

Extensive Maintenance Guideline

TerraEXT™ sedum blankets contain heat and drought tolerant plants that thrive on the hot and dry rooftop environment. The blankets are pre-cultivated with mature plants in our nursery with minimum vegetation coverage of 80% guaranteed at delivery.

The sedum blankets are disturbed during harvest, transport and installation. After installation, keep the blankets moist but not soggy during the first 4 weeks for the plants to recover or until they have rooted in. In general, frequent maintenance visits are required at the beginning to ensure the green roof has a good start. Once the plants have recovered, maintenance frequency can be reduced.

Maintenance needs are project specific and based on the client's expectation, e.g. visible or publicly accessible green roofs often have higher aesthetic expectation and thus require more maintenance. The schedule in Table 1 is intended for general recommendation only. It should be tailored according to project needs and climatic conditions.

Table 1: Maintenance schedule for TerraEXT™ pre-cultivated extensive green roof systems

After Installation	Frequency	Approximate timeline
Year 1: Installation month and following month	Semi-monthly	
Year 1: Spring (after last frost)	2x per season	Mid May - Early June
Year 1: Summer	4x per season	Mid June, Early July, Mid Aug, Early Sept
Year 1: Fall (before first frost)	1x per season	Early Oct
Total visits Year 1:	Approx. 7	
Year 2: Spring (after last frost)	1x per season	Mid May
Year 2: Summer	3x per season	Mid June, Mid July, Mid Aug
Year 2: Fall (before first frost)	1x per season	Mid Sept
Total visits Year 2:	5	
Year 3: Spring (after last frost)	1x per season	Mid May
Year 3: Summer	2x per season	Mid June - Mid July
Year 3: Fall (before first frost)	1x per season	Mid Sept
Total visits Year 3:	4	

1. Rooftop Safety

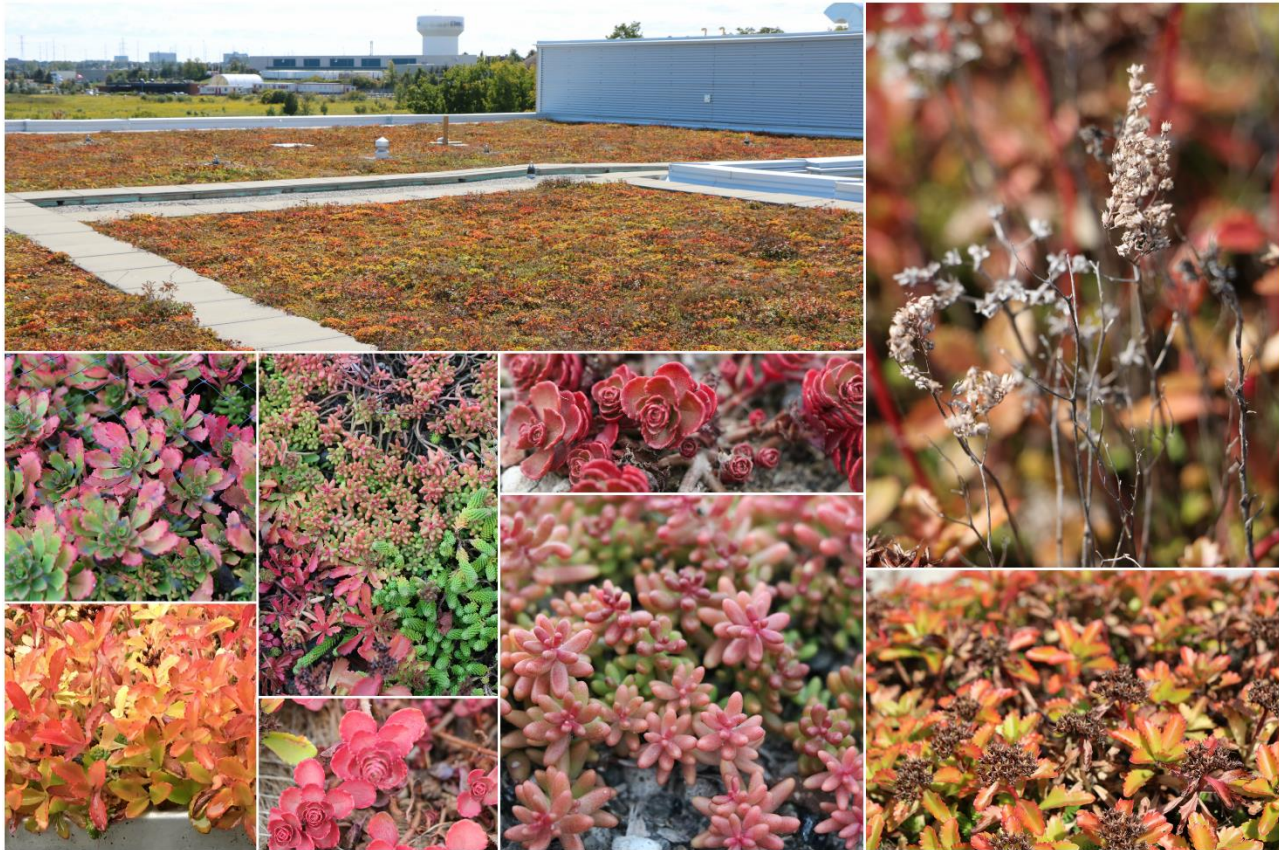
Rooftops present fall hazards. Maintenance crew must be trained in fall arrest protection and their work must comply with local labour code. All crew personnel shall be equipped with safety gear and tied off when working on rooftops. The crew must be properly trained in TerraEXT™ green roof systems and how to maintain them. Contact a Next Level Stormwater Management™ representative for details.

