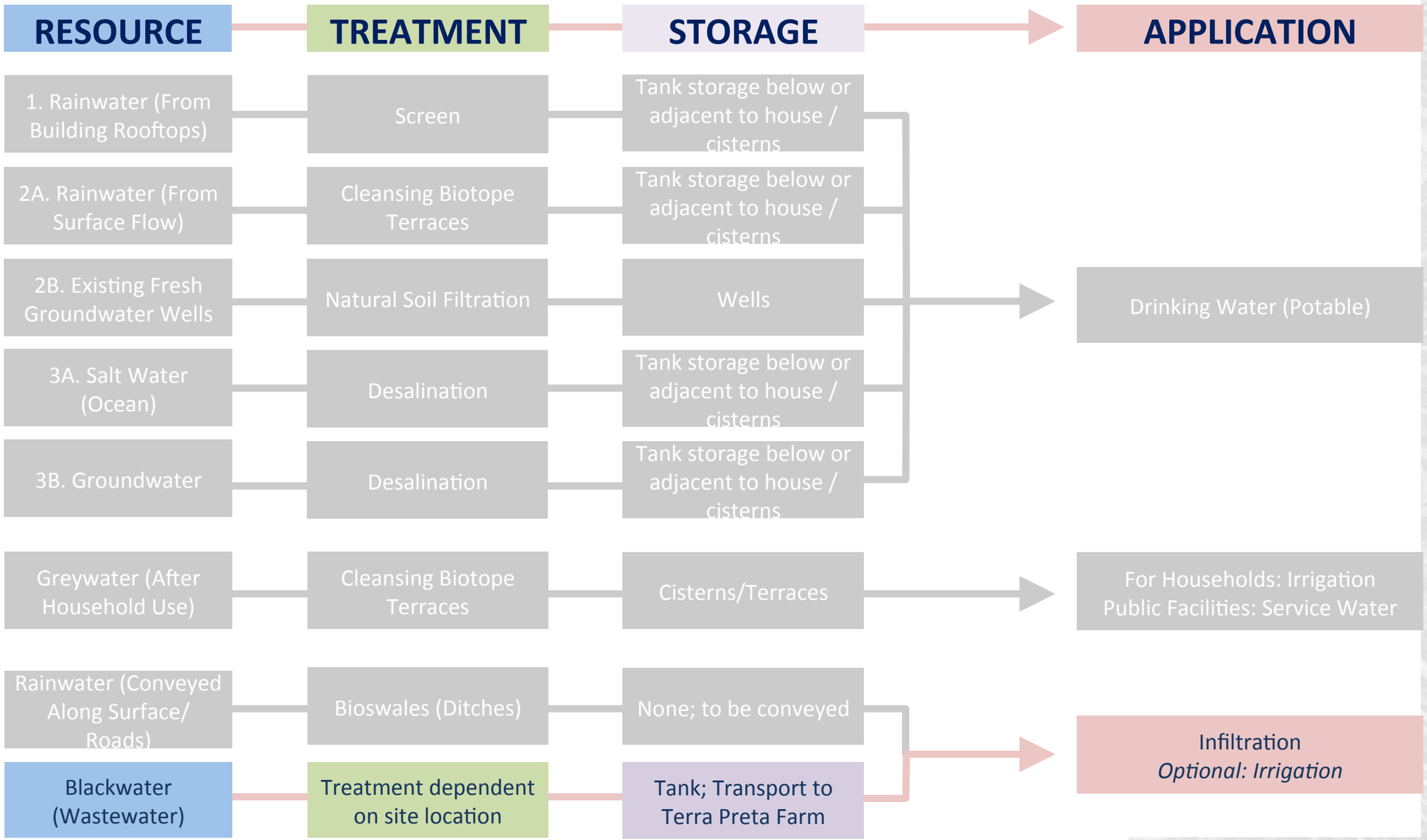
Goal 3: Create a Holistic Sanitation Strategy

CLEANSING AND TREATMENT: BUILT EXAMPLE OF CLEANSING BIOTOPE



Cleansing Biotope System Schematic: *Bishan Ang Mo Kio Park, from Atelier Dreiseitl*

Blackwater Schematic



Note: *Greywater from larger buildings (hotels, hostels, clubhouses) applied firstly as building service water*

