UBC Social Ecological Economic Development Studies (SEEDS) Student Report

New Sub Art Runoff

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Runoff
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NEW SUB PROJECT
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Executive Summary

This report details the conceptual design of the Runoff proposal for the New SUB Sustainability Art Project. Runoff is composed of a series of garden platforms suspended above a small pool. From the ceiling a small waterfall begins and falls from platform to platform down into the pool. Each platform can slowly rotate around the pool causing the path of the waterfall to change over time. The water would then be pumped back to the top via the central shaft so as to minimize wastage. The mechanism at the top which moves the platforms will be visible and be formed of a complex structure of gearing, resembling clockwork; a matching set of gearing will also reside within the pool. Sensors at the edge of the pool will detect the presence of passersby and viewers allowing the movement of the platforms and water to change based on the movement of the crowd.

This project is intended to integrate seamlessly into the New SUB Atrium by making use of the large amount of pre-existing vertical space available. It is suspended from the concrete ceiling of the atriums 3rd floor allowing for a very large structure that takes up comparatively little floor space. This pool is twelve feet in diameter and its silhouette is superimposed on the buildings floor plan on page 5 for visual reference.

Aesthetically, Runoff aims to be visually stunning not only in terms of scale but also in creativity and visual design. Each platform is intended to be its own piece of art, unique from every other platform. This will be accomplished by theming them after a different culture or environment and allowing difference groups from around campus to contribute to their design. This will be accompanied by an overarching color scheme and material selection which is intended to match that of the new SUB's interior.

Runoff's contribution to sustainability on campus will be in its message and its construction. The piece itself invokes water flowing from a mechanical and industrial beginning and filtering through the environment and agriculture down into a communal pool, from which the cycle repeats. Materials will be selected based on their sustainability and every effort will be made to source them locally. Through this we hope to illustrate that even technically complex construction can feasibility be undertaken while minimizing environmental impact.

Technically, Runoff is extremely ambitious and will require a substantial engineering effort to bring it to life. Several months of design work will be needed to turn the concept proposed in this report into a fully realized design. It will require a large scale interdisciplinary effort from engineers, architects and artists, as well as the aid of many others for fabrications and assembly. It is our hope that this piece will stand as a lasting tribute to both engineering and art at UBC.

Contents

Introduction

Purpose

Runoff is one of four projects being proposed to UBC's SEEDS (Social Ecological Economic Development Studies) council to be displayed in the main Atrium of the new Student Union Building. The purposes of these projects are to promote sustainable behaviour while minimizing UBC's ecological footprint.

Concept

Runoff is composed of a series of garden platforms suspended above a small pool. From the ceiling a small waterfall begins and falls from platform to platform down to the pool. Each platform can slowly rotate around the pool causing the path of the waterfall to change over time. The water is then pumped back up to the top via the central shaft so as to minimize wastage.

The mechanism at the top which moves the platforms will be visible and be formed of a complex structure of gears, resembling clockwork. Sensors at the edge of the pool will allow people to interact with the gearing through movement or simply by sitting on the bench, when this happens the gearing at the top will react to the movement and change the speed and direction of certain platforms, allowing viewers to change the course. The water flow can also change depending on water usage or the weather outside.

Runoff symbolizes the ever changing course of water as it flows through our environment. It was our purpose to show our interactions with water and it's interactions with us. The gears on top invoke a sense of industrialization and control while the garden platforms play the role of the green and natural ecosystems. The pool at the bottom reflects the body of water to which all water flows. With this display, we hope to give a sense of the scale that water plays in our lives and invoke discussions of our interactions with it.

Student engagement

We have been working with an interdisciplinary team of students and hope to continue to work together with them and others to complete the project. The original concepts and ideas were developed in weekly conversations with different student at the School of Architecture and Landscape Architecture. We went through many topics, discussing our views on environmental impact, student responsibility, recycling, growing waste … before we divided into subgroups to propose and prototype our different concepts. In the future, should we be presented the opportunity, we would like to consult them for further design and to collaborate with other departments like Land and Food systems to get input such as for garden designs on the platforms.

Design

Runoff was designed with several principles in mind: Minimizing footprint during operation and minimizing maintenance as much as practicable, while still providing an inspiring and interesting visual focus. The principle focus for the design was the "floating gardens", and all the other sections evolved to best accentuate this concept.