2. Dormancy

In Autumn, as winter approaches, green roofs enter the dormancy cycle. As rooftop conditions are harsher than at the ground level, the exposed vegetation on rooftops enter into the dormancy cycle earlier than at ground level. Dormancy is a natural reaction to adverse environmental conditions. It can happen in the summer during periods of intense heat and drought, or in the fall in preparation for the coming cold winter months. During dormancy, plants simply stop further growth and development to conserve energy. Dormancy is a plant's defense mechanism to keep itself alive. The retreating plants are not dead. Dormancy synchronizes with

the environment and can be triggered by a temperature drop or sudden changes in climactic conditions, such as reduction in rainfall and water shortages.

Green roofs lose their flowers and change colour creating a beautiful landscape of reds, bronze and browns, to deep purples.



During winter dormancy, coniferous sedum plants retreat to form a dense mat of glossy and fleshy leaves, while the leaves of deciduous sedum species completely fall off.

3. Plant Performance

Check coverage, health and diversity of vegetation. Note problematic areas and identify causes if possible. Some common problems and solutions are as follow:

- *Ponding:* For small ponding area, lift sedum blanket and water retention layers (if applicable), install additional drainage layer(s) as needed to raise the vegetation above ponded water.
- *Rotting:* Our plants are selected to thrive in hot and dry environment. They may rot and die in standing water. Check for ponding, roof drainage and reduce irrigation frequency as needed.
- *Wilting:* TerraEXT™ sedum blankets contain succulents that store water in their tissues. They will wilt and shrivel up as the water storage is being depleted during prolonged heat and drought. Irrigate until saturation. Repeat in a few days as necessary until conditions improve.
- *Dryness:* Check for causes such as fan exhaust and reflected surfaces (e.g. glass and metal sidings) on the roofs. Correct these conditions if possible and provide irrigation. If conditions do not improve, replace affected area with hard landscape such as pebbles and concrete pavers.
- *Disease:* Fungus growth is rare and usually an indication of excessive dampness. Check for ponding, reduce irrigation frequency and if necessary, apply an organic fungicide to control.

- *Pest:* Pest such as caterpillars and garden snails eat vegetation. If their population becomes too high and cause excessive damage to the green roof, apply an organic pesticide to control.

Act at first sight of problem to minimize potential damage to the green roof. When in doubt, please consult a Next Level Stormwater Management™ representative.

4. General Maintenance

Remove unwanted vegetation (e.g. weeds and grasses) before they flower, form seeds and multiply on the green roof. Remove any woody plants and tree seedlings as soon as possible. Remove overgrown vegetation in non-vegetated borders. Remove vegetation by hand; use of herbicide is not recommended.

Check sedum blankets for missing growing medium and replenish as needed. For small areas with poor vegetation growth, add seeds or cuttings (obtain from areas with lush growth) to bare areas and keep moist until germination or rooted in. For large areas with poor vegetation growth, cut out entire area and replace with new sedum blanket, keep moist until the plants have rooted in.

Fertilize the green roof in spring when the plants start active growth using a controlled release fertilizer (NPK 17-7-10 or similar), supplying nitrogen (N) at a rate of 15g/m² (use the following formula to calculate the application rate: nitrogen requirement divided by the percentage of nitrogen in the formula multiplied by 100. I.e.: $15g/m^2 \div 17 \times 100 = 88.2 g/m^2$.) Irrigate thoroughly to allow the fertilizer to settle. One application per year is usually sufficient. A second application may be needed to compensate for excessive nutrients runoff on slope roofs or following long periods of heavy rainfall.