Goal 3: Create a Holistic Sanitation Strategy

BLACKWATER

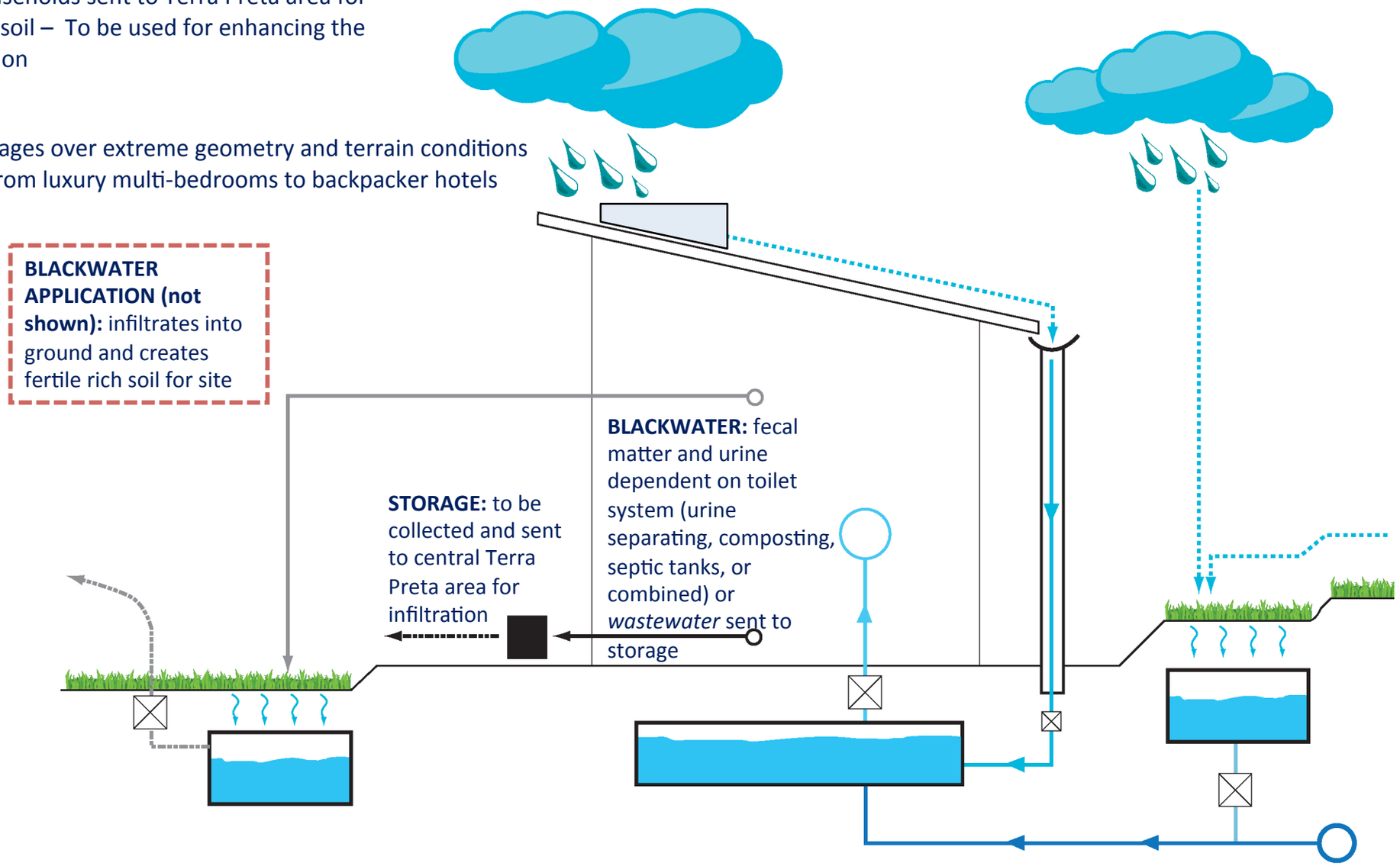
Blackwater Defined
- Water polluted by fecal matter or sewage

Cleansing and Treatment
- Separated wastewater flow system from greywater
- For toilet flushing, three options considered for a mixed sanitation scheme

Application
- Blackwater from households sent to Terra Preta area for production of fertile soil – To be used for enhancing the degraded soil condition

Challenges
- Widely dispersed villages over extreme geometry and terrain conditions
- Building types vary from luxury multi-bedrooms to backpacker hotels

Note: Graphic shown representatively and not to scale; roof areas dimensions to be based upon plan layout



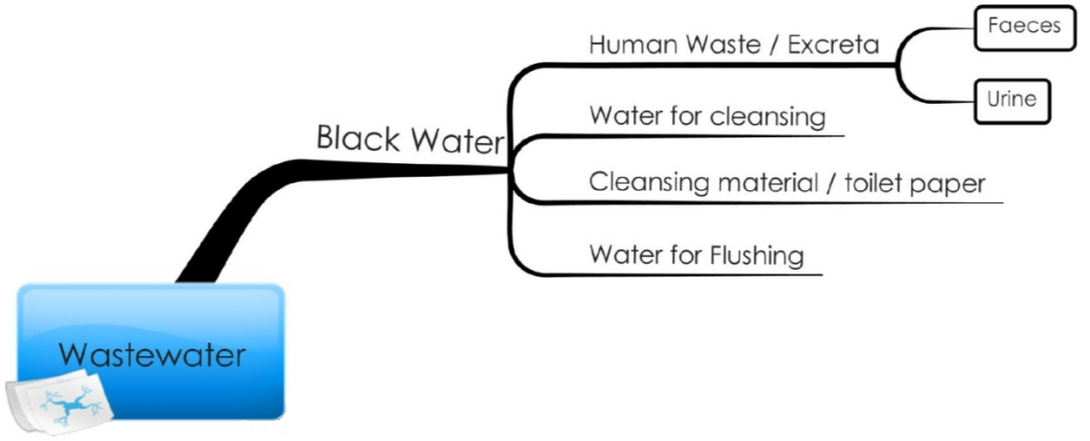
Goal 3: Create a Holistic Sanitation Strategy

SEWAGE TREATMENT, THREE OPTIONS:

Three sewage options offered to provide variety in the developments

- The options need to fit within the type of development
- A mix of options allows for both socially accepted practices to mix with more unconventional systems
- Should educate visitors on alternative toilet and sanitation advantages and benefits

In the end, all sewage is transported to Terra Preta are for infiltration



OPTION A:
Independent Dry Systems (Composting Toilet)

- Minimized use of water
- Urine diversion toilets within the house or composting toilet for those not wanting to separate
- Product brought to Terra Preta centralized area
- Hygienic and maintainable
- Solution for indepedent, self-sustaining household

OPTION B:
Conventional (Combined or Vacuum Sewerage)

