The Cubic Mile Project: Workshop Overview

Freeborough, K[1,2], Richardson, T[3], Laban, J[3], Munday, T[3]

1) UK Climate Resilience Programme Embedded Researcher
2) Applied Geohazard Scientist, British Geological Survey
3) Climate Resilience Team, City of London Corporation

The City of London Corporation and the British Geological Survey (BGS) hosted a workshop to conclude the 'Cubic Mile' project, an embedded researcher project carried out between November 2021 and October 2022. Focusing on the City of London (Figure 1), the year-long partnership investigated how urban subsurface space could be better utilised to improve the City's resilience to the impacts of long-term climate change and extreme weather. The workshop event brought together a range of stakeholders to discuss the progress of this project over the past 11 months, and to develop recommendations and next steps in the understanding, and potential development, of the urban subsurface for climate resilience.

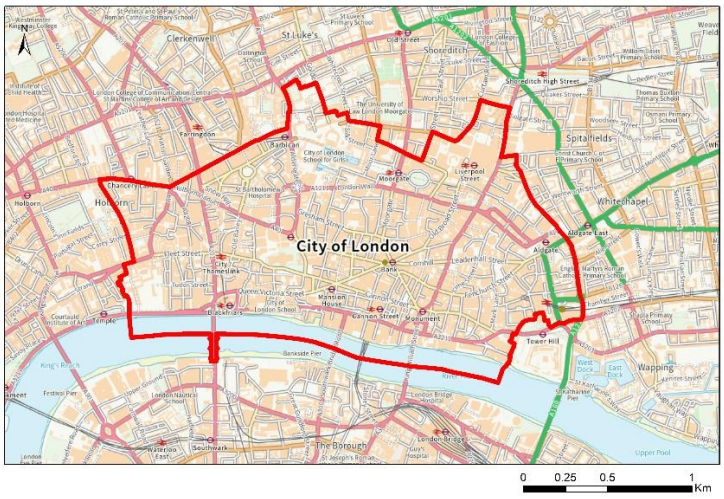

Figure 1: The City of London, also known as the Square Mile.
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The project aimed to identify the current gaps and uncertainty in subsurface use and associated data, focussing on five potential subsurface adaptation measures:

- Urban greening and tree planting
- Sustainable drainage systems (SuDS)
- Cool spaces below ground
- Ground source energy
- Resilience of buried utilities networks

This document provides a summary of key findings and recommendations from the workshop, as well as a more detailed insight into issues raised during the discussions. Further background information on the project, as well as more information on climate resilience, is available on the UK Climate Resilience Programme website: https://www.ukclimateresilience.org/projects/climate-action-strategy-for-city-of-london-adaptive-design-pathways-for-londons-cubic-mile/

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Executive summary of findings

The City of London's Climate Resilience Adaptive Pathways study, which underpins the Climate Action Strategy, identifies that "many of the actions to increase climate resilience in the City of London require changes to physical space or revisions to how the public realm is used". Identifying the need for a radical rethink of public space, it recommends "an assessment of utilisation of space above and below ground to identify potential opportunities as to how under-utilised space may be better used to improve climate resilience". The Cubic Mile project was initially designed to better understand how urban subsurface space can be used to deliver the climate resilience aims of the Climate Action Strategy.

The workshop successfully highlighted the progress made under the Cubic Mile project, but also indicated the remaining barriers and gaps in knowledge. From the activities and discussions, it became clear that there were three common issues that needed to be addressed in order to improve the use of the subsurface for climate resilience:

- Lack of urban planning and policy framework for climate resilience and adaptation.
- Lack of availability of subsurface data for climate resilience planning, including insufficient or poor-quality data (e.g., locations of basements, depth of assets, anthropogenic deposits), high costs and/or poor accessibility of data (e.g., for strategic mapping purposes) and associated security concerns.
- Insufficient documentation and coordination of developments and works affecting the subsurface that prevents improving climate resilience and adaptation outcomes.