The following sub-sections describe the design concept in the main atrium area (the lower agora). If Runoff were to be implemented in a different area of the SUB, dimensions and weights would change as a result. We chose to discuss the agora location design as it would be the most technically involved implementation (with the largest parameters), but also the most striking.

i) Location and Integration

The most desirable location for Runoff in our minds is near the center of the new sub Atrium. We would be able to exploit the most vertical space as well as create the most effective visual display. Another location that was suggested was around one of the pillars below the nest lounge.

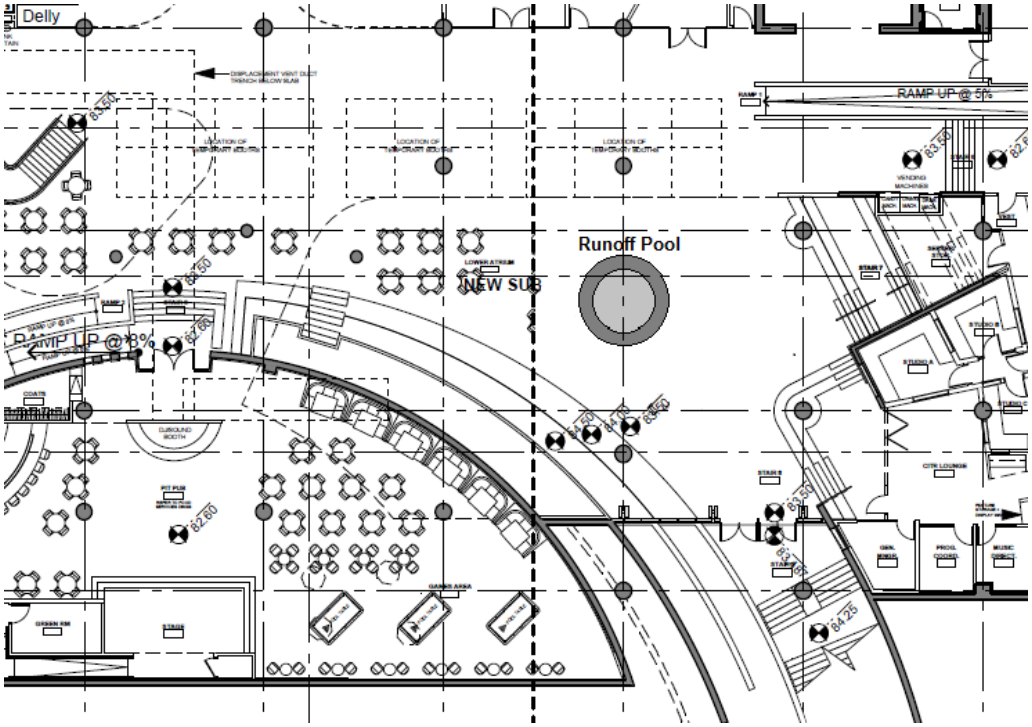

FIGURE 1: PROPOSED RUNOFF MODEL IN ARCHITECTURAL FLOOR PLANS

Integration into the atrium environment was a high priority of our design. We want Runoff to feel like it was always meant to be a part of the building, and this would be reflected in the wood colouring, and the design of the seats around the bottom pool. With the "floating" quality of the platforms, we hope that Runoff will not disrupt the openness of the Atrium, allowing the area to still feel large and airy. The render of a blown up model of the prototype is shown in the area to illustrate what we hope to accomplish with our choice of location.