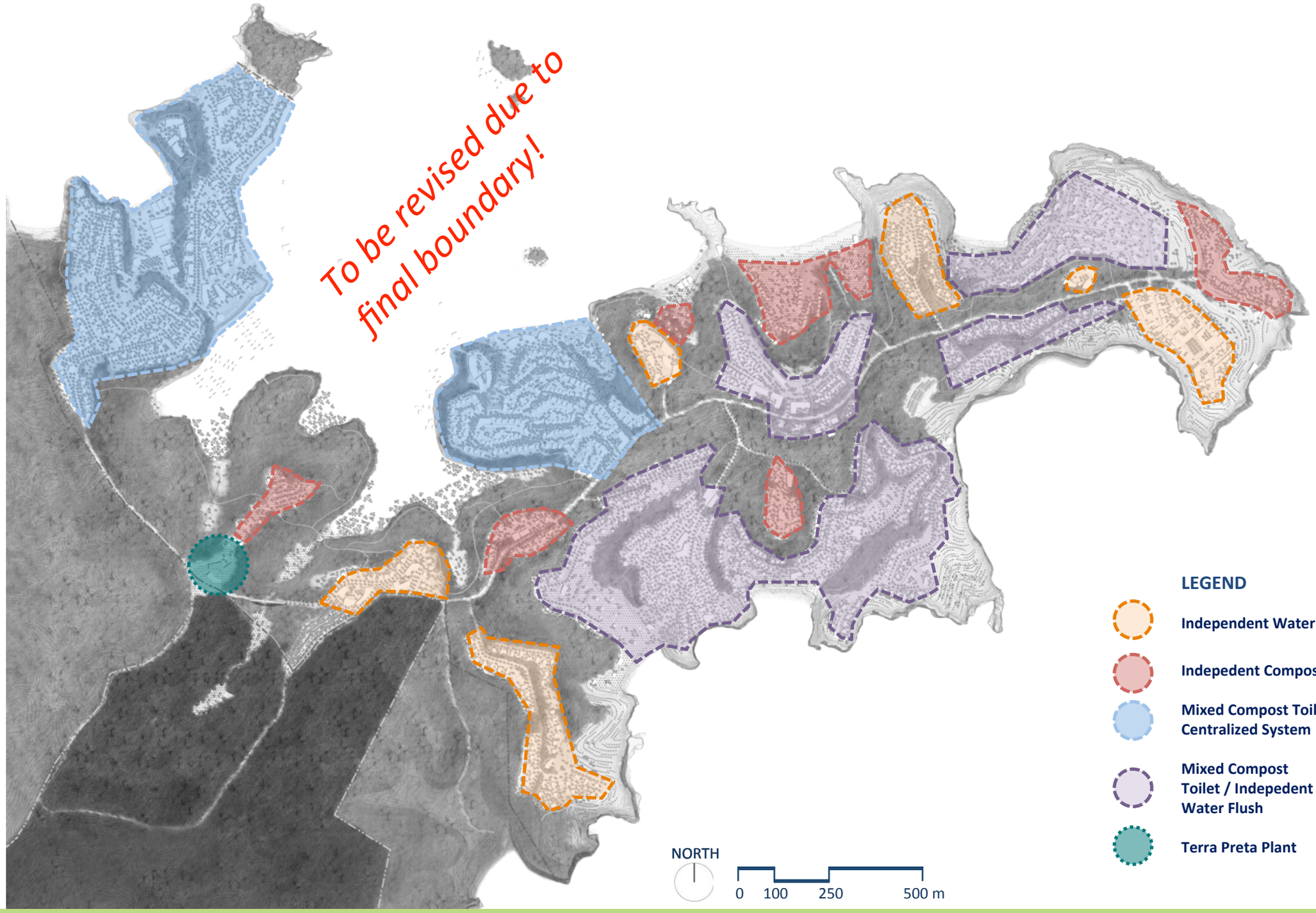
- Collects all sewage
- Combine with other system for effective *and* sustainable production
- Requires complex mainteance
- For specific site, complicated installation foreseen due to terrain and slope
- Blackwater collected/transported to Terra Preta

OPTION C:
Independent Water Based (Septic Tank/AUF)

- Septic tanks separate solid from liquid waste
- Liquid to sewage treatment terraces and use for irrigation or infiltration after treatment
- Solids transported by trucks to Terra Preta area

Goal 3: Create a Holistic Sanitation Strategy

VARIOUS SANITATION COMBINATIONS



Goal 3: Create a Holistic Sanitation Strategy

- All facilities to apply greywater treatment
- 24% shown as Terra Preta / Compost Toilet Users; 39% using Septic Tank / AUF; and 38% using a combined sewerage / vacuum sewarage approach
- *Estimates and calculations shall be periodically updated to match current masterplan*

Type of housing	Number units	Number beds	Terra Preta / Compost Toilet	Septic Tank / AUF	Combined Sewerage / Vacuum Sewerage
Marina Resort / Villas / Hotel *****	52	301	0	0	301
Marina Village *-***	71	458	0	0	458
Marina Management Houses + Villas ***-****	128	504	0	0	504
Stilt Houses ***	65	118	118	0	0
Forest Houses 1-2 ***-****	26	88	0	88	0
Pioneer Forest and Terra Preta Camp Houses ***	20	34	34	0	0
Arrival Village / Desa Raya (Village of Kings ***-****	24	76	0	0	76
Friend's Village – Mixed Use ***-****	218	952	0	0	952
Spa Hills and Villas ******	23	82	0	82	0
Garden Village ****	196	380	222	158	0
Ocean View Villas *****	34	356	0	356	0
Bay View Villas *****	30	439	0	439	0
Secluded Terrace Villas *****-******	57	406	164	242	0
Cliff Village (Artist's Village) ***-****	62	400	153	247	0
East Point ******	59	114	0	114	0
Cliff and Valley View Villas ****	85	404	210	194	0
Forest Camp + Houses ***	15	24	24	0	0
Bay 7 Resorts and Villas ***-****	99	190	111	79	0
Cliff View Resort ***-****	170	370	160	210	0
Bay 8 Villas ***	70	136	96	40	0
South of Bay 8 Villas ****	47	184	92	92	0
Islands	12	48	48	0	0
Total	***1.563***	***6.063***	***1.432 (24%)***	***2.341 (39%)***	***2.290 (38%)***

To be revised due to final boundary!