To address these shortcomings, a set of highest priority actions were identified as follows:

- A common, stronger regulatory framework to support climate resilience and adaptation activities.
    - Both national and regional level frameworks to coordinate planning and allowing appropriate timescales for local delivery, including sufficient guidance and funding for local authorities and delivery partners.
    - Improved communication and coordination at local level between organisations and stakeholders to deliver maximum benefits (for example, coordination between local authorities and utility companies to avoid 'digging up twice').
    - Changes in the cost-benefit approach to ensure longer term climate adaptation projects can be planned and delivered alongside smaller, 'quick-win' schemes.
- Strategic planning policies for the subsurface.
    - Policies to better coordinate use of underground space, including for climate adaptation measures such as local heat networks, water schemes and green infrastructure etc.
    - Improvements to planning and development data collection for the subsurface, such as legislation for required reporting.
- Regulations and obligations for data collection and sharing during subsurface works.
    - Regulations applicable to anyone working below ground
    - A clear framework for data sharing, including for strategic planning purposes
    - Wider uptake of standardised data formats (Model for Underground Data Definition and Integration (MUDDI)) and collaborations (National Underground Asset Register (NUAR)).

It was clear from the engagement at the workshop that there is both a drive **for better regulation of the subsurface** and an **improvement in collation and access to subsurface data**. There was a recognised value that this could bring to future of climate adaptation planning for wider stakeholders and an agreement that whilst a lot is being done at surface level, the subsurface needed more collaboration and a change in focus for some.

Data access and mining is a key theme that ran through all discussions in some form. Participants were keen that data be made more open for wider uses such as climate resilience planning. This project uncovered that **security may not always be a barrier if we can be clear on use cases**; detailed data tends not to be required for strategic level planning/understanding, although it is required for more detailed, site-specific design of resilience measures. Whilst it is understood some of the issues identified in this project were specifically related to the complexity of the subsurface within the City of London, many of the themes, comments and issues discussed are applicable at national level within towns and cities.

Even though attendees were from a range of backgrounds and sectors, the discussion consistently focused on the prohibitive costs of surveying the subsurface, and how the current approach of focusing on small areas of interest **does not allow for a strategic planning approach**. In areas of rapid urban development, reliable information on historic subsurface modification is still hard to obtain. This project found that the current approach of interrogating planning applications registers is not particularly helpful; descriptions tend to be inconsistent, there is a difficulty in determining which plans relate to as-built development, and it is only useful for post-1948 development.

Where some datasets are available to access, voluntary rather than mandatory recording of information is at the hands of individual organisations and can result in a local bias or incomplete information. It is clear that **changes in regulation and documentation need to be discussed**. Strategic changes in the planning process, and subsequent storage of that information would need guidance and drive at a higher level but would ultimately benefit a variety of stakeholders in addressing their climate resilience challenges and management of wider subsurface understanding. Geospatial and geological data is improving as more detailed information and new technologies are explored. Mapping in 3D can directly assist stakeholders in understanding the deeper subsurface, however discussions in the workshop mentioned anthropogenic deposits and the role that this specifically has to play in the City and complex urban areas. Shallow groundwater systems are complex and there needs to be a fuller understanding of them and the effects of subsurface development on conditions such as flow and temperature.

Siloed research (even in the same organisation) and localised, isolated implementation of schemes, combined with conflicts within own business spheres (e.g., strategic planners/resilience officers) were recognised. Participants discussed that there are limited statutory duties for wider climate resilience policy except for flood risk, and that a higher level of government intervention is required. Currently, it is principally being driven by local authorities, applying bottom-up pressure for climate resilience to be a key focus and lead the conversation around funding. If the subsurface is to become a wider part of this conversation (and it is clear that is should) there needs to be a greater focus on collaboration and mandatory reporting. Frameworks need to be set by higher bodies, preferably by national government. All discussions focused on how **communication and coordination** is key to moving forward, including effective data exchange that could help to break down barriers.

Detailed outcomes and discussions

The in-person workshop was held on the 19th October 2022 at the City Centre in London. It was attended by 24 participants from a range of roles representing 11 organisations.

- The City of London Corporation
- British Geological Survey (BGS)
- Greater London Authority (GLA)
- London Climate Change Partnership (LCCP)
- Environment Agency (EA)
- ARUP
- Geospatial Commission (GC)
- Thames Water
- Think Deep UK
- Tapestry (Urban design)
- E.ON Energy UK
- London Drainage Engineers Group (LoDEG)

The workshop began with an introduction to the Cubic Mile project and a presentation outlining the findings on using subsurface data to advance the five adaptations measures.