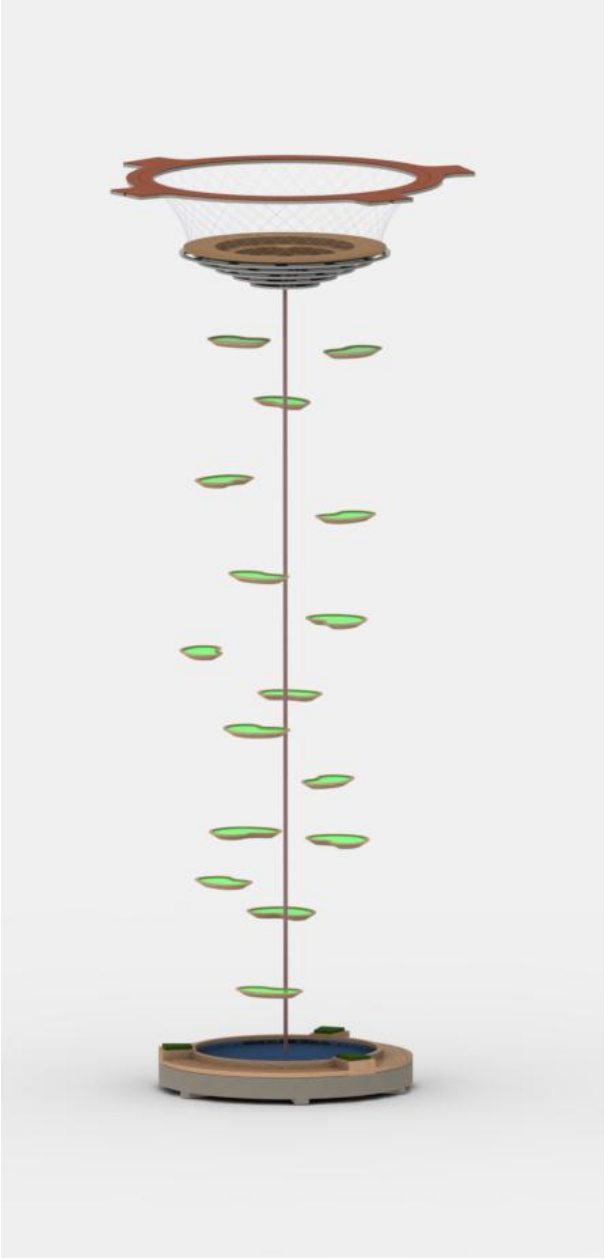

FIGURE 2: ENGINEERED RENDERING OF RUNOFF MODEL

ii) Gears

The gears for the full scale version of Runoff would look fairly different than the gears that are present on the prototype. Due to the large dimensions, we are proposing that they be manufactured in sections, and with several different components, in order to ease manufacturing and to minimize the weight of the top section while still retaining the stiffness and strength needed from these parts.

We propose that the gears should be manufactured from curved rectangular steel tube of the appropriate dimensions, with features machined into them to allow for the attachment and adjustment of gearing segments. This would allow us to manufacture the tube, which is the carrier of the platforms, to a much lower tolerance than the gear segments, and then fit the two together afterwards. The tube could also be manufactured in several segments and then bolted together in order to aid with assembly. The outer gears would be located in space by three interior spur gears, one driver and two idlers. The outside gears would also rest on a lip on the top support structure.

Proposed dimensions for the five outer gears are as follows

TABLE 1: DIAMETERS AND PROPERTIES OF PROPOSED RUNOFF GEARS

Inner Diameter	Outer Diameter	Height	Wall Thickness	Estimated Weight	Load
8’ 4”	10’	3”	0.125”	670	
6’ 4”	8’	3”	0.125”	530	
4’ 4”	6’	3”	0.125”	400	
2’ 4”	4’	2.5”	0.125”	260	
6”	2’	2”	0.125”	86	