Goal 3: Create a Holistic Sanitation Strategy

- Total estimated cost for three sanitation systems:
  - €900.000 + €150.000 (staff needs) = **~€1.500.000 for development**
- Average cost per house for sanitation = **€770**
- Average cost per bed for sanitation = **$200**
- *Estimates and calculations shall be periodically updated to match current masterplan*

Note: Needs to be updated following final masterplan figures.

Type of Housing	Greywater Treatment and Irrigation	Terra Preta / Compost Toilet	Septic Tank / AUF	Combined Sewerage / Vacuum Sewerage	TLP	100% Recycling	Cost (Rp mln.)
Average cost (5 persons) mln Rp.	***Rp 0.5***	***Rp 1.5***	***Rp 5.0***	***Rp 20.0***	***Rp 0.5***	***Rp 1.0***	
Bungalow Courtyards 12 ha *****	Rp 131	Rp -	Rp -	Rp 2.000	Rp -	Rp -	Rp 2.131
Marina Village *-***	Rp 269	Rp -	Rp -	Rp 2.000	Rp -	Rp -	Rp 2.269
Desa Raya (Village of Kings) ***-****	Rp 64	Rp -	Rp 160	Rp -	Rp -	Rp -	Rp 224
Friend's Village - mixed use	Rp 444	Rp 150	Rp -	Rp 2.000	Rp -	Rp -	Rp 2.594
Spa Hill and Villas ******	Rp 26	Rp -	Rp 50	Rp -	Rp -	Rp 104	Rp 180
Garden Village ****	Rp 225	Rp 264	Rp -	Rp -	Rp -	Rp -	Rp 489
Ocean View Hill *****	Rp 240	Rp -	Rp 400	Rp -	Rp -	Rp -	Rp 640
Ocean Bay Villas ***** (former VIP)	Rp 53	Rp -	Rp 70	Rp -	Rp -	Rp -	Rp 123
Retreat Terraces *****	Rp 180	Rp 180	Rp -	Rp -	Rp -	Rp -	Rp 360
Secluded Retreat Terrace Villas *****-******	Rp 57	Rp 29	Rp -	Rp -	Rp -	Rp -	Rp 86
East Point ******	Rp 110	Rp -	Rp 300	Rp -	Rp -	Rp -	Rp 410
South of Lighthouse Villas ****	Rp 32	Rp -	Rp -	Rp -	Rp -	Rp -	Rp 32
Bay 7 Resort and Villas ***-****	Rp 152	Rp -	Rp 540	Rp -	Rp -	Rp 304	Rp 996
Hill Villas ****	Rp 35	Rp -	Rp 50	Rp -	Rp -	Rp -	Rp 85
Bay 8 Resort ***	Rp 175	Rp 263	Rp -	Rp -	Rp -	Rp -	Rp 438
Small Island	Rp 2	Rp 3	Rp -	Rp -	Rp -	Rp -	Rp 5
Big Island	Rp 8	Rp 24	Rp -	Rp -	Rp -	Rp -	Rp 32
Total	***Rp 2.203***	***Rp 912***	***Rp 1.310***	***Rp 6.000***	***Rp -***	***Rp 356***	***Rp 10.425***

To be revised due to final boundary!

Goal 3: Create a Holistic Sanitation Strategy

TERRA PRETA AND BLACKWATER INTEGRATION:

Note: the process for the Terra Preta soil creation shall be expanded in detail in the *Reforestation and Planting Strategy*

Background: literally translated as *black earth,* a carbon and nutrient rich soil produced by pre-Columbian cultures by the incorporation of manure, charcoal and bones into the grounds

Application: rediscovered concept will be used in the Tanjung Ringgit site for the treatment of human faces and household wastes (e.g. kitchen wastes)

- A promising application of Terra Preta sanitation (TPS) is to use urine diverting toilets
- Currently the site has approximately a little over 50% Terra Preta compost toilets specified

Terra preta sanitation (TPS) systems: based on a two step process of collection (including urine diversion) and lactic acid fermentation

- Occasional vermicomposting can added
- Lacto-fermentation is an anaerobic process, but in opposition to anaerobic digestion no gases are produced
  - Odor-free process that holds many opportunities for household development