The presentation highlighted the broad benefits of the project for both the City of London and BGS, as well as discussing the main barriers which prevented further advancement of climate resilience using the subsurface, using examples such as data security concerns and accessibility to data on utilities and basements (including locations and depth information).

Following the presentation, participants were encouraged to discuss how climate resilience could be advanced if common constraints were removed. This was followed by a short plenary discussion where participants could share how they are working towards climate resilience in their existing roles and organisations.

The second part of the workshop included roundtable breakout discussions, focusing on the following three themes:

- Strategic planning for the subsurface and what work is already being done in this area
- Barriers to climate resilience – identifying data and knowledge gaps
- How the work can be used to inform climate resilience across the UK and elsewhere

The lessons learnt will be applicable to other cities and urban areas who wish to evaluate the use of subsurface space in climate resilience adaptation. The outcomes of the day will feed directly into the City of London's next phase of climate resilience planning, assist in the identification of suitable locations for potential adaptation measures, and support other projects such as the City's Cool Streets and Greening programme (https://www.cityoflondon.gov.uk/services/environmental-health/climate-action/climate-action-projects/cool-streets-and-greening-in-the-square-mile).

Climate resilience and adaptation without barriers – key ideas

An 'icebreaker' session, to encourage initial relaxed conversation between participants, was designed around innovation and 'blue-sky', free thinking. Participants were asked to imagine what adaptive measures could be implemented if all common physical, policy, social and financial barriers were removed. Ideas were encouraged to be completely free-thinking and fun.

The wide-ranging ideas were reviewed to establish if there were any key themes to the responses. Ideas ranged from relatively simple (tree planting everywhere), through to very possible but unlikely (banning all vehicular access and turfing all road surfaces), wildly extreme (opening all lost London rivers) and just entertaining (X-ray vision to establish underground assets easily). However, on review, responses were categorised into eight clear themes:

- Repurposing existing infrastructure
- Nature-based solutions
- Planning and legislation
- Technical innovation
- Cultural change
- Circular economy
- Open data
- Specific adaptations for water management and energy

All themes had linked ideas, and while many are highly unlikely to ever be realised, the exercise showed the enthusiasm the group had for the topic, and the clear barriers that are faced in the real world. Some of the ideas did filter through into later discussions as potential possible future developments (e.g. waste heat taxes).

Breakout discussion groups

Three breakout groups of 20 minutes each were facilitated in the second part of the workshop, focusing on three key themes for the future of subsurface information and climate resilience.

- **Strategic planning for the subsurface** – do we need to plan the subsurface? Facilitated by Janet Laban, Environmental Resilience Lead (City of London)
- **Barriers to climate resilience** – what are the common data and knowledge gaps? Facilitated by Tom Richardson, Environmental Resilience Officer (City of London)
- **Addressing climate resilience in the City of London** – what adaptation strategies could be implemented? Facilitated by Tim Munday, Senior Building Control and Resilience Officer (City of London)

The breakout sessions were successful, with full engagement by participants and a range of key points discussed. Naturally, the conversations did stray along certain tangents or to the more familiar 'surface' climate adaptation measures; facilitators worked to bring the conversation back towards the subsurface, or to give further prompts for discussion.

Strategic planning for the subsurface – do we need to plan the subsurface?

Participants all agreed that improved strategic planning for the subsurface would be beneficial. A suitable evidence base would need to be built, with comprehensive mapping of below ground spaces and standardised data protocols. There were a range of ideas for planning policies for the subsurface but some concerns about security of the data. Consultations with communities, utility providers etc. would be necessary. The discussions were easily sorted into key areas: data capture requirements, subsurface data sources and planning policy.

Data capture requirements

- Data is needed on land ownership both above and below ground to enable climate resilience measures to be pursued by local authorities.
- Accessible data should include utility grid, flood risk, presence of basements, ducts and sewers, below ground streams/rivers and deep aquifers. There is also a need to better record below ground 'junk', such as redundant pipes, cables and ducts as these below ground structures and spaces have potential to be repurposed for another use.