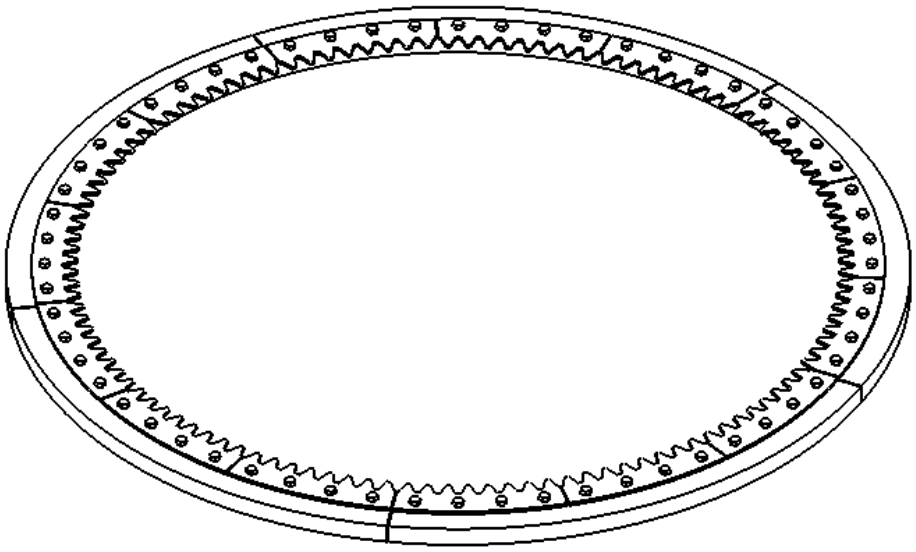

FIGURE 3: RUNOFF GEAR RENDER

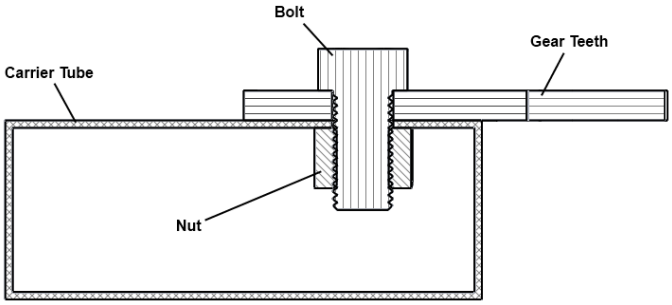

FIGURE 4: SECTION VIEW OF MOUNTING

The outer gears would require features to allow for the attachment, raising and lowering of the platforms, sensor mounts for the valve actuation system and some kind of electrical power transfer from the support to the gear like a slip ring.

iii) Top Support

The top support supports the gearing system and the platforms, provides connection points for the plumbing, and secures Runoff to the new SUB. The top support would be manufactured as much as possible from wood, with steel sections in areas where strength is needed. The top support interfaces to the new SUB via a net of steel cables that run from the roof of the atrium (The underside of the third floor slab), to the main support section. The cables are woven one on top of the other, causing the

overall look to be one of a rotated hyperbolic section. The top support holds the outside gears on a lip below the spur gears, and has geometry to locate and support the spur gears. There will be a catwalk around the outside of the support for maintenance access, as well as an interior hollow section, allowing access to all the lower gears. A access port will be placed on the floor above the supports to access the internal motors.

The top support will be manufactured out of wood beams laminated together, with dowels and bolts transferring force to the top of the structure. The support will be made in tiers, and then be assembled on site. The gears will run on a wooden lip sheathed in steel to provide an acceptable bearing surface.

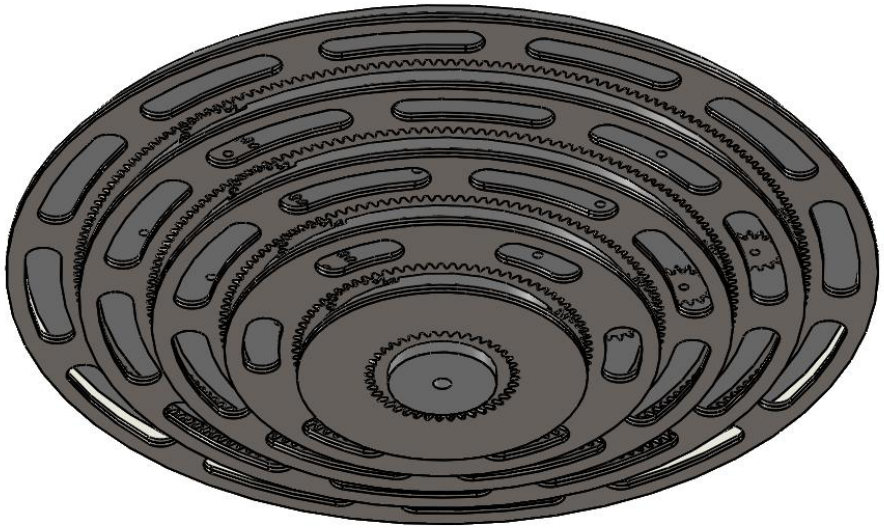

FIGURE 5: RENDER OF MODELS WITH TIERS

The top support will require features to hold the plumbing in place, as well as electrical connections to the gears and mates for the position sensors. Access to the spur gears would also be necessary.

iv) Platforms and Suspension

The platforms are the centrepiece of Runoff. They contain plants and store water until they are instructed to release it. The platforms are suspended from the outer gears, and secured to the pool with several very fine steel or polymer wires. As much of the platforms as possible will be made from wood, with a rubber coating on the interior in order to waterproof. The platforms will be suspended on a winch system in order to allow for raising and lowering to ease maintenance.

The suspension system needs to be able to support the weight of the unladed platform as well as the maximum weight of the water that can fill up the platform. We estimate this amount to be 100 lb. Additionally, the suspension system will be under tension from the lower tensioning lines to

minimize platform sway, which was identified to be a major issue in the top-suspended prototype. We estimate that the tension required to prevent the sections from swaying is 200 lb. The tensioning lines will feed into the pool and will rotate in phase with the upper gears.