Birds cannot damage sedum blankets because the plants are firmly rooted in. However, they may peck at the gaps between the sedum blankets and remove the water retention layers (fleece and rockwool) underneath for nesting materials. Tug damaged/displaced retention layer back, fill gap with growing medium, spread cuttings and keep moist until rooted in. Birds are not strong enough to lift the sedum blankets at the seams once the plants have rooted in.

5. Roof Servicing

Wind-blown garbage and dead plant biomass can accumulate on the green roof. Accumulation of debris in and around the drainage channels and roof outlets can hinder drainage, which can lead to ponding and excessive loading on the roof. Clear the roof drains of debris regularly, especially after major storm or rain events. Remove debris from vegetated areas, non-vegetated borders and access paths. Visually inspect exposed roof membrane and flashing for any sign of damage and leak.

6. Irrigation System

The green roof must be kept moist but not soggy during the first 4 weeks or until the roots have grown into the water retention layers underneath the sedum blankets. Once the plants can properly access the water stored in the sub-layers, they can better withstand heat and drought. An irrigation system is highly recommended for hot and dry climates.

Irrigation can be done manually with a garden hose or using automated systems such as drip lines or overhead spray. Drip system loses less water through evaporation and it is not affected by high wind compared to overhead spray however sprays system may provide more even coverage. Drip lines should be installed above the sedum blankets for ease of inspection and troubleshooting.

Check to ensure that the irrigation coverage is uniform. Adjust the irrigation system/regime as necessary, e.g. amount, time and frequency of irrigation zones. Avoid over- or under-watering. Routinely clean out dirt traps in the system to avoid blockage. Check often to ensure that the automated system is in working order. When lengthy repair is expected, make arrangement for a temporary sprinkler system or water manually with a garden hose until repair is completed.

Water deeply and infrequently to encourage deep root growth and robust plants. Ensure that the sub-layers are saturated with each watering. Runoff at roof drains does not necessarily mean that the sub-layers are saturated, such as on sloped green roofs where surface runoff is high compared to absorption. Check by lifting a corner of the sedum blanket and feel the sub-layers.

Allow the green roof to dry somewhat between watering to conserve water and promote hardy plants.

Avoid irrigating in mid-day during intense sunlight because of high evaporation loss. Irrigation is most effective during early mornings and evenings when the temperature is cool and the sun is less intense. Water has time to soak into the green roof for the plants to take up.

Irrigation regime (amount and frequency) depends on many factors such as the weather conditions, the water retention capacity of the green roof system and the slope of the roof. For example, a TerraEXT™ green roof system consisting of a pre-grown sedum blanket with 4" extensive growing medium has a water retention capacity of approximately 68L/m². When saturated, the system can go without water for about 2 weeks during the summer when the potential evapotranspiration rate is extremely high at 5 mm/day. However, it can last about 5 weeks without water during the spring and fall when the potential evapotranspiration rate drops to 2 mm/day. These should be taken into consideration when setting up an irrigation regime. Please consult a Next Level Stormwater Management™ representative for details.

7. Water Quality

Irrigation water can come from sustainable sources such as rain water capture and grey water reuse on site, or natural streams and ponds nearby. However, it is important that the irrigation water is free from chemicals and pollutants that might be harmful to the plants on the green roof. When in doubt, the irrigation water should be tested to confirm its quality.

8. Extreme Weather Events

Prolonged heat/drought: The succulent plants on the sedum blanket will start to shrivel and wilt when the water storage inside the plants are being depleted. The plants will go dormant and if the situation does not improve, they will eventually die. A rule of thumb is to compensate the evapotranspiration with irrigation. For example, if the daily evapotranspiration is 5 mm in the summer, irrigating the green roof with 25-30mm every 5-6 days will be sufficient.

Wind Storm: Hurricanes may displace the sedum blanket, especially on newly installed roof where the plants have not had a chance to root in. Check for displacement of blankets and re-secure. Check for missing growing medium and plants from wind erosion and replace as needed (see "*General Maintenance*"). Clear wind-blown debris from the roof, especially in and around the drainage channels and roof outlets. Check for displacement of pebbles in the non-vegetated borders, redistribute pebbles as needed. Ensure irrigation system remains in working order.

Heavy Rain: Heavy rain can wash off debris and dislodge growing medium from the sedum blanket. Check and clear dirt and debris from drainage channels, roof outlets and non-vegetated borders. Replenish growing medium and add cuttings as needed.

Hail: Hail stones can damage plants on green roof through crushing and freezing. Fortunately, the damage is usually temporary. Do not walk on frozen plants as this can cause further damage. Broken plant parts will become cuttings and some will take roots to form new plants. The green roof should recover in a few months.