- There is a need for a standardised data format for below ground mapping information.
    - There needs to be oversight of data standard – possibly through Building Control?
    - A policy and strategy for collection and management of subsurface data would be needed.
    - Licensing is in place for oil, gas, geothermal, ground-water and minerals but there is no such joined up legislation for the subsurface.
- There is good archaeological below ground data but more recent historical data from 20th century is missing. Better understanding of anthropogenic deposits in needed for measures such as SuDS and tree planting.
- Land contamination through the source-pathway-receptor model should be recorded.
- Below ground hazards such as areas of microbiologically-induced erosion should be identified.

Subsurface data sources

- Some information is available for immediate subsurface and deep level assets (through licensing).
- Information is available on the aquifer (Environment Agency) and the geology (British Geological Survey) but there is a gap in mid-level data, namely anthropogenic deposits.
- Data on basements and foundations could be better captured through changes to the planning application process.
- Mandatory information could be required from developers, utility companies etc. who should provide data to a common platform when they carry out below ground works. Prohibit digging unless below ground data is provided.
- National Underground Asset Register (NUAR) could be released for wider use cases in the future.
- High cost of moving utilities – some of the money that would be committed to this could instead be used to provide and/or update below ground data.
- Existing undertaker rights and responsibilities might be used to gather evidence.

Planning policy

- National Planning Policy Framework (NPPF) should set out the principles of subsurface planning – there should be guidance and direction from a national level. There must be a connection with surface planning.
- Policy could target spaces for climate adaptation measures such as basements as cool spaces. Planning conditions could be used to ensure spaces are available for climate risk mitigation alongside their main use e.g., basement spaces to be available as cool spaces during heatwaves.
- Policy could safeguard routes below and above ground. There would be a need to protect existing subsurface uses for climate resilience when a site is redeveloped.
- Policy should consider the impact of new basements on flood risk. Consider the use of roads and pavements for landscaping to combat flooding.
- There must be a balance between requirements for climate resilience and viability of development.

- New requirement to connect to heat networks is to be introduced in 2025 – planning policy should include heat network zoning with hierarchy of requirement to connect depending on proximity to existing network.
- Planning policy should protect below ground biodiversity and use of subsurface for carbon reduction.
- Ground source heat pumps need to be limited to prevent damage to the aquifer. There is a potential need for buffer zones around critical below ground infrastructure.
- Co-ordination of street works with climate resilience interventions would be beneficial.

Data security

Security concerns were expressed about making below ground data freely accessible, however conversations were also had on how much below ground data is actually sensitive – why is below ground data more sensitive than above ground mapping?

- A heat mapping approach which shows the density of infrastructure in each square without including detail could overcome security concerns.
- A risk hierarchy could be used to restrict access to different levels of detail in mapping.
- There is a role for the Centre for Protection of National Infrastructure.

Barriers to climate resilience – what are the common data and knowledge gaps?

Key barriers identified in these discussions included communication and coordination issues within and between organisations, and existing funding/regulatory models that prevent organisations moving forward with climate resilience.

Communication and coordination

All discussions focused on how communication and coordination is key to moving forward. Siloed research (even in the same organisation), very localised implementation of schemes, and conflicts within organisations' own business spheres were recognised.

- Strategic or combined authority knowledge will support strategic development with respect to climate resilience, as it is often siloed. There needs to be a collaborative effort for development of a subsurface issue evidence base and improved communication.
    - Planning process needs to change – programmes need to align between various sectors of an organisation and the local authority.
    - Alignment of timescales – avoid 'digging up twice' to save costs.
- There needs to be a strategic change in focus of cost-benefit analyses. This would include a greater investment in higher risk longer term projects (potentially with government backing), as current approaches seem to focus solely on financial factors rather than wider benefits.
    - 'Piggy backing' on existing projects could realise many benefits. This could result in many small wins, rather than solely focusing on major projects. For example, an optimised approach to SuDS could be taken: the implementation of the top 5% priority SuDS schemes leads to 60% of the SuDS benefit.
- Coordination is required on data collection for resilience purposes, particularly subsurface information. A common vision is required to allow for the uptake of common data standards.
- There is a need for better links with subsurface researchers and communications of needs.

Policy and framework barriers

Participants discussed that there are limited statutory duties for climate resilience except for flood risk, and that a higher level of government intervention in the policy area is required. At present, local or combined authorities tend to instigate projects, apply pressure to advocate for climate resilience and lead the conversation around funding. There was agreement to the need to drive forward at the local level in the interim.