We are proposing that the shapes of the platforms be created by groups around campus, within set restrictions of ~3 ft, ~1 ft. In doing so, we can engage the student community and perhaps the larger campus community in the project, contributing to a sense of ownership of Runoff.

v) Plumbing

The plumbing system consists of a pump and filter apparatus that moves water from the lower pool to the top support via a copper pipe running along the central axis of the gears. Once the water has reached the top it flows into a platform that is tied to the outlet of the pipe. The platforms then distribute water downwards to other platforms via a sensor actuated valve. When the valve is open, the water flows through a small pipe in the bottom of each platform and is spouted into the next platform. The water travels this way until it is within 6 feet of the pool, at which point it is released into the pool. In this way, the water cycle is self contained, although losses from evaporation and plant use must be replaced. We are proposing the losses be made up from the cistern water supply if possible. This would require plumbing being run to the lower pool or the top support though. Filter changes and cleaning of the pool will be necessary as well.

vi) Bench and Pool

The pool at the bottom of Runoff is, at MAXIMUM DIAMETER, fairly large. We propose recouping some of this space by adding benches around the outside of the pool. The pool itself will be made of sealed concrete and will be POOL HEIGHT tall, this will allow for a small backrest to be added to the bench. Additionally, we would like to incorporate a set of small planter boxes in the bench to add more immediately available green space. We believe that if we set the height of the pool to POOL HEIGHT and set the maximum height of the water to WATER HEIGHT we can eliminate splashing from leaving the pool. Ensuring that the water pours into the pool close to the centre will also aid in minimizing splash.

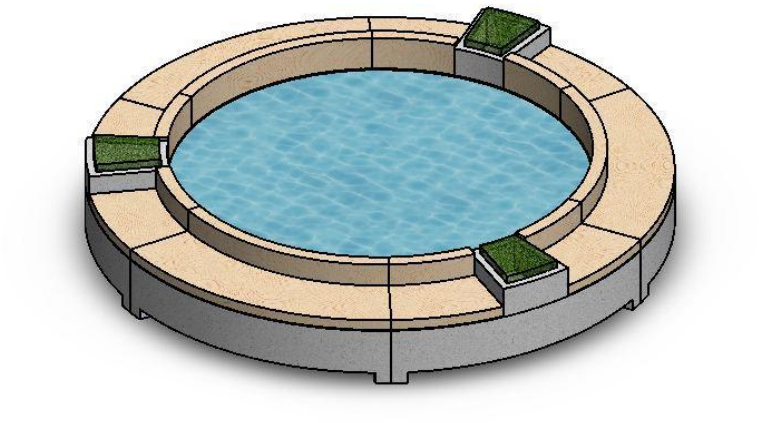

FIGURE 6: PROPOSED BENCHES ON THE PERIMETER OF THE POOL

vii) Gardens and Botany

Runoff's garden platforms are the core image that the rest of the project evolved around. As such, they should be allowed to strongly symbolize some of the concepts desired in the piece. The group that has nurtured this project up the current state consist of engineering and architecture students, and as such we do not have the expertise required to create the gardens that we envision. We propose, therefore, to engage the greater UBC community in designing the gardens for Runoff. We can provide data such as water flow, light conditions, and other details such as desire for low growth, no dropping of foliage and so on, and then allow groups, for example, the UBC farm or project groups in the department Land and Food systems or avid student gardeners to create their idea of the gardens of Runoff. From maintenance and sustainability considerations we are able to state that we would appreciate the use of native plants or locally grown plants, and that fast growing or aggressive plants such as most vines are likely not in line with the design philosophy.

viii) Actuation and Control

Runoff will require a moderate amount of actuation and associated control to achieve its desired motion. In order to actuate the outer gears, we propose a set of five electric motors mounted to one of the spur gears in each of the tiers. In this way we can vary the relative speeds of each of the gears and achieve a motion that appears for all intents and purposes to be random.

In order to get the platforms to drop their water only when they know that there is another platform below will require a set of sensors mounted on the gears to describe where each platform is in space. A block diagram of the control system is provided below. Other sensors that would be useful to have would be a water level sensor in the pool to control water supplementation, and water level

sensors in each platform to prevent other platforms from dropping water into a full platform, or to allow each platform to always have a minimum amount of water available at all times.