9. Foot Traffic

The TerraEXT™ sedum blanket contains light traffic succulent plants, which can be damaged by foot traffic. Avoid unnecessary foot traffic on vegetation at all times. Use designated access path or walk on stones in the non-vegetated borders whenever possible. When absolutely necessary, occasional foot traffic is permitted no more than once every 2 weeks. Avoid walking on the same path to minimize plant damage. Install designated access path to rooftop units that require frequent.

Avoid putting heavy load on green roof as this will crush the plants. Should this be absolutely necessary, lay plywood over the sedum blankets for no more than 4 hours to spread the load and protect the plants. Remove plywood to allow the plants to recover overnight. Any damage to the plants and sedum blankets must be repaired immediately (see "*General Maintenance*").

10. Membrane Repair

The components in a TerraEXT™ green roof system can be rolled back and removed to allow access to the roof membrane for repair.

For small area, cut and remove a section of sedum blanket, growing medium, water retention layers (if applicable), drainage layer and root barrier, layer by layer to expose the roof membrane. Take care not to damage the roof membrane when cutting. After membrane repair is completed, cut a new piece of root barrier, with at least 30 cm larger on all sides than the original cutout for overlap, place over the opening left by the existing root barrier. Replace all layers one by one into their original spots. Spread some growing medium along edge of the cut-out sedum blanket to promote plant growth across the seam. Keep the area moist until the plants have rooted in again, about 2-4 weeks.

For larger area, rolled back and remove sedum blanket. Store rolled up blankets in a cool, shady spot for no more than 24 hours. Otherwise, unroll on non-vegetated section of the roof or on the ground for longer storage. Roll back and remove sub-layers, one layer after another, to expose the membrane. Do not cut but roll the root barrier to one side. After membrane repair is completed, roll root barrier back into position, taking care to maintain the 30 cm overlap between sheets. Replace all other layers. Spread some growing medium between the sedum blanket to promote plant growth across the seam. Keep moist until the plants have rooted in again, about 2-4 weeks.

11. Roof Membrane Replacement or Relocation of the Green Roof System

Roll up sedum blanket. Unroll them on the ground or in a nursery with proper care. Unroll or remove the rest of the sub-layers such as water retention layers (if applicable), growing medium, drainage layer and root barrier...etc layer by layer. Store sub-layers indoors or cover to protect from rain. Remove all pebbles around the non-vegetated border. After replacement of the roof membrane, re-install all layers as a new installation. Keep green roof moist until the plants have rooted in again, about 2-4 weeks.

12. Routine Inspection

The owner or his/her representative is encouraged to conduct routine visual checks to help decide what maintenance measures and schedule to follow, e.g. irrigation regime and weeding frequency. Report any sign of problem (e.g. wilting or pest damage) immediately to a Next Level Stormwater Management™ representative for remedial actions to minimize potential damage to the green roof.

13. Third Party Materials

All our components have been tested for quality and compatibility according to the German FLL Green Roof Guidelines. To maintain the high performance of the TerraEXT™ green roof system, only approved components may be used for maintenance. This includes but not limited to sedum blankets, growing media, water retention layers, drainage/filter layer, root barrier, fertilizer, and metal edging. Please contact a Next Level Stormwater Management™ representative for details.

14. Disclaimer

This guideline serves as general recommendation only and does not preclude owner responsibility for routine green roof care and oversight. Specific projects may require special maintenance actions and schedule. Should there be any queries, please contact a Next Level Stormwater Management™ representative.

Next Level Stormwater Management™ Extensive Green Roof System - Maintenance Check List

Project Name: _____
 System Buildup: _____
 Completion Date: _____

Last Inspection Date: _____
 Inspection Date: _____
 Inspected by: _____

1. Plant Performance	Observations	Actions
a. Coverage		
b. Health - disease and pest damage		
c. Diversity		
2. General Maintenance		
a. Remove foreign and overgrown vegetation		
b. Remove vegetation in non-vegetated borders		
c. Replenish missing growing medium		
d. Repeat seeding / apply cuttings to bare areas		
e. Repair/replace sedum blankets		
f. Fertilize		
g. Irrigate		
3. Roof Servicing		
a. Clear debris from drainage channels, outlets and borders		
b. Ensure working order of drainage channels and outlets		
c. Inspect exposed roof membrane		
4. For Sloped Roof Only		
a. Check anti-sliding/anti-shearing elements		
b. Replace missing soil and plants from erosion		
c. Check for uniform irrigation coverage		
5. For Irrigation System Only		
a. Uniform irrigation coverage		
b. Over or under watering		
c. Clean out dirt traps		
d. Functioning of automated system		
6. Comments and Recommendations		