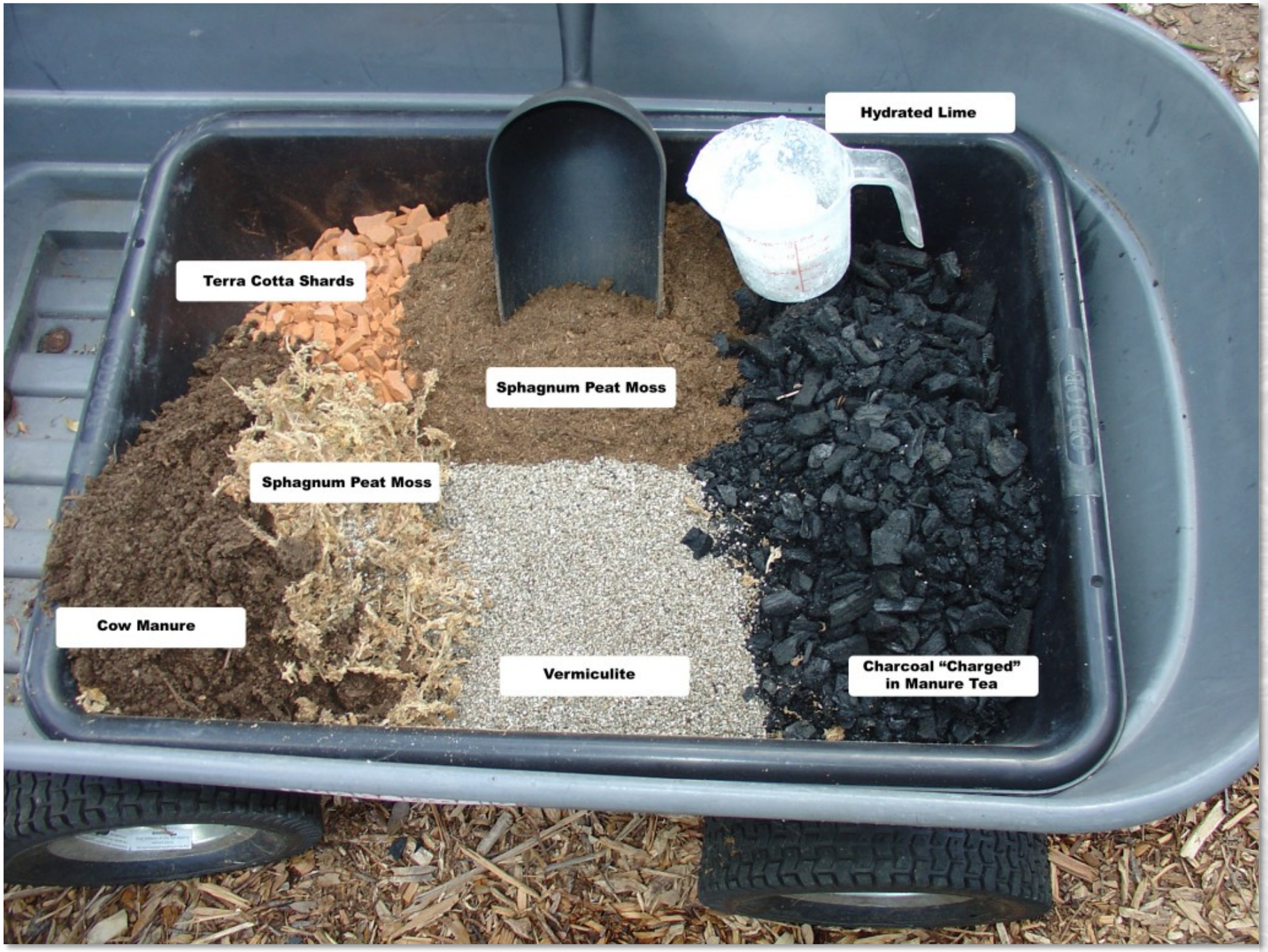
For the Tanjung Ringgit site it is proposed to centralize the Terra Preta site for all collection

The Terra Preta site has a high potential to prevent nutrient or carbon loss to the atmosphere by producing highly fertile compost (terra preta) and liquid fertilizer for agriculture

Comparing typical soil (left) and carbon rich Terra Preta (right)

Goal 3: Create a Holistic Sanitation Strategy

BLACKWATER

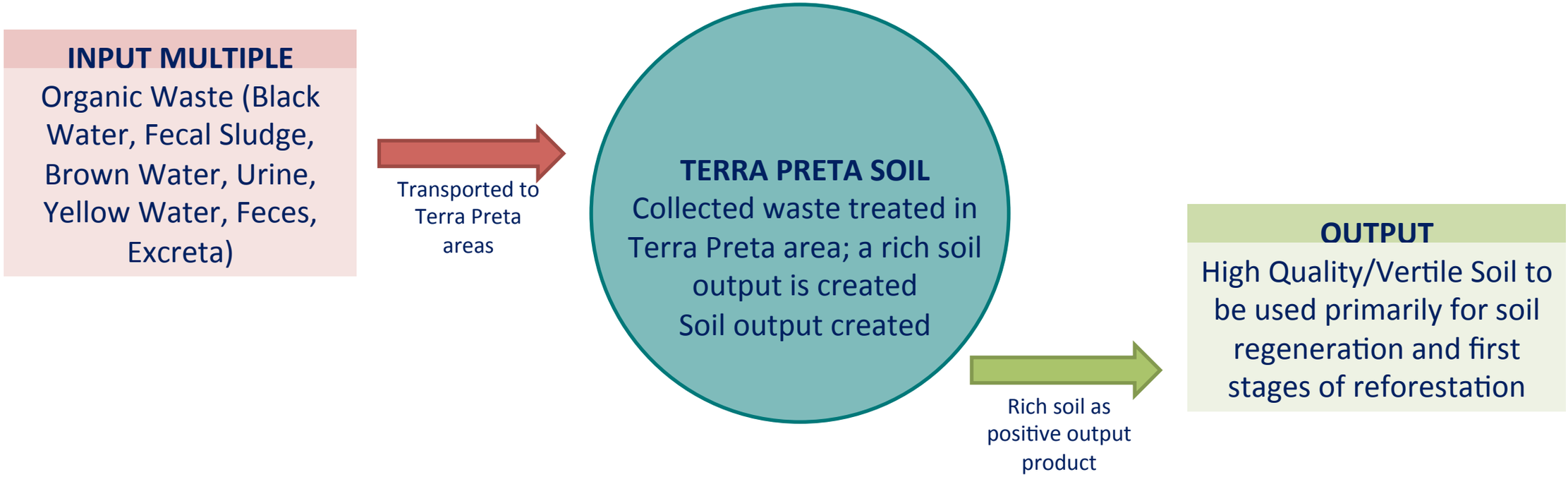


Material composition for basic Terra Preta soil creation

Goal 3: Create a Holistic Sanitation Strategy

TERRA PRETA CONCEPT:

- The proper achievement of a sustainable fertile soil source – crucial for the reforestation of the island as the base soil layer – requires professional consultants and specialists
- The client shall hire Terra Preta soil experts (such as Areal GmbH) for providing specialist knowledge and consultation for the production of the soil source
- Site placement can be centralized in the beginning; future phases may allow for decentralized Terra Preta areas
- Transportation of waste material reqiures service and maintenance costs
- Even though envisioned as the primary soil type to be used to replace the fairly damaged topsoil layer, the site may still require a secondary soil source
  - Waste content-biomass needed for the Terra Preta process will not be present at project start
  - Client must have an additional top soil source in place prior to establishment of Terra Preta farm area
- Soil can also be sent to productive gardens or gullies for agriculture or farming