Parameters we would like to use in the control system to determine the speeds of the gears and the water paths include the building water usage, proximity of persons to Runoff, and perhaps the time and date or the weather outside. It should also be possible to have Runoff shut down or enter a static state if desired, for maintenance or perhaps if there are conditions in which the sound of the water is distracting.

Cost, Materials, and Labour

We have made cost estimates for the material and construction of Runoff. While these are done to the best of our ability within the time we have, they are only rough estimates.

Gears		
	steel	$5000
	bearings	$1000
	machining/welding	$20000
Gear Supports		
	wood	$4500
	steel	$1500
	construction	$15000
Platform/suspension		
	wood	$5000
	plants	$2500
	construction	$7500
Pool		
	concrete	$5500
	wood	$4000
	plumbing	$5000
Control System		
	motors	$2500
	electronics	$3000
Total		$82000

Sustainability Considerations

Runoff is supposed to discuss and reflect sustainability issues present in our local and global community. We chose to focus on water management and the impact of seemingly local issues translating into an effect on the global picture. That being said, we should not discount other sustainability considerations to highlight our focus. We would like to build Runoff using sustainable materials wherever possible. One obvious area would be to minimize the transportation footprint of our materials by sourcing from the closest manufacturer. Steels and wood are also recyclable materials and can therefore be repurposed once Runoff has surpassed its use. We will strive to minimize the wastage of power from the actuation systems by careful motor and sensor selection and use of a low power processor unit. There may be carbon sequestration benefits from the plants used in Runoff, but we believe them to be too low to have much meaningful impact on the footprint of the project due to favouring slow growth and other factors, and we instead favour approaching the sustainability aspect from an efficiency and reduction of waste perspective.

Maintenance Considerations

The moving gears, water system, and will all require regular maintenance. The metals of the gear will need careful consideration, but given good choices in corrosion resistant steels and aluminium, it should not need more than regular annual inspections. The pool is re-circulating and will need to be emptied and refilled every couple of months. We estimate a six month or shorter maintenance cycle for the plants. For that we propose a winching system to either lower platforms down or raise workers up to trim the greenery.

Installation

Before the installations, the gears and supporters will be constructed and tested to fit on the ground. Then it will be disassembled and hosted up to the ceiling and attached to preinstalled mounting points attached to the concrete ceiling. The pool will be cast in place on the floor. The platforms and gardens will be attached to the gears last.

Technical Challenges

We acknowledge that Runoff is an ambitious proposal. As such, there are numerous technical challenges that must be considered before a full scale version could be attempted.

Noted challenges include:

Weight - How will we keep the weight of Runoff to an acceptable level both for the building supporting it and the consideration of an earthquake?

Gearing - How do we design a gearing system that is visually impressive from the ground, strong nough to support the platforms, and reliable enough to run for years before replacement? How do we manufacture the system once we design it? How do we install it?

Water flow - How do we minimize splashing? We want to minimize the humidity increase of the area to keep the HVAC from working too hard. Can we keep the water falling into the pool at a certain radius and create a still pool effect in the rest of the pool?

Control - What range of speeds can the gears rotate at?

Maintenance - How do we ensure that required maintenance is easy to perform? Can we access all moving parts without having to take anything apart? How do we guarantee the safety of maintenance personnel?

Botany - How do we keep the gardens alive? Do we have any way of monitoring plant conditions reliably?

These are some of the issues that were brought up during our brainstorming sessions, during the construction of the prototype, and during the public consultation. However, we firmly believe that all of these problems can be addressed, and that the payoff from addressing them is worthwhile.

Conclusion

Runoff will integrate wonderfully with the new SUB, taking full advantage of the vertical space of the atrium. The use of steel, wood and concrete in the design nicely complements the aesthetics of new SUB and the addition of gardens and water brings a pleasant touch of nature indoors. Control of the fountain and moving platforms could interact playfully with the occupants around it and reflect changing conditions like the weather just beyond the windows or time of day.

We tried to keep Runoff's ecological footprint as small as possible. The main materials for this project have been chosen with recyclability and sustainability in mind. The metals are recyclable and the wood can be easily sources from around BC. Water for the fountain is re-circulated and can be replenished from the cistern.

There are difficult technical challenges that will need to be overcome but none that cannot be overcome. This is one of the more ambitious project proposed but it is also one of the most striking and impressive. Scaled down versions and ones around a pillar have been discussed but we feel that it would have the greatest impact as a larger piece with imposing vertical scale.