- Adaptation reporting should be mandatory for a wider range of organisations e.g., under the National Adaptation Programme reporting power.
- Data sharing should be incentivised and reinforced with regulations if necessary. There is currently no common data platform (see also point regarding communication and coordination).
- The planning system makes keeping track of development difficult, raising questions such as: is it built? Which plan was submitted?
    - Digitisation of the planning and monitoring process should be required – currently this is done on an authority-by-authority basis with varying levels of success.
    - Better tracking of planning and development would feed better into e.g., energy demand prediction and planning.
- Surface water flooding projects are hard to instigate.
    - No set framework for implementation or evaluating the benefits
    - Benefits are difficult to quantify
    - Longer horizon times for 'payback' using existing cost-benefit methods.
- Installations such as GSHP and geothermal are complex with no lead authority; there is confusion between roles of regulators.
- Shallow groundwater systems are complex and there needs to be a fuller understanding of them.

Research and data collection – example of basements

The groups discussed the clear element of reactionary research and data collection in response to events rather than a more planned and anticipatory approach, using flooding of basements as an example. It was discussed that this could partly be funding driven.

- Basement flooding in 2021 triggered wide-scale collation of data about residential basements. This could be held in a central depository but currently is not.
    - Security concerns. These could potentially be overcome with approaches such as signposting, e.g. indicating data is held at a location and signposting to further contacts.
    - Basement information could be better managed with Land Registry.
- Technical knowledge underpinning basement impact assessments is mature, but there but there is a lack of coordination with where these are undertaken. A central database for these assessments could be an easy win to better coordinate subsurface information and gained knowledge.

Addressing climate resilience in the City of London – what adaptation strategies could be implemented?

Group discussions were wide-ranging, but focused mainly on heat networks, water management and cultural change.

Heat networks

Heat network discussions started by regarding the double element of the London urban heat island effect: the City absorbing heat combined with large buildings rejecting hot air, exacerbating the issue further. Is there a potential that in the future this heat could be utilized for heat exchange networks, or a future heat tax be implemented?

- There is a potential to have new networks and multi-centre networks with heat substations (subsurface?) as the focus – implementing this level of transformative change would be equal to the gas network change – but is it achievable?
    - If this level of transformation is possible, we need to start thinking about wider implications early and putting in effort to research.
    - If the community is moving to use the subsurface for more adaptation and resilience measures, could there be a situation where this is making the utility and asset congestion worse – a coordinated approach is needed and better data sharing.
    - Could buildings be designed to better absorb this change by including some of the infrastructure assets/subways – this would be taking space from buildings rather than adding more structures below street level.
    - Future detailed conversations are needed to review how to get to the 'network stage' – what is the scale being envisaged? The City could be a net exporter of heat/grey water resources.
- The subsurface transport network could be a source of waste heat, e.g., via vent shafts.

Water management and reuse

The theme of water management, capture and reuse arose in discussions. One idea was the possibility to legislate SuDS that have water reuse as the first principle (as opposed to e.g. water quality or runoff management).

- Future for potential net zero discharge sites and/or compulsory water reuse policy – clear crossover to planning policy discussions.
- Alternative sources of drinking water – potential to use the perched aquifer for cooling or vegetation irrigation
- Discussion on if the drinking water system could in future be a heat exchange network.

Open spaces need to be viewed differently. Parks and gardens are obviously key but also future roads and rooftops are assets for water.

- Space competition for subsurface nature-based solutions was raised.
- Can there be a community/network-based sharing of waste heat and grey water?

Localised climate adaptation

A separate discussion occurred around localised climate adaptation, and whether climate resilience 'offsets' would be appropriate. For example, if one area cannot achieve targets due to constraints (e.g., due to complex subsurface), could another area with space create additional measures that would have a benefit over a wider area?

- There is a crossover between climate adaptation and mitigation, e.g., necessity of carbon/energy reduction vs. active cooling in designated cool spaces.
- Nature-based solutions can become complicated when other issues are brought into consideration, and messaging on overall benefits needs to be clearer e.g., a green roof can be installed as a climate resilience measure and could also add value for biodiversity if managed correctly.
- The current chain of knowledge is circular: grassroots look up to councils -> GLA -> Government, who look back down to grassroots. Essential to have clear leadership and build momentum to move to mandated decision making on climate resilience. It is clear that actions need to start being implemented at many different levels.