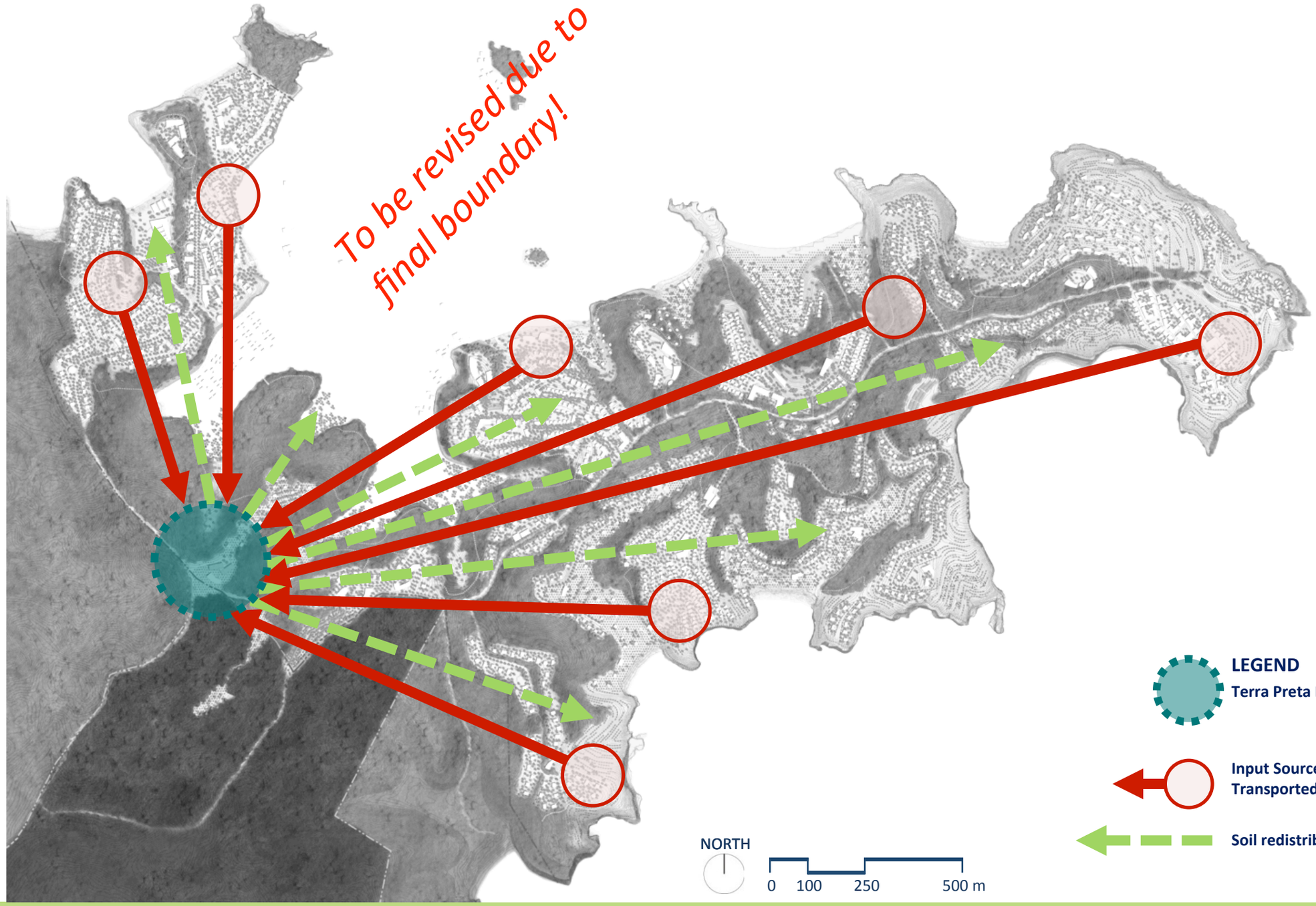


Concept for blackwater treatment within Terra Preta areas

Goal 3: Create a Holistic Sanitation Strategy

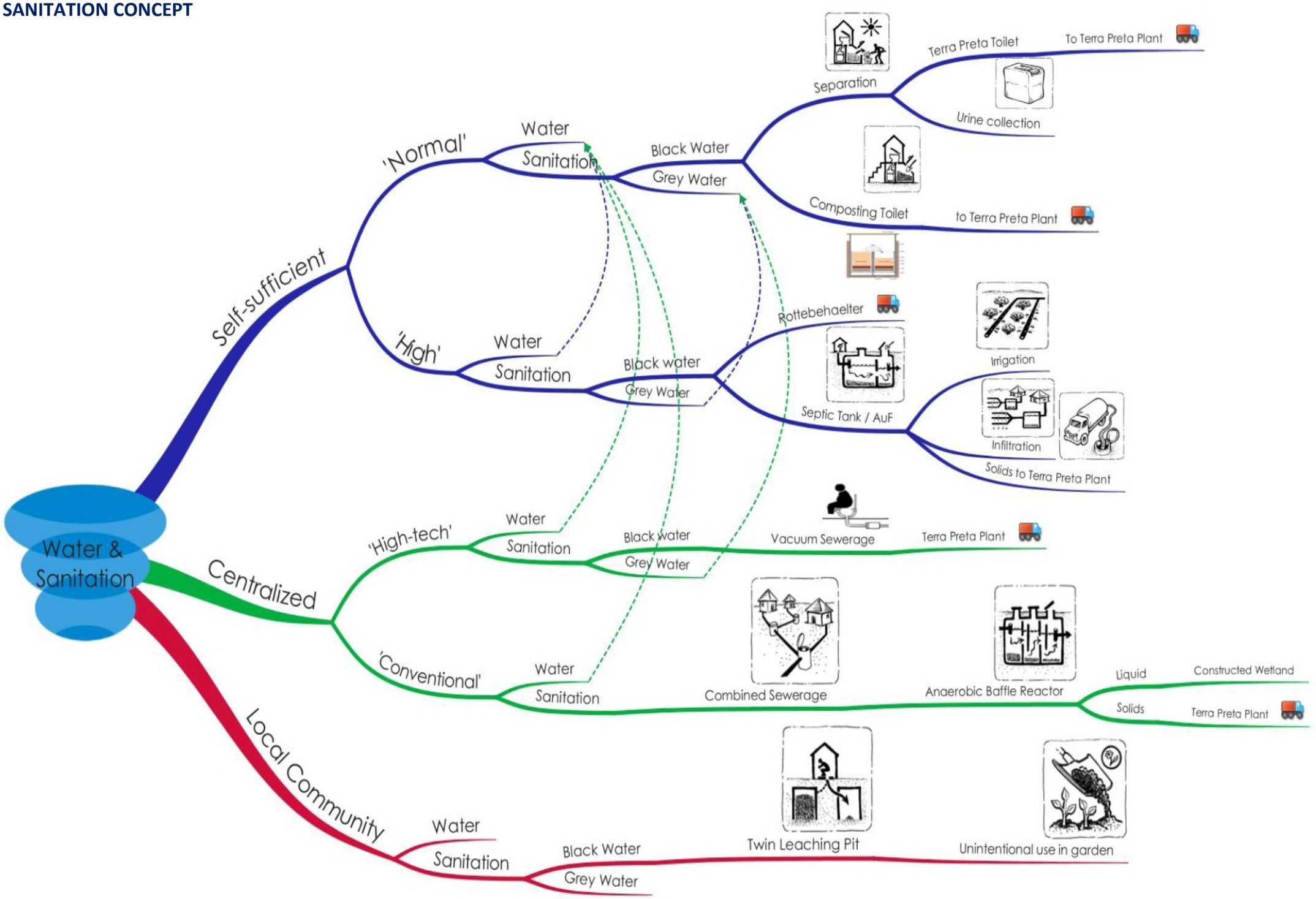
TERRA PRETA DISTRIBUTION CONCEPT

- Note: locations shown diagrammatically only in order to describe the strategy. Waste transported to main plant, treated and infiltrated, and Terra Preta enriched soil is produced. Shipped then as soil resource for landscape, gardens, and agroforests.



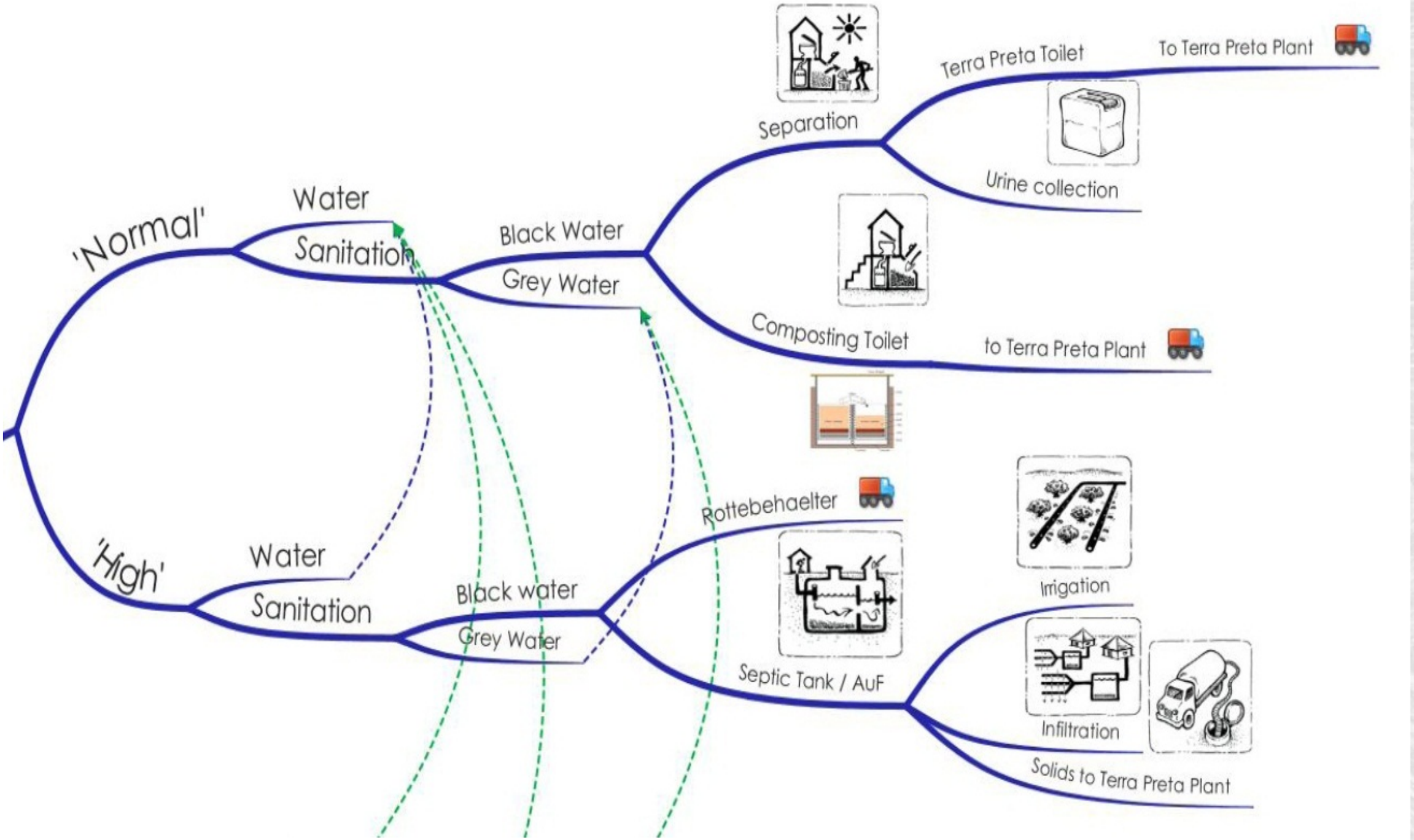
Goal 3: Create a Holistic Sanitation Strategy