Infrastructure repurposing and reuse

Focus should include infrastructure repurposing and reuse for climate adaptation.

- There is a large potential for use of abandoned assets – e.g., abandoned sewers with potential for repurposing. Mapping of these is still a sensitive and restricted topic area and conversations need to happen between asset owners and resilience teams to enable research potential.
- There needs to be a better understanding and communication of where accessible basements are and what basements are used for:
    - A local authority led activity – but who would lead?
    - Cumulative impact of dewatering through basement constructions needs better understanding.
- The palette of materials used in City developments is getting some push back – limitations on innovation due to business as usual whereas industry keen to change. New techniques need to be adopted.
    - If an organisation is digging up the road for pipe works, is there a potential that elements could be put back completely differently; permeable paving, grassed areas?
    - CIRIA Guidance offers buy-in but needs instigation and funding at the start.

Finally, the discussions also mentioned how there is a current assumption that you can get away with 'anything' in the ground (e.g., how many piles and go as 'deep as you want'). How far below the ground do you own/can you alter? This needs to be reviewed and better regulated.

Appendix 1 – No barriers to climate resilience

Participants were asked to imagine what adaptive measures the climate resilience community could implement if all normal physical, policy, social and financial barriers, were removed. Ideas were encouraged to be completely free thinking and fun. Reviewed responses were clearly able to be themed into eight clear themes:

Repurposing existing infrastructure

- Repurpose the gas grid
- Use drinking water as a heat source via water mains
- Use abandoned infrastructure to help with surface water management on the Square Mile
- Open access to ground floor A/C spaces during heatwaves, regardless of ownership
- Repurpose piles in buildings
- Repurpose redundant utility systems
- Grow fungi in redundant underground space
- Abandoned assets to be used as heat networks

Nature-based solutions

- Aquifer recharge
- Alter artificial road surfaces to natural vegetation
- River wall recess – give bank land to rivers edge
- Pedestrian sunken garden highways – swales
- Reopen old rivers and utilise space they currently occupy in subsurface
- Line every street with trees
- Remove all car parking and replace with retention and permeable paving
- Green roofs/walls on every building

Planning and legislation

- Single climate risk assessment and resilience plan from all stakeholders in CoL, synced with neighbouring authorities
- Planning – require justification for use of below ground space e.g., piles
- New financial modelling for innovative/high risk-high reward climate improvement projects
- Require all buildings to do survey to their height below ground
- Ground levy on new buildings to do very deep surveys
- Tax waste heat
- Safeguard below ground space as future cool spaces
- Leased basement space as usage changes
- Comprehensive subsurface 3D planning system/geospatial plan

Technical innovation

- Micro-grids for energy production, storage and reuse
- Below ground civilisation
- Underground swimming pools
- Intelligent trees – roots that avoid underground infrastructure and help identify leaks and waste heat

- Underground greenhouses
- Raise all buildings on stilts to be resilient to flooding (with kayak parking)
- X-ray vision for the subsurface

Cultural change

- Increase cycle routes
- Free tube and free bikes
- Last mile logistics
- Owner engagement
- Network of underground spaces and walkways between them
- Get rid of vehicles – remove tarmac to lessen heat island

Circular economy

- Use the river/aquifer for area scale heat capture in summer to reclaim in winter
- Remove unnecessary sources of heat – road transport and vehicles
- Enable circular energy economy – there should be no waste heat or cooling
- Recover waste heat from buildings
- Heat capture from the tube / harvest all LUL tunnel heat
- Waste heat from energy centres – energy sharing
- Incentives for waste – spaces, energy and buildings

Open data

- Tell everyone to provide data when they dig

Specific adaptation – water management

- Capture rainwater for reuse
- Use basements as flood storage
- Full hydrothermal model of the subsurface to use as a resource
- Surface water drainage retention
- SuDS are simple and anyone can design them
- Below ground water storage
- Rainwater harvesting

Specific adaptation – energy

- Energy capture from sewers
- Underground thermal storage/battery storage
- More rooftop space for solar PV
- City-wide integrated heating and cooling system
- Different interventions in response to infrastructure failures, e.g., energy supply failures not tackled with heat generating or polluting generators.

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