SANITATION CONCEPT



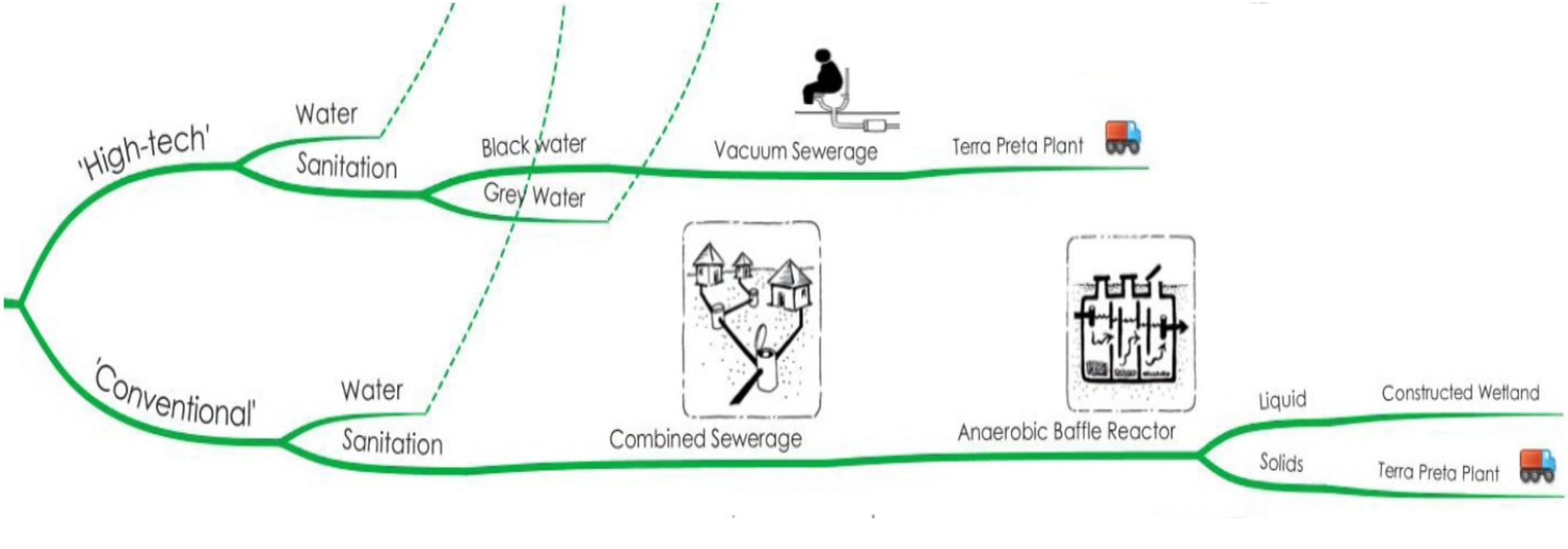
Goal 3: Create a Holistic Sanitation Strategy

SELF-SUFFICIENT SANITATION STRATEGY



Goal 3: Create a Holistic Sanitation Strategy

CENTRALIZED SANITATION STRATEGY



LOCAL COMMUNITY SANITATION STRATEGY

Goal 3: Create a Holistic Sanitation Strategy

OBTAINING TERRA PRETA SOIL, FROM SANITATION AND TOILETS:

Urine diversion toilets offer the advantage, as opposed to just flushing toilets, of separating urine and treating with microbial mix while also separating feces. The feces is then covered with a charcoal mix of charcoal, stone dust, finely cut wood or another bulking agent, and limestone soil (found in region). A lacto-fermination mix must then be added to the mix.

Composting toilets are another alternative that reduces water consumption considerably. The process occurs through aerobically by treating excreta via composting or managed aerobic decomposition. Mix with coconut coir, sawdust, or peat moss to reduce the odor.

In the end all blackwater is sent to the Terra Preta area for infiltration and conversion into a suitable soil substitute.

Composting toilets can still be attractive

Urine diversion toilet flushing example

Collection of bio-char / Terra Preta soil with the treated blackwater

Goal 4: Manage Stormwater

METHODS AND SUGGESTIONS:

Catch, clean, and manage stormwater at first point-of-contact

- Begin upstream by attempting to reduce speed and velocity using softer, more vegetated, wider channels
- Clean within treatment bioswales to improve water quality
- Integrate as infiltrated stormwater within landscape
- When treated in biotopes (and if necessary further mechanical treatment cycles), redistribute as part of the potable water system

Limit the disturbance caused by extreme weather conditions such as flooding

- Enact erosion control methods prior to start of construction and follow an established plan throughout development
- Attempt to slow down the discharge rate and retain a low run-off coefficient
- Ensure sufficient space for detaining or retaining stormwater
- Build infrastructure such as piping or ponds at proper and efficient size (not undersized because of costs or oversized due to safety concerns)

Create win-win situations

- Integrated systems enable efficient use of mechanical procedures combined with low-tech, cost-effective methods
- Synergetic relationships display the positive benefits of environmentally sustainable design through visible and experiential statements